PROJECT BORNEO

www.projectborneo.co.uk 2006

PRELIMINARY REPORT FOR THE UNIVERSITY OF EDINBURGH

Project endorsed by

Royal Geographical Society with IBG

Advancing geography and geographical learning

PROJECT BORNEO 2006: PRELIMINARY REPORT

Summary

Project Borneo 2006 was a undergraduate expedition from the University of Edinburgh to Malaysian Borneo, Sabah. The aim of the project was to compare arboreal and terrestrial small mammal communities between primary and secondary forest. The research took place in Danum Valley Field Centre (DVFC) situated in a 48,000ha conservation area of lowland dipterocarp forest in Sabah; Danum Valley Conservation Area (DVCA). The study was conducted between 5/6/06 and 15/8/06 in DVCA.

The team comprised four members working alongside two students from the local university; Universiti Malaysia Sabah. The project lasted for ten weeks during which data was collected on small mammal bait preference, ectoparasite load and community composition and forest vegetation structure in primary and secondary forest.

The methods involved intensive trapping in both forest habitats. There were 3,212 terrestrial trap nights with a further 802 in the canopy. According to the original aim of the project the canopy component was an important aspect. However, because of severe logistical difficulties and a poor capture rate (0.5% after six weeks) it was decided to discontinue arboreal work and concentrate on the terrestrial trapping. The terrestrial capture rate was still low – 4.5%, but this allowed us to focus our resources.

It is clear that the impacts of logging affected the community composition of small mammals. Different species were found in both habitats, with some found in one but not the other. The other studies also confirmed the affect of logging with bait preference and ectoparasite load different between the two habitats.

Acknowledgements

For his support and guidance throughout the planning stages of the project in Edinburgh we are indebted to Dr John Deag. We also thank Dr Maurizio Mencuccinni, Robert Lawrie, Glen Reynolds, Alex Karoulis, John Pike, James Aldred, Russel Cain, Daniel Pamin, Kalsum Mohd Yusah, *Faith* Nightclub.

Project Borneo 2006 would not have been possible without the generous support of the following organisations:

The University of Edinburgh through
The Davis Fund;
The British Association Travel Fund;
The Weir Fund;
and The James Rennie Bequest
The Gilchrist Educational Trust
The Royal Geographical Society with IBG
Carnegie Vacation Scholarship

PROJECT BORNEO 2006: PRELIMINARY REPORT

Introduction

Project Borneo 2006 was an undergraduate expedition from the University of Edinburgh. Planning for the expedition began in September 2005 with original aims to investigate primate behaviour. However, time constraints were too severe and it was decided that small mammals would be more suitable research topic. A reconnaissance trip was made in late September 2005 to Danum Valley Conservation Area (DVCA) with a purpose to meet with the research scientists and Danum Valley committee and discuss the intended research. This also helped to establish a link between Danum Valley Field Centre (DVFC) and the University of Edinburgh. Further contact was also made with the Universiti Malaysia Sabah (UMS). We were put in touch with Kalsum Mohd Yusah and Daniel Pamin; two Masters students with previous small mammal experience, through Glen Reynolds, the senior scientist at DVFC. With these connections in place we were able to maintain contact and seek advice (via email) whilst in the UK and throughout the whole planning procedure.

Original aims and research objectives

At the outset the project aimed to compare small mammal communities in primary and secondary forest.

The research objectives were:

1. Compare arboreal and terrestrial small mammal communities between primary and secondary forest.
2. Determine any differences between populations of the ground level and dipterocarp emergents of the canopy.
3. Investigate differences in populations and species richness between primary and secondary forest to determine the effect of anthropogenic deforestation on tropical species.
4. Identify any taxa that are rare in the secondary forest and so at particular risk from deforestation.
5. Further research techniques within the canopy environment.

Prior to leaving the country all members completed a Basic Canopy Access Proficiency course in Oxford. This was to provide canopy access skills for use in the arboreal aspect of the research.

Small mammal ecology

Small mammals exist in complex communities with high species richness. A recent estimate indicated 222 known native mammal species are found in Borneo, of which 28 to 31 are endemic (Shukor *et al,* 2003). Data on the fauna of DVCA have been accumulated through a range of studies, although the current list of species recorded at Danum Valley is far from complete (http://danum.swansea.ac.uk/).

There is a general lack of data concerning small mammal diversity in tropical forest ecosystems (Wells, 2004 1). In this environment, the focus has traditionally been on large mammals due to their charismatic appearance and unique life histories (Wells et al 2004 2). Many such species are now subject to worldwide conservation programmes, whilst data on small mammal fauna remains deficient.

The study of small mammal communities in tropical rainforests is still relatively new though their exceptionally high species richness and important ecological role have been recognised (Fleming, 1973; Bourlière, 1989). The comparatively slow development of small mammal studies is probably attributable to the practical difficulties associated carrying out such research.

Intensive trapping within the canopy has shown that terrestrial and arboreal small mammal communities are distinct. This result has been found to hold for studies conducted in Malaysia (Zubaid & Ariffin, 1997; Maklarin, 1998), Central Africa (Malcolm & Ray, 2000), and Brazil (Malcolm, 1991, 1995). Habitat complexity and heterogeneity both increase with height, thus arboreal small mammal communities in the canopy are thought to be more diverse than terrestrial communities (Fleming, 1973; Payne, 1996; Emmons et al., 1983).

Members of the families *Muridae*, *Sciuridae* and *Tupaiidae* make up the majority of the small mammal community in Sabah. *Muridae* and *Sciuridae* have been trapped in both arboreal and terrestrial habitats, whilst the *Tupaiids* are generally terrestrial. Both arboreal and terrestrial communities coexist spatially in the same ecosystem, though there are profound environmental and structural differences between the canopy and the forest floor. Canopy access techniques offer the opportunity to examine the differences in species assemblages between the two environments. Clearly, the canopy has a complex three-dimensional structure; one would therefore expect to find small mammals with specific physiological and morphological adaptations to cope with this habitat. There are also obvious distinctions in terms of microclimate and resource availability.

