DIVERSITY AND POPULATION OF NON-VOLANT SMALL MAMMALS AT HUTAN LIPUR SEKAYU, TERENGGANU

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DECLARATION

I hereby declare that this dissertation diversity and population of non-volant small mammals at Hutan Lipur Sekayu, Terengganu is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at UMT or other institutions. This report is submitted to the School of Marine and Environmental Sciences as partial fulfillment towards obtaining the Bachelor of Applied Science, Biodiversity Conservation and Management from School of Marine and Environmental Sciences, Universiti Malaysia Terengganu.

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Diversity And Population of Non-Volant Small Mammals At Hutan Lipur Sekayu, Terengganu

By

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Research Report submitted in partial fulfillment of

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ABSTRACT

Lowland forest is an important and suitable habitat to many species of non-volant small mammals. However, there is still lack of published information on the diversity and population of non-volant small mammals in lowland rainforest of Malaysia, particularly in eastern Peninsular Malaysia. Hence, this study proposed to provided (i) diversity and (ii) population size of non-volant small mammals for future conservation efforts in Hutan Lipur Sekayu, Terengganu. Capture mark recapture was applied in this study to estimate the population size of non-volant small mammals. Eight sampling sessions were conducted for three consecutive night for each sessions from July 2018 until February 2019. A total 11 species of non-volant small mammals from 54 individuals belonging to 3 families (Tupaiidae, Muridae and Sciuridae) were captured. *Tupaia glis* (Common tree shrew) was the most abundance species have been captured followed by *Maxomys surifer* (Red spiny rat). The total population size of non-volant small mammals was estimated as 595 individuals (95% confident interval of 177.9 to 3352.1 individuals). Based on the chi-square test, species and bait types has a significant difference. For instance, *T. glis* (χ^2=54, df=3, $p<0.05$) and *Callociurus notatus* (χ^2=8.6, df=3, $p<0.05$) preferred on banana and *M. surifer* (χ^2=22, df=3, $p<0.05$) preferred on potato with peanut butter. Our results suggest that the population sizes found by the study are larger. As a conclusion, this study provide baseline data on non-volant small mammals in Hutan Lipur Sekayu, Terengganu that can be used for the effective conservation and management.

DIVERSITI DAN SAIZ POPULASI MAMALIA KECIL TIDAK VOLAN DI HUTAN LIPUR SEKAYU, TERENGGANU

ABSTRAK

Hutan tanah pamah adalah habitat yang penting dan sesuai untuk banyak spesies mamalia kecil tidak volan. Walau bagaimanapun, masih terdapat kekurangan maklumat yang diterbitkan mengenai kepelbagaian dan populasi mamalia kecil tidak volan di hutan hujan tanah pamah di Malaysia, terutamanya di timur Semenanjung Malaysia. Oleh itu, kajian ini dicadangkan untuk menentukan (i) diversiti dan (ii) saiz populasi mamalia kecil tidak volan bagi usaha pemuliharaan masa depan di Hutan Lipur Sekayu, Terengganu. Kaedah tangkap, tanda dan lepas digunakan untuk kajian ini untuk menganggarkan saiz populasi mamalia kecil tidak volan. Lapan sesi pensampelan dijalankan selama tiga malam berturut-turut untuk setiap sesi dari Julai 2018 hingga Februari 2019. Sejumlah 11 spesies mamalia kecil tidak volan daripada 54 individu yang terdiri daripada 3 keluarga (Tupaiidae, Muridae dan Sciuridae) ditangkap. *Tupaia glis* (Tupai tanah) adalah spesies yang paling banyak telah ditangkap diikuti oleh *Maxomys surifer* (Tikus duri merah). Jumlah populasi mamalia kecil tidak volan dianggarkan sebanyak 595 individu (95% selang keyakinan adalah 177.9 hingga 3352.1 individu). Berdasarkan ujian chi-square, spesies dan jenis umpan mempunyai perbezaan yang signifikan. Contohnya, *Tupaia glis* (χ^2=54, df=3, $p<0.05$) dan *Callociurus notatus* (χ^2=8.6, df=3, $p<0.05$) lebih menyukai pisang dan *Maxomys surifer* (χ^2=22, df=3, $p<0.05$) lebih menyukai pada kentang dengan mentega kacang. Keputusan kajian ini menunjukkan bahawa saiz populasi yang dijumpai oleh kajian adalah besar. Sebagai kesimpulan, kajian ini menyediakan data asas mengenai mamalia kecil tidak volan di Hutan Lipur Sekayu, Terengganu yang boleh digunakan untuk pemuliharaan dan pengurusan yang berkesan.

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LIST OF ABBREVIATIONS

IUCN	-	Internation Union for Conservation of Nature
LC	-	Least Concern
NT	-	Near Threatened
VU	-	Vulnerable
E	-	Endangered

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Mammals are the most adaptable animals on the earth. These animals can be found almost on every continent and ocean and are made up of different sizes from small to larger sizes. All mammal species are warmly blooded and most of them have the same internal anatomy characteristics (Francis, 2008). Their movement is one of the characteristics of their dominated terrestrial habitat for example, terrestrial species use different types of movement, such as walking, jumping, climbing, digging and also some species capable of flying. Mammals are differentiated according to their external morphologies between other group such amphibian, reptile and birds.

In Southeast Asia there are approximately 500 mammal species recorded (Francis, 2008). Large mammals are classified by their weight between several kilograms and reach evens hundreds of kilogram. They are consists of herbivores species such as elephants and carnivorous species like bears (Noss et al., 1996). Small mammals are separated into two categories which are the volant and non-volant small mammal. Volant small mammal defined as small mammals with the ability to fly like bats. Meanwhile, non-volant small mammals are known as terrestrial mammals, which are unable to fly excluding bats. For example, Muridae (rats and mice), Sciuridae (squirrels), and Tupaiidae (tree shrews) are involved. According to Bernard (2004), non-volant small mammals have a weight of less than five kilograms. The total of 185

species of non-volant small mammals were recorded in Southeast Asia, 62 species are endemic and 123 are non-endemic species (Molur et al., 2005).

Southeast Asia's rainforests are the oldest, biologically rich. Southeast Asian forests are also the great biodiversity of land ecosystems on the earth (Gentry, 1992). Almost all of rainforest Southeast Asia are considered hotspot for biodiversity because they contains a large number of endemic species (Myers et al., 2000). Malaysia is one of the countries with the highest diversity of species of fauna such as insects, birds, reptiles, amphibians, fish and mammals in the ecosystem of the rainforests. There are approximately 210 species of mammals, 620 species of birds, 250 of reptiles and 150 species of frogs were recorded in Malaysia. Terengganu is one of the states in the Peninsular Malaysia that is rich in tropical rainforests and one of which is known as Sekayu lowland forest. Sekayu lowland forest has a complex structure that offers more diverse habitats for many small mammal species.

