COMPARATIVE BEHAVIORAL ECOLOGY OF SYMPATRIC *PRESBYTIS RUBICUNDA* AND *MACACA FASCICULARIS* IN TAWAU HILLS PARK, SABAH, MALAYSIA.

MAKLARIN BIN HJ. LAKIM

UMS
UNIVERSITI MALAYSIA SABAH

THESIS SUBMITTED IN FULFILLMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

INSTITUTE FOR TROPICAL BIOLOGY AND CONSERVATION UNIVERSITY MALAYSIA SABAH

2008

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN TESIS

JUDUL : _____
_____
_____

IJAZAH : _____
_____

SAYA : _____ **SESI PENGAJIAN** : _____
(HURUF BESAR)

Mengaku membenarkan tesis *(LPSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis adalah hak milik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

_____ _____
(TANDATANGAN PENULIS) (TANDATANGAN PUSTAKAWAN)

Alamat Tetap: _____
_____
_____
_____

_____
(NAMA PENYELIA)

TARIKH: _____ TARIKH: _____

Catatan:
*Potong yang tidak berkenaan.
*Jika tesis ini SULIT dan TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.
*Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana Secara Penyelidikan atau disertai bagi pengajian secara kerja kursus dan Laporan Projek Sarjana Muda (LPSM).

UMS UNIVERSITI MALAYSIA SABAH

DECLARATION

I hereby declare that this thesis is my own original work, except for quotations and summaries that have been fully acknowledged.

12 MAY 2008

MAKLARIN BIN HJ. LAKIM
PS 2001-005-292

UMS
UNIVERSITI MALAYSIA SABAH

CERTIFICATION

NAME : **MAKLARIN BIN HJ. LAKIM**

TITLE : **COMPARATIVE BEHAVIORAL ECOLOGY OF SYMPARTIC *PRESBYTIS RUBICUNDA* AND *MACACA FASCICULARIS* IN TAWAU HILLS PARK, SABAH, MALAYSIA**

VIVA DATE : **4 JANUARY 2008**

DECLARED BY

SUPERVISOR

PROF. DATIN DR. MARYATI MOHAMMED _____

CO-SUPERVISOR

DR. HENRY BERNARD _____

UMS
UNIVERSITI MALAYSIA SABAH

ACKNOWLEDGEMENTS

I am grateful to Datuk Dr. Lamri Ali, former Director of the Sabah Parks for his endless encouragement to me to complete this study while contemporaneously working with the Sabah Parks. I am also grateful to my supervisor Prof. Datin Dr. Maryati Mohamed, Director of Institute for Tropical Biology and Conservation (ITBC) and my co-supervisor Dr. Henry Bernard, Deputy Director of ITBC for their continuous guidance, encouragement and patience in making this study finally completed.

Many friends contributed directly and indirectly in making this study a success. At ITBC, UMS, I would like to thank Dr. Menno Schilthuizen, Dr. Monica Suleiman, Dr. Idris Mohd. Said, Dr. Homathevi Rahman, and later towards the end, Assoc. Prof. Dr. Abdul Hamid Ahmad and Anna Wong for various help and making my stint as a student at ITBC, UMS meaningful and beneficial. Special thanks to Prof. Dato' Dr. Noramly Muslim, Datin Glenda Noramly and Margaret Larke for their invaluable help, constructive comments and encouragement during the final preparation of this thesis.

Conducting a part time study like this was a daunting task. Therefore, I would like to thank my immediate office superior, Dr. Jamili Nais for his support and understanding in my partial 'absence' from normal duties throughout the course of this study. At Kinabalu Park office, I would like to thank Hj. Abdul Wahab Hj. Siman, Rimi Repin, Fred Tuh Yit Yu, Alim Biun, Mohd. Zaini Wahab, Paul Imbun, Sinail Dunsul and Easther Yakin for various direct and indirect helps to enable me to complete this study without much interferences. Thanks also due to Martinah Latim for her various helps in data storage and assist in drawings preparation for this thesis.

Many thanks to Dolois Sumbin for his help in identification of plant materials I collected from the field, including his effort to bring it over to FRC Sandakan, for further identification. I would like to thank Dr. Lee Ying Fah, head of FRC at Sepilok, Sandakan, for his permission and thanks John Sugau, Leopold Madani, Diwol Sundaling and Postar Miun for their help in identifying plant specimens for this study.

At Tawau Hills Park, I would like to thank Salimin Hj. Jadil (deceased), Abdul Momin Hj. Jadil, Simon Limbawang, Samie Angkusong and later at the end of this study, Jufri Hj. Nasri and Roslizan Sallin for their help of various sorts during my fieldwork at this particular park. I would like to thank my fellow field crews Suati Selimon, Didacus Lun, Frederick Gansau @ Johan Abdullah, Benedict Butit, Safrie Hatimin, David Sumpongol and Dominic Tinggoh who have provided vital support during the course of fieldwork at Tawau Hills Park over the period of 2002 to 2003. Their dedication and friendship in the field have made the data collection works both enjoyable and rewarding.