PROJECT BORNEO 2006: PRELIMINARY REPORT

Borneo

Borneo is a centre of particular natural interest, renowned for its remarkable and unique biodiversity.. It is the second largest tropical island after New Guinea and the third largest island in the world. Due to its position, prehistoric development and island status it is home to a large number of endemic species. Species belonging to the family *Dipterocarpaceae* are dominant among both true canopy and emergents in South East Asian rainforests. There are 284 dipterocarp species in Borneo of which 180 are found in Sabah. The dipterocarp forest has been recognised as one of the oldest ecosystems on earth; according to the study of fossil pollen, it has existed with a relatively stable history for more than 30 million years (Whitmore, 1984). As dipterocarps have a high commercial value, South East Asian rainforests have been heavily exploited for their timber reserves over the past 40 years (http://www.cpb.bio.ic.ac.uk/borneo/borneo.html). In Sabah the forest has been degraded over the last three decades by destructive felling and extraction practices and, as a result, dipterocarp regeneration is seriously threatened. The ecological consequences reach far beyond the trees themselves with the physical environment as well as all flora and fauna being adversely affected. The need for rehabilitation has long been recognised and ecological surveys in the area have the potential for shedding light on the wider conservation issues caused by irresponsible levels of logging (http://www.cpb.bio.ic.ac.uk/borneo/borneo.html). The WWF fears that at the current rate of logging (often for palm oil plantations), sufficient fragmentation and loss of forest area may render many species genetically unviable by the year 2020 (http://news.bbc.co.uk/1/hi/world/asia-pacific/4083016.stm).

It has been considered that 32% of Bornean mammal species are endemic (Groves, 1985) and a previously undiscovered mammal, thought to be a *viverrid*, was found in Indonesian Borneo in December 2005 (http://news.bbc.co.uk/2/hi/science/nature/4501152.stm). Due to the unique and rich nature of the natural environment, Borneo is justifiably the focus of conservation work which is of global relevance and importance.

Danum Valley Conservation Area (DVCA) 117°48' E, 4°58' N

This study was conducted between 5/6/06 and 15/8/06 in DVCA.

Location and History

DVCA is a 48,300 hectare area located in Eastern Sabah, within the Yayasan Sabah Concession Area. The field centre was opened in 1986 as a collaborative venture involving a number of Malaysian companies, state and federal bodies, and the Royal Society. The field centre is dedicated to research and environmental education. It is closely linked with the Tropical Institute at the Universiti Malaysia Sabah and there is a team of eight full-time research assistants on site at DVFC.

PROJECT BORNEO 2006: PRELIMINARY REPORT

Physical Environment

Temperature and relative humidity in Danum Valley are typical of equatorial rainforest locations with an average temperature around 27°C. The mean relative humidity averages between 72% and 94%. The terrain of DVCA is rugged and at moderate elevation. All but 9% of the area is below 760m above sea level (the upper limit for lowland forest) with a further 36% of the area at lower elevation but with slopes exceeding 25°.

Flora and Fauna

The area is home to an enormously diverse flora including 8,000-10,000 higher plant species. While the flora varies at different elevations, it is dominated by lowland forest consisting mostly of trees of the family *Dipterocarpaceae*, which form a canopy of up to 70m in height. In fact, between 80% and 90% of all canopy trees within the area belong to this family. Although a complete species list does not exist for the fauna of Danum either, there are estimated to be over 120 mammal species, approximately 300 species of bird and 60 and 75 species of amphibians and reptiles respectively. Globally recognised species such as the Orang-utan and Malayan Sun Bear contribute to the conservation status of the area.

Facilities

The research facilities at Danum Valley include a computer lab with broadband internet access and a number of laboratories. In addition, there is a library incorporating a full complement of all work completed at the research station as well as literature covering the flora and fauna of the area. A comprehensive record of logging around the conservation area dating back to the 1970s is available. Two laboratories at the field centre contain a range of standard scientific equipment and four canopy towers with viewing platforms are in place. Transport to the city of Lahad Datu, 81km away is available from the field centre itself. DVFC was awarded a grant by the Darwin Initiative (a Defra funded scheme). This award has allowed the Global Canopy Programme to purchase the equipment required by canopy researchers, including climbing equipment and a full medical kit. There is a network of well-maintained trails allowing easy movement around areas of both primary and secondary forest. This is of benefit in assessing the ecological consequences of logging.

Logging history in Danum

The very nature of this project requires access to logged areas, or coupes, of secondary forest. To the East and North of the conservation area logging has been carried out at a constant rate of between 2,000 and 5,000ha every year for some 35 years, a record of which has been kept at the field centre.

The damage which logging created in the surroundings partially depended upon the method of logging used. The majority of the area was selectively harvested using a combination of tractor logging in areas of moderate terrain, and cable or high-lead yarding on steeper slopes. High-lead yarding involves pulling logs up or down a slope towards a collection point around the machine itself. Areas of twenty hectares or more surrounding the high-lead machine are completely devastated, as well as the corridors along which the trees are winched. Tractor logging, however, results in a more-or-less random mosaic of skid tracks and damaged trees as well as lightly or even completely undisturbed forest remnants.

Of these two techniques high-lead yarding is more damaging to vegetation, whereas the use of tractors causes more soil compaction, erosion and nutrient leaching. High-lead yarding was banned by the Sabah Forestry Department in 1996; hence all subsequent coupes have been logged using tractors only. The DVFC holds extensive data on pre and post-logging areas.

Team members

Name and age	Nationality	Position	Academic status	Qualifications	Experience
Alex Scott-Tonge, 22	British	Expedition leader	Ecology (BSc) 4th year	BCAP course, Canopy Access Ltd. British Army bursar Wilderness First Aid	Coral Cay Conservation, Fiji, 2002. Project Bolivia 2005. Animal Keeper, Cotswold Wildlife Park.
Andrew McKay, 23	British	Health and safety officer	Zoology (BSc), 4th year	BCAP course, Canopy Access Ltd. Wilderness First Aid	Project Trust 2002 Project Trust 2003 Project Bolivia 2005.
Ailie Robinson, 21	British	Medical officer	Zoology (BSc), 4th year	BCAP course, Canopy Access Ltd. Wilderness First Aid	Durrel Conservation Trust Veterinary practice 2002
Jennifer Sanderson, 20	British	Equipment officer	Zoology (BSc), 3rd year	BCAP course, Canopy Access Ltd. Wilderness First Aid	Coral Cay Conservation, Malaysia, 2005
Kalsum Mohd Yusah, 26	Malaysian	Science Officer	Forestry (BSc)	ACAP course, Canopy Access Ltd	
Daniel Panim	Malaysian	Research assistant	Forestry (BSc) Nature toursim (MSc)	ACAP course, Canopy Access ltd Science officer, Bornean Biodiversity & Ecosystem Conservation	

Materials and Methods

Study Area

The study was carried out on twelve 0.48Ha grids in the Danum Valley Conservation Area, Sabah, Malaysia. Six grids were positioned in primary forest in the vicinity of the Danum Valley Field centre, and another six in secondary forest, logged in 1989, on the access road to the field centre.

