JAMES RENNIE BEQUEST

REPORT ON EXPEDITION/PROJECT/CONFERENCE

Expedition/Project/Conference Title: Project Borneo 2007

Travel Dates: 15th June – 15th August 2007

Location: Danum Valley, Sabah, Borneo

Group Member(s): Toby Nowlan, Josephine Beynon, Stephen Spencer, Dash Strebel, Sarah Newberry, Andrew Laing

Aims: To discern the impacts of logging on reptile and bird communities

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OUTCOME (not less than 300 words):-

Project Borneo 2007 report

1. ABSTRACT

Project Borneo 2007 was an undergraduate expedition from Edinburgh University, which took place between 15/06/07 and 15/08/07.
The aims were to compare species diversity between primary and selectively logged forest in Danum Valley Conservation Area, Sabah, Malaysia, using amphibians, birds and reptiles as the indicating taxa. Five 50 metre pitfall transects were used in each habitat to trap reptiles and amphibians. Point samples were taken daily at a randomly selected pitfall transect in each of the two environments to record bird species and numbers. It was found that primary rainforest is more diverse than secondary rainforest for all taxonomic groups excluding amphibians where this trend was reversed.

2. INTRODUCTION

2.1 DANUM VALLEY CONSERVATION AREA

The 48 300 ha Danum Valley Conservation Area (DVCA), is located 83km southeast of Lahad Datu, Sabah, Borneo, Malaysia. The conservation area itself is dominated by 180 dipterocarp species, yet surrounding areas have been subject to three decades of intense logging. The DVCA is montane Directly adjacent to DVFC, forested zones exist which were subject to selective logging in the 1980s using tractor and high lead extraction methods (which took all commercially viable stems >0.6 m diameter) (Marsh and Greer: 1992). The area of selectively logged forest we surveyed was logged in 1989 and is referred to as coup '89.

In threatening future dipterocarp regeneration, logging has led to extensive forest fragmentation and subsequent change in species diversity and abundances of endemic species (Whitmore, Sayer: 1992).

"Despite much research there is little consensus on impacts of disturbance on biodiversity", Dumbrell and Hill (2004).

Tropical deforestation is leading to unprecedented species extinctions. Despite this, knowledge of tropical forest species status, ecology, abundance and distribution is immensely poor (Whitmore, Sayer: 1992), supporting the need for increased research in such areas.

Less than five percent of the world's tropical forests are protected, "and many of these are in so-called 'paper parks.'" (Cleary: 2004). Therefore many species may depend entirely upon exploited forests, so relevant management decisions will determine these species' survival. Thus an understanding of the primary rainforest ecosystem and the role of communities' within it is required for the continued conservation (through total preservation and/ or sustainable forestry) of tropical rainforest in the DVCA, Borneo and across the world. Indicator taxa can be used to monitor forest management and exploitation.

2.2 ORIGINAL AIMS AND OBJECTIVES

The aim of Project Borneo 2007 was to complete an accurate biodiversity comparison between the primary rainforest and selectively logged secondary rainforest through species-specific data collection from 5 different classes.
The project also aimed to educate 11-19 year olds in the UK upon completion of the project, through a series of presentations to a range of secondary schools of our findings.

The field project aimed to assess the following between primary and secondary rainforest, according to the transects accomplished:

1. Relative bird diversity (all families, both arboreal and terrestrial)
2. Relative terrestrial small mammal diversity
3. Relative reptile and amphibian diversity
4. Relative butterfly diversity (arboreal and terrestrial)

As a result of 1-4, we quantitatively assessed diversity discrepancies (with diversity indices) between primary and secondary forest in the valley. Our predictions were that extinction risk for relevant taxa, and overall effects of anthropogenic logging in the area on biodiversity
We performed a reconnaissance for recording bat diversity with several trials for the team's future trips, prospectively in 2008.

Increase zoological field experience for assessing biological diversity

However as a result of circumstances beyond our control four members of the original ten dropped out, leadership changed and two of the proposed taxa (terrestrial small mammals and butterflies) and the bat diversity reconnaissance had to be dropped.

Our predictions were that there would be a greater species diversity in all taxa in the primary rainforest relative to the species diversity in the secondary rainforest.