Small mammals were important for the ecosystem because they play the role as seed dispersers of many tree species (Wells & Bagchi, 2005). Unfortunately, because of rapid development and agricultural activities, most of these species have been threatened by habitat loss. Urgent conservation actions are therefore desperately needed. The information about population estimates, species richness, diversity, and abundance are among the important information, which are needed to understand a certain species before any effort in trying to conserve them. However, knowing and understanding the spatial distribution of certain species within its habitat are also important for interpreting ecological processes and plays an important role in planning the conservational process.

1.2 Justification of Study

Lowland forest is an important and suitable habitat to many species of non-volant small mammals. However, there is still lack of published information on the diversity and population of non-volant small mammals in lowland rainforest of Malaysia, mainly in eastern Peninsular Malaysia including Terengganu. There were few studies carried out on the non-volant small mammals in Terengganu such as at Bukit Taat, Tasik Kenyir (Mazlan et al., 2015), Tasik Kenyir, Hulu Terengganu (Nor Zalipah et al., 2019; Noor et al., 2019) and Pulau Perhentian Besar (Rahim et al., 2016). However, the diversity and population of non-volant small mammal at Hutan Lipur Sekayu, Terengganu is still unknown.

By doing this study, the lack of information on the diversity and population of non-volant small mammals species at Hutan Lipur Sekayu will be filled in. Thus, this study will help to establish new checklist on the diversity and population of non-volant small mammal species at Hutan Lipur Sekayu.

1.3 Objectives of the Study

The major aims of this study are:

1. To determine the diversity of non-volant small mammals at Hutan Lipur Sekayu, Terengganu
2. To determine the population size of of non-volant small mammals at Hutan Lipur Sekayu, Terengganu.

CHAPTER 2

LITERATURE REVIEW

2.1 Non-Volant Small Mammals

Non-volant small mammals are the most abundance, and they have adapted to almost every habitat in the world. In Malaysia, non-volant small mammals are including as a particular species of rats and mice from are family Muridae, tree shrews from are family Tupaiidae and squirrels are from Sciuridae family. This group of small mammals can be found at logged and unlogged forest sites (Bernard, 2004). Some of these species are generally active at night (nocturnal) and inactive in daytime (Wells et al., 2006). Other than that, they are usually found in primary and regenerating lowland mixed dipterocarp forest (Kemper & Bell, 1985). Normallly non-volant small mammals were commonly found in rotting logs, leaf litters, tree stumps and also at rocky areas (Davis, 1962; Kemper & Bell, 1985). This is because this habitat provides abundances of food sources and also serves as nesting and rearing of young (Tomblin & Alder, 1998).

In general, small mammals including non-volant small mammals shares almost common diet with other animals as they eat insect, arthropods and fruits (Langham, 1983; Payne et al., 1985). Most species of small mammals feed on combination of seeds, fruits and roots (Wells & Bagchi, 2005). In addition, majority of small mammals in Southeast Asian forests are considered to have an omnivorous and opportunistic diet, including a wide range of plant materials (Langham, 1983).

Small mammals also often crucial to the ecosystem and always play an important role as a seed dispersers to many tree species (Terborgh et al., 2001). Wells and Bagchi (2005), investigated the high rate of seed removal by small mammals. They also found that small mammals have the habit of removing seeds before consumption and have the ability to germinate half - eaten seed indicated that these species act as important dispersers of seeds. The impact on the landscape will occur if small mammals are controlled by their eating habit. Thus, the presence of small mammals in forest ecosystem also transform the physical and biotic landscape as they may contribute to the functioning of the ecosystem and restore habitat, since they act as dispersers agent (Vieira et al., 1991). Through it, the presence of small mammals will affect the functioning of ecosystems and diversity of species. Small mammals also the major role as ecological food web (Acharya, 2001). Small mammals serve as important links in the energy flow as they are the primary prey for many carnivorous mammals, snakes, and birds. Study by Pardini et al. (2005), found that most of non-volant small mammals functioned as good biological indicators because they were susceptible to environmental impacts and disturbances associated with changes in habitat structures.

2.2 Threats to Small Mammals

Southeast Asia that has high species richness and the endemism is linked to its complex ecological history (Sodhi et al., 2004). The rainforest of Southeast Asia extremely have been experienced the highest rate of deforestation, including of illegal activities, agriculture activity because of rapidly urbanization that has resulted in the decline of species (Sodhi et al., 2010).

Small mammals are generally threatened by interference with human activities resulting in habitat fragmentation. Habitat destruction is defined as discontinuity in the spatial distribution of resources and conditions in an area at a given scale that affects the occupancy, reproduction or survival of a species resulting from a set of mechanisms (Franklin et al., 2002). Many previous studies have been carried out on effects of forest fragmentation on small mammals (Lynam & Billick, 1999; Pardini, 2004). Therefore, many factors and biological processes such as species dispersal, population size, and structure of habitat will be affected (Pardini, 2004). Based on previous study at Hulu Telemong Forest Reserve, Terengganu recorded the lowest species diversity and

richness of non-volant small mammal community because of human invasion and disruption (Noor et al., 2019).

Logging usually involves the removal of tall trees, thus threatening the survival of certain species. Although past studies have proven that logging activities can affect species richness, abundance and composition of many species, selective logging is not expected to reduce food availability or the number of the nesting site drastically (Syakirah et al., 2000). Logging also enables the threat of non-volant small mammal populations. The effect of small mammal population to forest logging has received less attention in Asia tropical forest (Bernard, 2004). Based on collected data from several locations in Northern Borneo, it shows the highest diversity and species richness of small mammals in unlogged forests compared to logged forests (Wells et al., 2007).

Deforestation is more concentrated and accessible on the lowland forest (Sutton & Collins, 1991). Generally, lowland small mammals are threatened because of deforestation activity and because of its habitat can be easily accessed by threats, especially humans (Brooks et al., 1999). In general, terrestrial small mammals are adapted to shelter in forest areas and would not survive in agriculture or cleared areas. Thus loss of habitats will indirectly result in a decline in the total population of species (Francis, 2008).

2.3 Population Size Estimation

The most common method to estimate population size of small mammal usually involve the capture-mark-recapture method (Williams et al., 2002). Traps are arranged in rectangular grids or along line transect to estimate population size (Hopkins & Kennedy 2004). This method allows a wide variety of demographic parameter and abundance or density to be investigated (White et al., 1982; Williams et al., 2002). In general, estimation of population requires at least two trapping occasions. First, a population is sampled and the captured individuals are marked and released afterwards. After a certain time, the population is usually re-sampled using the same methods for the next day. Next, the unmarked individuals are marked and the identity of recovered animals is recorded.

In this study, capture mark recapture method was used to estimate the population size of non-volant small mammals in this area. Population size can be classified as open or closed population. There are three main estimators for closed population size estimation which are Peterson, Schnabel, and Schumacher and Eschmayer methods with its assumptions (Krebs, 2014). While open population that involve unconditional changes of size and composition in a population over long period time. Abundance of a species in an area can be estimated using closed population which assume that there is no births, death, as well as immigration or emigration during sampling period. Meanwhile, open populations is a population changes in size and composition from births, deaths and movements.