Several peoples have helped me out to formulate this study from the beginning. I would like to thank Dr. Masaaki Yoneda for various help during his stint as a JICA advisor for BBEC programme at the Sabah Parks. I also thank Dr. Akinori Mizuno of JICA-BBEC for a fruitful discussion in the early stage of the study planning. I also thank Drs. Marc and Isabell Ancrenaz, Dr. Benoit Goosen, Dr. Joana and Prof. Dr. Michel Brufort, for their advice and valuable points during my participation in a Conservation Biology Course at ITBC, UMS and the Kinabatangan Scientific Expedition in 2002. I also thank Hans Scotte Moeller, chief advisor of DANCED for Maliau Basin Conservation Project for significant help at the very beginning of fieldwork particularly in providing

UNIVERSITI MALAYSIA SABAH

fund and research equipments for a bird project at Maliau Basin which were indirectly valuable for this project.

I am also indebted to many visiting scientists of the Sabah Parks throughout the course of this study. Prof. Dr. Kanehiro Kitayama, Assoc. Prof. Dr. Tatsuyuki Seino from Kyoto University and Dr. Shinichiro Aiba from Kagoshima University for many occasions of valuable discussions at Kinablau Park, Tawau Hills Park and during a visit to Japan in 2002, which included a fruitful discussion with Prof. Dr. Yoshi Kawamoto at the Primate Research Institute of Kyoto University. I have also benefited from the presence of Dr. Konstans L. Wells of Wurzburg University, Germany during his study in Sabah, especially at Kinabalu Park and Tawau Hills Park for frequent help and numerous fruitful discussions related to this study. I am also indebted to Prof. Dr. Eduard K. Linsenmaier, Dr. Brigette Fiala and Dr. Martin Pfeiffer of Wurzburg University, Germany for their kindness, support, and in providing reference materials related to this study which were proven invaluable during writing up. Assoc. Prof. Dr. Mohd. Tajuddin Abdullah and Prof. Dr. Indraneil Das of University Malaysia Sarawak for their encouragement and academic discussions during intermittent visit to Kinabalu Park.

This list would not complete without acknowledging Emeritus Prof. Dr. Mohd. Nordin Hj. Hasan. I would like to thank him for his kind support, advice and encouragement for the development of the long term primate research project at Tawau Hills Park, where this project was harnessed to. Before I successfully secured a place to study in UMS, I was in contact with Prof. Dr. Colin Groves of Australian National University (ANU), and I would like to thank him for his favorable interest, support and encouragement towards the initiation of this project which lead to the initial acceptance of the project by ANU despite my unsuccessful attempt in securing necessary research grant to enroll there.

During the early phase of the fieldwork at Tawau Hills Park, I have been partially supported by the Clive Marsh Conservation Fund (CMCF) of the Wildlife Conservation Society (WCS), New York. Thus, I would like to thank Dr. Elizabeth L. Bennett of WCS, New York as well as Dr. Geoffrey W.H. Davison for their support and recommendation to enable me to obtain the grant. The rest and bulk, of the research works were supported by the Sabah Parks. I am most grateful to this organization.

I would finally like to thank my entire family in Semporna and Kota Belud for their patience, understanding and support throughout the prolonged gestation of this project, and especially to Salina Abin, Anwar Mahmud, Azyan Zahirah, Arif Muzaffar and Alisha Zakiyah who have tolerated, conditioned and adapted into my frequent and repetitive absence from home throughout the course of this study.

MBL

ABSTRACT

COMPARATIVE BEHAVIORAL ECOLOGY OF SYMPATRIC
PRESBYTIS RUBICUNDA AND *MACACA FASCICULARIS*
IN TAWAU HILLS PARK, SABAH, MALAYSIA.

