THE POPULATION ECOLOGY OF NON-VOLANT SMALL MAMMALS WITH PARTICULAR REFERENCE TO THE COMMON TREESHREW (*Tupaia glis*) IN GUNUNG JERAI, KEDAH

MARK RAYAN DARMARAJ

UNIVERSITI SAINS MALAYSIA

2006

THE POPULATION ECOLOGY OF NON-VOLANT SMALL MAMMALS WITH PARTICULAR REFERENCE TO THE COMMON TREESHREW (*Tupaia glis*) IN GUNUNG JERAI, KEDAH

by

MARK RAYAN DARMARAJ

Thesis submitted in fulfilment of the requirements for the degree of Master of Science

May 2006

ACKNOWLEDGEMENTS

I have worked with a great number of people whose contribution in various ways led to the research and the making of this thesis. It is a pleasure to convey my gratitude to them all in my humble acknowledgement. First and foremost I would like to thank God, for giving me the grace and perseverance to pull through those lonely days and nights spent in the jungle. My deepest appreciation goes to my mum, sister, brother, brother in-law, my soul mate-Sylvia and friends especially Retna, Saradambal, Shariff, and Surin, for their support and encouragement.

I would also like to record my gratitude to my supervisor, Associate Professor Dr. Shahrul Anuar Mohd.Sah for his supervision, advice and guidance from the very early stage of this research as well as giving me an opportunity to be exposed to a research method such as radio-telemetry. I am indebted to him more than he knows. I am very grateful to the Forestry Department of Kedah, especially Ranger Ramli Kamis, for the long gruesome hours spent helping me on the field.

Thanks also to the staffs of the School of Biological Sciences, University Science of Malaysia for their indispensable help in providing transportation and help on the field, namely, Mr. Ganesh, Mr. Muthu and others. My special appreciation goes to Ms. Nurul Ain who was always ready to lend a hand, be it in the field conducting research or during the thesis writing stages. Also not forgetting Ms. Nor Zalipah and many others who were of great help out in the field. I gratefully thank Dr. Shukor, Dr. Dino, and Gareth for their constructive comments on my work and this thesis in the midst of all their activity and tight schedule. Finally, I would like to thank everybody who was important to the successful realization of my thesis, as well as expressing my apology that I could not mention personally one by one. This research was funded by research grant IRPA No: 08-02-05-1026 EA 001.

TABLE OF CONTENTS

CHAPTER FOUR : RESULTS

CHAPTER FIVE : DISCUSSION

CHAPTER SIX : CONCLUSION

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

EKOLOGI POPULASI MAMALIA KECIL NON-VOLAN DENGAN TUMPUAN UTAMA KEPADA TUPAI MUNCUNG BESAR (*Tupaia glis*) DI GUNUNG JERAI, KEDAH

ABSTRAK

Satu kajian dua fasa ke atas mamalia kecil dengan tumpuan utama kepada Tupai Muncung Besar (*Tupaia glis*) telah dijalankan di dua zon vegetasi yang berbeza (tapak kajian A; Hutan Dipterokarp Bukit dan tapak kajian B; Hutan Pergunungan Myrtaceous) di Gunung Jerai, sebuah gunung terpencil di Kedah. Fasa satu dijalankan dengan mengunakan Kaedah Tangkap-Tanda-Lepas pada setiap bulan dengan menggunakan 100 perangkap dawai yang dijarakkan 10m, di dalam grid seluas 0.81ha di setiap kawasan tapak kajian. Persampelan dijalankan dari bulan Oktober 2002 sehingga bulan Jun 2003. Sejumlah 10 spesis mamalia telah dicerap di kedua-dua tapak kajian. Kejayaan penangkapan di tapak kajian A dan B adalah 6.00% dan 6.81% masing-masing. *Tupaia glis* dan *Maxomys rajah* mendominasi tapak kajian A, manakala di tapak kajian B pula adalah *T. glis* dan *M. whiteheadi*. Kawasan tapak kajian B menampung komposisi mamalia kecil yang lebih kaya dan berkepelbagaian dibandingkan dengan kawasan tapak kajian A, dan ini disebabkan oleh kejadian pertindihan spesis yang ketara di kawasan tapak kajian B. Pengagihan individu antara spesies adalah lebih seragam di kawasan tapak kajian A dibandingkan dengan tapak kajian B dan ini kemungkinan disebabkan oleh peningkatan keterdapatan mikrohabitat dan sumber makanan di kawasan tapak kajian A. Bagi *Tupaia glis* pembiakan berlaku sepanjang tahun terutamanya antara April dan Ogos dengan tiada perbezaan tempoh antara kedua-dua tapak kajian. Kepadatan *T. glis* di kedua-dua tapak kajian didapati hampir sama (4±1/ha di A dan 5±1/ha di B). Fasa dua dijalankan dengan menggunakan kaedah radio-telemetri ke atas lima individu *T. glis* dari Disember 2003 sehingga Mac 2004. Di setiap tapak kajian, corak aktiviti adalah bimodal. Jumlah tempoh masa keaktifan harian, jumlah jarak yang dilalui setiap hari dan jumlah kadar pergerakan harian bagi individu dewasa di B didapati lebih panjang dan lama secara

signifikan jika dibandingkan dengan individu di A (Ujian-Mann-Whitney *U*-Test). Individu dewasa di tapak kajian B mempunyai saiz kawasan kediaman dan saiz kewasan kediaman pusat yang lebih besar secara signifikan jika dibandingkan dengan di A (Mann-Whitney *U*-Test). Kualiti habitat dari segi keterdapatan sumber makanan yang berubah mengikut altitud berkemungkinan besar merupakan sebab utama bagi perbezaan tersebut. Secara keseluruhannya, saiz kawasan kediaman adalah 0.80–1.18ha (MCP95%) manakala kawasan kediaman pusat adalah 0.34- 0.57ha (HM50%). Di A, hampir 88% daripada jumlah sarang didapati berada dalam pokok tumbang dan lubang pokok sementara di tapak kajian B, hampir 89% daripada sarang didapati berada di dalam lubang yang digali di kaki akar pokok. Individu-individu di kedua-dua tapak kajian didapati bersarang di kawasan kediaman pusat. Indeks interaksi statik menunjukkan organisasi sosial monogami bagi kedua-dua populasi *T. glis*.