CHAPTER 3

METHODOLOGY

3.1 Study Area

The study was conducted from July 2018 until February 2019 in Hutan Lipur Sekayu, located at the north eastern of Peninsular Malaysia, in the state of Terengganu (Figure 3.1). This recreational forest is located 16 kilometers from the town of Kuala Berang and 56 kilometers from the city of Kuala Terengganu. The forest has a total area of about 405 hectares. Hutan Lipur Sekayu is one of the famous recreational areas in Terengganu. This is because Hutan Lipur Sekayu is a dipterocarp forest with waterfalls and rich with dipterocarp trees species (Siwar et al., 2011). The recreational park is complete with recreational facilities such as chalet, huts, campsites and toilets.

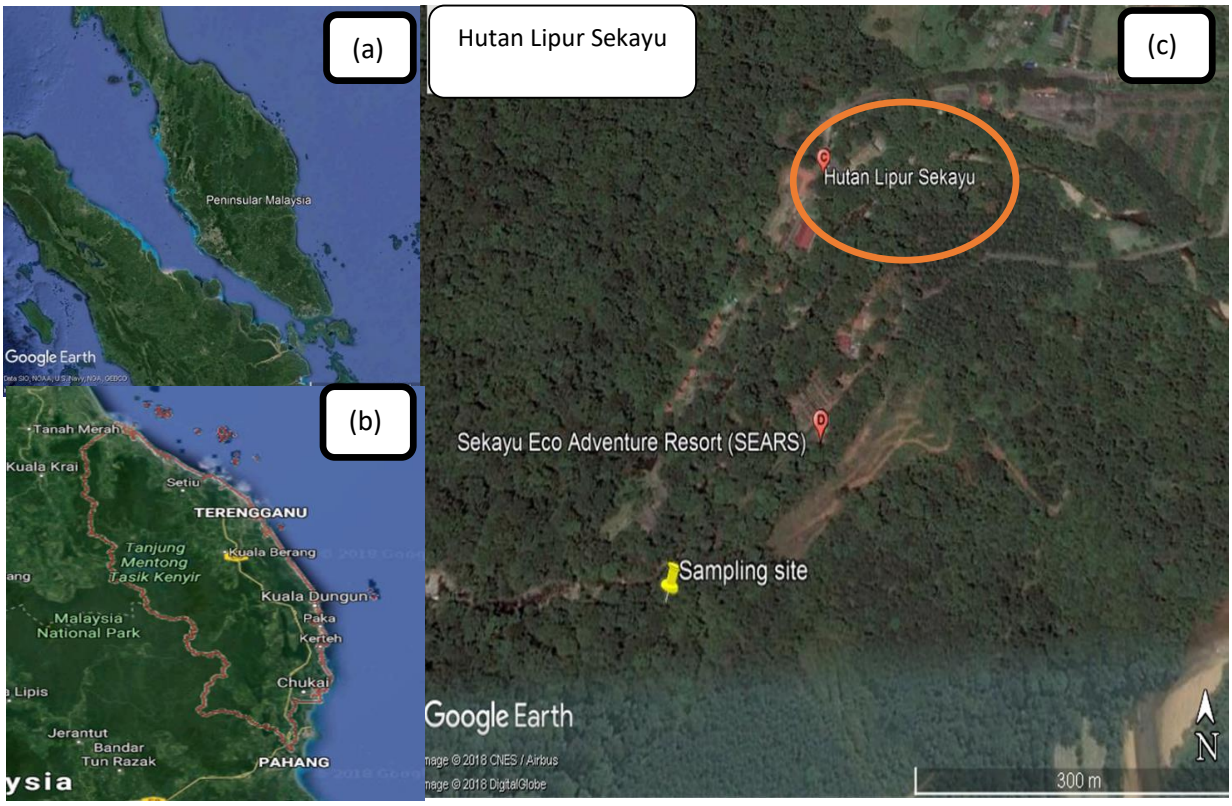

Figure 3.1 (a) Map of Peninsular Malaysia, (b) Map of Terengganu, (c) Map of Hutan Lipur Sekayu, Terengganu.

3.2 Sampling Technique

3.2.1 Live cage trapping

The study of small mammal populations generally involves the use of capture-mark recapture trapping (Williams et al., 2002). This study use capture-mark-recapture method to estimate the population size of non-volant small mammals. A total of 100 live cage traps measuring 45.72 cm x 12.7 cm x 13.97 cm were used in this study (Figure 3.2). Traps were placed by using a trapping grid arrangements of 100 x 100 meters (Figure 3.3). Furthermore, traps were checked twice a day in early morning (between 8.00 am until 9.00 am) and late evening (between 5.00 pm until 6.00 pm). Traps were baited with slice of banana, roasted coconut, slice of sweet potato with peanut butter and dried fish. Baits were set up with systematic random sampling for each cage. Baits were replaced to keep the freshness of the bait if needed. Traps were

set up on the forest floor to target for nonarboreal small mammals, 10 m apart from each other, thus resulting a square trapping grid that covered 1 hectare area. Furthermore each cage were tagged with flagging tape to facilitate the process of detecting the trap after the installation process is completed. All traps were left for three consecutive days for every session.

Figure 3.2 Live cage trap (45.72 cm x 12.7 cm x 13.97 cm)