A comparative ecological study was carried out on sympatric red leaf monkeys (*Presbytis rubicunda*) and long-tailed macaques (*Macaca fascicularis*) at Tawau Hills Park, Sabah. The study was aimed at comparing the approaches adopted by the two primate species in the utilization and sharing of natural resources within their surroundings. Intensive field data collection was carried out over a period of 18 months. Data collection involved following of monkey groups and observing their behavior using instantaneous scan sampling method and *ad libitum* sampling method. Density and population of primates was estimated employing the line transect survey. The site is characterized by primary and old secondary lowland dipterocarp forests. A total of 551 trees with >30 cm gbh were recorded at botanical plot 1 representing 39 families and 164 species. Another 545 trees enumerated from botanical plot 2 comprised of 42 families and 128 species. Dipterocarpaceae and Euphorbiaceae are dominant in both plots. Forest structure also showed similarity in terms of gbh, basal area and tree height. The leafing, flowering and fruiting phenology showed significant differences between primary and secondary forest areas. A total of 1,300 behavioral observation hours was collected evenly from each study primate group. *Presbytis rubicunda* was observed for 647: 00' hrs with 54 full day follows while *Macaca fascicularis* was followed for 658:40' hrs with 54 full day follows. Four behavior-ecological aspects, namely activity pattern, food selection, ranging behavior and social organization were compared between the two primate species. In terms of activity pattern, *Presbytis rubicunda* tended to rest (36.80%) while *Macaca fascicularis* spent more time in foraging (29.59%). Monthly and daily activity patterns of both groups were significantly different. In the selection of food, *Presbytis rubicunda* included a total of 79 plant species in its diet, consuming a large amount of young leaves (60.76%). In contrast, *Macaca fascicularis* restricted its diet to only 26 plant species, consuming a lot of fruits (49.00%) and include a large amount of animal matter (5.45%) in its diet. Food plant species similarity index is 47.7 % indicating considerable similarity but, given the differences in the selection of plant parts eaten, this figure is an exaggeration. In the use of space, *Presbytis rubicunda* used 78.5 ha of area and *Macaca fascicularis* used 80.0 ha. Home ranges overlap was 56.82% and both study groups utilized primary and secondary forest habitats equally. *Presbytis rubicunda* tended to use a large area of coverage compared to *Macaca fascicularis* that tended to use the core area repetitively. Defendability index suggested that *Macaca fascicularis* was territorial while *Presbytis rubicunda* was not. The use of forest canopy strata was also comparable between both groups, where they spent a large amount of their time in the middle (16-25m) and the upper (26-35m) canopy strata. Social organization structure was conspicuously different as implied by their group size where *Presbytis rubicunda* comprised only about one-forth of the group size of *Macaca fascicularis* (30 individuals). Nevertheless, results of transect survey indicated a higher density of *Presbytis rubicunda* (2.02 group/km^2) compared to *Macaca fascicularis* (0.43 group/ km^2). Social interaction between both study groups indicated a very high tolerance and sharing. However, fierce competition was observed between different groups of similar species for both *Presbytis rubicunda* and *Macaca fascicularis*.

ABSTRAK

*Satu kajian ekologi perbandingan telah dijalankan ke atas lotong merah (*Presbytis rubicunda*) dan kera (*Macaca fascicularis*) simpatrik di Taman Bukit Tawau, Sabah. Kajian ini dilakukan untuk membandingkan cara penggunaan dan perkongsian sumber-sumber semulajadi oleh kedua-dua spesies primat ini. Pengumpulan data telah dilaksanakan secara intensif selama 18 bulan. Kerjalapangan ditumpukan kepada aktiviti mengikuti kumpulan monyet dan mengkaji kelakuan hariannya menggunakan kaedah persampelan imbasan dan kaedah persampelan* ad libitum*. Penganggaran kepadatan dan saiz populasi primat turut dibuat menggunakan kaedah garis transek. Keadaan habitat dicirikan oleh hutan dipterokarpa tanah pamah primer dan sekunder. Sejumlah 551 pokok dengan gbh > 30 cm telah direkodkan di dalam plot 1 mewakili 39 famili dan 164 species. Manakala sejumlah 545 pokok daripada 42 famili dan 128 spesies telah direkodkan di plot 2. Pokok Dipterocarpaceae dan Euphorbiaceae dominan di kedua-dua plot. Struktur hutan menunjukkan persamaan dari aspek gbh, luas basal dan ketinggian pokok. Fenologi berpucuk, berbunga dan berbuah pokok-pokok menunjukkan perbezaan bererti di antara plot. Keseluruhannya sejumlah 1,300 jam pemerhatian telah dikumpulkan dalam jumlah yang setara di antara kedua-dua kumpulan kajian.* Presbytis rubicunda *telah diikuti selama 647:00′ jam dengan 54 hari-penuh, manakala* Macaca fascicularis *diikuti selama 658:40′ jam dengan 54 hari-penuh. Empat aspek ekologi-kelakuan iaitu; pola kelakuan, pemilihan makanan, kelakuan pembanjaran dan organisasi sosial telah dibandingkan di antara kedua-dua spesies. Dari segi pola kelakuan,* Presbytis rubicunda *cenderung berehat (36.80%) manakala* Macaca fascicularis *lebih kerap mencari makanan (29.59%). Pola kelakuan bulanan dan harian menunjukkan perbezaan bererti di antara kedua-dua kumpulan ini. Dari segi pemilihan bahan makanan,* Presbytis rubicunda *memakan 79 spesies tumbuhan dan memilih banyak bahagian pucuk (60.76%). Sebaliknya,* Macaca fascicularis *menghadkan makanannya kepada 26 spesies tumbuhan sahaja dan memilih banyak buah (49.00%) serta sumber haiwan (5.45%). Kesamaan spesies tumbuhan makanan ialah 47.7% menggambarkan kesamaan yang tinggi tetapi dibezakan dengan pemilihan bahagian tumbuhan yang dimakan. Dalam penggunaan ruang,* Presbytis rubicunda *mendiami kawasan seluas 78.5 ha manakala* Macaca fascicularis *mendiami kawasan seluas 80.0 ha. Pertindihan kawasan kediaman adalah 56.82% dan kedua-dua kumpulan mendiami habitat hutan primer dan sekunder dengan sekata.* Presbytis rubicunda *cenderung menggunakan kawasan secara berselerak berbanding* Macaca fascicularis *yang sering bertumpu di kawasan empulur secara berulang-ulang. Indeks defendabiliti menunjukkan* Macaca fascicularis *bersifat kewilayahan manakala* Presbytis rubicunda *tidak bersifat kewilayahan. Kedua-dua spesies memperlihatkan persamaan dalam penggunaan strata kanopi hutan di lapisan kanopi pertengahan (16-25m) dan atas (26-35m). Struktur sosial kedua-dua kumpulan menunjukkan perbezaan yang ketara khususnya dari segi saiz kumpulan di mana* Presbytis rubicunda *hanyalah seperempat daripada saiz kumpulan* Macaca fascicularis *(30 ekor). Namun demikian hasil tinjauan transek menunjukkan kepadatan kumpulan* Presbytis rubicunda *(2.02 kumpulan/km^2) adalah jauh lebih tinggi daripada* Macaca fascicularis *(0.43 kumpulan/ km^2). Interaksi sosial di antara kedua-dua kumpulan menunjukkan tahap toleransi dan perkongsian yang tinggi di antara mereka. Sebaliknya, persaingan berlaku di antara sesama spesies bagi kedua-dua kumpulan* Presbytis rubicunda *dan* Macaca fascicularis*.*