Terrestrial Trapping

The study was carried out over three sampling periods, each lasting 15 trap nights with two nights off after every fifth trap night. During each period, trapping was carried out simultaneously on two grids in the primary forest and two in the secondary forest. Between sampling periods, the location of grids was changed, totalling 12 grids between June 5th and August 15th 2006. Each grid measured 80m × 60m and comprised four parallel 80m-long transects running from north to south at a distance of 20m from each other. Transects were marked with red 2mm rope and five trap points were marked on each with red and white warning tape at intervals of 20m. Transects were numbered 1-4 from east to west and points were designated A-E from south to north to give each of twenty 20 traps an identification grid reference (1A-4E). Traps were positioned within a 5m radius of the trap point according to Barnet (1995). Throughout the study, wire-mesh rat-traps measuring 35cm × 15cm × 15cm with a mesh of 1cm^2. Black polythene was secured around each trap with tape to provide a rain cover and prevent distress to captures. A short piece of rope was tied around the bottom of each trap's doorway to prevent damage to mammals' tails. Traps were baited according to transect line with ripe banana, toasted oil-palm fruit, toasted coconut, and sweet potato being used on lines 1 to 4 respectively. Traps were checked once daily and rebaited after every capture and when bait was missing or had deteriorated in quality.

Captured mammals were transferred from traps to cotton sacks. A small piece of cotton wool soaked in 5ml of chloroform measured using a 25ml syringe was then placed in a plastic container measuring 40cm × 30cm × 8cm. Captured mammals were transferred from the sack to the container to be anaesthetised. Immediately following loss of consciousness, mammals were removed from the container to be identified, marked and measured. Mammals were marked by fur clipping. A patch was clipped from the left shoulder for the first capture then from a different position on the back for each recapture. For each captured mammal, the species, sex, maturity, bait, and trap identification number were recorded. Further, the head and body, tail, hind-foot, ear and anogenital distance were measured in millimetres using a steel rule and the mass in grams was determined using a digital balance.

Arboreal Trapping

For the purpose of trapping in the canopy, traps of the same specifications as terrestrial traps were used. Lines on which to raise traps were placed by propelling a 300 gram throw-bag attached to thin throw-line over an anchor branch above the target branch using a *Bigshot* catapult (www.proclimber.co.uk). Lines were then placed by attaching 4mm nylon rope to the throw-line using a double fisherman's knot and pulling it over. The ends of the rope were tied together forming a loop over the branch, with enough slack to tie off both sides. Traps were attached to pieces of wood approximately 80cm long and of 5cm diameter using 2mm galvanized wire (see Figure 5). They were placed with the back approximately 10cm from one end of the wood and secured at the front, the back and in the middle by twisting the wire around the wood with pliers. To allow the trap to hang, a piece of wire was attached to form an inverted V-shape above the door, the apex of which was attached to the rope (see point A, Figure 5). The rope was also tied to the centre of the top, back edge of the trap (see point B, Figure 5) with the tension adjusted to allow the trap to hang horizontally. A clove hitch was then tied around the back of the piece of wood (see point C, Figure 5). An additional length of rope tied to the front end of the wood (see point D, Figure 5) was often useful for directing the trap into position. Arboreal traps were baited with banana and raised by pulling the side of the loop with no trap attached. While one person raised the trap to the correct height, another directed the traps suing the other end. Traps were placed with the piece of wood resting either above or below the branch. The tension of the rope was adjusted so the trap was firmly place and both ends were tied to small trees. Ten arboreal traps were set on a minimum of five trees within every plot and were rebaited every third day. The distance and three-figure bearing to each arboreal trap from the nearest terrestrial trap was recorded for ease of location. Heights of canopy traps were determined by measuring the length of rope from point C when the trap was set (Figure 5) to the ground. To aid identification of the canopy traps from the forest floor red tape was attached to the door. If sprung the tape was visible from the ground improving the checking process. Small sections of string were also attached to the doors to prevent damage to captures' tails.

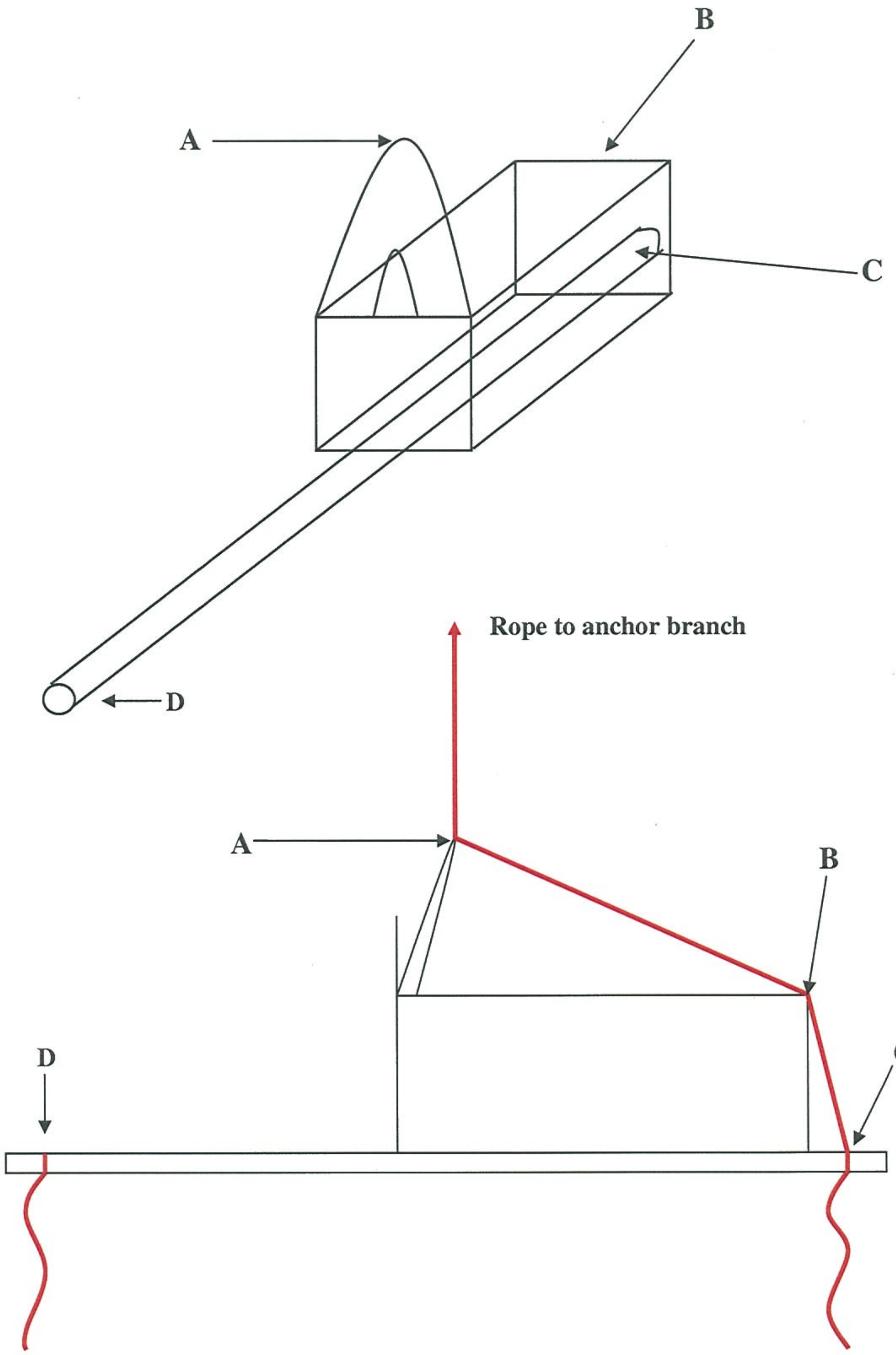

Figure 5. The rope hanging from the target branch was tied to the wire at point A then the trap at point B, and finally using a clove hitch to point C on the piece of wood. The red line shows the path of the rope.