THE POPULATION ECOLOGY OF NON-VOLANT SMALL MAMMALS WITH PARTICULAR REFERENCE TO THE COMMON TREESHREW (*Tupaia glis*) IN GUNUNG JERAI, KEDAH

ABSTRACT

A two-phase study on small mammals with particular reference to the Common Treeshrew (*Tupaia glis*), was conducted at two different floristic zones (Site A; Hill/Upper Dipterocarp Forest and Site B; Montane Myrtaceous Forest) on Gunung Jerai, an isolated mountain in Kedah. Phase one consisted of a monthly Mark-Recapture study using 100 cage wire traps, spaced 10m apart in a 0.81ha trapping grid on each site. Trapping was carried out from October 2002 till June 2003. A total of 10 species of small mammals were recorded at both sites. Capture success at Site A and B were 6.00% and 6.81% respectively. *Tupaia glis* and *Maxomys rajah* were the two dominant species at Site A, whilst at Site B these were, *T. glis* and *M. whiteheadi*. Site B proved to be more rich and diverse in small mammal composition than Site A due to the considerable degree of species overlap taking place at Site B. Distribution of individuals among species was more even at Site A compared to Site B probably due to increased microhabitat and food resource availability at Site A. For *T. glis*, breeding occurred throughout the year with a peak between April and August, without any marked differences between both sites. Density for *T. glis* at both sites were similar (4±1/ha at Site A and 5±1/ha at Site B). Phase two of this study consisted of a radio-telemetry study on *T. glis* which was carried out from December 2003 till March 2004. Five individuals were radio-collared at each site. Individuals at both sites conformed to a bimodal activity pattern. Total length of daily active periods, total daily distances moved and daily rate of movements by adult individuals at Site B were found to be significantly longer and higher compared to individuals at Site A (Mann-Whitney *U*-Test). Adult individuals at Site B had significantly larger home range size and core area size than individuals at Site A (Mann-Whitney *U*-Test). Habitat quality in terms of food availability, which varied altitudinally is highly likely the prime influential factor for these differences. Overall home range sizes were 0.80-1.18ha (MCP95%), whilst core areas were 0.34-0.57ha (HM50%). At Site A, almost 88% of nests were found to be in fallen logs and tree holes whilst, at Site B, almost 89% of nests were found in dug burrows at the base of the roots of trees. Individuals at both sites were found to preferentially nest in core areas. The static interaction index revealed a monogamous social organisation for both populations of *T. glis*.

CHAPTER 1
INTRODUCTION

1.1 General introduction and justification

Malaysia is endowed with a great diversity of fauna species in its forests. These forests are able to support such a rich diversity of wildlife due to the adaptations of each species to utilise different spatial and temporal niches within the forest mosaic. In Malaysia, a total area of 1.39 million hectares are gazetted as national parks, protected areas and wildlife sanctuaries but the majority of these consist of scattered fragments, isolated amidst matrices of agricultural and developmental areas (Anon., 1998).

Habitat fragmentation is a major threat to wildlife population, particularly for area demanding species such as mammals and since the 1960's, Malaysia has experienced considerable forest loss (Laidlaw, 2000). Several studies have investigated the impacts of forest conversions and logging activities on wildlife, and changes in forest structure due to logging have been related to local extinction of mammal species, while others do well in logged forests (Johns, 1992; Johns, 1997; Fimbel *et al*., 2000). With this in mind, it should be stressed that it is essential to gain a basic understanding of primary ecosystems and the role of the various communities of plant and animal species in an undisturbed habitat. However, research on species composition and distribution of various animals in different types of habitats or floristic zones is still in its infancy in Malaysia.

Malaysia has a particularly diverse small mammal fauna. Small mammals play an important role in forest ecosystems serving several important functions, such as seed dispersal, preying on insect pests and also as being a prey itself to predators (Brisbal, 1986; Miura *et al.*, 1997; Zubaid & Khairul, 1997; Ray, 1998; Shanahan & Compton, 2000). Several species are threatened and endangered (Ratnam *et al*., 1991). Because experimental studies or even observational studies are not possible on endangered, large or rare species, ecological model species or systems are sometimes used to test predictions of how a species will respond to some perturbation (Wolff, 1999). But before we can formulate an ecological model species or system, detailed information regarding the biology and natural history of a certain species and its community is vital.

Information about population size, reproduction, diet, home range, social organization and nesting behaviour are among the basic vital information, which is needed to understand a certain species before any effort in trying to conserve them and their habitats are to be enforced. Understanding the spatial distribution and movements that a certain species makes within its habitat is important for interpreting ecological processes and plays a vital role in formulating conservational management plans.

The primary objective for this small mammal study was to increase the information available on tropical small mammals with particular reference to the Common Treeshrew (*Tupaia glis*) at two different elevations. Many studies have shown that changes in physical characteristics over a short distance along an elevational gradient would affect the species diversity, distribution and abundance of organisms (Kano, 1940; Terborgh, 1977; Kitayama, 1992; Yu, 1994; Zainab *et al.*, 2001). Altitude determines either the presence or the absence of certain plants and the abundance of fauna. There have been very few long term studies on comparing diversity and other aspects of the ecology of Malaysian small mammals in different habitat zonations or elevations. The very few studies done have contributed to the understanding of small mammal species composition along an elevational gradient (Shukor, 2001; Zainab *et al.*, 2001) but no long term studies have been done on isolated mountains such as Gunung Jerai in Peninsular Malaysia. Although this study did not concentrate on an elevational gradient throughout a mountain but rather in two distinct floristic zones, each occurring at different elevations, this study does offer an important contribution to the understanding of species composition and ecology of small mammals on an isolated mountain.

For most of the past century, scientists thought that treeshrews were primitive primates. Systematics has played an important role in differentiating animals based on certain characteristics. According to Emmons (2000), treeshrews suffer from a chronic case of mistaken identity for they are not shrews and most are not found in trees. Earlier studies involving taxonomy, morphology, reproduction and social behaviour of treeshrews have considered only a single species, *T. glis* and there has been a tendency to regard this species as “the” treeshrew and consider findings as characteristic of the family Tupaiidae. But studies made of other species have shown that there are marked behavioural differences between species (Sorenson & Conoway, 1968). Although, there have been quite a number of anatomical, embryological and behavioural studies carried out on captive treeshrews (Sorensen & Conoway, 1968; Sorenson, 1970), only two detailed field ecology studies (Kawamichi & Kawamichi, 1979; Langham, 1982) have been done on the Common Treeshrew in the wild in Malaysia. As a result, there is still very little known about the Common Treeshrew although its name itself suggests that it is ‘common’. Thus, this study represents a key contribution to the understanding of the ecology of the Common Treeshrew in its natural habitat.