CONTENTS

		Page
DECLARATION		ii
CERTIFICATION		iii
ACKNOWLEDGEMENTS		iv
ABSTRACT		vi
ABSTRAK		vii
CONTENTS		viii
LIST OF TABLES		xii
LIST OF FIGURES		xiii
LIST OF PHOTOS		xviii
LIST OF ABBREVIATIONS		xix
CHAPTER 1	**GENERAL INTRODUCTION**	
1.1	Introduction	1
1.2	Aims of study	4
1.3	Thesis structure	5
CHAPTER 2	**LITERATURE REVIEW**	
2.1	Introduction	6
2.2	Sympatry, competition and niche in primates	8
2.3	Primate communities in the tropics	9
2.4	Primate communities in Borneo	10
2.5	Cercopithecids	12
	2.5.1 Colobines	12
	2.5.2 Macaques	20
2.6	Comparative aspects of the sympatric colobines and macaques	21
CHAPTER 3	**GENERAL METHODOLOGY**	
3.1	Introduction	24
3.2	Initial phase of data collection in the field	25
3.3	Habituation	25
3.4	Study group selection	27
3.5	Intensive data collection in the field	27
	3.5.1 Following technique of *Presbytis rubicunda*	28

UMS
UNIVERSITI MALAYSIA SABAH

3.5.2 Following technique of *Macaca fascicularis* 29
3.6 Instantaneous Scan Sampling Method 29
3.7 Data collected for analysis 33
3.8 Statistical analyses 33

CHAPTER 4 STUDY SITE

4.1 Introduction 35
4.2 Flora of Tawau Hills Park 37
4.3 Fauna of Tawau Hills Park 38
4.4 Research trail system 39
4.5 Forest at Tawau Hills Park Headquarters 42
4.6 Botanical plots 43
4.7 Forest composition and structure 45
4.8 Climatic conditions 51
4.9 Forest phenology 53
4.10 Discussion 58

CHAPTER 5 ACTIVITY PATTERNS

5.1 Introduction 60
5.2 Methodology 62
5.3 Overall activity pattern 64
5.4 Monthly activity pattern 67
5.5 Daily activity pattern 74
5.6 Discussion 81

CHAPTER 6 FOOD SELECTION

6.1 Introduction 86
6.2 Methodology 88
6.3 Food-plant species preferences 91
6.4 Plat-parts preferences 98
6.5 Seasonal plant-parts preferences 98
6.6 Diurnal plant-parts preferences 100
6.7 Feeding heights 102
6.8 Foraging for prey by macaques 104

UMS
UNIVERSITI MALAYSIA SABAH

6.9 Discussion 106

CHAPTER 7 RANGING BEHAVIOUR

7.1 Introduction 112
7.2 Methodology 114
7.3 Daily ranging 116
7.4 Distribution of night sleeping sites 120
7.5 Home range 121
7.6 Use of different stratum in the forest 127
7.7 Monthly variation 128
7.8 Diurnal variation 133
7.9 Discussion 139

CHAPTER 8 SOCIAL ORGANIZATION

8.1 Introduction 143
8.2 Methodology 146
8.3 Study group composition 147
8.3.1 *Presbytis rubicunda* 149
8.3.2 *Macaca fascicularis* 151
8.3.3 Group composition comparison 152
8.4 Population density estimate 152
8.5 Inter-individual spacing 155
8.6 Inter-group interactions 157
8.7 Interactions between primate groups and other mammals 159
8.8 Interactions with other non-mammal vertebrates 160
8.9 Discussion 161

