

**ECOLOGY AND BEHAVIOUR OF *Tarsius syrichta*
IN BOHOL, PHILIPPINES: IMPLICATIONS FOR CONSERVATION**

By

Irene Neri-Arboleda D.V.M.

**A thesis submitted in fulfillment of the requirements for the degree of
Master of Applied Science**

**Department of Applied and Molecular Ecology
University of Adelaide, South Australia**

2001

TABLE OF CONTENTS

	<u>page</u>
Title Page.....	1
Table of Contents.....	2
List of Tables.....	6
List of Figures.....	8
Acknowledgements.....	10
Dedication.....	11
Declaration.....	12
Abstract.....	13
Chapter 1 GENERAL INTRODUCTION.....	15
1.1 Philippine Biodiversity.....	16
1.2 Thesis Format.....	19
1.3 Project Aims.....	20
Chapter 2 REVIEW OF TARSIER BIOLOGY.....	21
2.1 History and Distribution.....	22
2.1.1 History of Discovery.....	22
2.1.2 Distribution.....	24
2.1.3 Subspecies of <i>T. syrichta</i>	24
2.2 Behaviour and Ecology.....	27
2.2.1 Home Ranges.....	27
2.2.2 Social Structure.....	30
2.2.3 Reproductive Behaviour.....	31
2.2.4 Diet and Feeding Behaviour.....	32
2.2.5 Locomotion and Activity Patterns.....	34
2.2.6 Population Density.....	36
2.2.7 Habitat Preferences.....	37
2.3 Summary of Review.....	40
Chapter 3 FIELD SITE AND GENERAL METHODS.....	42
3.1 Field Site.....	43
3.1.1 Geological History of the Philippines.....	43
3.1.2 Research Area: Corella, Bohol.....	44
3.1.3 Physical Setting.....	47
3.1.4 Climate.....	47
3.1.5 Flora.....	50
3.1.6 Fauna.....	53
3.1.7 Human Population.....	54

	<u>page</u>
3.1.8 Tourism.....	55
3.2 Methods.....	55
3.2.1 Mapping.....	55
3.2.2 Geographic Information Systems (GIS).....	56
3.2.3 Mistnetting and Hand Capture.....	57
3.2.4 Morphological Measurements.....	63
3.2.5 Radiotelemetry.....	65
3.2.6 Habituation.....	67
3.2.7 Informal Behavioural Observations.....	67
3.2.8 Population Density.....	68
3.2.9 Vegetation Survey.....	69
3.2.10 Rainfall Data Collection.....	71
Chapter 4 HOME RANGES, SPATIAL MOVEMENTS AND HABITAT ASSOCIATIONS	72
4.1 Introduction.....	73
4.2 Methods.....	74
4.2.1 Radiotelemetry.....	74
4.2.2 Radiotelemetry Bearing Accuracy.....	76
4.2.3 Independence of Movements.....	79
4.2.4 Habitat Classifications.....	79
4.3 Results.....	80
4.3.1 Triangulation Bearing Accuracy.....	80
4.3.2 Home Ranges.....	80
4.3.3 Sleeping Sites.....	89
4.3.4 Movements and Activity Patterns.....	91
4.3.5 Habitat Associations.....	96
4.4 Discussion.....	102
4.4.1 Home Ranges.....	102
4.4.2 Movement Patterns.....	104
4.4.3 Habitat Associations.....	105
4.5 Summary.....	107
Chapter 5 SOCIAL ORGANIZATION AND REPRODUCTIVE BEHAVIOUR.....	109
5.1 Introduction.....	110
5.2 Methods.....	111