On the whole, the primary contribution that this study offers is that methods and results interpretation about the Common Treeshrew and its community could be used as a model to study other small mammal species or even other bigger mammals with mathematical and statistical modifications. In addition, this study provides future researchers and conservation managers with information on spatial and population dynamics of small mammals that inhabit different floristic zones, especially on an isolated mountain.

1.2 Research objectives

The objective of this study was to obtain information on the small mammal community with particular reference to the Common Treeshrew that inhabit two different floristic zones on an isolated mountain (Figure 1.1). Thus, the research objectives can be divided into two main parts as mentioned below:

a) To investigate the ecology of terrestrial small mammals at two different floristic zones with specific emphasis on determining the following:
   1) To identify and compare species composition and abundance
   2) To investigate the probable reproductive season according to species using trapping data
   3) To estimate population size and density according to species
   4) To estimate the home range of small mammals according to species using trapping data

b) To investigate the ecology of *Tupaia glis* at two different floristic zones with specific emphasis on determining the following:
   1) Activity and movements
   2) To estimate the home range using radio-tracking data and also to compare estimates derived from trapping data
   3) Nesting behaviour
   4) Social organisation

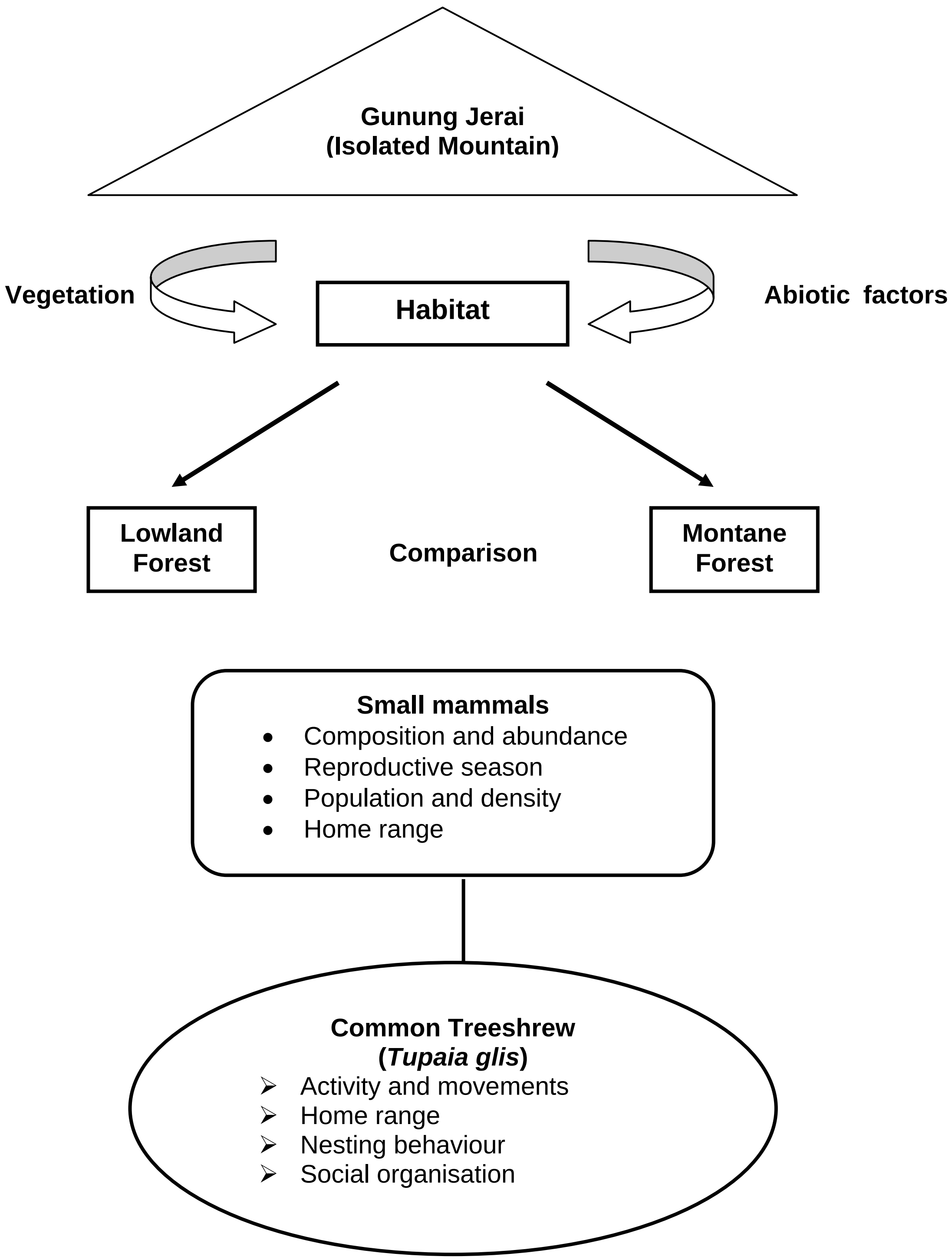

Figure 1.1: A model chart that describes the study objectives.

CHAPTER 2
LITERATURE REVIEW

2.1 Previous researches in Gunung Jerai

The botanists were probably the first professional biologists to explore Gunung Jerai since colonial times. Research on flora in Gunung Jerai started in the late 19th century. Most of the botanist collected specimens for the purpose of adding to their herbarium collection. Thomas Lobb was the first among researchers who collected horticultural materials for the Kew Herbarium in London (Ridley, 1916). Although Gunung Jerai is located very close to southern Thailand, the flora in Gunung Jerai has been noted to inherit the characteristics of Malaysian flora.

According to Ridley (1916), the vegetation in Gunung Jerai is identical to that found in Gunung Ledang, Johor, based on the assumption that both these mountains used to be islands that were isolated from the mainland. Apart from Ridley, Mohamed Hanif of the Singapore Botanic Gardens also collected plants from Gunung Jerai in 1915. Robinson & Kloss (1916) reported that more than 200 flowering plants species (mainly orchids) were found at an altitude of above 800m above sea level. Between the 1920s and 1940s, massive specimen collection was conducted in Gunung Jerai, for collection purposes in the Singapore Botanical Gardens.