CHAPTER 9 GENERAL DISCUSSION

9.1 Introduction 167
9.2 Overview 167
9.3 Primate conservation recommendations 172
9.4 Future research 175
9.5 Conclusion 177

UMS
UNIVERSITI MALAYSIA SABAH

REFERENCES 178
APPENDIX 197

UMS
UNIVERSITI MALAYSIA SABAH

LIST OF TABLES

		PAGE
Table 3.1 :	Parameters related to condition of surrounding forest environment.	31
Table 3.2 :	Age-sex classification of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	32
Table 4.1 :	Forest composition of botanical plots 1 and 2 at Tawau Hills Park.	46
Table 5.1 :	Ethogram of *Presbytis rubicunda* and *Macaca fascicularis* (Adapted from Davies, 1984).	63
Table 6.1 :	Definition of plant parts and animals matters eaten by *Presbytis rubicunda* and *Macaca fascicularis* (Adapted from Davies, 1984).	90
Table 6.2 :	Species of food plants of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF). Species marked with asterisk are shared by both primate groups.	92
Table 6.3 :	Family of trees in botanical plots listed as food plants of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF).	96
Table 6.4 :	Crops in the diet of *Presbytis rubicunda* and *Macaca fascicularis.*	97
Table 6.5 :	Animal species recorded as food sources of *Macaca fascicularis.*	105
Table 7.1 :	Classification of tree height according to forest canopy strata.	115
Table 8.1 :	Group composition of the study group of *Presbytis rubicunda* based on the 8 selected counting sessions.	150
Table 8.2 :	Group composition of the study group of *Macaca fascicularis* based on the 5 selected precise counting sessions.	150
Table 8.3 :	Density of sympatric diurnal primate species at the study site using the line transect method.	154

UNIVERSITI MALAYSIA SABAH

LIST OF FIGURES

		PAGE
Figure 2.1 :	Map of South East Asia to show geographical distribution of *Presbytis rubicunda* and *Macaca fascicularis*	17
Figure 2.2 :	Map of Borneo to show geographical distribution of *Presbytis rubicunda* sub-species	18
Figure 2.3 :	Map of Southeast Asia to show geographical distribution of *Macaca fascicularis* sub-species	19
Figure 2.4 :	A comparison of some of anatomical characters between colobines and macaques (adapted from Oates & Davies, 1994).	22
Figure 4.1 :	Location of Tawau Hills Park in Sabah	36
Figure 4.2 :	Trail system (indicated with dotted line) and botanical plots at the study site in Tawau Hills Park Headquarters	40
Figure 4.3 :	Site plan of the park headquarters of Tawau Hills Park	41
Figure 4.4 :	Secondary forest habitat at the study site in Tawau Hills Park Headquarters indicated with shade.	44
Figure 4.5 :	Frequency distribution of trees in the botanical plots according to girth at breast height (gbh) classification	47
Figure 4.6 :	Frequency distribution of trees in the botanical plots with gbh exceeds 30 cm in a 5 cm height classification	47
Figure 4.7 :	The fifteen highest tree families in term of basal area from botanical plot 1 (BP1) and botanical plot 2 (BP2)	48
Figure 4.8 :	The fifteen most represented tree families of botanical plot 1 (BP1) and botanical plot 2 (BP2)	48
Figure 4.9 :	The fifteen richest tree families in term of species number within botanical plots 1 (BP1) and botanical plot 2 (BP2)	49
Figure 4.10 :	Monthly rainfall at Tawau Hills Park during the study period	52
Figure 4.11 :	Mean monthly minimum and maximum air temperature and relative humidity	52
Figure 4.12 :	Klimagraph of Tawau Hills Park during the study period	53
Figure 4.13 :	Number of tree species involved in leafing, flowering and fruiting season during the study period	55
Figure 4.14 :	Leafing phenology of trees in the botanical plot 1 and 2	55

UNIVERSITI MALAYSIA SABAH

Figure 4.15 :	Flowering phenology of trees in the botanical plot 1 and 2	56
Figure 4.16 :	Fruiting phenology of trees in the botanical plot 1 and 2	56
Figure 5.1 :	Percentage of record on individual by age-sex classification using scan sampling method for *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	65
Figure 5.2 :	Activity budget of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	65
Figure 5.3 :	Synchrony of activities in *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	67
Figure 5.4 :	Amount of behavioural data collection across the months for *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	68
Figure 5.5 :	Monthly individual record of *Presbytis rubicunda*	69
Figure 5.6 :	Monthly individual record of *Macaca fascicularis*	69
Figure 5.7 :	Monthly activity pattern of *Presbytis rubicunda*	70
Figure 5.8 :	Monthly activity pattern of *Macaca fascicularis*	70
Figure 5.9 :	Comparative monthly inactivity (IA) pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	72
Figure 5.10 :	Comparative monthly movement (MV) pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	72
Figure 5.11 :	Comparative monthly foraging pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	73
Figure 5.12 :	Comparative monthly feeding pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	73
Figure 5.13 :	Comparative monthly social behaviour pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	74
Figure 5.14 :	Amount of data collected according to hour of day for *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	75
Figure 5.15 :	Daily individual record of *Presbytis rubicunda* (N= 3,464, weighted data)	76
Figure 5.16 :	Daily individual record of *Macaca fascicularis* (N= 3,525, weighted data)	76
Figure 5.17 :	Daily activity pattern of *Presbytis rubicunda* (N= 3,464, weighted data)	78

