UNIVERSITI PUTRA MALAYSIA

A COMPARISON OF MAMMALS COMMUNITY BETWEEN LOWLAND DIPTEROCARP FORESTS AND FRUIT ORCHARDS

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By

NUR SYAZLINA BINTI OMAR

A Project Report Submitted in Partial Fulfillment of the Requirements
for the Degree of Bachelor of Forestry Science in the
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Specially dedicated to,

My one and only beloved parents,
Dad, Omar Bin Abdul Karim and Mom, Rosni Binti Abdullah
for believing in their daughter to bring the best of her in finishing the whole thesis at the end of my study.

Not to forget,
my two brothers and sister,

and
My helpful Supervisor
Dr. Badrul Azhar Bin Md. Sharif

Without whose love and encouragement this journey would never have been possible.

ABSTRACT

Forest patches are becoming more isolated and dispersed because of human encroachment and growing forest fragmentation. Agroforestry has been hailed as a sustainable way for the agricultural industry to produce crops, connect forest sections, and give wildlife alternate habitats outside of protected areas. The purpose of this preliminary survey was to assess the mammal assemblages found in the lowland dipterocarp forest (Angsi Forest Reserve) and agroforestry orchard in Rembau, Pahang. A total of 198 animal images were captured by the 44 camera trappings deployed across the forest and the agroforestry fruit orchard study sites. From the images, 15 mammal species were identified with 13 species recorded in the Angsi Forest Reserve and 8 species in the agroforestry orchard. However, the findings demonstrate that forest specialists that are sensitive to disturbance can also be supported by less intensively maintained agroforest, such as agroforestry orchards. In order to support sustainable agriculture and promote mammal diversity, future biodiversity data in agroforests will be integrated into agricultural management methods.

ABSTRAK

Tompok hutan semakin terpencil dan berselerak akibat pencerobohan manusia dan pemecahan hutan yang semakin meningkat. Perhutanan tani telah diuji sebagai cara yang sesuai dan mampan untuk industri pertanian menghasilkan tanaman, menyambung bahagian hutan, dan memberikan habitat ganti hidupan liar di luar kawasan perlindungan. Tujuan kajian ini adalah untuk menilai himpunan mamalia yang terdapat di hutan dipterokarpa tanah pamah (Hutan Simpan Angsi) dan dusun buah-buahan di Rembau, Pahang. Sebanyak 198 imej haiwan telah dirakam oleh 44 perangkap kamera yang digunakan di seluruh hutan dan tapak kajian dusun buah-buahan. Daripada imej tersebut, 15 spesies mamalia telah dikenal pasti dengan 13 spesies direkodkan di Hutan Simpan Angsi dan 8 spesies di dusun buah-buahan. Walau bagaimanapun, kajian sebelum ini mendapati bahawa spesies spesialis yang sensitif terhadap gangguan juga boleh berinteraksi di dalam satu komuniti di hutan yang kurang diselenggara secara intensif, seperti dusun buah-buahan. Untuk menyokong pertanian mampan dan menggalakkan kepelbagaian mamalia, data biodiversiti masa depan dalam pertanian tani akan disepadukan ke dalam kaedah pengurusan pertanian.

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APPROVAL SHEET

I certify that this research project report entitled "A Comparison of Mammals Community Between Lowland Dipterocarp Forests and Fruit Orchards" by Nur Syazlina binti Omar has been examined and approved as a partial fulfillment of the requirements for the degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia.

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
AFR	Angsi Forest Reserve
DF	Degree of Freedom
GLM	Generalized Linear Method
GPS	Global Positioning System

CHAPTER 1

INTRODUCTION

1.1 General Background

Malaysia is one of the most diversified nations in the world. According to the National Biodiversity Index, which is based on estimations of country richness and endemism in four terrestrial vertebrate classes and vascular plants, it is also placed 12th in the world (Convention On Biological Diversity, n.d.).

The amount of land that is covered in trees and forests is a key measure of the state of the ecosystem. Because they provide habitat, food, protection, connectedness, and other ecosystem services, trees are crucial to maintaining animal populations. According to the Food and Agriculture Organisation of the United Nations' (FAO) most recent assessment of global forest resources, the total forest area decreased by 3% between 1990 and 2015, from 4128 million hectares to 3999 million hectares (Keenan et al., 2015). Mammals play a significant part in ecosystems by providing crucial functions such controlling insect populations, seed dissemination, and pollination as well as acting as indicators of the overall health of ecosystems (Jones et al., 2011).

Forest fragmentation is the process by which a natural landscape is divided into smaller, isolated ecological patches within a matrix of areas where human activity is predominate (Wilcoveet al., 2013; Hunter,1996). One of the main causes of fragmentation is anthropogenic activity, such as clearing land and changing the kind of plant. Concern for conservation is raised by the appearance of fragmentation since it may affect and change the natural species assemblages by rupturing the continuity of the habitat, resulting in a number of issues like lowering reproductive success and genetic diversity in species (Damian, 2012).

Environment and biodiversity have been significantly impacted by agriculture. Invasive species may lose their habitats or possibly become extinct when surroundings are overly transformed or contaminated by industrialised agriculture, damaging biodiversity. A loss of biodiversity frequently occurs when natural environments are turned into agricultural land. Many mammal species are specialised and adapted to certain ecosystems, and when those habitats are lost or changed, the populations of these species decrease.

The trade-off between land-sparing and land-sharing techniques has been used to frame the issue of balancing biodiversity protection and agricultural output (Matson and Vitousek, 2006; Fischer et al., 2008; Phalan et al., 2011). Land conservation maximises the trade-offs between agricultural productivity and variety in many locations (Phalan et al., 2011; Balmford et al., 2015). However, land-sparing agricultural intensification can unintentionally encourage agricultural expansion by increasing fertiliser and pesticide runoff

(Matson and Vitousek, 2006; Chappell et al., 2009). Through wildlife-friendly farming methods including the preservation of natural, structurally diversified flora, the alternative land-sharing model blends food production and biodiversity conservation (Luck and Daily, 2003; Fischer et al., 2008).