2.3 TEAM MEMBERS

Name and age	Nationality	Position	Academic status	Qualifications	Experience
Andy Laing 21	British	Science officer	3rd year (BSc) Zoology	Wilderness first aid. Jungle survival.	Volunteer with Royal Zoological Society of Scotland. Conservation work in Edinburgh John Muir award.
Tobias Nowlan 20	British	Expedition Leader	1st year (BSc) Ecology	Wilderness first aid. Jungle survival.	Young birder of the year 2003. Wildlife guiding experience Kenya. BBC young environmental journalist of the year. Ecological research expedition Sri lanka 2006
Dash Strebel 20	South African	Logistics officer	2nd year (BSc) Genetics	Wilderness first aid. Jungle survival.	Conservation work Denali National park, Alaska 2005.
Josephine Beynon 20	British	Treasurer/ deputy leader	2nd year (BSc) zoology	Jungle survival. RGS wilderness medical training- far from help, far from help 2.	Widely travelled. Interviewed Ray Mears, David Bellamy.
Stephen Spencer 20	British	Medical officer	3rd year (BSc) zoology	Jungle survival. RGS wilderness medical training- far from help, far from help 2	Widely travelled. Experienced Balinese rainforest, Kirthar National park Pakistan, Thar

					desert south Pakistan.
Sarah Newberry 21	British	Equipment officer	2nd year (BSc) ecology	Jungle survival. Wilderness first aid. Advanced BTEC diploma; Tropical habitat conservation.	Widely travelled, experienced mountaineer. World challenge expedition South Africa 2003. Biodiversity survey Ream national park Cambodia 2004. Jatun sacha biological station Ecuador 2005.

2.4 COLLABORATION AND ORGANISATION

The expedition was arranged through local Royal Geographic Society officer and 'chief scientist' at the Danum Valley Field Centre, Dr. Glen Reynolds, we collaborated with The Tropical Biology and Conservation Institute (ITBC) at University Malaysia Sabah (UMS). Five UMS undergraduate students worked with us for 4 days collecting and recording data from Coup '89 gathering valuable data and learning rainforest field skills required to carry out work for their future dissertations. Dr Reynolds also provided us with local research assistants working at the field centre who had extensive expert local knowledge of the valley's species distributions, densities and ecology.

2.5 PHYSICAL ENVIRONMENT

Danum Valley has a rugged topography, 90% of the area is under 760m altitude. There are 3 major summits within the conservation area; Mt. Danum, Mt. Nicola and Mt. Tribulation. The geology of the area is mainly crystalline basement, chert-spillite and kuamut.

2.6 REPTILE ECOLOGY

Literature available on the reptile ecology of Borneo is unfortunately minimal and has been concentrated in the Mt. Kinabalu National park area. However, the available literature relating to reptile diversity of the Bornean rainforests suggests that Danum valley is home to approximately 75 species of reptile, including; skinks, monitors, geckos, agamids, hard and soft shelled turtles and several species of snake.

2.7 AMPHIBIAN ECOLOGY

Amphibians are represented at Danum Valley by more that 60 species including the rare Wallace's flying frog, harlequin and emerald tree frogs and the Bornean horned frog (Loucks, 2001). The identification of new species is not rare, in the eight years leading up to 2005 at least 13 new frog species were identified on the island of Borneo (Inger et al, 2005).

2.8 BIRD ECOLOGY

The need for increased research and hence this specific project as an indicator of avifauna decline throughout South-east Asian rainforest is pronounced as Brooks et al., (1999) state that their predicted losses of endemic bird species (in both montane and lowland SE Asia) threatened with extinction frequently overestimate or underestimate actual losses. The DVCA is montane and thus exhibits 23 endemic species (21 near-endemic). Borneo's mountains are largely ornithologically unexplored; knowledge of endemic species' habitat requirements and distributions of many species are incomplete (Stattersfield et al., 1998). Castelletta et al., (2000) describe the avifauna mass extinction unfolding in SE Asia through case study Singapore, where 95 % of native lowland forest has been cleared. Here 65 avian species have been extirpated in the last 75 years, 94 % of which were dependent on primary or old-secondary forest. "Based on this fact, the countries within Southeast Asia should reconsider their heavy deforestation practices" (Castelletta M et al.,: 2000). Brooks (2002) echoes this thought: "Without urgent conservation intervention, we face mass extinctions in the [insular biodiversity] hotspots".