Marchette (1965) discovered a new species of ‘Monkeys Cup’ *Nepenthes albomarginate* on this mountain. He also added new plant species to the list of higher plants in the gymnosperm and angiosperm groups. Dunn (1967) added 18 species of ferns which accumulated to a total number 78 fern species or rather 16% of the ferns that was listed in Malaysia during that time. Kochummen (1982) demarcated the difference in vegetation according to altitudinal gradient in Gunung Jerai. His findings stirred great interest among other botanists as he reported that the Oak Laurel forest that were found in other highlands in Malaysia was absent in Gunung Jerai.

Kochummen (1982) classified this floristic zone as ‘Myrtaceous’, as it was dominated by this Genus at an elevation of above 780m above sea level.

Research on fauna in Gunung Jerai began as early as 1915 by Robinson & Kloss (1916). They listed 10 species of small mammals, 36 species of birds and 13 species of herpetofauna in the area. Researches on insects have also been carried out on this mountain. Hislop (1949) described the differences in butterflies from the Genus Milium that was found here and in two other mountains in Malaysia (Gunung Ledang and Gunung Padang). Domrow & Nadchatram (1963) found that most of the small mammals in Gunung Jerai had ecto-parasites, belonging to the Family Mesostigmata and Prostigmata.

Yong (1969) recorded three species of small mammals; two of which were new records for Gunung Jerai at that time. These new species were *Sundamys muelleri* and *Niviventer sp*. A total of 11 species of small mammals in Gunung Jerai were recorded by Langham (1983). Gregory-Smith (1994) recorded 67 species of birds in Gunung Jerai. He found that due to the absence of ‘true’ montane bird species, lowland bird species had dispersed to higher altitudes.

A freshwater crab species (*Phricotelphusa amnicola*) which is believed to be the third record for Peninsular Malaysia from the family Gecarcinucidae was found in the waterfalls of Gunung Jerai at an altitude of 800m above sea level (Ng, 1994). A recent study conducted on the distribution of understorey bats along an elevational gradient, recorded a total capture of 317 individuals from 18 species comprising of four Families (Rhinolophidae, Hipposideridae, Vespertilionidae and Pteropodidae) (Shahrul *et al*., 2003). They found a decrease in number of bat species with increasing elevation and inferred that it was most likely due to the unfavourable climatic condition at higher elevations. It is important to note that the literature mentioned in this sub-chapter is taken only from published journals and does not include researches that would have been conducted for the purpose of thesis writing.

2.2 Previous researches conducted on small mammals in highlands in Malaysia

There has not been many researches conducted on small mammals in highlands in Malaysia mainly due to the consequences of sampling in difficult terrain in a tropical environment. The few studies that have been carried out (Medway, 1972; Lim, 1974; Langham, 1983; Shukor, 1997; Zainab, 2001) although not all, have been extensive rather than intensive in which sampling was conducted during a limited period of time (not representative of all climatic seasons). Nevertheless, such studies mentioned above are important in producing predictions as to how non-volant small mammal species richness and abundance change with increasing altitude within various floristic zones.

Apart from the studies mentioned above, there are other short-termed studies that have been conducted in highlands such as Robinson & Kloss (1916), Domrow & Nadchatram (1963) and Yong (1969; 1974) but these researches offered only anecdotal evidence about diversity and abundance of small mammals that inhibited different floristic zones across an elevational gradient. Among all the studies mentioned above, only Shukor (1997) and Zainab (2001) extensively focused their study on distribution and diversity of small mammals across an elevational gradient within five (lowland, lower montane, upper montane, sub-alpine) and four (lowland, hill dipterocarp, submontane and montane) different floristic zones. Shukor (1997) concentrated more on explaining the elevational diversity pattern of small mammals that inhibited Mount Kinabalu. His study produced evidence of a hump shaped diversity pattern occurring across an elevational gradient.

He reported that the maximum diversity of small mammals occurred at the elevation where a highland and a lowland assemblage overlapped of which several types of plants reached their maximum diversity and within this transition zone, rainfall and humidity was also recorded to reach their maxima. Although his study proved to be invaluable in predicting elevational diversity patterns of small mammals in highlands, the population dynamics and demographic details of small mammals inhibiting the different floristic zones on Mount Kinabalu, have yet to be documented. On the whole, various aspects such as population size, home range and reproductive strategies (e.g. reproductive seasons) pertaining to heterospecific populations of small mammals in differing floristic zones across an elevational gradient have yet to be documented in Malaysia.

Although Zainab (2001) did not look into the aspect of reproductive strategies of small mammals at different elevations, she did manage to estimate home range size of at least one species (*Leopoldamys sabanus*) in five different elevations with the use of live traps. She found that the home range of this species seem to increase as elevation increased but only from lowland (300m a. s .l.) till sub-montane forest (1100m a. s. l.) after which home range size was smaller on montane forest (1350m a. s. l.). She deduced that the differences in home range size across different floristic zones was mainly influenced by the density of individuals of which supported the hypothesis of inverse correlation of home range size and density.

In summary, most small mammal studies on highlands in Malaysia, as mentioned above, have solely restricted their research on either figuring out diversity patterns across elevational gradients or investigating demographic patterns of small mammals (particularly abundance) with relatively low sampling effort within certain arbitrarily chosen elevations. Functional relationships of small mammals may vary according to habitat. Having acknowledged this in the context of investigating small mammal ecology across an elevational gradient, this study aims to gain information on population demographics of small mammals on two distinct floristic zones. It is hoped that a better understanding of the complexity of small mammal dynamics in two differing habitats associated with differing vegetation (both in structure and composition) will be attained.

2.3 Previous researches conducted on small mammals using radio-telemetry in Malaysia

Gaining information on the ecology of small mammals with the use of radio-telemetry is still in its infancy in Malaysia as indicated by the very few citations mentioned in this sub-chapter although interestingly the first ever radio-tracking study in this region was conducted four decades ago. Since then, only two other detailed radio-telemetric studies have been conducted on small mammals in Malaysia. Thus this study although focusing on a single species, is probably the fourth detailed radio-telemetric study conducted on small mammals in Malaysia.

Sanderson & Sanderson (1964) used modified miniature transistorized radio transmitters that weighed about 16-32g which were rather heavy compared to the units that were used in my study that weighed 4.5g. They radio-tracked nine rats from the species *Sundamys mulleri*, *Leopoldamys sabanus* and *Rattus tiomanicus* for a period of one to sixteen days in the Ulu Gombak area of Selangor. They noted there was overlapping of home ranges of rats of the same species and of different species.