1.2 Problem Statement

Due to wildlife's sensitivity to landscape alteration, forest conversion to agricultural fields, a major cause of forest loss in Southeast Asia, has significantly altered species compositions and abundances. Local biodiversity including mammals can be affected by these forest changes due to the conversion of nature forest to this agricultural land.

Understanding the species richness, composition and site occupancy of the mammals will provide information for biodiversity conservation. This study will also provide information to the responsible parties to promote wildlife management by understanding the fruit orchards.

1.3 Objectives

The objectives of this study were:

1) To compare the species richness and species composition of mammals in lowland dipterocarp forests and fruit orchards.

2) To determine the site occupancy of mammals in lowland dipterocarp forests and fruit orchards.

3) To examine the relationship between number of animal images and habitat quality.

1.4 Significance of Study

The findings of the study will provide the following:

1) Updated baseline survey data will improve conservation effort and wildlife management in forest habitat and agricultural lands.
2) Data can be used to understand the impacts of land use changes on mammalian biodiversity in the future.
3) Data is required to justify both land sparing which is mainly used for conservation or protected area as well as land sharing such as wildlife-friendly farming strategies.

CHAPTER 2

LITERATURE REVIEW

2.1 Central Forest Spine (CFS)

Angsi Forest Reserve is characterized as a lowland and hill dipterocarp forest that is dominated by Shorea species. Meanwhile, fruit orchards in Rembau, Negeri Sembilan are well planted with various fruit species including durian, mangosteen, rambutan and others. According to the Department of Town and Country Planning Peninsular Malaysia (PLANMalaysia) 2010, using ecological corridors to unite Peninsular Malaysia's fragmented forests, Malaysia has launched a programme dubbed Central Forest Spine (CFS) to expand existing forested regions.

There are 17 core links and 20 secondary linkages, totaling 37 ecological corridors. Angsi Forest Reserve (Angsi FR) was identified as Secondary Linkages 7 (CFSII SL7). The old and new roads from Seremban to Kuala Pilah, as well as the conversion of forest to agricultural area and settlements close to the forest reserves, divided the Angsi Forest Reserve and the Berembun Forest Reserve in this ecological corridor. Large patches have been created on the Main Range in east Seremban as a result of the land-use changes. In order to preserve communication throughout the southern portion of the Main Range forest complex, it is imperative that this CFSII SL7 be connected to and secured.

Primary forest (including legally protected areas), secondary forest, forest islands, private property, towns, and several other mixed land use and activities that are located along Peninsular Malaysia's projected backbone are all included in CFS areas (DTCP, 2009a). There are presently little research on wildlife in the forests outside of permanent forest reserves, protected areas, and CFS areas in Peninsular Malaysia. Biodiversity assessments conducted in the last fifteen years have primarily examined legally protected areas, like national parks and wildlife reserves (DWNP, 2008a, 2008b, 2008c, 2008d, 2008e, 2008f, 2009a, 2009b, 2017). Wildlife is able to migrate across remote protected areas thanks to ecological pathways. To lessen the chance of a species going extinct, this will aid in the migration of wildlife, the exchange of genes, and the spread of pollen and seeds (Good, 1998).

The authorities can develop and accomplish specific actions with the help of information about mammal occurrences in the corridors. For management and conservation purposes, the study's two main goals were to first gather and update data on the wildlife in the corridors and then periodically monitor wildlife occurrences in the area.

2.2 Mammals in Lowland Hill Dipterocarp Forest

Mammals can be defined as a group of warm-blooded animals that can suckle their young milk and whose bodies are wholly or partially covered with hair (Tweedie, 1978). Lowland hill dipterocarp rainforests act as a home to many types of mammals ranging from tiny size to big size mammals. Big and medium mammals especially primates are most known compared to small, nocturnal, and inconspicuous mammals. About 1135 genera and 4630 species of living mammals are currently recognized (Koopman et al., 1993). There is no particular definition for small mammals, but Fleming (1979) categorized them as the species which has weight less than 5 kg. Meanwhile, Smithsonian National Zoological Park, considers small mammals as that mammals that are measuring less than one foot including the head and body. Generally, this group applies to any mammals weighing less than 1 kg when adult or we can consider any mammals that size smaller in appearance. The most abundant kind of mammals in the rainforest are bats and rodents. Amongst a small group of mammals, Rodentia is the largest mammalian order with 34 families, 354 genera, and about 1700 species. Furthermore, the second largest order is Chiroptera which is a bat species with approximately 168 genera and 153 species (Vaughan, 1972).

2.3 Inventory of Camera Trapping: Mammals

The inventory of mammals is made up of two categories which are invasive method and non-invasive method. Invasive method has a direct impact on animals such as live trapping meanwhile non-invasive method does not require capturing and handling animals like camera-trapping. In the past, mammals in Peninsular Malaysia were studied using various methods, which includes, live trapping, track counts, interview surveys and direct observations. Mammals in Peninsular Malaysia were studed in the past using a variety of techniques, such as live trapping, track counts, interview surveys, and direct observations (Topani 1990; Ratnam et al. 1995). Camera trap is efficient for inventories, especially of cryptic animals, as well as for population studies of species which can be individually recognized by marks (Carbone et al., 2011).

For a long term, camera trap may serve as a tool to analyze the status and changes in species diversity and activity patterns. The important indicators that can be derived from camera trapping data include: (i) animal species diversity, (ii) relative abundance of species, (iii) wildlife activity patterns, and (iv) wildlife population estimates (Liu et al., 2013). Camera trapping method has been widely used in population studies of tiger (Karanth & Nicholas, 1998) and bears (Kucera & Barrett, 1993). The studies of camera trap usually used for terrestrial mammals in class of big mammals compare to small-medium mammals. Especially in Malaysia, the examples of inventory are mist nets, live traps, capture and recapture, walking transect, direct sighting, and a few in number of camera trap (which include the big mammals or all terrestrial mammals). The use of camera trapping for wildlife studies has increased exponentially in the last decade as it is an efficient, cost-effective, and easily replicable tool to study and monitor ground-dwelling terrestrial mammals and birds (O'Connell & Bailey, 2011).

In addition to species biology and management issues such habitat associations, activity patterns, feeding, sickness monitoring, and wildlife crossing monitoring, camera traps have been used extensively for faunal surveys, monitoring, and population size estimations (Rovero et al., 2013).