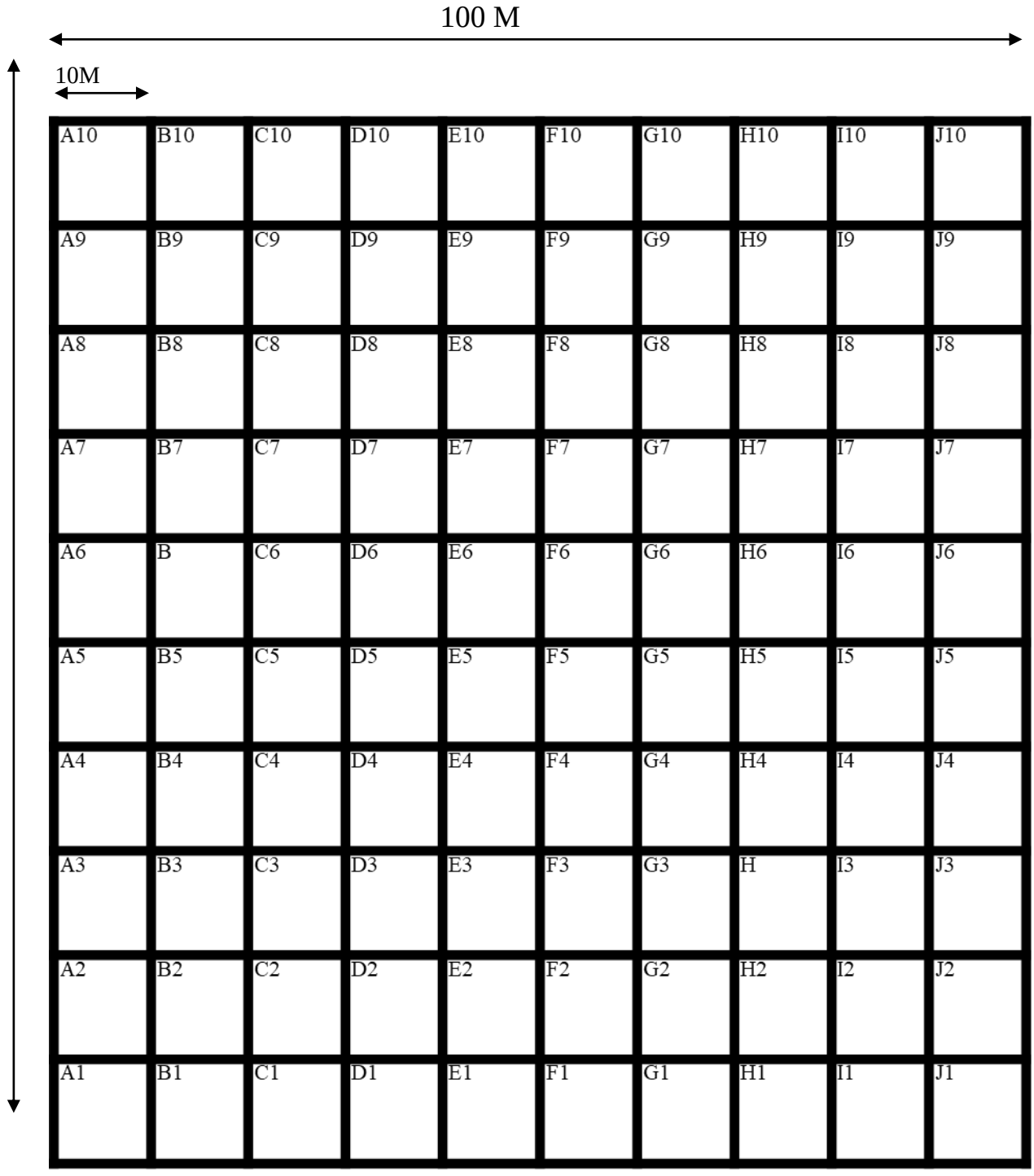

Figure 3.3 Trapping grid (100 m x 100 m)

3.2.2 Identification of species

All captured non-volant small mammals were transferred into a transparent plastic bag and were anaesthetized with chloroform. Body measurements were recorded for each individual by using ruler or measuring tapes. The head-body length (HB) was measured from the anus to the anterior of the nose. Tail (T) was measured from the anus to the tip of the tail. Hind foot (HF) was measured from the heel to the end of the longest toe. Ear length (EL) was measured from the bottom of the exterior opening of the ear to the tip (Figure 3.4). Captured individuals were weighed using digital scale. All individuals were marked with waterproof spray before they were released back to the capture spot immediately after measurements were done. The photograph of non-volant small mammals were taken using a digital camera. Identification process was conducted using a key from Francis (2008).

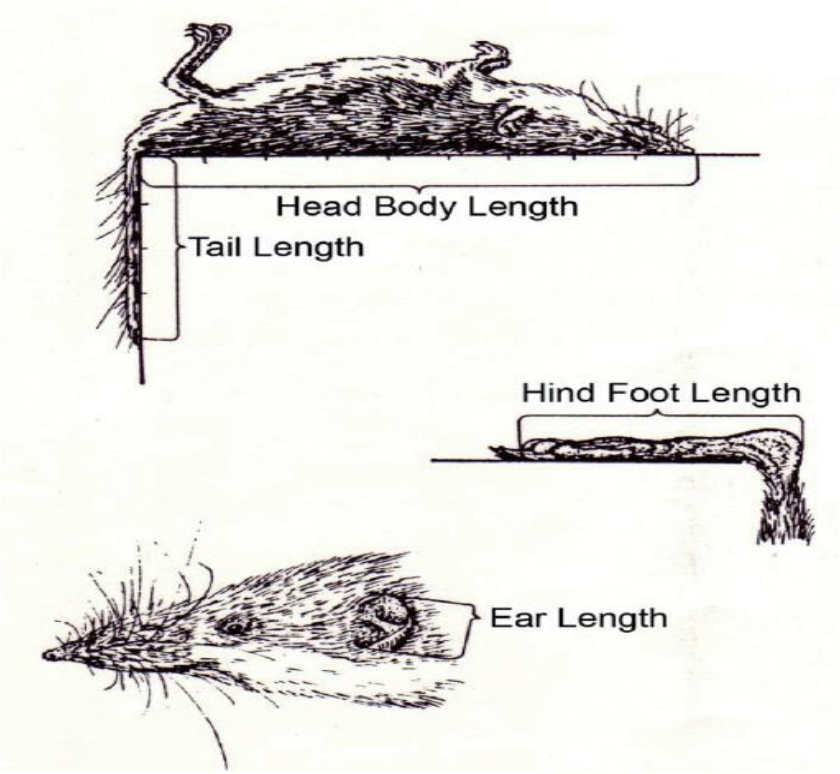

Figure 3.4 The measurements of non-volant small mammal

(Adapted from Google Image)

3.3 Diversity Measurements

Data were analyzed by using statistical software such as Paleontological Statistic (PAST) software version 3.0. The diversity of species is determined by calculating ecological indices including the Shannon Index (H') and the Simpson Index (1-D) of diversity. Margalef and Menhinick indices are used for the richness of species.

3.4 Rank Abundance Curve (RAC)

Rank abundance curve is a graph used to shows species abundance at Hutan Lipur Sekayu. It can also be used to shows species richness and species evenness. The slope of the graph show the level of evenness either high or not. Rank abundance curve consists of different models such as log normal, broken stick, geometric and log series models.

3.5 Species Accumulation Curve (SAC)

Species accumulation curve (SAC) is used to estimate the number of species in a specific area and to see whether sampling effort is enough or not (Colwell et al. 2004). If the sampling effort is enough, the specific line of the graph will reach the asymptote.

3.6 Percentage of Trapping Success

Trapping success was calculated for all consecutive sampling for eight months from July 2018 until Feb 2019. The measurement of trapping success was determined with total number of individuals captured and the number of trapping efforts. The formula is given below.

$$\text{Percentage of trapping success} = \frac{\Sigma\, Number\ of\ individuals\ captured}{number\ of\ trapping\ night} \times 100$$