So it has been shown that bird diversity has changed and is changing drastically as a result of logging practices in tropical rainforests. This study may reveal how abundances of specific species are affected by selective logging, as well as bird diversity as a whole. The study may highlight how bird communities in Bornean lowland rainforest shift and change in response to logging disturbance.

3. An assessment of the discrepancy of avian diversity between primary and logged Bornean lowland rainforest

3.1 ABSTRACT
The difference in bird diversity between primary and selectively logged or secondary (disturbed and logged in 1989) rainforest was tested in Sabah, Borneo. Point samples were taken (recording all observations and sounds) daily at a randomly selected pitfall transect (used for monitoring reptile communities as part of a joint study) in each of the two environments. Illegal logging is responsible for the modification of considerable areas of rainforest in Borneo. The study found a higher total avian diversity in the primary forest section, while a higher mean diversity and abundance was recorded in the secondary forest. The study may, in some small way, assist in assessing the extent of damage caused to bird species diversity by logging.

3.2 INTRODUCTION

3.2.1 Background

The need for increased research and hence this specific project as an indicator of avifauna decline throughout South-east Asian rainforest is significant. Brooks et al., (1999) state that their predicted losses of endemic bird species (in both montane and lowland SE Asia) threatened with extinction frequently overestimate or underestimate actual losses. The DVCA is montane and thus exhibits 23 endemic species (21 near-endemic). Borneo's mountains are largely ornithologically unexplored; knowledge of endemic species' habitat requirements and distributions of many species are incomplete (Brooks: 1999). Castelletta et al., (2000) describe the avifauna mass extinction unfolding in SE Asia through case study Singapore, where 95 % of native lowland forest has been cleared. Here 65 avian species have been extirpated in the last 75 years, 94 % of which were dependent on primary or old-secondary forest. "Based on this fact, the countries within Southeast Asia should reconsider their heavy deforestation practices" (Castelletta M et al.,: 2000). Brooks (2002) echoes this thought: "Without urgent conservation intervention, we face mass extinctions in the [insular biodiversity] hotspots".

Thus it has been shown that bird diversity has changed and is changing drastically as a result of logging practices in tropical rainforests. This study may reveal how abundances of specific species are affected by selective logging, as well as bird diversity as a whole. The study may highlight how bird communities in Bornean lowland rainforest shift and change in response to logging disturbance.

Point samples in an investigation in neotropical rainforest in Guiana by Thiollay (1997) showed an overall bird species richness and abundance depression by 27-34%. The most vulnerable were mature forest understorey species and the causes are presumed to be habitat specialisation leading to (when subjected to a logged forest environment) physiological intolerance, reduced diversity/ availability of food categories, strengthened predatorial exposure and increased density of understorey vegetation providing difficulty for those species relying on specific foraging behaviour in the gaps. It is unclear whether the similar patterns will arise from this study. Nevertheless the hypothesis for the investigation is that "the diversity of bird species is higher in primary rainforest than in selectively logged/ secondary rainforest".

3.2.2 Borneo's birds

The avifauna in the Danum Valley Conservation Area is expectedly diverse, as is any avifauna of a tropical rainforest environment. It is characterised by large hornbill species (though not all obvious, for example, the elusive white-crowned hornbill), which largely use the upper canopy. Flycatchers and jungle flycatchers feed in the lower canopy, as do trogons, some broadbill species, including black and red broadbill and black and yellow broadbill, woodpeckers, Accipiter (hawk) species, white-eyes, spiderhunters, sunbirds, leafbirds, piculets, cuckoos, bulbuls, most babblers, tailorbirds, drongos, ioras, minivets and other families. Wren babblers, ground cuckoos and pittas are exemplar of typical ground avifauna. 37 (10%) of Borneo's bird species are endemic, though these are mostly montane (Mackinnon, Phillipps: 2006). There are lowland endemics however, including Bulwer's Pheasant and Bornean Bristlehead (which was recorded in the primary forest samples). 24% of Borneo's land birds are montane and were thus not recorded in the study (Mackinnon, Phillipps: 2006).