	<u>page</u>
5.3 Results.....	111
5.3.1 Morphometrics and Body Weights.....	111
5.3.2 Home Range Overlap.....	113
5.3.3 Resource Distribution.....	116
5.3.4 Communication.....	117
5.3.5 Reproductive Behaviour	117
5.3.5.1 Birth months and Parental Care.....	117
5.3.5.2 Testicular size.....	118
5.4 Discussion.....	118
5.5 Direction for future research.....	121
Chapter 6 FORAGING AND TRAVELLING BEHAVIOUR.....	123
6.1 Introduction.....	124
6.2 Methods.....	124
6.2.1 Behavioural Observations.....	124
6.2.2 Data Analyses.....	126
6.3 Results.....	128
6.3.1 Activities Recorded by 5-minute Interval Sampling.....	128
6.3.2 Foraging.....	128
6.3.3 Travelling.....	133
6.4 Discussion.....	138
Chapter 7 POPULATION VIABILITY ANALYSIS.....	141
7.1 Introduction.....	142
7.2 Methods.....	144
7.2.1 The PVA Model.....	144
7.2.2 Data Input to ALEX.....	145
7.2.2.1 Age Classes and Mortality.....	145
7.2.2.2 Litter Size and Sex ratio.....	146
7.2.2.3 Home Range Size.....	147
7.2.2.4 Environmental Variability.....	147
7.2.2.5 Catastrophe.....	148
7.2.2.6 Biomass Function.....	149
7.2.3 Analysis.....	149
7.2.3.1 Minimum Viable Population.....	149
7.2.3.2 Sensitivity Analysis.....	149
7.2.3.3 Catastrophe and Patch Variation.....	151

	<u>page</u>
7.3 Results.....	152
7.3.1 Minimum Viable Population and Habitat Area.....	152
7.3.2 Sensitivity Analysis.....	153
7.3.3 Catastrophe and Patch Variation.....	153
7.4 Discussion.....	158
Chapter 8 CONSERVATION.....	162
8.1 Introduction.....	163
8.2 Legislation Efforts.....	163
8.3 Management Options.....	164
8.3.1 Captive Breeding.....	164
8.3.2 Ecotourism.....	165
8.3.3 Local Communities.....	165
8.3.4 Protected Areas.....	168
8.4 Conclusions and Recommendations.....	171
References Cited.....	173
Appendices.....	192
1 Taxonomic list of identified tree species.....	193
2 Importance Value Index of tree species identified.....	197
3 Minimum Convex Polygons of areas covered during continuous tracking sessions.....	199
4 Home ranges estimated from discontinuous point data.....	206
5 Kernel 95% and 50% probability polygons.....	213
6 Morphological measurements of <i>Tarsius syrichta</i>.....	220
7 Home range overlap of adjacent males and females using Kernel 95%.....	222
8 Foraging and travelling data.....	227
9 Foraging and Travelling fitted Models.....	231

LIST OF TABLES

	<u>page</u>
Table 2.1	Mode of Locomotor, activity patterns, support type and substrate use frequencies of free ranging tarsiers..... 35
Table 3.1	Trapping records at Corella, Bohol in 1999..... 62
Table 3.2	Description of the morphological measurements taken on the living tarsier <i>T. syrichta</i> individuals..... 64
Table 3.3	Definition of the behavioural states recognised during the study..... 69
Table 4.1	Basic information on radio-tracking for estimation of home range of tarsiers..... 86
Table 4.2	Philippine tarsier home range estimates calculated for minimum convex polygon (MCP) and Kernel analysis (KER) 95%..... 87
Table 4.3	List of sleep trees..... 90
Table 4.4	Summary of continuous (15 min) tarsier tracking results for 12 hour shifts..... 93
Table 4.5	The mean distance travelled per hour by females in varying reproductive states..... 96
Table 4.6	Range use of individual tarsier using continuous 12-hour tracking... 98
Table 4.7	Support diameter (cm) used for foraging..... 101
Table 4.8	Support diameter (cm) used for travelling..... 102
Table 4.9	Reported home range of different wild tarsier species in various habitat types from radiotelemetry studies..... 103
Table 4.10	Most preferred substrate types and sizes of different free ranging tarsier species..... 106
Table 5.1	Relative weight of the transmitter package for each individual and changes in body weights during capture..... 114
Table 5.2	Sex differences in numerous morphological measurements..... 115
Table 5.3	Percentage overlap of home ranges of adjacent individuals using the 95% Kernel home range..... 116
Table 5.4	Infant-mother weight ratio..... 118
Table 5.5	Testis-body weight ratio..... 118
Table 6.1	The range of information collected for each factor of interest: the type of activity, the substrate used and locomotor mode..... 125
Table 6.2	The number of 5-minute behavioural sampling on selected activities in relation to the substrate used..... 128
Table 6.3	Summary of models fitted for foraging data..... 129
Table 6.4	Expected mean number of foraging activities for each substrate..... 130
Table 6.5	Expected mean number of foraging activities for each locomotor type used..... 130
Table 6.6	Mean height used by <i>T. syrichta</i> while foraging as influenced by substrate..... 133
Table 6.7	Mean height used by <i>T. syrichta</i> while foraging as influenced by locomotor type..... 133
Table 6.8	Summary of models fitted for travelling data..... 134
Table 6.9	Expected mean number (and standard error) of travelling movements for substrate by locomotion interaction..... 135
Table 6.10	Mean height used by <i>T. syrichta</i> while travelling as influenced by substrate and different modes of locomotor..... 137