UNIVERSITI MALAYSIA SABAH

Figure 5.18 :	Daily activity pattern of *Macaca fascicularis* (N= 3,525, weighted data)	78
Figure 5.19 :	Comparative daily inactivity pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	79
Figure 5.20 :	Comparative daily movement pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	79
Figure 5.21 :	Comparative daily foraging pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	80
Figure 5.22 :	Comparative daily feeding pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	80
Figure 5.23 :	Comparative daily social behaviour pattern of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	81
Figure 6.1 :	Plant-parts eaten by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	99
Figure 6.2 :	Food items in the diet of *Presbytis rubicunda* (PR, N=880) and *Macaca fascicularis* (MF, N= 520) based on record of feeding behaviour by Scan Sampling Method	99
Figure 6.3 :	Monthly food item of *Presbytis rubicunda* (N= 880, weighted data)	101
Figure 6.4 :	Monthly food item of *Macaca fascicularis* (N= 502, weighted data)	101
Figure 6.5 :	Daily food item of *Presbytis rubicunda* (N= 880, weighted data)	103
Figure 6.6 :	Daily food item of *Macaca fascicularis* (N= 502, weighted data)	103
Figure 6.7 :	Canopy strata used for feeding by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	104
Figure 7.1 :	Daily range of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF) based on records during full day followings	117
Figure 7.2 :	Movement pattern of *Presbytis rubicunda* based on 54 full day followings	118
Figure 7.3 :	Movement pattern of *Macaca fascicularis* based on 54 full day followings	119
Figure 7.4 :	Distribution of sleeping sites of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF) within the study site	122

UNIVERSITI MALAYSIA SABAH

Figure 7.5 :	Accumulated number of area occupied by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	124
Figure 7.6 :	Monthly number of quadrats entered per day by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	124
Figure 7.7 :	Pattern of space use by *Presbytis rubicunda*	125
Figure 7.8 :	Pattern of space use by *Macaca fascicularis*	126
Figure 7.9 :	Pattern of canopy use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	128
Figure 7.10 :	Monthly canopy use by *Presbytis rubicunda* (N= 3464, weighted data)	1301
Figure 7.11 :	Monthly canopy use by *Macaca fascicularis* (N= 3525, weighted data)	130
Figure 7.12 :	Comparative monthly ground use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	131
Figure 7.13 :	Comparative monthly lower canopy use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	131
Figure 7.14 :	Comparative monthly middle canopy use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	132
Figure 7.15 :	Comparative monthly upper canopy use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	132
Figure 7.16 :	Comparative monthly emergent use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	133
Figure 7.17 :	Daily canopy use by *Presbytis rubicunda* (N= 3464, weighted data)	135
Figure 7.18 :	Daily canopy use by *Macaca fascicularis* (N= 3525, weighted data)	135
Figure 7.19 :	Comparative daily ground use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	136
Figure 7.20 :	Comparative daily lower canopy use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	136
Figure 7.21 :	Comparative daily middle canopy use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	137
Figure 7.22 :	Comparative daily upper canopy use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	137

UNIVERSITI MALAYSIA SABAH

Figure 7.23 :	Comparative daily emergent use by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	138
Figure 8.1 :	Transects used to survey primates at the study site indicated with dotted line	148
Figure 8.2 :	Comparison of individual composition within the study groups of *Presbytis rubicunda* and *Macaca fascicularis*	151
Figure 8.3 :	Frequency distribution of perpendicular distances at 5 m intervals of primates records using line transect method	153
Figure 8.4 :	Mode, median and mean of inter-individual distances of *Presbytis rubicunda* (PR, N= 8,581) and *Macaca fascicularis* (MF, N= 9,859)	156
Figure 8.5 :	Species of animals recorded interacting with the *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF)	158
Figure 8.6 :	Responses of *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF) towards approaching animals within their occupied area	158
Figure 8.7 :	Other mammals recorded within the area occupied by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF) during monkey follows throughout the study period.	160
Figure 8.8 :	Other non-mammal animals recorded within the area occupied by *Presbytis rubicunda* (PR) and *Macaca fascicularis* (MF) during monkey follows throughout the study period.	161