Ectoparasite Sampling

When mammals were anaesthetised, the majority of their ectoparasites fell into the plastic container and those which did not were removed from the fur using forceps. All ectoparasites were collected in 2ml, screw-top vials containing 1.5ml of 75% ethanol. Masking tape was used to label vials with the date, trap identification reference and mammal species. The parasites were later examined using a dissecting microscope, identified to family level and counted.

Processing and analysing data

Data was recorded in waterproof notebooks in the field and then entered daily into a Microsoft Excel spreadsheet using the PCs at DVFC. All data was saved on a PC and on two USB storage devices. A hardcopy of data was also kept in a hardback A4 notebook as back up.

Difficulties, innovations and modification

Injury to mammals

Early in the study period, some captured animals suffered injury. Two types of injury were observed: damaged to tails caused by trap doors closing on them, and injured noses caused by distressed animals running into the sides of the trap. Tail injury was prevented by tying a short length of rope to the bottom of trap doorways to prevent the door closing fully. The incidence of nose injury was reduced by replacing clear plastic covers with black plastic which helped to keep mammals calmer while in the traps. However, nose injury still occurred occasionally.

Trap damage

On several occasions during the period of field work traps were damaged or destroyed by animals, including snakes and elephants. Occasionally traps would be found some distance from the original trap point, presumably because of animal interference It is therefore advisable to have a stock of spare working traps so that the trapping effort is not seriously interrupted by such damage. During the sampling period approximately 30 traps had to be replaced. Further, it is useful to have wire and pliers available for the repair of minor trap defects such as missing bait-hooks.

Canopy access

Initially it was intended that researchers would set arboreal traps by climbing into trees and attaching traps directly on to branches. All team members were trained in Basic Canopy Access Proficiency by Canopy Access Limited (www.canopyaccess.co.uk) before departure. However, it emerged that raising arboreal traps from the ground was more time and energy efficient and canopy access skills were not exploited. It follows that for trapping of this nature, no climbing skills are required and the cost of training could be avoided.

PROJECT BORNEO 2006: PRELIMINARY REPORT

Rope management

Both 2mm and 4mm nylon rope, used for transect marking and rigging arboreal traps respectively have the tendency to become tangled. Both are sold in 200m reels so it is recommended that rope is tied into neat bundles. of appropriate length before entering the field to avoid time consuming untangling exercises.

Line placement

The placement of lines for arboreal traps was limited by vegetations structure. Very small targets could not be hit using the Bigshot and very dense vegetation or poor line of sight prevented line placement. Using the catapult technique, these problems are difficult to overcome. Further, the throw-bag was often fired a considerable distance over the anchor branch, beyond branches and lianas on the far side. If lines are left over a lot of vegetation, friction prevents smooth lowering and raising of traps. Ideally, the line should rest over only one branch. It was found that placement could be improved by attaching a weight (a rock in a sock) to one end of the rope. This could then be pulled back over branches and lianas and dropped immediately on the other side of the anchor branch.

Escaped mammals

Some trapped mammals escaped during transfer from the trap to the cotton sack. The main problem was the neck of the cotton sacks being too small to comfortably fit over the front end of the trap. Using larger cotton sacks, approximately half the size of a pillow case would help to counteract this difficulty. Escapes occurred from the plastic box because of improperly closed lids as well as when handling mammals. Once a mammal escaped from a closed sack emphasising the importance of tying the sacks tightly.

Often during the sampling period, traps were found closed with the bait missing, suggesting that small mammals were entering the traps and being able to push their way back out of the door. By ensuring strong springs are installed on every trap or, preferably, using traps with a simple locking mechanism, this problem could be avoided.

PROJECT BORNEO 2006: PRELIMINARY REPORT

Vegetation study

Methods

The ground level traps were placed in a grid of four by five, 20m apart in eight different locations (four in primary forest, four in secondary forest). Vegetation data was taken from alternate trapping sites, giving a spacing of approximately 28.3m and a total of 80 ground trap sites for analysis. Ten canopy traps were distributed upon location of suitable trees within the 1-hectare trapping area. There was no minimum spacing between canopy traps, with >1 trap often placed within the same tree and hence giving repeated vegetation data. Vegetation data was taken for each canopy-trapped tree, giving 80 canopy sites for analysis.

The sampling sessions for each plot lasted five trap nights and were repeated three times, vegetation data was taken throughout this period.

Vegetation was measured using the following variables:

- Under-storey density was measured using a "profile board" technique. A plastic rod measuring 3m, marked in coloured segments of 20cm was placed vertically at each ground site. The number of segments touched by vegetation gave a score for the density of the area.

- Proximity and diameter at breast height (DBH) of the 5 nearest trees (DBH > 10cm) to each ground site were recorded.

- Scoring scales of 0-3 were used to measure tree connection (canopy sites only), tree crown density (within 5m radius), log abundance (diameter > 10cm, within 5m radius) and litter density (1m quadrat).

- The absence /presence of lianas and/or fruit in a 10m radius of each trap site were recorded.

Results

Vegetation data was analysed using a Wilcoxon two-sample test to test the significance of any difference between primary and secondary forest. A set value of $p<0.05$ was used to show significance.

Mean values of the distance to and DBH of the 5 nearest trees (DBH>10cm) were used for statistical analysis. A significance was found showing a difference between primary and secondary lateral density (distance; $W=1297$, $p<0.001914$, DBH; $W=1400$, $p<0.03467$). The secondary forest demonstrated a higher mean distance to and higher DBH of the 5 closest trees.

Log abundance ($W=1358.5$, $p<0.01202$) and under-storey density ($W=1354.5$, $p<0.01077$) both showed a significant difference between primary and secondary plots with primary holding the lower value in each case. Meanwhile tree crown density ($W=1512$, $p<0.3032$) and litter density ($W=1603.5$, $p<0.8776$) gave insignificant differences.