	<u>page</u>
Table 7.1 Values of the life history and environmental parameters used in ALEX for the metapopulation analyses of the <i>T. syricta</i>	150
Table 7.2 Values of the catastrophe and movement parameters used in ALEX for the metapopulation analyses of the <i>T. syricta</i>	151
Table 8.1 The ten priority sites under the National Integrated Protected Area System (NIPAS).....	168

LIST OF FIGURES

	<u>page</u>
Figure 1.1	Philippine tarsier <i>Tarsius syrichta</i> 18
Figure 2.1	Geographical distribution of <i>T. syrichta</i> 23
Figure 2.2	Map of Southeast Asia showing the distribution of recognised tarsier species..... 25
Figure 2.3	Map of Sulawesi showing sites cited in the literature..... 26
Figure 3.1	Philippine faunal region and tectonic features..... 45
Figure 3.2	Map of Bohol..... 46
Figure 3.3	Map of Corella..... 48
Figure 3.4	Topographical map of the study site..... 49
Figure 3.5	Monthly rainfall in Corella, Bohol during 1999..... 51
Figure 3.6	Annual rainfall in Bohol over 35 years..... 51
Figure 3.7	GIS Procedure Flowchart..... 58
Figure 3.8	GIS Analysis Flowchart..... 59
Figure 3.9	Trapping sites in Corella and Sikatuna, Bohol..... 60
Figure 3.10	Vegetation survey sites in Corella and Sikatuna, Bohol..... 70
Figure 4.1	Bearing triangulation geometry..... 77
Figure 4.2	Habitat map of the study site..... 81
Figure 4.3 a & b	Habitat gradient showing different classifications based on vegetation types..... 82
Figure 4.4	Grassland corridors..... 83
Figure 4.5	Agricultural land habitat classification based on land use..... 83
Figure 4.6	Swamp representing the only body of water in the study site..... 84
Figure 4.7	Birth months for the collared and other non-collared females..... 86
Figure 4.8	Incremental area plot of the radiotagged tarsiers..... 87
Figure 4.9	Minimum convex polygon (MCP) home ranges..... 88
Figure 4.10	Types of sleeping sites used by study individuals..... 90
Figure 4.11	Nightly activity patterns of 11 tarsier individuals..... 92
Figure 4.12	Nightly activity patterns of individuals 2730 and 4505..... 92
Figure 4.13	Nightly activity patterns of individuals 4533 and 2963..... 93
Figure 4.14	Polyline of adult male 4533 showing maximum distance travelled... 94
Figure 4.15	Polyline of adult female 2730 showing minimum distance travelled . 94
Figure 4.16	Characteristic movement patterns of male individual as represented by adult male 2843..... 95
Figure 4.17	Characteristic movement patterns of female individual as represented by adult female 4511..... 97
Figure 4.18	Nightly range use of the Philippine tarsier..... 98
Figure 4.19	Observed utilisation versus available proportions of habitat classes... 99
Figure 5.1	Boxplot of adult male and female body weights..... 112
Figure 6.1	Substrate used for foraging..... 131
Figure 6.2	Locomotor mode and postural behaviour used for foraging..... 132
Figure 6.3	Substrate used for travelling..... 135
Figure 6.4	Locomotion used for travelling..... 136
Figure 7.1	Probability of extinction when the number of female tarsiers was increased..... 152
Figure 7.2	Probability of extinction when the annual mortality of female newborn tarsiers is varied..... 155