2.4 Threats on Mammals in Malaysia Forest

Deforestation and unsustainable hunting in the tropics have degraded many landscapes to the point that they now no longer support viable populations of threatened species (Sodhi et al., 2009; Bennett, 2011). Traditional approaches to conserve these landscapes and their wildlife populations have tended to focus on protected area management (IUCN 1994; De Fries et al., 2005). However, it is questionable whether the existing protected areas provide adequate habitat cover quality or indeed protection for threatened species (Catullo et al., 2008), as designation is often based on socio-economic and political priorities rather than assessments of wildlife habitat requirements (Margules & Pressey, 2000). This has, for example, led to significant sized patches of lowland tropical forests being excised from protected areas for commercial logging (Daily et al., 2009).

The threat posed by deforestation tends to disproportionately affect large-bodied mammals because of their large range requirements (Kinnaird et al., 2003). Thus, to halt the ongoing loss of large-bodied mammal populations, identification of high conservation value areas is required (Hoffman et al., 2010), but the detailed information on the distribution of species required for this purpose is often lacking (Rondinini et al., 2005). The requisite distributional data for developing conservation priorities, whilst available for many species in the form of regional range data (Rodrigues et al., 2004), are less useful for conservation agencies that require finer-scale information, such as spatial distribution and use of habitat under varying levels of protection. With its greater diversity of mammals despite its smaller landmass, Malaysia faces an immediate threat of extinction if proper management measures are not taken (Jayaraj et al., 2013).

CHAPTER 3

METHODOLOGY

3.1 Materials and Methods

In this study, camera traps were used to capture animal images in the fruit orchards and the forest. Two types of digital cameras were used which are Bushnell Trophy Cam HD and Suntek Trail Camera HC800A Model. The factory-set was used by 1 second interval of response speed for the Bushnell Trophy Cam HD and the cameras were set to operate 24 hours per day with 3 images per trigger. Additionally, the camera traps SD cards and batteries were changed once in two weeks. A rangefinder is used to measure tree heights in both study area while GPS is used to record the location of the camera trappings.

Figure 1: Bushnell Trophy Cam HD and Rangefinder

3.2 Study Area

This study was conducted in two sites which are the Angsi Forest Reserve (AFR) and the nearby native fruit orchards. Angsi Forest Reserve is in Kuala Pilah district, at longitude 2° 39' N to 2° 44' N and latitude 102° 03' E to 102° 06' E and was gazetted as a virgin forest reserve in 1959. AFR is also a permanent forest reserve with the highest point, Gunung Angsi which is part of the Titiwangsa Range is the highest peak in this forest reserve with a height of 825 m above sea level. The forest reserve covers an area of approximately 7,716 hectares and is known for its rich biodiversity, including various plant and animal species.

Figure 2: Location of camera trappings in Kuala Pilah and Rembau

Figure 3: The location of camera trappings in different habitats (AFR and fruit orchard)

3.3 Sampling Method

30 cameras were deployed for 25- to 30-day intervals during October 2022-August 2023. The aim was to photograph any mammals that occurred to be in the area where the cameras were deployed at. To obtain any mammals to be captured by the cameras, each camera trap was placed on an animal trail where their signs (scats, scent deposits, tracks) occurred. The camera trap locations were chosen by utilizing distinct animal tracks, footprints, scats, and tree markings, considering whether a certain place would be advantageous for animals (Karanth & Nichols, 1998). Example of mammal's nail scratch by a Malayan sun bear can be seen in Figure 4. Each camera was placed on relatively flat terrain 0.4-0.5m off the ground on a tree and all vegetation and debris were cleared from the field of view so that both medium-size and large animals had the opportunity to be photographed.

Figure 4: Example of mammal signs (sign of a Malayan sun bear found on the tree trunk)

Figure 5: Camera traps practices (the camera trap was attached 0.4-0.5 meters from the ground on the tree and each SD cards from the camera were changed every two weeks)

3.4 Data Analysis

Given the abundance and uniformity of species within a certain environment, species diversity will increase as habitat diversity increases. A measure of evenness is the relative abundance of the species that will make up a species richness in a certain habitat or area (Bibi & Ali, 2013).

SIMPER Analysis can be used to determine species composition (from dominant to less dominant) in lowland and hill dipterocarp forests and fruit orchards while ANOSIM Analysis can be used to compare species composition between lowland and hill dipterocarp forests and fruit orchards. PRIMER version 7 software will be used to conduct SIMPER and ANOSIM by using the multivariate analyses.

Estimation of site occupancy of selected species (based on data available) will be calculated by using null models & covariate models in PRESENCE version 2.13.47.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Capture Summary

A total of 198 animal images were captured by the 44 camera trappings deployed across the forest and the agroforestry fruit orchard study sites. From the images, 15 mammal species were identified with 13 species recorded in the Angsi Forest Reserve and 8 species in the agroforestry orchard (Table 4.1).

Macaca fascicularis was the species caught most frequently (N=63), *Sus scrofa* and *Macaca nemestrina* were the second and third most common species, with (N=48) and (N=33) individuals, respectively. Species with the least number for catches belonged to the *Manis javanica*, *Muntiacus muntjac*, and *Paradoxurus musangus*.

Panthera pardus, *Viverra zibetha*, *Paradoxurus musangus* were recorded as singletons in the agroforestry fruit orchards. Among the species captured, *Tragulus javanicus* is listed as Data Deficient while *Prionailurus bengalensis*, *Muntiacus muntjac*, *Sus scrofa*, and family from Viverridae, *Viverra zibetha*, *Viverra tangalunga*, *Paradoxurus hermaphroditus*, and *Paradoxurus musangus* are listed as Least Concern in the IUCN Red List. Moreover, *Rusa unicolor* and *Helarctos malayanus* are listed as Vulnerable, as *Tapirus indicus*, *Macaca nemestrina*, *Macaca fascicularis* are listed as Endangered while *Manis javanica* is listed as Critically Endangered in the IUCN Red List.

Table 4.1: Name of species captured, conservation status and study sites involved.