Lianas were abundant throughout all sites, as only presence was recorded no difference was found between primary and secondary forest. No fruit was found at any site. Canopy site data was not used for analysis as the placement of the sites within the plot was not standardized and so would not give a true representation of the area studied. Captures totaled 28 in primary forest and 21 in secondary forest, which is insufficient to perform statistical analysis. One species was only found in the primary forest; *Leopaldamys sabanus*, and two in secondary forest; *Tupaia tana* and *Tupaia picta*. The major population structure of both forests portrayed no great differences; both displayed a large number of *Maxomys* species and small numbers of other species. Eight different species were found in total.

Discussion

Logging is one of the most severe impacts made by man on tropical rain forests. Upon observing the primary and secondary forest it is immediately possible to identify obvious differences between the two. Primary rainforest is more open, the flora has reached maximum canopy cover so little or no light reaches the forest floor to sustain understorey species. Secondary forest however, has large gaps in the canopy where trees have been felled, so lower level vegetation is able to thrive and creates a much denser habitat.

The lower mean distance of trees (DBH>10cm) found in primary forest indicates a laterally denser forest, though shrubs and saplings were visually more abundant in secondary forest (demonstrated by the significant difference in under-storey density). Much low level flora, including small-scale trees, is damaged through the logging process as logs are dragged through the forest or by movement of the vehicles involved. These gaps are initially filled with dense undergrowth <2m high, which will then progress to reform the sub canopy layer. Tree crown density was not found to differ between sites, suggesting that all the gaps in the secondary forest had been filled by sub-canopy species. A greater number of logs in secondary forest indicate a low survival rate of upper level flora, as there are fewer nutrients available.

There is an insufficient amount of data to suggest any implications of vegetation structure on mammal populations. Commonly trapped generalist species such as *Maxomys rajah* will not differ in population number between primary and secondary forest. Log fall in primary forest produces heterogeneity which is utilized by small mammals (Wells, 2004). The most successful species will be those who are well adapted for survival in both closed canopy and gap areas. Selectively logged forest simulates this log fall effect where generalist species are able to thrive. Major differences would be found in presence and abundance of rare and specialized small mammals, such as arboreal species, in a larger scale research project (Wells, 2004).

Bait study

Methods

The study was carried out over three sampling periods, each lasting 15 trap nights with two nights off after every fifth trap night. During each period, trapping was carried out simultaneously on two grids in the primary forest and two in the secondary forest. Between sampling periods, the location of grids was changed so sampling was carried out on a total of 8 grids between June 5th and July 24th 2006.

The traps were baited according to transect line with ripe banana, toasted oil-palm fruit, toasted coconut, and sweet potato. These were used on lines 1 to 4 respectively. Oil-palm fruit and coconut were toasted in order to maximize the scent emitted by the bait. Traps were checked once daily and rebaited after every capture and when bait was missing or had deteriorated in quality. While these methods were adequate, it should be noted that rebaiting was a daily task for many traps, which attracted not only small mammals but also primates and ants.

Results

Chi-squared analyses were used to compare the observed proportion of captures with expected, had they been equally distributed between different bait types. For three degrees of freedom, a chi-squared statistic that exceeds 7.81 is required to reject the null hypothesis. The chi-statistic obtained from analysing all captures from both forest treatments did not exceed this critical value (Table 1). The same result was obtained when analyzing observed captures in primary and secondary forest separately (Tables 2 and 3). Therefore, these analyses do not allow rejection of the null hypothesis that different bait types will attract equal numbers of captures.

PROJECT BORNEO 2006: PRELIMINARY REPORT

Table 1. Chi-squared analysis for all captures. The chi-squared statistic does not exceed the critical value for three degrees of freedom, 7.81 (p=0.05).

	Banana	Palm oil	Coconut	Sweet potato
Observed proportion of captures	22	23	13	13
Expected proportion of captures	17.75	17.75	17.75	17.75
$(0-E)^2/E$	1.01761	1.55282	1.271127	1.271126761
χ^2	**5.112676**			

Table 2. Chi-squared analysis for captures from the primary forest. The Chi statistic, 1.0171, does not exceed the tabulated value for three degrees of freedom, 7.81 (p=0.05).

	Banana	Palm oil	Coconut	Sweet potato
Observed proportion of captures	13	9	9	7
Expected proportion of captures	9.5	9.5	9.5	9.5
$(0-E)^2/E$	0.94231	0.00277	0.00277	0.069252078
χ^2	**1.0171**			

Table 3. Chi-squared analysis for captures from the secondary forest. The Chi-statistic, 6.88, is a high value indicating some degree of discrepancy between expected and observed values. However it does not exceed the tabulated value for three degrees of freedom, 7.81 (p=0.05).

	Banana	Palm oil	Coconut	Sweet potato
Observed proportion of captures	9	14	4	6
Expected proportion of captures	8.25	8.25	8.25	8.25
$(0-E)^2/E$	0.06818	4.00758	2.189394	0.613636364
χ^2	**6.878788**			

The data suggests that different species of small mammal respond to bait type differently (Figure 1). However insufficient data prevented each mammal species bait preference being analysed individually, and as such the null hypothesis that all bait types would attract the same species of mammal could not be statistically rejected. Banana and oil-palm fruit have widespread appeal among most of the small mammal species captured in this study.

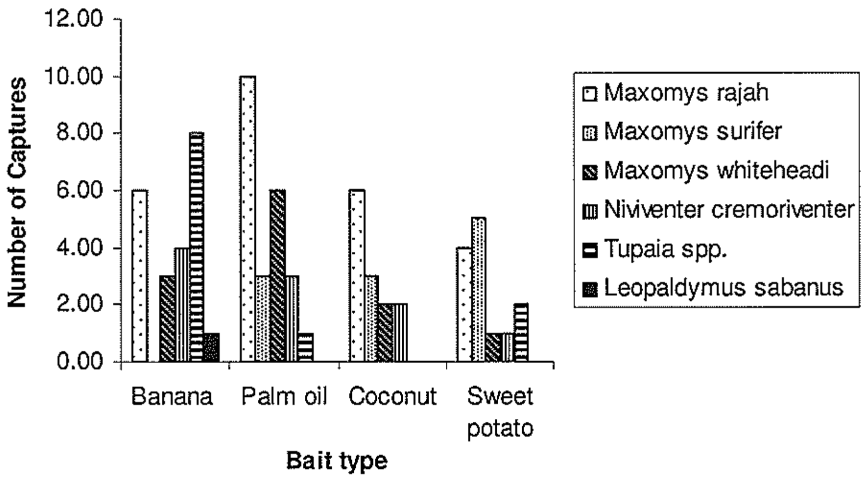

Figure 1. When data from all treatments is grouped by species it appears that different species have differing bait preferences.