3.3 MATERIALS AND METHODS

This investigation was coupled with a herpetological study in the same time duration. A team measured reptile and amphibian diversity at five points in primary rainforest and subsequently at five points in secondary rainforest. The author conducted this study at the same study sites, which were randomly sited (on map grid references) and angled 50 m transects. Daily, an hour-long point sample of birds would be taken at a randomly selected transect. All birds seen and heard were recorded (abundances and species). The samples were taken at the same time of 6:30 am (-7:30 am) every day because birds are more active (displaying, calling and foraging during this time) (Orians: 1969). For the first ten days the author considered all data collected as trivial (not included in the results). The purpose of this initialising period was to familiarise the researcher with the bird species of the region so all sightings and sounds recorded or heard could be identified with the same degree of certainty throughout the recording period. The author did this initialising to a lesser degree before he began to set the investigation up in the rainforest, with bird voice recordings on CD, including Jelle Scharringa's CD-ROM Birds of Tropical Asia 2. Identification books, including the standard avian guide: 'A field guide to the Birds of Borneo, Sumatra, Java and Bali', from Mackinnon and Phillips (Oxford, 2006) were also studied beforehand in preparation. 8x32 Swarovski binoculars were used to observe/ identify birds.

The 500m2 plots of rainforest selected for studying (i.e the sects of primary and secondary rainforest where the point samples were taken) were chosen randomly in areas that typically represent the regions primary or secondary forest respectively (in terms of tree composition and canopy height) – the DVCA.

15 days of data recording will be allowed for the primary forest and 15 days for the secondary, giving a total of 30 days of sampling.

3.4 RESULTS

The final results from the point samples found that we observed more species in total in the primary rainforest but more birds in total in the secondary forest (as shown by figure 4), as well as a higher daily mean of species and individuals in the latter (figure 3). The data is summarised below. The data set has been included in appendix 1 as well as the GPS coordinates for the rainforest sections and point sample sites. Figure 1 shows sample results (species records) for all sampling days. The table displays whether they were recorded or not and how many of each species were recorded.

Table 1.

	Primary Rainforest	Secondary Rainforest

Total Species	108	81
Total Organisms	335	394

The formula for the Simpson's Index was used to estimate the relative diversity between the two populations:

Primary Rainforest Diversity = 0.1
Logged Rainforest Diversity = 0.04

Some species were recorded on most or all transects, such as the little spiderhunter, while others were recorded just once, on one sample, such as the Bornean ground cuckoo. It was also calculated that 33 bird species were recorded solely in the primary forest (and not in the secondary), whilst only 7 species were found solely in the secondary and not the primary.
Note that the Pacific swallow makes up a high proportion of the birds recorded at the site P1 as displayed in figure 2 pie chart in appendix 2 (refer to the discussion below for the bias that this presents).

3.5 DISCUSSION

Based on these results one can conclude that bird diversity is less in forest that has been selectively logged.
The results indicate a greater diversity of bird species in the observed section of primary rainforest as described above, though a higher mean number of species recorded per sample site and higher abundance of individuals were recorded at the secondary forest site. Considerably more species were also recorded solely in primary forest compared to the secondary forest. That 26 more bird species were recorded solely in the primary forest section suggests a higher diversity and that logging does indeed have long term effects on the biodiversity of birds in affected areas. However there are many factors to be considered that may have influenced this outcome.
This suggests that birds are more easily observed in the secondary forest but that the species diversity is in fact higher in the primary forest.

Variable weather conditions significantly influenced the recording of results. Both bird activity (foraging and calling) as well as visibility were affected by the weather. For instance, heavy rain in the early morning reduces calling and foraging of most passerines (Leopold, Eynon: 1961).

In both sections of rainforest (primary and secondary) the canopy was often so high that the birds that preferentially use this habitat could not be seen (and thus could only be identified if heard). This presented a bias for species of broadbill and often hornbill. The selectively logged rainforest had large trees removed to different extents and different densities in 1989. Thus the effects of this process on local avian fauna, if there has been any, have been varied and heterogeneous (see Aleixo: 1999, Robinson and Robinson: 1999, Mason: 1996).

Whilst the study is incredibly useful in terms of a reconnaissance for future studies of its kind, it is of limited value with regards to reliably determining the differences in avian diversity between primary and secondary rainforest. This is due to the fact that sampling time and number of sampling points were limited. In future studies, more samples must be taken in more rainforest sections (this assessment sampled only one 500m2 area per forest environment) over a far greater time period; thirty days or more of sampling per forest environment is suggested to be adequate.