			Conservation status		Study sites	
Family	Common name	Scientific name	IUCN red list	Protection status	Forest	Fruit Orchard
Felidae	Leopard	*Panthera pardus*	V	TP	✓	
	Leopard Cat	*Prionailurus bengalensis*	LC	TP	✓	✓
Cervidae	Sambar Deer	*Rusa unicolor*	V	P	✓	
	Barking Deer	*Muntiacus muntjak*	LC	P	✓	
Tapiridae	Malayan Tapir	*Tapirus indicus*	E	TP	✓	
Ursidae	Malayan Sun Bear	*Helarctos malayanus*	V	TP	✓	
Cercopithecidae	Pig-tailed Macaque	*Macaca nemestrina*	E	C	✓	✓
	Long-tailed Macaque	*Macaca fascicularis*	E	P	✓	✓
Suidae	Wild Boar	*Sus scrofa*	LC	P	✓	✓
Manidae	Sunda Pangolin	*Manis javanica*	CE	TP	✓	
Tragulidae	Javan Chevrotain	*Tragulus javanicus*	DD	C	✓	
Viverridae	Large Indian Civet	*Viverra zibetha*	LC	TP	✓	✓
	Malayan Civet	*Viverra tangalunga*	LC	TP	✓	✓
	Asian Palm Civet	*Paradoxurus hermaphroditus*	LC	P		✓
	Common Palm Civet	*Paradoxurus musangus*	LC	P		✓

Figure 6: Mammal images captured by the camera traps for both study sites

4.2 Statistical Analysis

Every picture taken by the camera traps was categorized, and each picture of an animal was identified using a mammal guide written by Francis (2008). ANOSIM analysis to test for differences in species composition at different locations. This was analysed by performing 999 permutations (random sample from a large number). Both SIMPER and ANOSIM were performed using PRIMER version 7.

Based on the table 4.2.1 which shows the SIMPER Analysis for mammals species composition in forest, *Macaca nemestrina* (Pig-tailed Macaque), has the highest average abundance among the species found with 12.74 individuals and a percentage contribution of 40.87. The second highest is *Macaca fascicularis* (Long-tailed Macaque) with 13.19 individuals and a percentage contribution of 22.57. The lowest average abundance among the mammals is *Rusa unicolor* (Sambar Deer) with 2.25 individuals and percentage contribution of 1.37.

Table 4.2.1: SIMPER Analysis table for mammal species composition in forest

Species	Av. Abundance	Av. Sim	Sim/SD	Contribution (%)	Cumulative Cont.
Pig-tailed Macaque	12.74	2.86	0.31	40.87	40.87
Long-tailed Macaque	13.19	1.58	0.13	22.57	63.44
Wild Boar	6.46	0.99	0.20	14.15	77.58
Leopard	5.11	0.69	0.16	9.85	87.43
Sun Bear	3.78	0.34	0.12	4.82	92.25
Leopard Cat	2.97	0.26	0.12	3.68	95.93
Tapir	2.27	0.10	0.07	1.37	97.30
Lesser Mousedeer	2.10	0.10	0.07	1.37	98.66
Sambar Deer	2.25	0.10	0.07	1.37	100.00

Table 4.2.2 shows the SIMPER Analysis for mammal species composition in fruit orchard where the family Cercopithecidae has the highest average abundance with both 22.12 and 9.34 individuals equally. *Macaca nemestrina* (Pig-tailed Macaque) has the highest percentage distribution of 64.88 followed with *Macaca fascicularis* (Long-tailed Macaque) with 16.88%.

Table 4.2.2: SIMPER Analysis

Species	Av. Abundance	Av. Sim	Sim/SD	Contribution (%)	Cumulative Cont.
Pig-tailed Macaque	22.12	6.64	0.40	64.88	64.88
Long-tailed Macaque	9.34	1.73	0.25	16.88	81.76
Wild Boar	10.18	1.36	0.24	13.29	95.05
Asian palm civet	6.49	0.25	0.13	2.49	97.54
Malayan civet	4.44	0.25	0.08	2.49	100.00

However, *Muntiacus muntjak* (Barking Deer), *Manis javanica* (Sunda Pangolin), *Viverra zibetha* (Large Indian Civet) and *Paradoxurus musangus*, (Common Palm Civet) were not used as main data in the SIMPER analysis. This is because of their rare occurrences, where each of them was only noticed once throughout the survey. As the SIMPER study indicated, species with low abundances or occurrences would not significantly contribute to the overall similarity because they were not consistently present throughout the analyzed sites. Despite their few occurrences, the importance of these observations lies in their collective contribution to the reserve's overall biodiversity. Their elusiveness, which makes them difficult to reliably find during the survey, may be the reason for their rarity.

4.3 Site Occupancy of Mammals

The program PRESENCE version 2.13.47 was used to estimate the site occupancy of targeted species that had been identified using the “Single Species with Covariates” methods.

Based on Table 2.3.1, the site occupancy for *Macaca nemestrina* is estimated at 0.3861, meaning that the species is likely to be found in about 38.61% of the area surveyed. For density, it is estimated at 0.5380 individuals per unit area and total abundance about 12.91 individuals within the surveyed area.

The second highest total abundance is 11.92 individuals of *Panthera pardus* within the surveyed area. The site occupancy is estimated at 0.3537, suggesting that this species is present in roughly 35.37% of the area surveyed. For density, it is estimated at 0.4968 individuals per unit area, with a standard error of 0.6212.

Prionailurus bengalensis shows the least number of individuals which in only 3.82 and the site occupancy is 0.1370 meaning that there is about 13.70% species can be found of the area surveyed. For density, it is estimated at 0.1591 individuals per unit area.

While based on Table, *Macaca fascicularis* has the highest site occupancy at 0.5098 suggesting that the species is likely to be found in about 50.98% of the fruit orchard surveyed. For density, it is estimated at 0.8469 individuals per unit area and the total abundance about 16.94 individuals within the fruit orchard.