	<u>page</u>
Figure 7.3	Probability of extinction when annual mortality of female juvenile tarsiers is varied..... 155
Figure 7.4	Probability of extinction when annual mortality of female adult tarsier is varied..... 156
Figure 7.5	Probability of extinction when the probability of female being born is varied..... 156
Figure 7.6	Probability of extinction with different scenarios..... 157
Figure 7.7	Probability of extinction when a patch area is subdivided into smaller equal patches..... 158
Figure 8.1	Map of the Philippines showing 116 Protected areas..... 169
Figure 8.2	Map of the Philippines showing 4 selected Protected areas..... 170

ACKNOWLEDGMENTS

The funds for this research were provided by National Geographic Society, Primate Conservation, Inc., Australian Agency for International Development, Research Abroad Fund and Department of Applied and Molecular Ecology, University of Adelaide. Permits were issued by the Protected Areas and Wildlife Bureau – Department of Environment and Natural Resources, Philippines. Logistics in the field were generously facilitated by the Board of Directors and Staff of the Philippine Tarsier Foundation, Inc. Thanks especially to Father Camacho, Anos Fonacier, Danny Nazareno and Manong Lito Pizarra.

I am grateful to my supervisors Philip Stott, Hugh Possingham and Sue Carthew for all the support extended during the various stages of this study. Thanks also go to other university staff: Margaret Cargill for providing comments on drafts of the manuscript. Michelle Lorimer for her kind assistance with statistical analyses. Greg van Gaan and John Willoughby for providing input to my queries re GIS software.

Robyn Wilson of James Cook University, North Queensland, who during the final phase of her field study, generously accommodated me at Atherton Tablelands and initiated a neophyte to the challenge of tracking nocturnal species in the tropical rainforest.

The staff of the Botany Division, Philippine National Museum for the extensive assistance during the conduct of the vegetation survey and identification of plant specimen.

Carsten Niemitz for sending complimentary copies of 'The Biology of Tarsiers'. Sharon Gursky, Marian Dagosto and Myron Shekelle for sending over relevant tarsier literature from across the globe. WWF-Philippines and Haribon Foundation for the Conservation of Natural Resources for providing related references on Philippine fauna and ecotourism.

Gitta Siekmann for translating some references from German to English.

Steve Ball for the helpful conversations and careful review of the PVA chapter.

Dexter for being such a real trooper and able assistant in the field.

Nilo Arboleda for all the reality checks, endless brainstorming sessions, patience and support during the very late nights and frequent early mornings in the rainforest and in helping collate and process data, without whom this study will not be completed, I cannot thank enough.

DEDICATION

**To Niccolo and Marco
and the rest of the younger generations...
may you always hold in wonder, awe and respect the treasures of this beautiful planet
and embrace the opportunity to work for its preservation in your own time**

DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the Department of Applied and Molecular Ecology thesis collection following examination and correction, being available for loan and photocopying. Any reference of this thesis or the information contained therein must be fully acknowledged in any publication.