Apart from that, they also mentioned that with some exceptions, most of the radio-tracked rats returned to the same nests each day. Although important information on spatial ecology of some rats were discovered, the authors (Sanderson & Sanderson, 1964) described their findings in a rather descriptive manner with hourly or daily accounts of individual movement. Nevertheless, it is important to note that observations such as the ones mentioned above, would not be possible if radio-telemetry had not been used.

A field study on Bornean treeshrews with the use of radio-telemetry was conducted between 1989-1991 in Sabah. This study (Emmons, 2000) was actually the first ever detailed radio-telemetry field research carried out on six species of treeshrews (*Ptilocerus lowii, Tupaia minor, T. gracilis, T. montana, T. tana* and *T. longipes*). Emmons (2000), describes in detail the diet, nesting behaviour, home range, activity pattern and social organisation of the six treeshrew species mentioned above. Furthermore, she also successfully managed to observe the absentee maternal care in the wild, of which previously was only observed in captive studies. She stresses that none of the above mentioned ecological observations particularly the lack of maternal care in *T. tana* would have been possible without the use of radio-telemetry. Generally, one of the important conclusions that she made was that each treeshrew species differing lifestyles could be explained or attributed to their differences in foraging sites and prey. Although Emmons (2000) covered various aspects of ecological differences that exist within six treeshrew species, the Common Treeshrew *T. glis* which is also present in Sabah, was not included in her study. In fact, Emmons (2000) noted that there has not been any detailed study on the nesting behaviour of the Common Treeshrew in Malaysia. Thus, this study which aims to gain information on the nesting behaviour of the Common Treeshrew may well be the first to document this aspect in detail.

Although the third published radio-telemetry small mammal study in Malaysia was carried out in 1992-1993, surprisingly, it was only published eight years later. Saiful *et al*. (2001), investigated the home range sizes and spatial overlap of four sympatric species of squirrels (*Callosciurus caniceps, C. notatus, C. nigrovittatus* and *Lariscus insignis*) in a lowland Dipterocarp forest in Ulu Gombak, Selangor. The radio-transmitter collars that were used by Saiful *et al*. (2001) weighed about 6-7g. They found that generally, home range size did not differ seasonally. However, they did note that home range overlap among intraspecific individuals was common but differed among species mainly because of the differing space use of the vertical strata of the forest.

On the whole, all three radio-telemetry studies mentioned above, generally found radio-tracking small mammals to be difficult in Malaysia due to the soil, terrain and dense foliage which evidently caused interference to radio signals. Finally, it is worthy to note, that only researches that have been published in journals are cited in this sub-chapter. Although there might have been radio-telemetry studies conducted on small mammals in Malaysia purely for the purpose of fulfilling the requirements of a degree through a dissertation, these were not included in this sub-chapter due to the probable nature of findings that were perhaps inadequate to be published in journals.

2.4 Previous researches carried out on the Common Treeshrew (*Tupaia glis*) in Malaysia

There are only two detailed field studies (Kawamichi & Kawamichi, 1979; Langham, 1982) carried out in the wild on the Common Treeshrew (*Tupaia glis*). Another researcher, Lim Boo Liat also carried out field observations on the social behaviour of paired *T. glis* (Lim, 1995a) but these were very subjective in nature as acknowledged by himself in his paper. Apart from this, removal studies through trapping (Lim, 1995b; 1998) were also carried out to gain information on the food habits and reproductive pattern of *T. glis.* Despite having four field studies (inclusive of Lim, 1995a; 1995b) that have been carried out on *T. glis*, certain aspects of its natural life history such as activity pattern, movement pattern and nesting behaviour have yet to be documented. A brief summary of the nature of each previous research mentioned above are given in the next paragraphs.

Langham (1982) carried out a three year (1972-1975) study on *T. glis* through live trapping in the states of Penang and Kedah. He collected comprehensive data on space use in terms of vertical stratification, reproduction, density, survivorship, mortality and diet. Although Kawamichi & Kawamichi (1979) published their findings earlier than Langham (1982), their field research was carried out from end of September 1974 till end of March 1975.

Technically their (Kawamichi & Kawamichi, 1979) research should not be included in this sub-chapter because their research was actually carried out in Singapore. However, their research is a significant contribution towards understanding the spatial organisation of *T. glis* and due to the fact that the geographical difference does not vary very much (difference only in terms of classification of sub-species), their research needs to be mentioned here. Kawamichi & Kawamichi (1979) carried out direct observations on 117 *T. glis* that indicated that they were more terrestrial than arboreal. They reported that the social organisation of *T. glis* was mainly monogamous of which a solitary ranging pair occupied an area of less than 1ha. Findings from the same study related to the timing of independence of offspring were later published in another journal (Kawamichi & Kawamichi, 1982). They inferred that juveniles of different sex dispersed according to the reproductive status of their mothers.

Lim (1995a) also noted from direct observations that *T. glis* were mainly terrestrial. Interestingly, Lim (1995a) managed to observe the copulation of a pair of *T. glis* in his study. Lim (1995b) examined 85 stomach contents of *T. glis* and concluded that insects were their prime diet (just as Langham (1982) had inferred). Lim (1998) concluded that *T. glis* were found to breed all year round but with a peak from March to June similar to the findings of Langham (1982).

Although the researches mentioned above have contributed towards a better understanding of *T. glis* in the wild and proved to be invaluable, however it is evident that to some extent the methods that were used (trapping and direct observations) in their research precluded them to gain other sorts of information. Certain aspects on the ecology of *T. glis* such as activity pattern and nesting behaviour can only be revealed by means of radio telemetry or other tracking methods and it has to be stressed here that the use of such a method has never been carried out on this particular species in the wild. Thus, the current research in this study may well constitute the first radio-telemetry study to shed some light into the ecology of *T. glis.*

CHAPTER 3
METHODOLOGY

3.1 Sampling period

This study was carried out in two phases. The first phase was to carry out a monthly Mark-Recapture study on small mammals which was done from the month of October 2002 till June 2003 (Phase 1). The second phase was to carry out a radio-telemetry study on the Common Treeshrew (*Tupaia glis*) which was done from the month of December 2003 till March 2004 (Phase 2). The breakdown of activities of the two phases are better reflected in Table 3.1.

3.2 Description of study area

This study was conducted in Gunung Jerai Permanent Forest Reserve, Kedah. Gunung Jerai, which was formerly known as Kedah Peak, is an isolated mountain in the state of Kedah (Figure 3.1). This isolated mountain lies at a latitude of 5°47'N and a longitude of 100°26'E and rises to an altitude of 1217m above sea level (a.s.l.). The general structure of Gunung Jerai has been described as a hill composed mainly of sandstone and quartzite, with a core of granite (according to Kochummen, 1982 referring to Bradford, 1972).