Table 2.3.1: Site occupancy of the mammals found in forest

Species		Estimate	Standard error	95% confidence interval
Macaca nemestrina	Site occupancy	0.3861	0.1461	0.1581-0.6780
	Density	0.5380	0.3129	0.1721-1.6822
	Total abundance	12.91	7.51	4.13-40.37
Panthera pardus	Site occupancy	0.3537	0.2882	0.0442-0.8662
	Density	0.4968	0.6212	0.0428-5.7613
	Total abundance	11.92	14.91	1.03-138.27
Macaca fascicularis	Site occupancy	0.1747	0.0804	0.0663-0.3870
	Density	0.1909	0.0980	0.0697-0.5223
	Total abundance	4.58	2.35	1.67-12.53

Table 2.3.1- continued

Sus scrofa	Site occupancy	0.2700	0.1236	0.0976-0.5585
	Density	0.3363	0.2014	0.1040-1.0875
	Total abundance	8.07	4.83	2.50-26.10
Prionailurus bengalensis	Site occupancy	0.1370	0.0757	0.0433-0.3577
	Density	0.1591	0.0969	0.0483-0.5248
	Total abundance	3.82	2.53	1.16-12.60
Helarctos malayanus	Site occupancy	0.1533	0.0924	0.0442-0.4224
	Density	0.1687	0.1126	0.0456-0.6244
	Total abundance	4.05	2.70	1.09-14.99

Table 4.3.2: Site occupancy of the mammals found in fruit orchard

Viverra tangalunga	Site occupancy	0.2639	0.2104	0.0412-0.7497
	Density	0.3269	0.3451	0.0413-2.5884
	Total abundance	6.54	6.90	0.83-51.77
Macaca fascicularis	Site occupancy	0.5098	0.1640	0.2233-0.7901
	Density	0.8469	0.5120	0.2589-2.7700
	Total abundance	16.94	10.24	5.18-55.40
Sus scrofa	Site occupancy	0.2579	0.1003	0.1106-0.4926
	Density	0.3126	0.1437	0.1269-0.7698
	Total abundance	6.25	2.87	2.54-15.40
Paradoxurus hermaphroditus	Site occupancy	0.2816	0.1555	0.0799-0.6388
	Density	0.3431	0.2490	0.0827-1.4230
	Total abundance	6.86	4.98	1.65-28.46

4.4 Spearman's Rank Correlation Coefficient

Spearman's Rank Correlation Coefficient was used to assess the directions of correlation between variables. It was recommended that the analysis's correlation coefficient is less than 0.05. Value around -1 indicate a strong negative monotonic correlation, whereas value near 1 indicate a strong positive monotonic correlation. The correlation coefficient ranges from -1 to 1.

Based on Table 4.4.1, a value of 0.266 suggests a weak positive association between the two variables being analyzed. The slight difference between 0.266 and 0.265 suggests that there are ties in the data, but they don't have a major impact on the correlation. The p-value is less than 0.05, it is suggesting that the correlation is significant at the 5% significance level.

Table 4.4.1: Spearman's rank correlation coefficient of response variables

Correlation	0.266	Positive
Adjusted for ties	0.265	
Sample size	44	
Exact probability	0.021	Significant
t Approximation	1.78 (df = 22)	p = 0.082

Table 4.4.2: Regression Analysis

Response variate	No_Images
Distribution	Poission
Link function	Log
Fitted terms	Constant+Number_of_trees+Mean_tree_height_m +Habitat

Table 4.4.3: Summary of Analysis

Source	d.f.	Deviance	Mean deviance	Deviance ratio	Approx. chi pr
Regression	3	62.3	20.776	20.78	<0.001
Residual	40	354.1	8.853		
total	43	416.1	9.685		

Approximate Chi-Square Probability is a p-value that tests the null hypothesis that the model with more parameters (the regression model) does not fit the data significantly better than the model with fewer parameters (just the intercept). A p-value of <0.001 indicates that the regression model significantly improves the fit over the intercept-only model, to a degree that would be expected by chance less than 0.1% of the time.

4.5 Wald Tests

To determine the key drivers of mammal species richness between species occurrence and habitat quality attributes, significant explanatory variables were determined using Wald's test. Global models containing all predictor variables were used to perform multicollinearity correlation tests among the variables. Since all explanatory variable pairs were not characterized by strong collinearity (r > 0.7), none of the predictor variables were dropped from the global model (Dormann et al., 2013).

Table 4.5: Wald tests for dropping terms.

Term	Wald statistics	d.f.	Chi. pr.
Number_of_trees	46.75	1	<0.001
Mean_tree_height_m	0.93	1	<0.334
Habitat	15.88	1	<0.001

4.6 Generalized Linear Model Analysis

According to Kohavi and Quinland (2002), overfitting is a prevalent problem in statistical model development that can result in subpar data performance. Because of the small ratio sample size of 22—that is, less than 40—and the desire to prevent overfitting while promoting improved performance, adjusted R^2 was used.

Table 4.6: Regression Model Analysis of habitat quality and number of mammal images

R^2	Adjusted	Df	Mean tree height	Habitat
14.75	10.59	3	.000	.000
		Coefficient	0.0135	0.765 (Forest)

Figure 7: Scatterplots with regression (red) line and 95% confidence intervals (blue line) showing the relationship between the number of images and number of trees. By default for GLMs, the fitted relationship is plotted on the original scale, but the option use the scale of the linear predictor was selected to check for potential non-linearity in the response. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