UNIVERSITI MALAYSIA SABAH

LIST OF PHOTOS

		PAGE
Photo 2.1 :	Vigilance posture of *Presbytis rubicunda chrysea*, Davis, 1962 (Red-leaf Monkey)	14
Photo 2.2 :	Feeding posture of *Presbytis rubicunda chrysea*	15
Photo 2.3 :	Climbing posture of *Macaca fascicularis fascicularis*	15
Photo 2.4 :	Vigilance posture of *Macaca fascicularis fascicularis,* Raffles, 1842 (Long-tailed Macaques)	16

UMS
UNIVERSITI MALAYSIA SABAH

LIST OF ABBREVIATIONS

asl	:	Above sea level
BP1	:	Botanical Plot in Primary Forest
BP2	:	Botanical Plot in Secondary Forest
CCs	:	Sorensen Community Coeffiecient Index
CEP	:	Competitive Exclusion Principle
D	:	Defendability Index
gbh	:	Girth at breast height
GPS	:	Global Positioning System
ha	:	Hectare
hrs	:	Hours
IUCN	:	International Union for Conservation of Nature and Natural Resources
km	:	Kilometer
LTERS	:	Long Term Ecological Research Site
m	:	Meter
MF	:	*Macaca fascicularis* (Long-tailed Macaque)
PR	:	*Presbytis rubicunda* (Red Leaf Monkey)
PVC	:	Polyvinylchloride
SPSS	:	Statistical Package for Social Sciences
%	:	Percentage

UMS
UNIVERSITI MALAYSIA SABAH

CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

Primate reaches the highest diversity in the tropics. The occurrence of more than ten species in one particular area is common (Bourliere, 1985). Having a high number of sympatric primate species in a limited area is intriguing and raising questions on how the species divide available resources among them and what mechanisms allow them to co-exist. Sympatric species are vulnerable to inter-specific competition, more so in degraded habitat (Dunbar & Dunbar, 1974). However, the history of co-existence in primates dated back a long time and in most cases, they prevailed. This implied that the mechanisms for resource partitioning must have been highly functional. Comparative ecological study between several sympatric primates is of utmost importance to increase our understanding on this issue (Gauthier-Hion, 1973; Bennett & Davies, 1994).

Primate community studies or primate synecology is not new. Since 1970s a number of such studies related to community structure have been conducted in tropical sites across the globe, for example in Cosa Cashu, Peru (Terborgh, 1983); Bolivia (Yoneda, 1984); Campo-Ma'an, Cameroon (Matthews & Matthews, 2002); Ethiopia (Dunbar & Dunbar, 1974); Shimla, India (Ross *et al*., 1993); Polonnarwa, Sri Lanka (Hladik, 1977); Ketambe, Sumatera (Ungar, 1995); and Krau Game Reserve, Peninsular Malaysia (Curtin, 1976; Chivers, 1980; Caldecott, 1980; MacKinnon & MacKinnon, 1980). However multi species studies are usually less popular among researchers and outnumbered by studies on single species of primates which are aimed at gaining baseline data for the knowledge and conservation of that particular species. These include studies in Barro Colorado, Panama (Milton, 1980); Mauritius (Sussman & Tattersall, 1986); Jodhpur, India (Agoramoorthy, 1994); Sumatera, Indonesia (van Schaik & van Noordwijk, 1985; Ungar, 1995); Kalimantan, Indonesia (Supriatna *et al*., 1986; Rodman, 1991); Sulawesi, Indonesia (Kawamoto,1996), Sarawak, Malaysia (Bennet & Sebastian, 1988) and Sabah, Malaysia (Bernard, 1996).

UNIVERSITI MALAYSIA SABAH

In the Malaysian state of Sabah alone almost all long-term primate studies have focused on several species in various places namely: on Orang-utan at Ulu Segama (MacKinnon, 1972), Red-leaf monkey at Sepilok, Sandakan (Davies, 1984), Proboscis monkey at Kinabatangan Wildlife Sanctuary (Boonratana, 1993) and Grey-leaf monkey at Tabin Wildlife Reserve (Mitchell, 1994). These have provided baseline data for that particular species. However, such studies on a single primate species lack the ability to explain the complex interactions involved in primate community and how these interactions are linked to their natural habitats. Therefore, despite numerous studies of various aspects on single species of primates, our understanding related to community structure of different sympatric species of primate in tropical forest remains rudimentary and as more knowledge gained from one study to the other, the vacuum of our knowledge evidently revealed (Bourliere, 1985; Else & Lee, 1986; MacLarnon, 1999; Lee, 1999; Fleagle *et al*., 1999). It is expected that many previous studies have emphasized on the importance of comparative ecological studies on sympatric primate communities (see Boonratana, 1993; Bennett & Davies, 1994; Thierry *et al*., 2004).