In addition to specific mammal species responding differently to bait type, the data suggests that bait types were not equally successful in both treatments. In primary forest banana was the most successful bait (13 captures), whereas in secondary forest most mammals were captured in traps baited with oil-palm fruit (14 captures). When captures from both treatments are grouped, oil-palm fruit is marginally more successful than banana. Coconut and sweet potato have equal success rates (13 captures). The differences in bait success are compared in figure 2.

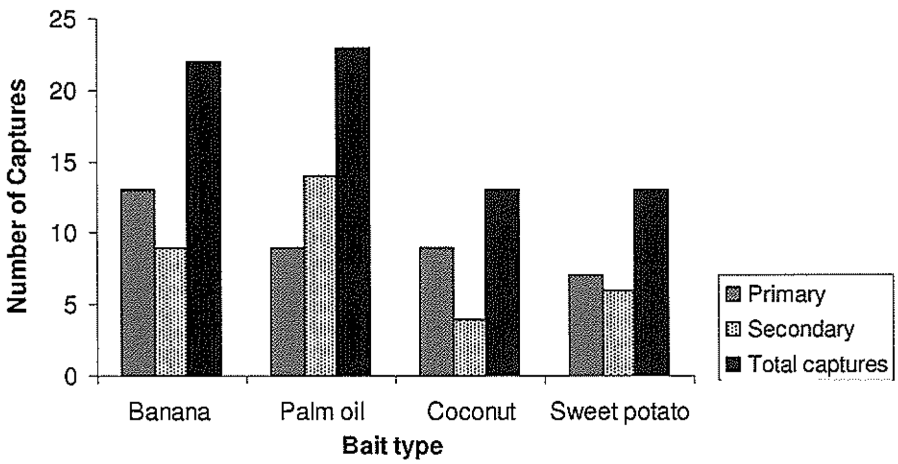

Figure 2. Bait type success in the two treatments, primary and secondary forest, and when all captures are grouped.

PROJECT BORNEO 2006: PRELIMINARY REPORT

Discussion

The objectives of this research were to determine the extent to which bait type influenced the mammal species captured and to assess the efficacy of various baits. The data does not allow rejection of the null hypothesis that all baits attract an approximately equal number of individuals. Although this analysis could not statistically reject the null hypothesis that bait types attract the same species of mammal, this is due to an insufficient body of data.

Our results suggest that different bait types do appeal to different species. For example, the majority of *Maxomys whiteheadi* were caught with oil-palm fruit, and while these trends require further confirmation this should be considered when developing small mammal trapping methodologies. The data indicates that banana and oil-palm fruit are the most widely effective baits.

A discrepancy between the most effective bait in primary and secondary forest may be the product of some underlying difference in species composition. It appears that primary forest has greater species richness but only as a consequence of the capture of one *Leopaldymus sanbah.* However, time constraints and insufficient capture data prevent the assertion of any firm conclusions regarding differences in species composition between the two treatments. The discrepancy in bait efficacy may therefore be attributable to random variation, but this finding is worthy of further investigation.

Aside from time constraints, the greatest problem encountered was that of mammals tampering with the traps. Problems included elephants trampling the traps beyond recognition, and macaques, sun bears and orangutans removing bait. In addition, there was evidence that predators attacked trapped mammals. These included cats (potentially leopard cats, clouded leopards or marble cats) and constrictor snakes.

Further research is required to assess categorically which baits have greatest efficacy with regards to particular species. Additionally, more data are required to determine whether banana or oil-palm fruit is the more successful bait type in terms of total captures. While these two bait types appear to attract a comparatively wide range of species, Chi-squared analysis revealed no departure from the expectation of equal efficacy among all four types.

PROJECT BORNEO 2006: PRELIMINARY REPORT

Ectoparasite study

The aim of this study was to investigate ectoparasite family composition and load on small mammals captured both in primary forest, and secondary forest. One aim of this study was to identify the families of ectoparasite that infested the small mammals in this locality. Further, a number of hypotheses were tested to elucidate any differences in ectoparasite load between species and between forest treatments. The hypotheses being tested were: hard tick load will not differ significantly between mammal species; hard tick load will not differ significantly between mammals captured in the two forest treatments; and hard tick load will not differ significantly between mammals of the same species captured in the two forest treatments. Additionally, ectoparasite load was plotted against mass for all mammals captured to examine any relationship between the two variables.

Methods

Terrestrial Trapping

The study was carried out over three sampling periods, each lasting 15 trap nights with two nights off after every fifth trap night. During each period, trapping was carried out simultaneously on two grids in the primary forest and two in secondary forest, logged in 1989. Between sampling periods, the location of grids was changed so sampling was carried out on a total of 8 grids between June 5th and July 24th 2006. Each grid measured 80m × 60m and comprised four parallel 80m-long transects running from north to south at a distance of 20m from each other. A total of twenty traps were set on each grid: one every 20m along each transect. Throughout the study, wire-mesh rat-traps measuring Xcm × Xcm × Xcm with a mesh of 1cm × 1cm squares were used. Traps were baited according to transect line with ripe banana, toasted oil-palm fruit, toasted coconut, and sweet potato. These baits were used on lines 1 to 4 respectively. Traps were checked once daily and rebaited after every capture and when bait was missing or had deteriorated in quality.

Ectoparasite Sampling

For the purpose of taking measurements, mammals were anaesthetised in a plastic container using chloroform. During this process, the majority of ectoparasites fell into the container and those that did not were removed from the fur using forceps. All ectoparasites were collected and placed in 2ml, screw-top vials containing 1.5ml of 75% ethanol. Masking tape was used to label vials with the date, trap identification reference and mammal species. The parasites were later examined using a dissecting microscope, identified to family level and counted. Adults and immature stages from one family were counted together.

Results

Using the methodology outlined above, the overwhelming majority of ectoparasites collected were ticks from the family Ixodidae. Only two ticks from the family Argasidae were collected and will therefore be ignored. During the sampling period, most captures were rat species, from which substantial numbers of ectoparasites were collected. However, no ectoparasites were recovered from either the tree shrews or the long-tailed giant rat, *Loepoldamys sabanus*. Therefore, four forest rat species will be considered in this analysis: the brown spiny rat, *Maxomys rajah*; the red spiny rat, *Maxomys surifer*; Whitehead's rat, *Maxomys whiteheadi* and the dark-tailed tree rat, *Niviventer emoriventer*.

Mean observed hard-tick loads for each species were compared will the mean load across species using a chi-square analysis (see Table 1). The chi-square statistic generated was 18.93 which exceeds the critical value for three degrees of freedom at the 1% level, 11.35. It is therefore possible to reject the null hypothesis that parasite load would not differ between rat species. While *N. cremoriventer* and *M. whiteheadi* individuals had a lower mean load than would have been expected assuming no difference between species, *M. surifer* and *M. rajah* had a greater load.