Gunung Jerai is a forest reserve managed by the Kedah Forestry Department. Some parts (mainly on the western part) of the mountain have been previously selectively logged. Other parts of the mountain (mainly below an elevation of 300m a.s.l.) have been cleared for rubber plantations and fruit orchards. There is one main road leading up to the mountain's telecommunication station and resort.

Table 3.1: The breakdown of activities for the sampling period.

Phase	Year	2002					2003												2004		
	Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	Activities																				
Phase 1	Identifying main study area & setting up the study grid	◄	►																		
	Small mammal monthly Mark-Recapture study at both sites simultaneously			◄	—	—	—	—	—	—	—	►									
Phase 2	Pilot study for radio-telemetry on the field and habitat assessments												◄	—	—	—	►				
	Sampling Period for radio-tracking study & prey abundance sampling																	◄	—	—	►

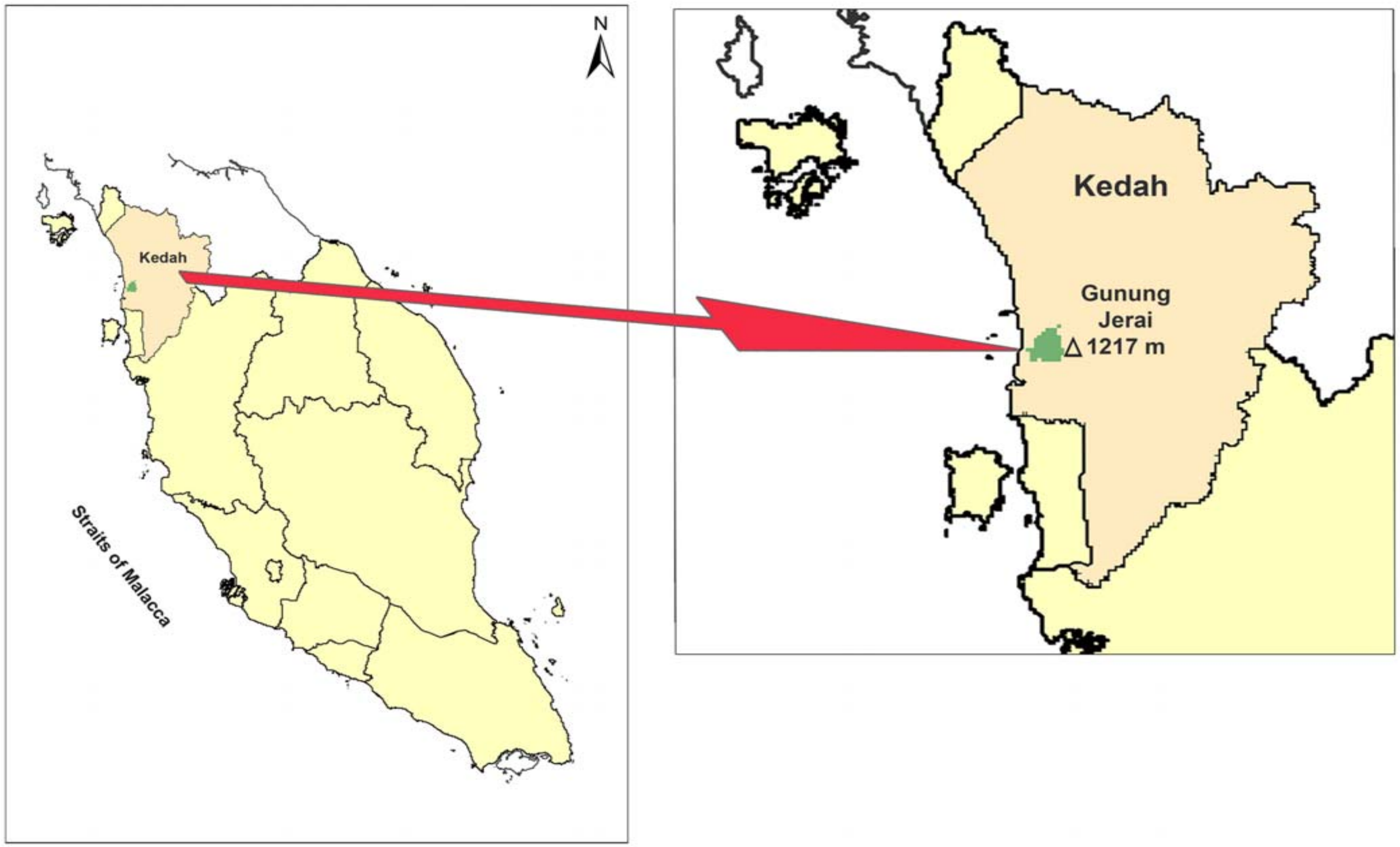

Figure 3.1: Location of Gunung Jerai on the Peninsular Malaysia map. **Note**: This map is not to scale.

3.2.1 Climate, topography, soils and habitat types

The average rainfall for the ten year period of 1965-1975 was 357cm/year and the wettest months are May to October and driest is February (Kochummen, 1982). Rainfall data provided by the Muda Agricultural Development Authority (MADA), for the nine year period of 1994-2002, averaged about 309cm/year. The monthly variation of rainfall for the year 2002 and 2003 is given in Figure 3.2.

In terms of topography, Gunung Jerai is an isolated massif forming a single peak that sweeps down on all sides into flat lowlands. Escarpments with steep to vertical drops of considerable extent are frequent on the western, south-western and north-western sides (Anon., 1977). The slopes are generally steep; the steeper slopes to the north and west are of hard quartzite, while the more gentle southern slopes are underlain by granite or schist (Kochummen, 1982).

Gunung Jerai has been isolated for a geologically lengthy period and in the past has been an island. The geological structure of the mountain and its present flora seem to attest to the fact that it was an island before. The massif is largely granite and sandstone, and in many places the bedrock is exposed as flat expanses of rock or as large boulders. The soil compositions at different elevations, especially at different floristic zones are distinctively unique. Above an elevation of 750m a.s.l., the sandy nature of much of the soil has in several areas resulted in the production of heath forest. The soil under this forest is nutritionally poor, patchily covered with peatmoss (*Sphagnum* sp.), typified by a slow decay rate of organic matter and retention of an acidic milieu (Kochummen, 1982). Below an elevation of 750m a.s.l., the soil is much richer, resulting in the production of a taller and more diverse forest.