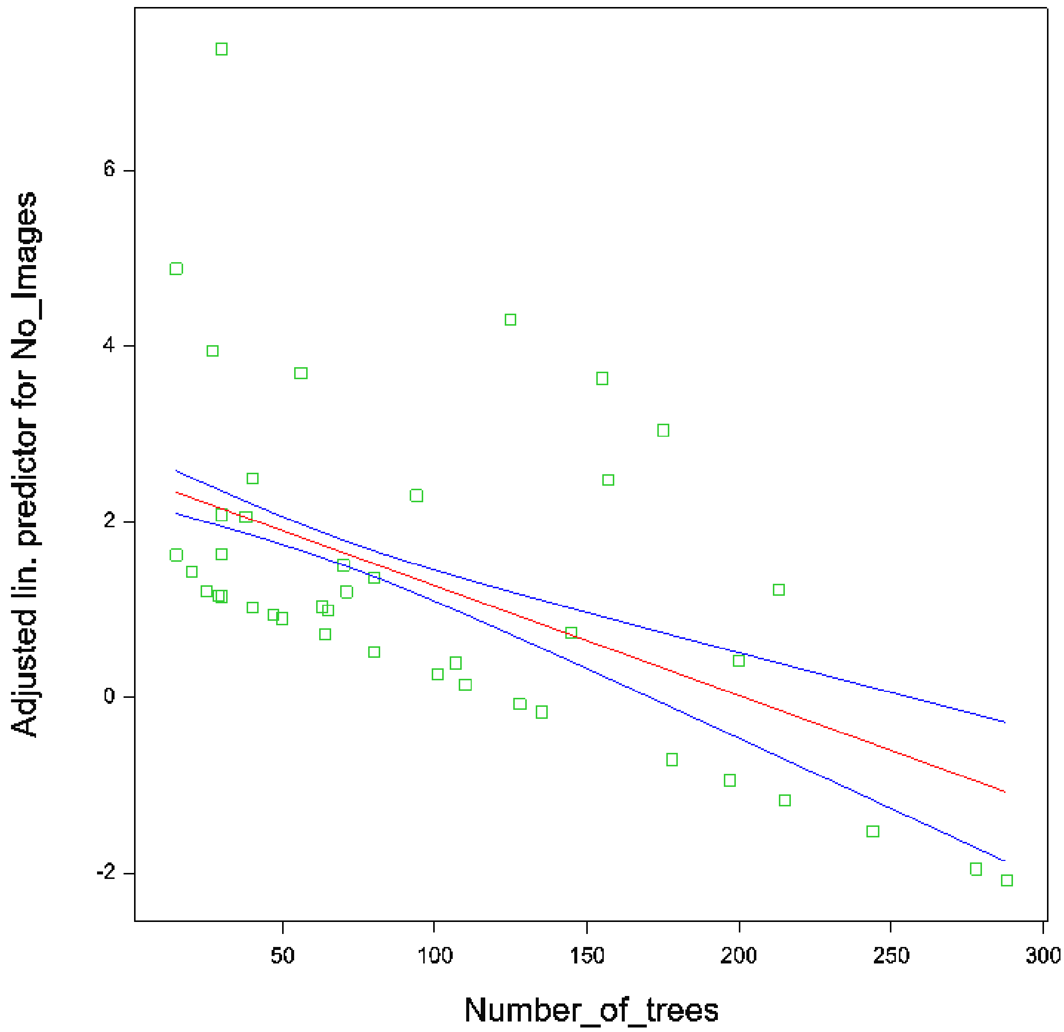
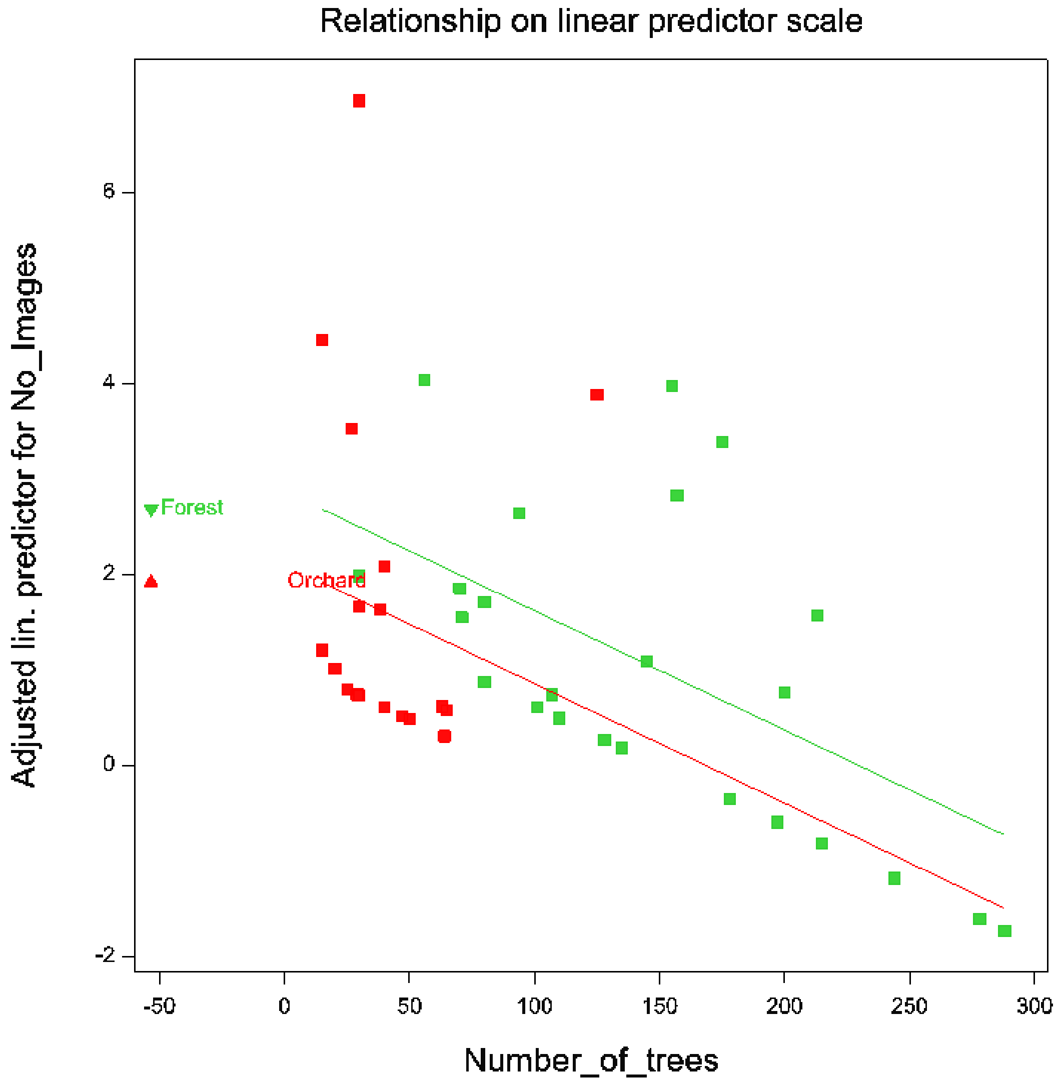


Figure 8: Relationship between the number of trees (independent variable on the x-axis) and the adjusted linear predictor for the number of images captures (dependent variable on the y-axis).