3.7 Population Size of Non-Volant Small Mammals

The population size of non-volant small was estimated using the data obtained from mark-recapture method. Population of the species was considered as closed population. Schnabel estimator can be applied for the estimation of closed population size that allows for more than two captures-recaptures encounter with minimum of three captures, no limit as to maximum number of recapture required and the number of accidental death is assumed to be small (Alcoy, 2013; Krebs, 2014). Graph in Figure 3.5 shows the linearity for total number of marked non-volant small mammals (Mt) against the proportion of marked animals in each sample (R_t/C_t), which allows Schnabel estimator for the population size estimation. The estimation of non-volant small mammals was calculated using Schnabel (1938) as follows:

$$\text{N} = \frac{\Sigma(C_t M_t)}{\Sigma(R_t + 1)}$$

$$\text{Variance } \frac{1}{N} = \frac{\Sigma(R_t)}{\Sigma(C_t M_t)2}$$

$$\text{Standard error of } \frac{1}{N} = \sqrt{Variance\ \frac{1}{N}}$$

N = Size of population at time of marking

M_t = Total number of previously marked animals at time t

C_t = The number of individuals caught at time t

R_t = The number of marked individuals caught/observed at time

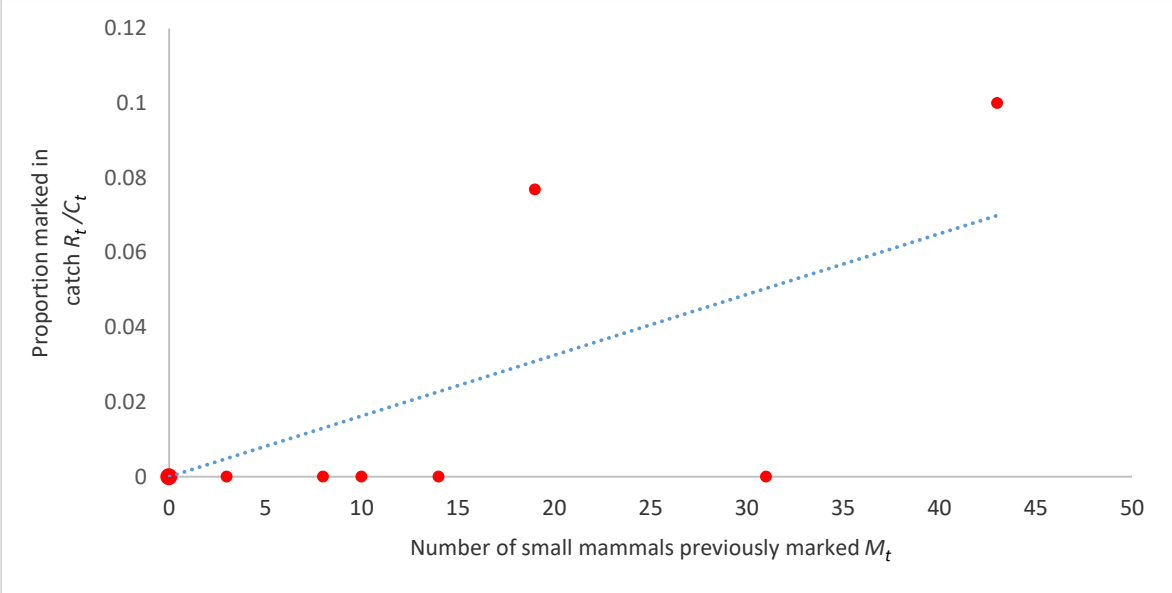

Figure 3.5 Plot of accumulated number of marked animals (M_t) against the proportion of marked animals in each sample (R_t/C_t).

Ninety five percent of confidence intervals for estimated population were obtained from the Poisson frequency distribution table in Krebs (2014) since the total number of recaptures (ΣR_t) is less than 50. Equation used to obtain limits:

$$\text{Lower 95\% confidence limit} = \frac{\Sigma(C_t M_t)}{\Sigma R_t \ (95\ \%\ upper\ limit)}$$

$$\text{Upper 95\% confidence limit} = \frac{\Sigma(C_t M_t)}{\Sigma R_t \ (95\ \%\ lower\ limit)}$$

CHAPTER 4

RESULTS

4.1 Species Composition

A total of 54 individuals from 11 species of non-volant small mammals were successfully captured during eight sampling sessions. There were 11 species of non-volant small mammals comprised of 18 tree shrews, 30 rats and six individuals of squirrels. All the captures can be grouped into two orders, Rodentia, Scandentia and three families which are Tupaiidae, Muridae and Sciuridae. Almost half of the species caught in this study belonged to the family Muridae (56%) followed by Tupaiidae (33%) and Sciuridae (11%) (Figure 4.1).

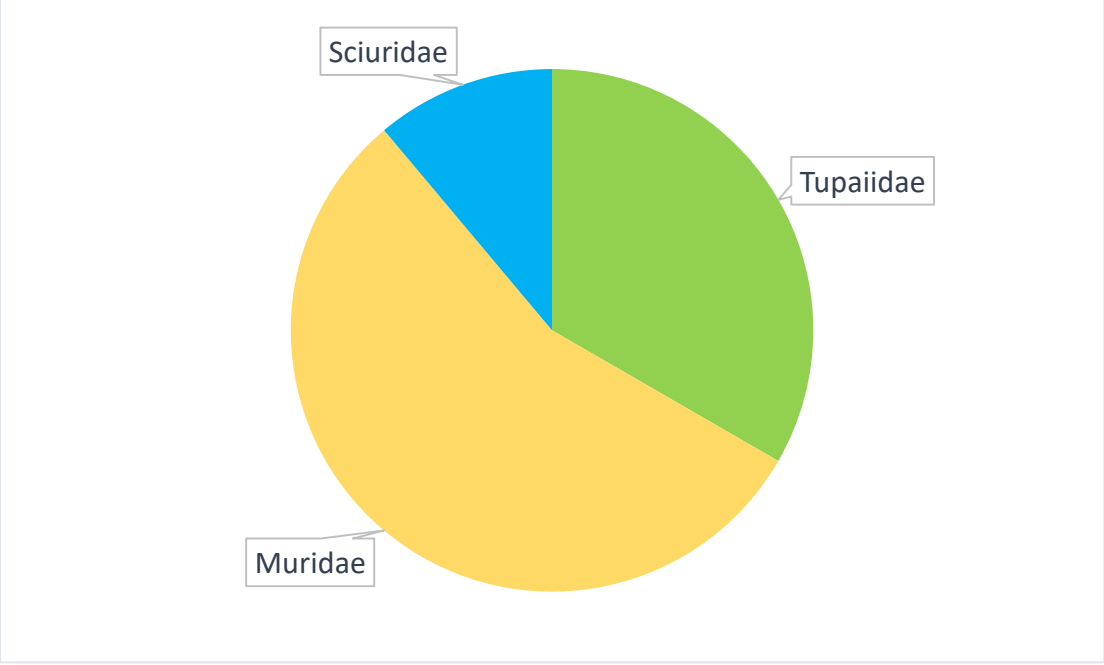

Figure 4.1 Abundance of non-volant small mammals by family

Member of family Muridae showed the most abundance captured which consist of eight species which were *Rattus exulans*, *Rattus rattus*, *Maxomys rajah*, *Maxomys surifer*, *Maxomys whiteheadi*, *Leopoldamys sabanus*, *Niniventer cremoriventer* and *Sundamys muelleri*. Family of Sciuridae were represented by only two species which were *Callociurus notatus* and *Sundasciurus tenuis*. While for family Tupaiidae had the lowest number of species captured which only *T. glis*. There were three species of rats are listed as Vulnerable (VU) under IUCN Red List. These species were *M. rajah*, *M. whiteheadi* and *N. cremoriventer* (Table 4.1).