Table 1. Chi-square analysis comparing ectoparasite loads in four rat species, across treatments.

	N. cremoriventer	*M. rajah*	*M. surifer*	*M. whiteheadi*	χ^2
Observed load	15.00	47.12	61.20	38.45	
Expected load	43.80	43.80	43.80	43.80	
$(O-E)^2/E$	18.93	0.25	6.92	0.65	**18.93**

When comparing the mean mass of an individual from each species with the mean hard tick load for the same species, a relatively strong, positive correlation ($r = 0.67$) was observed (see Figure 1.). However, on closer examination, when hard tick load was plotted against mass for all individuals, the relationship was weaker and the goodness of fit much poorer ($r = 0.07$).

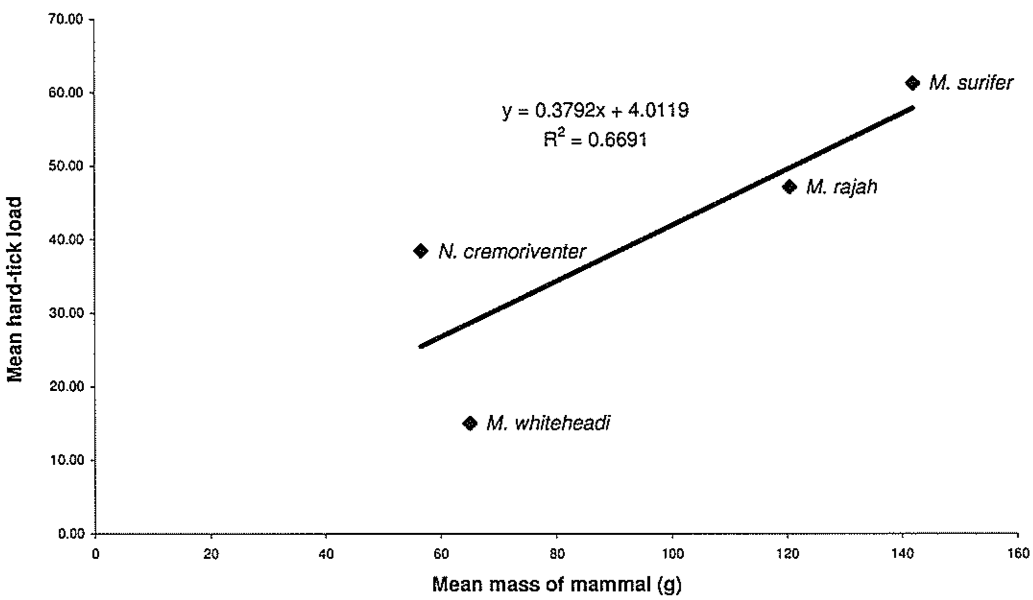

Figure 1. Scatter-plot comparing mean hard-tick load with mean mass for each species.

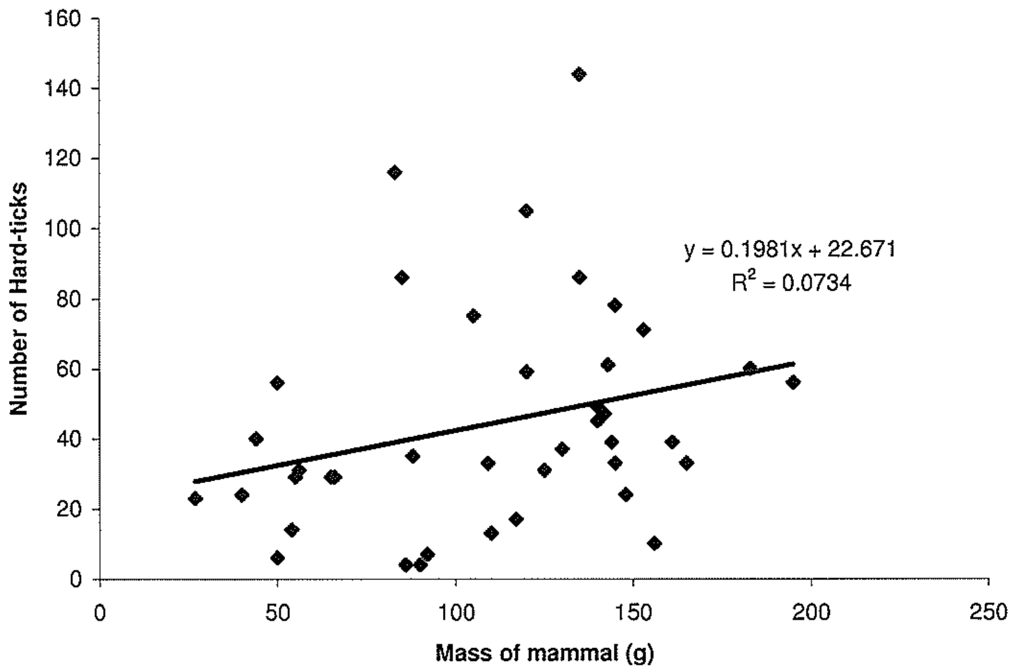

Figure 2. Scatter-plot comparing hard tick load with mass for all rats.

The observed mean ectoparasite loads per individual irrespective of species within each treatment was compared with the mean load across treatments using a chi-square analysis (see Table 2). The chi-square value generated was 0.04 which does not exceed the critical value at the 5% level, 3.84. Thus, the null hypothesis that ectoparasite load would not differ between treatments cannot be rejected and it would appear that forest treatment has no influence on the degree of ectoparasitism.

Table 2. Chi-square analysis comparing ectoparasite loads on rats of all species, between forest treatments.

	Primary Forest	Secondary Forest	χ^2
Observed load	42.58	44.09	
Expected load	43.80	43.80	
$(O\text{-}E)^2/E$	0.034	0.002	**0.036**

To test whether forest treatment had a significant influence on ectoparasitism within species, mean loads for each treatment were compared to the overall mean load for individuals of that species. Chi-square analyses were performed for each species (see Table 3.) The analyses reveal that forest treatment has no significant influence on the ectoparasite load for *N. cremoriventer* and *M. whiteheadi* as the chi-square statistics generated, 0.17 and 1.67 respectively, do not exceed the critical value for 1 degree of freedom at the 5% level, 3.84. However, the chi-square statistic for *M. rajah* exceeds the critical value for 1 degree of freedom at the 1% level, 6.64. Therefore the null hypothesis that forest treatment has no influence on ectoparasite load can be rejected for this species. The mean load was greater for *M. rajah* individuals in the primary forest. The null hypothesis that forest treatment has no influence on parasite load can also be rejected for *M. surifer* as the chi-square statistic generated exceeds the critical value for I degree of freedom at the 1 % level, 6.64. In this case, the mean load was greater for individuals captured in the secondary forest.