The importance of comparative ecology on sympatric species lies in the spatial and temporal resources utilization that is shared by the species involved. Such comparative analysis points to interesting differences between species involved in their shared habitats, reflecting ecological niche and possibly also implying the recent evolutionary history (Owen, 1980; McFarland, 1981; Fooden, 1982; Yoneda, 1984; Fried, 1990; Pough *et al*., 1996; Jones *et al*., 1999). Other underlying questions are related to the understanding of how sympatric primate species reduce competition among themselves in favor of co-existence and augmentation of their adaptability into ever dynamic and changing habitats. Comparative study is one of the basic approach used to explore the importance and the roles of competition, predation and mutualism in natural habitats (Dunbar, 1988; Keddy, 1991; Ungar, 1996a; Ungar, 1996b, Lee, 1999). It is related to animal survival strategies that are aimed to solve two underlying and counter-intertwine issues: firstly, to obtain enough food and secondly, to avoid predators. These strategies are therefore related to nutritional requirements, dietary selection, optimal foraging, habitat exploration, economic of territoriality and predator avoidance (Terborgh, 1983; Richard, 1985; Else & Lee, 1986; Dunbar, 1988). It is believed that, among sympatric primate species, their ecological aspects in terms of activity pattern, feeding ecology, ranging behavior and social organization are different. However our

UNIVERSITI MALAYSIA SABAH

knowledge on the extent and patterns of these differences are lacking. This is especially true for the primate community in a hot-spot region of the tropics like on Borneo Island where colobines reached its highest diversity (Meijard & Nijman, 2001).

As tropical forest habitats are facing exaggerated degradation over the last decades, it existence is currently marginalized to limited and in most cases isolated into pockets of either protected areas or otherwise (Marsh & Wilson, 1981; Marsh & Greer, 1992; Poore *et al*., 1992; Turner, 2001; Meijaard & Nijman, 2003). Most of current primate problems are related to habitat depletion through logging, forest conversion, forest fire and uncontrolled hunting. Thus, primate together with other animals within their community are confined to their original habitats in the remote parts of the forest that are also getting smaller and exposed to subsequent encroachment. Extended forest opening has changed these refuges into forest fringes as well as degraded in terms of structure and resources quality. Since such trend seems inevitable, at least in an immediate time, primate adaptability and responses into their changed natural habitats is crucial. The ability of primates to adapt into the current altered habitats is central for their survival (Bourliere, 1985; Cowlishaw & Dunbar, 2000).

Widely distributed primate species like macaques are well known for their ability to adapt easily into changed environment while others, especially rare and endemic species like colobines are less adaptive to such situation and might also be vulnerable to various sorts of threats (Marsh & Wilson, 1981; Meijaard & Nijman, 2003). Comparison of adaptability among sympatric primate species is the interest of this comparative study. Comparative approach could provide satisfactory evidence related to our understanding on the extent of relative adaptability among or between sympatric species (Bennett & Davies 1994; Ungar, 1996b; Lee, 1999). The presence of two sympatric primate species of the family of Cercopithecidae at Tawau Hills Park has permitted the conduct of this comparative ecological study. The two different primate groups are the colobines, represented by Red leaf monkey (*Presbytis rubicunda*), and the macaques by Long-tailed macaque (*Macaca fascicularis*). Both species have interesting and contrasting biological features and adaptive strategies into their surrounding environment and yet occupied overlapped home ranges.

UNIVERSITI MALAYSIA SABAH

1.2 AIMS OF STUDY

This study inquired into the extent of ecological parameters that have enabled the sympatric *Presbytis rubicunda* and *Macaca fascicularis* to co-exist harmoniously in their shared habitats. The comparison was based on activity patterns or time budget, feeding ecology, ranging behavior and social organization of both species. These ecological parameters are the core of behavioral ecological aspects of primate communities represented by the two groups and are influenced by the productivity of the habitat occupied in terms of food availability, abundance and seasonal and diurnal variations. All of these ecological aspects are taken into account for the comparison between the two primate species in order to reveal the extent of differences and similarities between them and the extent of resource partitioning for their successful co-existence. The specific aims of the study were as follows:

1. To describe the forest structure and composition as a habitat of the primates, i.e., pristine primary forest and old regenerating secondary forest logged over more than 20 years ago, bordering mostly with oil palm and cocoa plantations at the headquarters of Tawau Hills Park;
2. To monitor and compare the botany and phenology aspects of the forest i.e. in terms of production of young leaves, flower and fruits as a source of food for the primates at the study site;
3. To compare the behavioral activity patterns or time budget of *Presbytis rubicunda* and *Macaca fascicularis* to indicate the differences in temporal activity between them;
4. To compare the feeding ecology of *Presbytis rubicunda* and *Macaca fascicularis* in terms of food-plant species and plant parts selection as well as other animal (vertebrates and invertebrates) in the diet;
5. To compare ranging behavior of *Presbytis rubicunda* and *Macaca fascicularis* in relation to the usage of space that characterized their sympatry at the study site;
6. To compare the social organization of *Presbytis rubicunda* and *Macaca fascicularis* in relation to their density, distribution and inter-specific interactions within their community.

UNIVERSITI MALAYSIA SABAH