Based on the graph, the forest (green line), the decrease in the predicted number of images is steeper than for the fruit orchard (red line), suggesting that the presence of trees in a forest setting has a more pronounced effect on the number of images than in the fruit orchard setting.

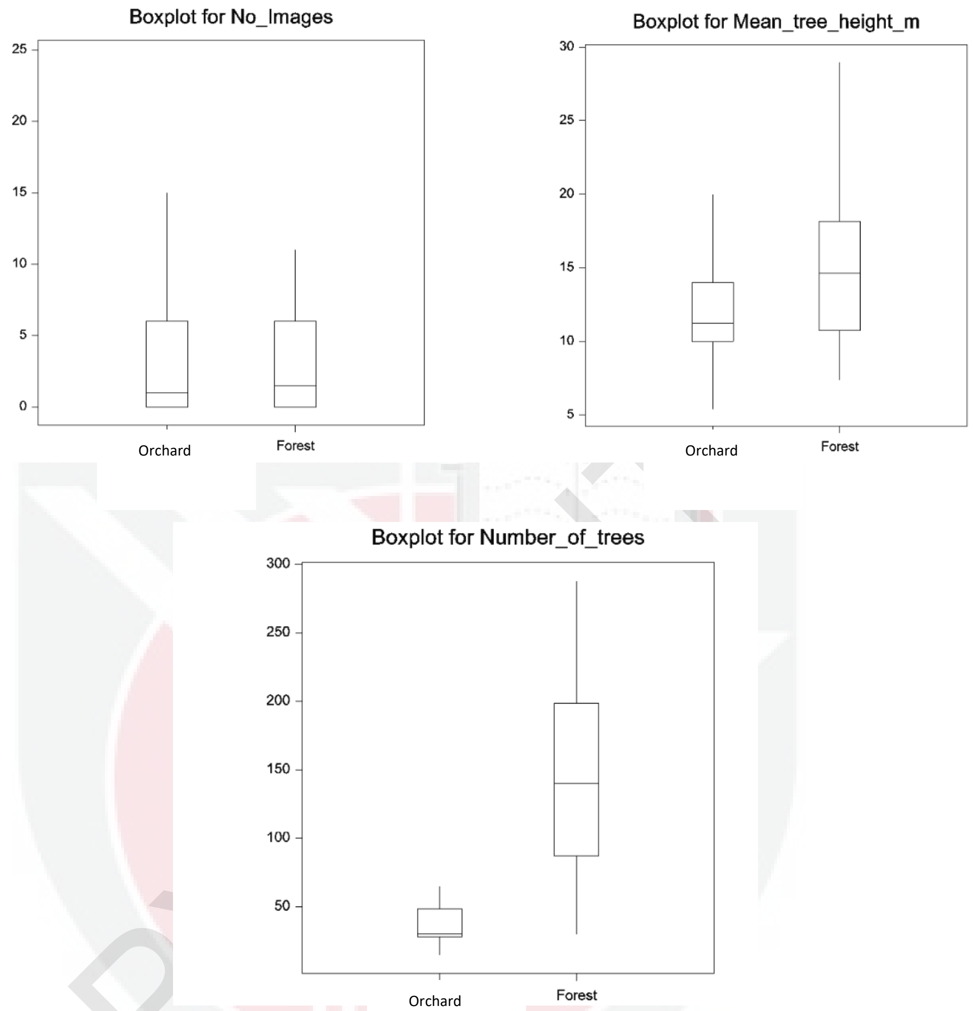
Both settings show a decline in number of images when number of trees decreased. This is because the camera's field of view may be obstructed by dense foliage and several tree trunks. This may cause animals to be entirely or partially hidden from the camera, making it challenging to take sharp pictures of them.Fruit orchards are purposely planted and managed for food production, but forests are naturally occurring ecosystems that have evolved over time, meaning that forests have a higher tree population than orchards.

4.7 Box Plot

The box plox below shows the median position and the inter-quartile range (lower and upper quartile) of the variables according to each study sites (fruit orchard and forest).

This boxplot demonstrates that although ("No_Images": Number of images) in fruit orchard" has a little higher central tendency (median) than in forest, the middle 50% of the data in both categories is distributed similarly. Given the longer whiskers, fruit orchard has slightly higher variability in the data. Comparing the two categories, it is evident that forests have a wider range and likely a higher median number of trees compared to fruit orchards. The variability in the number of trees is also greater in forests than in fruit orchards. This can be inferred from the height of the boxes and the length of the whiskers. ("Mean_tree_height_m": Mean tree height in meter) in forest shows a higher median compared to fruit orchard.

Figure 9: Boxplot of predictor variables (mean tree height, number of images and number of trees) in two different study areas (fruit orchard and forest).



CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Camera trapping is a non-intrusive sampling method compared to live trap which is more reliable and accurate in surveying rare and elusive forest species. Without physically upsetting the animals or their surroundings, camera traps aid in the study of wildlife. Since typical field surveys may provide skewed results or interfere with the animals' natural behavior, this non-intrusive approach is especially crucial for researching elusive or sensitive species.

Since *Macaca fascicularis* adapts well to a variety of forest settings and agroforestry orchards, it is the most abundant species among the others. This study demonstrated that small- to medium-sized mammals depend on forests with adequate resources, good cover, and a temperate environment. According to this study, there is a low species richness since it is difficult to distinguish between members of the same species because they have similar morphological traits. The abundance of the species was also not identified by analyzing all the mammal images.

In conclusion, this study shows that forest had a greater species richness compared with the agroforestry orchard and identified the key vegetation structural characteristics that were associated with those differences. More mammals could easily be found in the forest compared to agroforestry orchard. Disturbed forest that has been logged does support more biodiversity in the forest compared to the agroforestry orchard. Human activities such as pesticide use, agricultural methods, and harvesting may affect orchards. Mammal populations and behavior may be impacted by these actions.