Table 4.1: Checklist of non-volant small mammal species recorded at Hutan Lipur

Order	**Family**	**Scientific name**	**Common name**	**Total individuals (N)**	**IUCN**
Scadentia	**Tupaiidae**	*Tupaia glis*	Common treeshrew	18	LC
Rodentia	**Muridae**	*Rattus exulans*	Polynesian rat	2	LC
		Rattus rattus	Black rat	2	LC
		Maxomys rajah	Brown spiny rat	6	VU
		Maxomys surifer	Red spiny rat	12	LC
		Maxomys whiteheadi	Whitehead's spiny rat	3	VU
		Leopoldamys sabanus	Long-tailed giant rat	1	LC
		Niniventer cremoriventer	Dark-tailed tree rat	2	VU
		Sundamys muelleri	Muller's giant sunda rat	2	LC
	Sciuridae	*Callociurus notatus*	Plaintain squirrel	5	LC
		Sundasciurus notatus	Slender squirrel	1	LC
			Total individuals	54	

*IUCN Classification: Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (E)

Species accumulation curve was plotted for six sampling months in Figure 4.2. While, for July and September were not included because only one species has recorded for these months. The curve showed that January was the most distant curve than other month. All the curve showed increasing pattern and did not reach the asymptote, representing other unrecorded species in Hutan Lipur Sekayu.

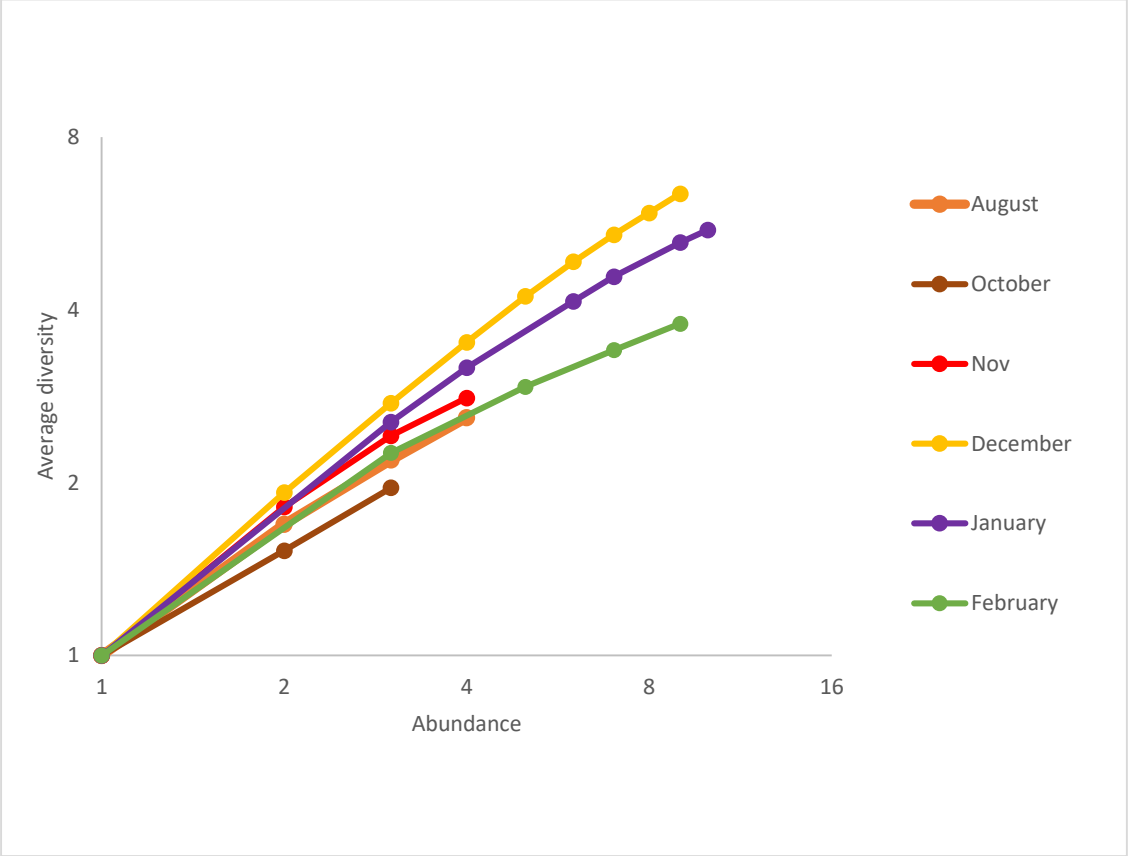

Figure 4.2 Species accumulation curve of non-volant small mammal species at Hutan Lipur Sekayu

Based on Figure 4.3, the most dominant species captured at Hutan Lipur Sekayu was *T. glis* with 18 individuals followed by *M. surifer* with 12 individuals. Other species such as *R. rattus*, *R. exulan*, *L. sabanus* and *S. tenuis* were only found in certain sampling period with only two, two and one individuals respectively.

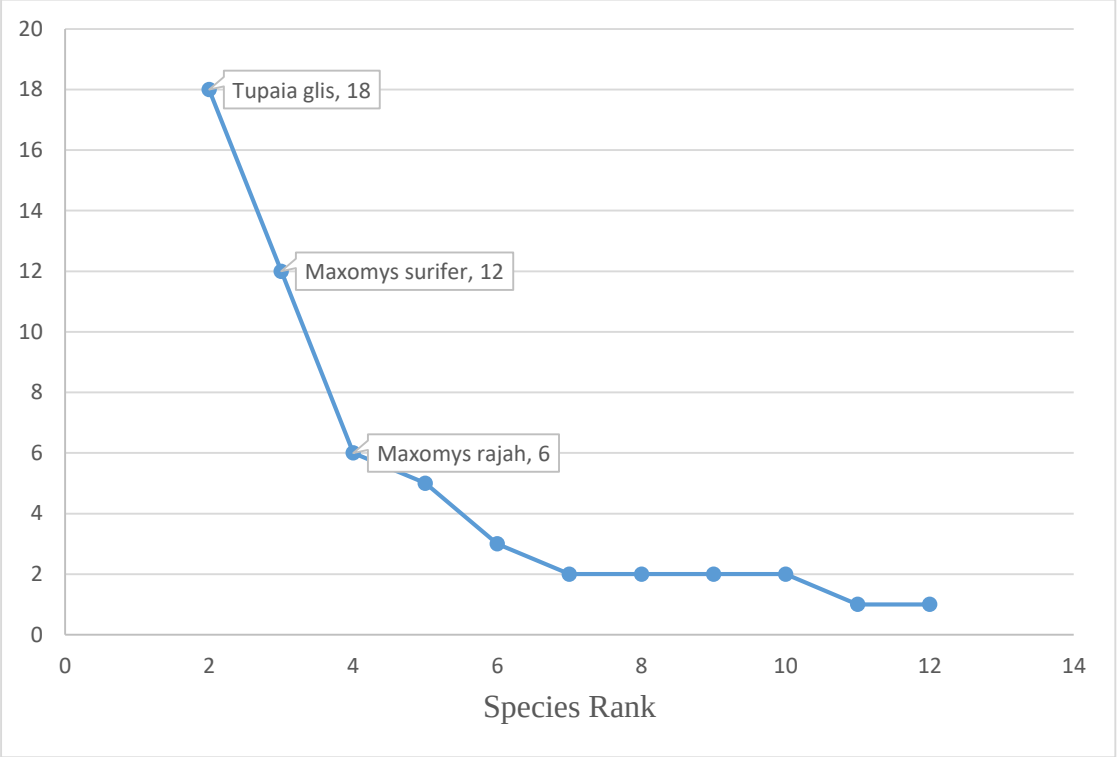

Figure 4.3 Rank abundance curves for non-volant small mammal species at Hutan Lipur Sekayu.