Irene Neri-Arboleda

ABSTRACT

The Philippine tarsier *Tarsius syrichta* is a small, nocturnal, insectivorous prosimian that is distributed in the islands of Leyte, Bohol, Samar, Maripipi, Dinagat, Siargao and Mindanao. It was first described in the late 17th century by J. G. Camel and the description was later published by Petiver in 1705 (Hill, 1955). The Philippine tarsier was described as a 'small monkey with big, round eyes that never or rarely closed; hairless ears; mouse-like fur and a tail and hindfeet as long as the rest of its body'. Its primary mode of locomotion is through vertical cling and leap, and the species is arboreal and cryptic in habits. There is limited knowledge of the species in captivity and very insufficient data on its ecology and behaviour in the wild.

The IUCN/SSC Primate Specialist Group has given *T. syrichta* a Conservation Priority rating 4, which defines the species as highly vulnerable (Eudey, 1987). The IUCN Red Data Book (2000) has further classified it under the Data deficient category. It was only in 1997 that *T. syrichta* was protected by law in the Philippines (PTFI, 1997). In order to implement an effective conservation plan for *T. syrichta*, a species whose landscape is becoming increasingly fragmented, it is important to understand its spatial and habitat requirements. In order to achieve this objective, a radio-tracking study was conducted in Corella, Bohol. The principal objectives of this study were: 1) to determine home range sizes and configurations and from which social group characteristics can be inferred from patterns of home range use; 2) to describe movements and activity patterns of the animal; 3) to examine habitat associations using vegetative cover and land use patterns; and 4) to evaluate conservation prospects of the species.

Home ranges, spatial movements and habitat utilisation patterns were determined for four male and six female Philippine tarsier *T. syrichta* in Corella, Bohol from early March-October 1999. The field site was a 174 ha area that has been proposed as a sanctuary for the Philippine tarsier and being developed for ecotourism activities. The forest itself forms a mosaic of different successional stages and adjacent to it are flat lands cultivated for agriculture. This was the first radiotracking study of the Philippine tarsier that included both breeding adult males and females. Home ranges were calculated using the Geographic Information Systems (GIS)/ Arcview 3.2 program extension Animal Movement Analyst

software package (Hooge and Eichenlaub, 1997). Home ranges averaged 6.45 ha for males and 2.45 ha for females (average for MCP and Kernel 95%), allowing for a density of 16-41 tarsiers per 100 hectares. The home range of one male overlapped extensively with that of one female and to a lesser extent that of a second female. Male home ranges (Kernel 95%) showed little overlap (2.71%) and the same had been observed among the females (3.35%). Nightly travel distance averaged 1,636 m for males and 1,119 m for females. Individuals were observed to forage and sleep solitarily. *T. syrichta* form groups of one adult male and one or two adult females and their offspring.

The study suggests that the social organisation of *T. syrichta* is polygynous, supported by the following factors: The overlapping home ranges between males and females, and the fact that paired males and females foraged apart and did not share the same sleeping site indicated opportunities for extra pair matings. No paternal care was observed during the study and males not investing in parental care duties can expend increased time and energy on intrasexual competition for resources and mates. Morphometric data indicated dimorphism in body size between males and females; there was a significant difference between male and female body weights, with males being larger than females (two-sample *t*-test, $P = 0.019$). Larger males increase their reproductive success by defending a larger territory that overlaps with that of multiple females, thereby maximizing the frequency of matings. The fragmented forest and the propensity of the tarsiers to forest edges suggested uneven spatial distribution of resources (arthropods) that encourages polygamy, as some individuals gain control over a larger quantity or better quality of resources.

The habitats utilised are primarily located in secondary lowland rainforest in early to mid succession stage, but individual tarsiers readily traversed narrow grassland areas to move in between forest patches. They also utilised shrubs, palm and bamboo. However, the tarsiers avoided, residential areas, adjacent clearings and agricultural plantations. The preference of *T. syrichta* for regrowth forest in early to mid succession stage indicates the importance of maintaining the cycle of regrowth of tropical rainforest in areas where tarsiers are known to inhabit, to provide adequate habitat for the species. This habitat preference further suggests that tarsier conservation is not incompatible with regulated exploitation of the forests' resources.