The absence of large-sized mammals in both selectively logged and unlogged forests is a major concern that requires serious attention and revision of the current forest management system in Peninsular Malaysia. This information is essential to develop successful policy guidelines for managing tropical forestry landscapes

5.2 RECOMMENDATION

Increasing the sample point in the research region is the first recommendation since it would improve the identification and capture of a wider variety of animal species. Furthermore, it will be simpler to identify mammals precisely based on characteristics like sex, size, and scars if there are more video traps at each place.

When compared to camera spacing and area covered, the density of camera traps has a significant impact on the photographs of mammals. Although increasing the number of camera traps may not ensure the detection of additional species, at least the standard error can be reduced.

Aside from that, extending the study period can aid in gathering more species data and enhance the chance of observing a more uncommon species. An appropriate government body must standardize and preserve the data gathered from the video traps in order to deter animal poaching and to serve as guidelines for logging activities inside the forest region.

The spatial scale of habitat should be included as a factor in estimating the compositions of mammals. For instances, diameter of mother tree, diameter breast height (DBH) of the trees in the area, the number of trees and altitude. A good habitat quality influences the number of species compositions in the areas.

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APPENDICES

Appendix 1: Data sheet of mammal images in forest

	Camera Point				
No	Latitude	Longitude	Species	No. of Images	Activity
1	N02.65993	E102.09127	NO DATA	-	-
2	N02.66064	E102.09008	*Panthera pardus*	1	Passing
			Rusa unicolor	1	Foraging
			Tapirus indicus	1	Passing
3	N02.65858	E102.08840	Macaca nemestrina	4	Passing
			Sus scrofa	6	Passing
			Panthera pardus	1	Passing
4	N02.65866	E102.08656	NO DETECTION	-	-
5	N02.65686	E102.08798	NO DATA	-	-
6	N02.65474	E102.08951	Sus scrofa	1	Staring at camera
			Macaca nemestrina	1	Passing
7	N02.652964		Macaca nemestrina	14	Passing, jumping
			Prionailurus bengalensis	11	Passing
			Sus scrofa	3	Passing
			Macaca fascicularis	3	Passing
8	N02.654875	E102.07476	Macaca nemestrina	1	Resting
9	N02.391067	E102.43581	Tapirus indicus	1	Pass/Forage
			Macaca nemestrina	3	Pass/Forage/Jump
			Sus scrofa	1	Pass/Forage
			Tragulus javanicus	1	Passing
10	N02.871111	E102.10111	NO DATA	-	-
11	N02.9016667	E102.13556	Panthera	2	Passing

			pardus		
			Helarctos malayanus	1	Passing
			Prionailurus bengalensis	1	Passing
			Macaca nemestrina	1	Passing
12	N0 2.653611	E102.142500	NO DATA	-	-
13	N0 2.687500	E102.151666	Panthera pardus	1	Passing
			Helarctos malayanus	1	Passing
			Sus scrofa	1	Passing
14	N02.711389	E102.164167	Helarctos malayanus	2	Passing
			Muntjacus muntjak	1	Passing
			Rusa unicolor	1	Passing
			Tragulus javanicus	1	Passing
15	N02.656667	E103.111445	Macaca fascicularis	4	Socializing
16	N0 2.655278	E103.120833	Macaca fascicularis	10	Socializing
17	N02.222222	E102.976889	Viverra tangalunga	1	Passing
			Macaca nemestrina	2	Passing
			Viverra zibetha	2	Passing
			Prionailurus bengalensis	1	Passing
			Manis javanica	1	Passing
18	N02.576389	E102.986389	NO DETECTION	-	-
19	N02.545278	E102.016944	Macaca fascicularis	3	Passing
20	N02.544722	E102.044444	NO DETECTION	-	-
21	N02.519167	E102.093333	NO DETECTION	-	-
22	N02.502222	E102.123611	NO DETECTION	-	-
23	N02.745278	E102.123611	NO DETECTION	-	-
24	N02.496944	E102.102222	NO DETECTION	-	-

Appendix 2: Data sheet of mammal images in fruit orchard

	Camera Point				
No	Latitude	Longitude	Species	No. of Images	Activity
1	N02.6404	E102.09054	Paradoxurus musangus	1	Passing
			Macaca nemestrina	4	Pass/Forage
2	N02.623028	E102.039194	NO DATA	-	-
			Tapirus indicus	1	Passing
3	N02.620389	E102.037472	Macaca fascicularis	1	Foraging
4	N02.736667	E102.310278	Sus scrofa	1	Passing
			Macaca fascicularis	3	Resting
5	N02.617583	E102.040389	Macaca nemestrina	3	Resting
5	N02.65686	E102.08798	Macaca fascicularis	1	Resting
6	N02.818889	E102.214167	NO DATA	-	-
7	N02.722500	E102.118889	Paradoxurus hermaphroditus	1	Jumping
8	N02.623611	E102.183333	Paradoxurus hermaphroditus	2	Pass/Forage
	N02.654875	E102.07476	Macaca fascicularis	3	Pass/Rest
9	N02.690000	E102.358333	Viverra zibetha	1	Passing
			Sus scrofa	19	Pass/Forage
			Macaca fascicularis	3	Resting
10	N02.765278	E102.307500	Macaca fascicularis	5	Pass/Forage
			Sus scrofa	2	Passing
11	N02.756389	E102.306667	Sus scrofa	10	Pass/Forage
			Paradoxurus hermaphroditus	2	Pass/Forage
			Macaca fascicularis	1	Resting
			Viverra tangalunga	1	Foraging
12	N02.587500	E102.090556	NO DATA	-	-

13	N02.651667	E102.240278	Macaca fascicularis	26	Socializing
			Prionailurus bengalnesis	1	Passing
			Sus scrofa	4	Forage
			Paradoxurus hermaphroditus	2	Foraging
			Viverra tangalunga	1	Foraging
14	N02.504167	E102.191111	NO DATA	-	-
15	N02.765833	E102.107222	NO DATA	-	-
16	N02.638889	E102.128611	Viverra tangalunga	2	Pass/Rest
17	N02.787778	E102.149167	NO DATA	-	-
18	N02.724444	E102.272778	NO DATA	-	-
19	N02.628611	E102.137778	NO DATA	-	-
20	N02.798056	E102.117778	NO DATA	-	-