4.2 Diversity Indices

Diversity indices consists of three major parts which were species diversity, richness, and evenness. The calculated diversity and richness index showed that December (1.95) was the most diverse while November (0.96) was the most even in term of number species compared to other months (Table 4.2).

Table 4.2 Diversity indices for non-volant small mammal species in recreation of Hutan Lipur Sekayu

Indices \ Month		August	Oct	Nov	Dec	Jan	Feb
	Individuals	5	4	5	13	12	10
Species diversity	Simpson_1-D	0.56	0.63	0.64	0.84	0.78	0.64
	Shannon_H	0.95	1.04	1.05	1.95	1.63	1.17
Species richness	Menhinick	1.34	1.50	1.34	2.22	1.73	1.27
	Margalef	1.24	1.44	1.24	2.73	2.01	1.30
Species evenness	Evenness_e^H/S	0.86	0.94	0.96	0.88	0.85	0.80
	Equitability_J	0.87	0.95	0.96	0.94	0.92	0.84

4.3 Estimation Population Size of Non-Volant Small Mammals

Schnabel method were used to estimate population size of non-volant small mammal from capture mark recapture data. The overall estimates of the non-volant small mammals was 595 individuals (with a confident interval of 177.9 to 3352.1) with the total number of capture individuals were 54 and two recaptured. The trapping success based on all capture was 2.25%. (Table 4.3)

Table 4.3 Descriptive summary of capture-mark-recapture for population estimation.

	Sampling session	**Captured (Ct)**	**Recapture (Rt)**	**Newly marked (Ut)**	**Total marked (Mt)**
2018	1 (July)	3	0	3	0
	2(Aug)	5	0	5	3
	3(Sept)	2	0	2	8
	4(Oct)	4	0	4	10
	5(Nov)	5	0	5	14
	6(Dec)	13	1	12	19
2019	7(Jan)	12	0	12	31
	8(Feb)	10	1	9	43
		54	**2**	**52**	**128**
Number of trap night		**2400**			
Trapping success (%)		**2.25**			
Total estimated population size (N)		**525 individuals**			

4.4 Bait Preferences

Chi-square tests was used to determine significant differences between non-volant small mammal species and bait types. The statistical analyses was performed using SPSS version 15.0 (Table 4.4). Based on the chi-square test, the bait preferences for *T. glis* (χ^2=54 , df=3, p<0.05) and *C. notatus* (χ^2=8.6 , df=3, p<0.05) was banana, but potato with peanut butter for *M. surifer* (χ^2=22 , df=3, p<0.05).

Table 4.4 Bait preferences on non-volant small mammals

Family	Species	Types of baits					
		Banana	Roasted coconut	Dried fish	Potato with peanut butter	χ^2	p-value
Tupaiidae	*Tupaia glis*	18	0	0	0	54	0.001*
	Rattus exulans	0	0	0	2	6	0.112
	Rattus rattus	0	0	2	0	6	0.112
	Maxomys rajah	0	3	0	3	6	0.112
	Maxomys surifer	1	1	0	10	22	0.001*
	Maxomys whiteheadi	0	1	0	2	3.67	0.300
	Leopoldamys sabanus	0	0	0	1	3	0.392
	Niniventer cremoriventer	0	2	0	0	6	0.112
	Sundamys muelleri	1	1	0	0	2	0.572
Sciuridae	*Callociurus notatus*	4	0	1	0	8.6	0.035*
	Sundaciurus tenuis	1	0	0	0	3	0.392
	Total	**25**	**8**	**3**	**18**		

*Significantly different by χ^2test (p<0.05)

CHAPTER 5

DISCUSSION

5.1 Species Composition of Non-Volant Small Mammals in Hutan Lipur Sekayu

Overall of 54 individuals of non-volant small mammals were captured represented by 11 species. All captured individuals consisted of two orders which is Scadentia and Rodentia and three families which is Tupaiidae, Muridae and Sciuridae. In this study, family Muridae was the highest captured species followed by Tupaiidae and Sciuridae. This is because Muridae its largest mammalian family of rodents. Other studies in Hulu Terengganu had recorded similar result that these three families were commonly found in lowland dipterocarp forest (Khalib et al., 2018; Nor Zalipah et al., 2019). Majority of species are recorded in Hulu Terengganu, are the common small mammals were found in lowland dipteropcarp in Peninsular Malaysia (Nor Zalipah et al., 2019; Noor et al., 2019). For instance, species have been recorded in this study which were *Maxomys rajah, Maxomys surifer, Maxomys whiteheadi, Leopoldamys sabanus and Niniventer cremoriventer*. Previous study, they have found that many species from these three families act as dispersal agents in forest indicate that small mammal play an important role to forest ecosystem (Wells & Bagchi 2005; Wells et al. 2009).

In addition, rats from family Muridae well-known to have high adaptations towards different areas of habitats and also have high rate of reproduction (Payne & Francis, 2007; Francis, 2008). Most of all species captured from this family are habitat generalists that feed on a combination of leaves, seeds, fruit and roots (Wells & Bagchi, 2005). Generalist species usually have low sensitivity to habitat changes (Bernard et al. 2009), and have high adaptations to enable them to survive under a wide variety of conditions. Other species that were often caught in this study included tree shrews (family Tupaiidae) and squirrels (family Sciuridae). Some of these arboreal species are known to feed on the ground for fruit and insects, such as *Callociurus notatus* and *Tupaia glis* (Bernard et al. 2009), which may explain why they are often caught in traps that were placed on the forest floor. Since all traps were mainly placed on the forest floor, no arboreal species was captured in this study. The Common Treeshrew (*T. glis*) and the Plantain Squirrel (*C. notatus*) have high tolerance towards habitat disturbance (Zakaria et al., 2001).

Habitat of great structural diversity and vegetation might provide a perfect habitat for variety species of non-volant small mammals, which will affect the species richness indirectly (Yasuda et al., 2003). Rank abundance curve shows that *T. glis* (tree shrew) was the most abundant species with 18 individuals recorded. This species is normally active during day time (diurnal) and commonly found at many types of forest such as secondary forest, agricultural estate and gardens (Francis, 2008). From previous study in Terengganu this species was the most commonly caught in forest habitat (Rahim et al., 2016; Noor et al., 2019). Meanwhile, only one individual of *L. sabanus* was captured in this study. This species has a large distance of movement, so it needs a widespread range of homes to travel within the forest (Wells et al., 2008). Previously this species were limited to disturbed forest but in the present this species adapted well with disturbed habitats (Bernard et al., 2009).