In terms of habitat types, there appears to be few quantitative studies on the changes of vegetation in Peninsular Malaysia (Kochummen, 1982), except for previous work on the classification of forest types with respect to altitude (Symington, 1943;

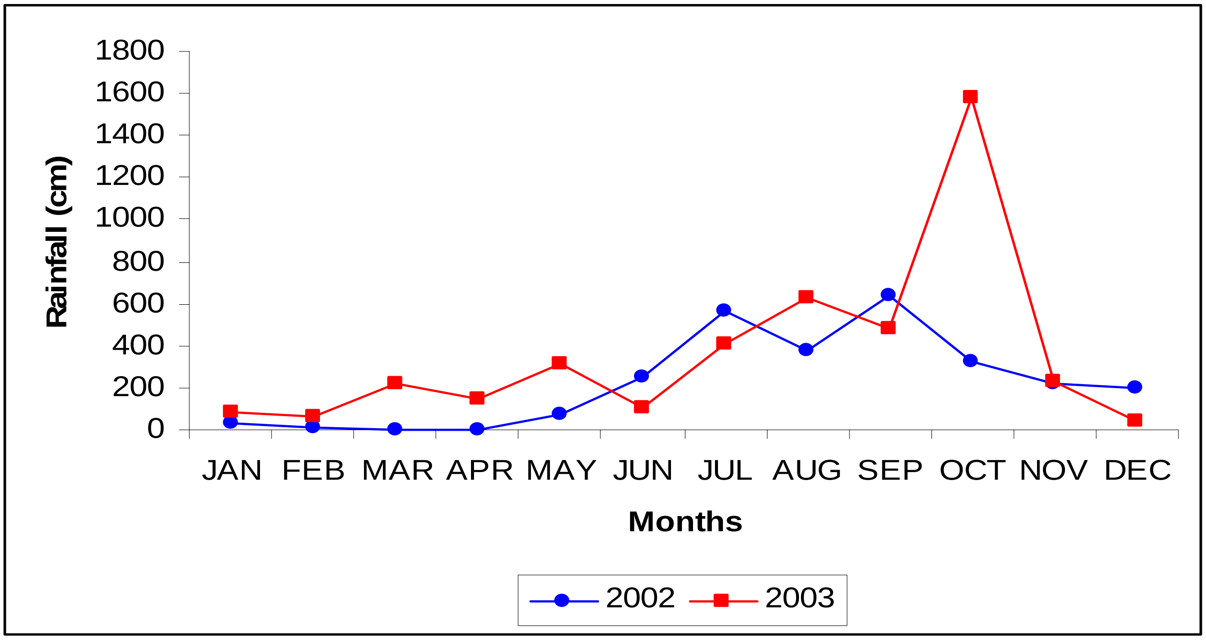

Figure 3.2: Monthly variation of rainfall for the year 2002 and 2003.

Burgess, 1969; Whitmore, 1985). Because of its isolation, Gunung Jerai has the "telescoped" zonation by altitude similar to islands and isolated peaks; the montane oak forest vegetation type, common on hills of the main range between an elevation of 1000m and 1500m is absent here, instead the myrtacecous forest and ericaceous forest is obvious at these elevations (Kochummen, 1982). The lower and upper Dipterocarp forest types seem to be merged between the elevations of 480m and 750m above sea level. The altitudinal zones of vegetation in Gunung Jerai as summarised by Kochummen (1982), is given in Table 3.2.

3.2.2 Location, description and selection of main research area

Two study sites were chosen to fulfil the study objectives. Site A (500m a.s.l.) and Site B (900m a.s.l.) were chosen mainly because both sites fall on two different floristic zones described by Kochummen (1982) which are Hill/Upper Dipterocarp Forest (merged) and Montane Myrtaceous Forest respectively. For logistic reasons and also to avoid disturbance, both sites chosen, were at least 200 meters away from the road that lead to the chalet (Figure 3.3). For the purpose of this study, a site is defined as the general area chosen to locate a trapping grid. Trapping grid parameters for both sites are described in sub-chapter 3.3.3.1.

At first sight, the structure of the forest at Site A (ranged from 500 – 520 m a.s.l.) is like any lowland forest type with emergent trees reaching to heights of 60 to 80 m. But according to Kochummen (1982), the vegetation at this elevation (500m), is a mix of Hill Dipterocarp Forest and Upper Dipterocarp Forest. Site A is mainly dominated by trees from the family Dipterocarpaceae, such as *Shorea curtisii* and *Shorea ovata*. At mid-storey level, *Eugeissonia tristis* or commonly referred to as 'Bertam", a common understorey palm, is abundant at this site. Because this site has huge canopy hovering trees and abundance of palm trees, there is not much light penetrating the forest floor, hence

Table 3.2: The altitudinal zones of vegetation on Gunung Jerai (Kochummen, 1983)

Floristic Zones	**Elevation above sea level (meters)**
Lowland Dipterocarp Forest	150 – 210
Hill / Upper Dipterocarp Forest (merged)	480 – 750
Montane Myrtaceous Forest	780 – 1140
Montane Ericaceous Forest	1200