Table 3. Chi-square analyses comparing ectoparasite loads for individuals in each treatment with the overall mean load for each species.

		Primary	**Secondary**	χ^2
N. cremoriventer	*Observed load*	14.40	16.50	
	Expected Load	15.00	15.00	
	$(O-E)^2/E$	0.02	0.15	**0.17**
	Observed load	56.24	29.89	
M.rajah				
	Expected Load	47.12	47.12	
	$(O-E)^2/E$	1.77	6.30	**8.06**
	Observed load	40.17	92.75	
M. surifer				
	Expected Load	61.20	61.20	
	$(O-E)^2/E$	7.23	16.26	**23.49**
	Observed load	31.50	42.43	
M. whiteheadi				
	Expected Load	38.45	38.45	
	$(O-E)^2/E$	1.26	0.41	**1.67**

Discussion

While no ectoparasites were recovered from the tree shrews or the long-tailed giant rat, this does not necessarily indicate that none were present. As mammals were only anaesthetized for a very short period of time, it was not always possible to search the fur, so ectoparasites collected were generally those that fell into the box during anaesthetic. It is, therefore, possible that some ectoparasites remained in the fur of mammals, even those for which ticks were recovered. Further, some ectoparasites may not have been detected with the naked eye, and as a result smaller groups or individuals may have been neglected.

One chi-square analysis reveals a departure from the expectation that all species would have the same mean hard tick load (see Table 1), with two rat species having more ticks than expected and two species having less. Examining the relationship between mass and hard tick load (see Figures 1 & 2) revealed that the two smaller species, *N. cremoriventer* and *M. whiteheadi*, generally had a smaller hard-tick load than the larger species, *M. rajah* and *M. surifer*. While the *r*-value generated by linear regression for individual mass versus hard-tick load (Figure 3) is insufficient to assert that a significant correlation exists, it appears that there is a positive relationship between the two variables. It follows that the ectoparasite load differs due to differences in mammal size rather than mammal-species preference by the parasites. However, in order to assert this conclusion, it would be necessary to conduct research on larger mammal sample and identify all ectoparasites to species level.

When all four rat species were considered together (Table 2), it appeared that there was no difference in mean hard-tick load between animals captured in the primary forest and those capture in secondary forest. However, closer examination revealed that for *M. rajah* and *M. surifer* there a significant difference in hard tick load between individuals captured in primary forest and those captured in secondary forest (see Table 3). *M. rajah* individuals captured in secondary forest had a lower mean hard tick load than their primary forest dwelling counterparts while for *M. surifer* the opposite is true.

References

Akbar, Z. & Ariffin, M. K. E. 1997. A Comparison of Small Mammal Abundance Between a Primary and Disturbed Rainforest in Peninsular Malaysia. *Malayan Nature Journal*, 50: 201-206.

Bourliere, F (1989) Mammalian species richness in tropical rainforests. *Vertebrates in complex tropical systems* (ed. By L. Harmelin-Vivien and F. Bourliere), pp. 153-169. Ecological studies **69**, Springer Verlag, New York.

Emmons, L.H., Gautier-Hion, A. & Dubost, G. (1983) Community structure of the frugivorous–folivorous forest mammals of Gabon. Journal of Zoology, **199**, 209–222.

Fleming T H 1973 Numbers of mammal species in North and Central American forests. Ecology 54:555-563.

Groves, C. (1985). Plio-Pleistocene mammals in island Southeast Asia. Modern Quaternary Research SE Asia, **9** : 43-54.

Harrison, J. L. 1969. The Abundance and Population Density of Mammals in Malayan Lowland Forest. *Malayan Nature Journal.* 22: 174-178

Jum, A. B. 1987. *Tinjauan ekologi mammalian kecil di lantai hutan Lembah Danum.* B.Sc Thesis, Universiti Kebangsaan Malaysia.

Kemper, C & Bell, D. T. 1985. Small Mammals and Habitat Structure in Lowland Rain Forest of Peninsular Malaysia. *Journal of Tropical Biology*, 1.1: 5-22

Langham, N. 1983. Distribution and Ecology of Small Mammals in Three Rain Forest Localities of Peninsula Malaysia with Particular References to Kedah Peak. *Biotropica*, 15.3: 199-206.

Malcolm, J.R. (1991) Comparative abundances of Neotropical small mammals by trap height. *Journal of Mammalogy* **72:** 492-499.

Malcolm, J.R. (1995) Forest structure and the abundance and diversity of neotropical small mammals. In Forest Canopies (ed. by M.D. Lowman & N.M. Nadkarni), pp. 179-197. Academic Press, San Diego, California.

Malcolm, J. R. & Ray J. C. (2000). Influence of timber extraction routes on Central African small-mammal communities, forest structure, and tree diversity. *ConservationBiology*, **14** : 1623-1638.

Maklarin, B.L. (1998) A small mammal community in the tropical rain forest canopy at Poring Hot Springs, Kinabalu Park. Sabah Parks Nature Journal, **1**, 93–105.

Payne, J., Francis, C. M. & Phillipps, K. (1985). A Field Guide to the Mammals of Borneo. The Sabah Society & World Wildlife Fund Malaysia. Kota Kinabalu, Kuala Lumpur.

Payne, J. (1996). Mammals. In: *Kinabalu. Summit of Borneo* (Ed. by Wong, K. M. & Phillips, A.), pp. 439-451. The Sabah Society & Sabah Parks. Kota Kinabalu.

Shukor Md. Nor, Norhayati Ahmad, Yusoff Ahmad, Juliana Senawi, & I Mila Laumba 2003. Abstract of Research Proposals: Mammals of Danum Valley. Faculty of Sciences and Technology, University Kebangsaan Malaysia.

Wells, K. 2004. Use of Arboreal and Terrestrial Space by a Small Mammal Community in a Tropical Rain Forest in Borneo, Malaysia. *Journal of Biogeography*, 31.4: 641

Wells K, Lakim M. B., Bernard H, Pfeiffer M (2004). Small mammals in the rainforest canopy: a neglected group of conservational concern? ASEAN Review of Biodiversity & Environmental Conservation. http://www.arbec.com.my/smallmammals/ **1.**

Wells K, Lakim M. B., Bernard H, Pfeiffer M, Linsenmair K E. 2004. Spacing patterns of the large pencil-tailed tree mouse, Chiropodomys major (Muridae), in a rainforest in Sabah, Malaysia. Ecotropica 10: 15–22 **2.**

Whitmore, T. C. (1984). Tropical rain forests of the Far East. Clarendon Press. Oxford.

Zubaid, A. & Ariffin, M.K.E. (1997) A comparison of small mammal abundance between a primary and disturbed lowland rain forest in Peninsular Malaysia. *Malaysian Nature Journal,* **50,** 201-206.