Furthermore, from the total number of individuals captured there were three species from family Muridae are listed as vulnerable (VU) in the IUCN Red List which were *M. rajah*, *M. whiteheadi* and *N. cremoriventer*. The population of these three rats are commonly species have been found in Southesat Asia and expected to be endanger because of the habitat destruction in certain parts of the area (Francis, 2008).

Availability of food resources and defense from the predators, are the important things to support habitats for non-volant small mammals.

Based on the result, December was the most diverse while in November was the most even in term of the number of species compared to other months. This might be due to the monsoon season in December. Meteorological data have shown high rainfall during monsoon seasons from November to January along the east peninsular Malaysia including Terengganu (Malaysia Meteorology Department, 2019). The number of individuals captured kept increasing starting from July until December and started to decline from January. Based on the finding, it was believed that small mammals are most captured during wet seasons compared to dry seasons. Some studies on small mammals have been conducted in Terengganu (Mazlan et al., 2015; Nor Zalipah et al., 2019; Noor et al., 2019), however there is lack of study to measure species abundance change because of climate factors. Therefore, little information about the relationship of non-volant small mammal between abundance fluctuations by climate factor in Peninsular Malaysia (Ruppert et al., 2015). Therefore, further study needs to be conducted to assess community structures and fluctuations in abundances due to climate factor. Species diversity on first session sampling (July) was the lowest probably might due to lacks of baits variability. Only one type of bait was used during the first sampling which was banana. Bait types might affect the capture rate of different species of non-volant small mammals (Ruppert et al., 2015).

The species accumulation curve at Hutan Lipur Sekayu based on trapping month shows that all curve posed an increasing trend. Thus, more species could be found if longer period of sampling were conducted since the species accumulation curve of non-volant small mammals has not reached the asymptote level. Therefore, additional sampling need to be conducted in order to record all the remaining species. Preston, (1948) noted that the sampling duration might affect the captured rate of non-volant small mammals.

5.2 Population Size Estimation

The estimated population size of non-volant small mammals was assumed as closed population. It has been prove since the plot of the accumulated number of marked animals (M_t) against the proportion of the marked animals in each sample (R_t /C_t) showing linearity. Thus this allows the application of Schnabel estimators for population estimation of non-voalnt small mammals in this study. Schnabel (1938) estimator is one of the method to estimate the closed population of a group of mobile organisms which includes multiple markings and recaptures technique (Krebs, 2014). Besides that, the chosen estimators can be applied with the minimum of three capture individuals and has no limits to the maximum number of recaptured.

The estimated population size of non-volant small mammals in Hutan Lipur Sekayu between July 2018 until February 2019 was 595 individuals. Our results suggest that the population sizes found by this study might support a large population in Hutan Lipur Sekayu. Large population might increase community stability and better genetic variability (Connel et al., 1964). These results suggested that Hutan Lipur Sekayu can support more species of non-volant small mammals and it also play an important role as a suitable habitat for some small mammals. In addition, there are three species were listed as vulnerable under IUCN in study area. Thus, population surveys of non-volant small mammals are important to ensure the stability of the current status of non-volant small mammals species in Malaysia is at stable.

5.3 Bait Preferences of Non-Volant Small Mammals

The total of 2400 trap nights were analyzed for bait preferences, majority all species captured of non-volant small mammals were preferred banana followed by potato with peanut butter compared to another baits. Banana showed highly significant preferences for *T. glis* and *C. notatus.* Study by Ruppert et al. (2012), also found that banana was the most food preferences for *T. glis*. Thus, it suggested that *T. glis* prefer with strongly smelly food like banana compared with other foods. While, *M. surifer* show highly significant preferences for potato with peanut butter. According to Langham (1983), commonly of small mammals in Southeast Asia were considered as omnivores and opportunistic diet. However, other species showed no significant of bait preference. According to Ruppert et al. (2012), variability of baits may influenced the captured rates of different species.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

As a conclusion, this study found that Hutan Lipur Sekayu support a diverse and rich community of non-volant small mammal species based on the number of species recorded during my sampling. Overall, there are about 11 species with 54 individuals from three different families which composed of 18 three shrews, 30 rats, six squirrels, have been recorded during my sampling. The most dominant species in this area was *Tupaia glis*. Approximately 20% of the total non-volant small mammal species recorded for Peninsular Malaysia.

The population size of non-volant small mammals in Hutan Lipur Sekayu are considered are large population. Total estimated population size of non-volant small mammals in Hutan Lipur Sekayu was 595 individuals. Sampling effort is crucial for mark-and-recapture study in order to obtain maximum capture number and finest population estimation.

However, this study can be an important study to compare the diversity of non-volant small mammals between pre-monsoon, monsoon and post-monsoon seasons. Parameter such as vegetation and temperature were not taken due to time restriction thus these parameters should be taken in the future to support and test whether temperature and vegetation are significantly different to influence the diversity of non-volant small mammals in this particular area. Moreover, even there are lack of time and budget, many species were discovered. Thus, if proper and efficient sampling technique and sampling period were used, many more species could be observed.

Longer duration of sampling and great efforts can be done so that opportunities to get more species will be high because catching small mammal species is mostly dependent on opportunistic appearance.

Therefore, continuous monitoring efforts are needed for long-term trends of population size and health in Hutan Lipur Sekayu. Besides that, the area of lowland forest in Hutan Lipur Sekayu should be well preserved to ensure the maintenance and the conservation of non-volant small mammal diversity in this recreation area.

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APPENDICES

Appendix A

List of non-volant small mammals in Hutan Lipur Sekayu

Callociurus notatus

Sundasciurus tenuis

Rattus exulans

Rattus rattus

Maxomys rajah

Maxomys surifer

Maxomys whiteheadi

Niniventer cremoriventer

Leopoldamys sabanus

Sundamys muelleri

Tupaia glis

Appendix B

Data sheet

No	Date	Time	Species	Cage	Sex	Body measurement (mm)				Body weight(g)	Point capture
						E	HF	HB	T		

CURRICULUM VITAE

Name	: Muhammad Zaim bin Zamri
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Place of Birth	: Kedah
Nationality	: Malaysia
Race	: Malay
Gender	: Male
Religion	: Islam

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SMK Alor Janggus 2008-2012

- SPM (2012)

Work Experience : **RESTORAN SYAHADAH (NASI ARAB)**

- Waitress (Business management)
- 2012

NORTHERN CORRIDOR IMPLEMENTATION AUTHORITY (NCIA) (BIOTECH CENTRE)

- Internship
- November – Jan 2016
- Technical Assistant
- February – March 2016

Skills :

- Proficient in Microsoft Office/Excel/Power point
- Photography Skills
- Adobe Photoshop