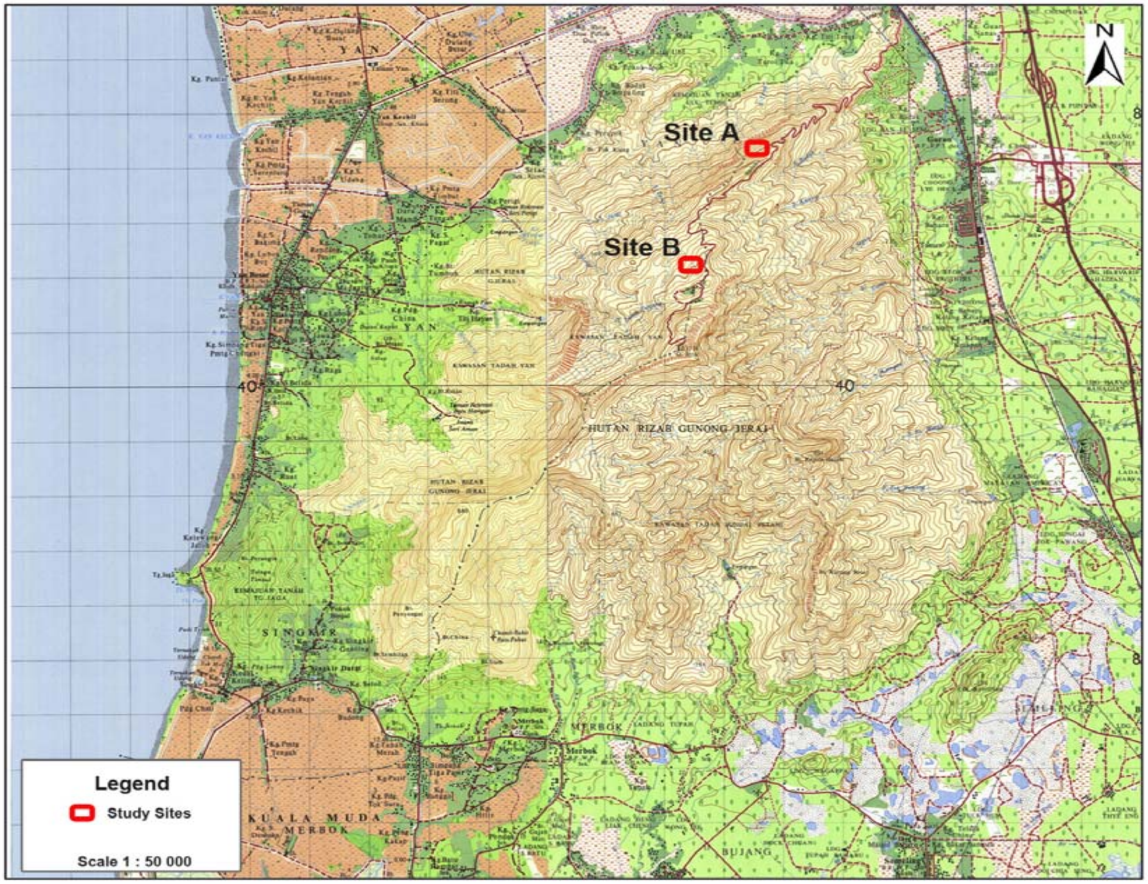

Figure 3.3: Map showing the two study sites (Site A- 500m above sea level & Site B- 900m above sea level).

contributing to conditions that do not favour dense vegetation on the forest floor. Another characteristic that is distinct to this site is the huge size and length of the fallen logs on the forest floor.

Site B (ranged from 900–940 m a.s.l.), is classified by Kochummen (1982) as Montane Myrtaceous Forest due to the abundance of trees from the family Myrtaceae and also because the Oak-Laurel floristic zone is absent at this elevation. Site B is mainly dominated by trees from the family Myrtaceae, such as *Eugenia* sp. and *Tetractomia tetrandra.* The trees at this site do not exceed a height of 30m. Two main characteristics distinct at this site are the abundance of leaf litter and dense mid-storey vegetation, such as shrubs, herbs and vines.

The research areas (Site A and Site B) were selected mainly for the following reasons:

- Other possible sites at different elevations, which constitute different floristic zones such as 100m to 300m and above 1000m to 1217m, were habitats that had some kind of disturbance. For example, most of the habitats from the foothills of Gunung Jerai till an elevation of about 350m have already been converted to fruit orchards. Thus, only two floristic zones (Site A and B) could be used to investigate the parameters mentioned in the study objectives.
- Other possible sites along the same elevational gradient were deemed too steep and logistically difficult. Due to this limitation, it was not possible to set trapping grids or rather have replicates for both sites along the same elevations.
- Both sites were not disturbed by the general public who visited the area mainly because both sites were chosen to have a buffer distance of at

least 200 meters from the road. Apart from that, there were no existing nature trails that lead to both study sites.

3.3 Methods

3.3.1 Abiotic factors

Abiotic factors include edaphic, all aspects of climate, geology and atmosphere that may affect the biotic environment (Oxford-Dictionary., 2000). For the purpose of this study the term abiotic factors refer to two elements, which are temperature and relative humidity. Data for both temperature and relative humidity were collected using a data logger devise called HOBO H8 Pro Series (BoxCar, 2001), which automatically logged readings in the devise itself on an hourly basis.

This devise was used to collect data on temperature and relative humidity during the sampling period (Phase 1 of study). The devise was left on the study site during the sampling period and removed from the field when sampling ceased. The data was obtained from the devise once it was plugged into a computer. It is important to note that the purpose of obtaining this data was to have additional information to support any inference made on other parameters. No data analyses were conducted and the results of this sampling method are presented in a descriptive manner in sub-chapter 4.1. This topic (temperature and relative humidity) is not discussed as a single sub-chapter in Chapter 5, but instead would be included in the discussions of other related sub-chapters if necessary.

3.3.2 Habitat description

Methods of assessing and analyzing habitat parameters are numerous with extensive statistical treatments underlying each method (Smith, 1990; Brower *et al*., 1998). Mammals typically are irregular, often patchily distributed in a habitat and individual species occur in microhabitats which are limited subsets of habitats at each site (Inger & Wilson, 1996). Microhabitat information is useful for determining ecological distributions of each species but taking such data can be time consuming and may result in overwhelming data sets which would then be needed to correlate with the use of habitat for a certain species.

Since microhabitat use by small mammals was not part of the study objectives, the habitat description or rather the forest strata for each study site were assessed using 12 variables measured quantitatively and four variables measured qualitatively. Each of the variables were chosen based on the guidelines provided from Dueser & Shugart (1978). The list of variables and each of its unit of measurement is given in Table 3.3. For reference purposes, types of common families and species vegetation occurring at elevations 500m and 900m as described by Kochummen (1982) is given in Appendix 1.0.

3.3.2.1 Sampling techniques

Sampling for habitat assessments were conducted using the trapping points of the grid as a focal point with a five meter radius around each point. Within this area of a five meter radius, 16 variables were measured. At both sites, each grid had 100 trapping points with a 10m interval between points comprising an area of $8100m^2$. On the whole, the 16 variables were measured in area of 7855 m^2 (size of each sampling area x 100 points; $\pi\ r^2 x100 = 7855$, $\pi = 3.142$, r = 5m.) Thus, almost 97% of the total area of the grid was sampled.

For the four variables measured qualitatively, the percentage of cover was estimated using the six coverage classes according to Gysel & Lyon (1980). The six coverage classes are 0-5%, 5-25%, 25-50%, 50-75%, 75-95% and 95-100%. Canopy height or rather the height of the tallest tree was estimated using the formula suggested by