It is of course worth bearing in mind that the degree of specialisation and niche width of rainforest bird species varies greatly geographically (Marsden S.J, Whiffin M: 2003), thus conclusions from studies such as this can only be appropriated to the local area (in this case the Danum Valley Conservation Area and other lowland rainforest sites in north east Borneo).

Whilst there is zero to minimal local avian migration in the forest environments tested (as advised by resident ornithologist Dr. Dave Edwards who was leading an avian ringing study from the University of

Leeds (2007)), there is the possibility of population fluctuations due to unknown reasons such as outside influences affecting predation and food availability during the period of data recording.

The selection of the forest plots and indeed the pitfall transects (which, incidentally, were the sites of the point samples for avian sampling) was random to the greatest extent possible. However, the positioning of the transects and thus the point sample sites were influenced to some degree by accessibility. On occasion, challenging topography or extreme density of the vegetation prohibited the location of transects in exact straight lines. The varied proximity to certain physical features such as streams, gullies, large trees were influential with regards to records of habitat-specific or skulking species such as chestnut-capped thrush and Bornean wren-babbler (see Tobias J.A et al., 2006).

Perhaps the greatest bias arose from the sampler's identification capabilities. While all measures were taken to ensure a constant standard of identification by call and sighting, as the sampling progressed, the sampler's experience with the local avian fauna inevitably increased and may have affected the number of reliable records. Sightings, particularly of skulking or elusive species, were brief, reducing certainty of absolute identification in many instances. In these cases, such records had to be discounted for risk of presenting false data.

The other source of significant bias may have been the time difference between recording sessions in each forest environment – the primary forest was sampled for fifteen days, followed by the secondary forest for fifteen days. This was unavoidable as the study fitted in with the expedition which was only logistically possible on this itinerary. This interval between the first records at each site may have allowed, for example, foraging advantages to change due to adjustments in ripening fruits. This can be exemplified by the increased abundance of sunbird sightings in the final few secondary forest samples.

All samples were taken between the hour of 6:30 and 7:30 am, thus several bird families and genera may have been misrepresented in terms of their abundance; such as raptors (primarily eagles, serpent eagles, hawk eagles) which are active later in the day when temperatures are higher and visibility greatest (following early morning 'mists') (Leopold, Eynon: 1961).
Species which are not reliant on either forest environment and happen to be sighted airborne from the point sample site at the time of recording may have resulted in misrepresented diversity discrepancy conclusions. For example, swift (Apus) species, which do not perch or use the internal forest environment below the canopy and were always/ often sighted catching insects on the wing above the canopy. In fact it remains open to whether such families or genera should be excluded from recording altogether and this should be considered by those looking to repeat the test at the same or similar sites. The same goes for Hirundines such as the Pacific swallow.

The variable size of bird territory (for instance, they may overlap or may not) and presence of certain bird territories at particular recording sites may inhibit the presence of other species'/ individuals' territories due to competition or predation (Schoener: 1968). Thus the data from each site is barely representative of the actual proportional abundance of each species in the tested environment by itself, only when collated with many other datasets from different sites. This supports the need in all future tests of similar methodology to repeat the sampling at more and different point sample sites. For instance, if a pair of blue-headed pitta were resident near one particular sample site, every sample taken there would most likely record the presence of this species. Whereas, other sample sites would likely not be within a pitta territory so would not record its presence. However, being able to identify and record all bird voices as well as sightings helps to eliminate these 'site-specific species patterns'.

3.6 CONCLUSIONS

The considerable probable influence of the factors discussed above no doubt influenced the sample results and any conclusions following. No doubt a greater number of sample sites and sampling time, where primary and secondary forest is sampled simultaneously would reduce the bias of these factors significantly. The results show a higher mean diversity of bird species per sample site and a higher number of observed individuals in secondary forest, contrary to the study's hypothesis, though a higher total number of species were recorded in primary forest and a higher diversity as shown by the Simpson's index. It remains to be seen, however, if lengthier studies reach similar conclusions.

4. Herpetological study

4.1 ABSTRACT

The difference in reptile and amphibian diversity between primary and selectively logged (disturbed and logged in 1989) rainforest was tested at Danum Valley in Sabah, Borneo. Five 50M transects, each with 10 buckets evenly spaced along the line

were used in each environment. Illegal logging is responsible for the modification of considerable areas of rainforest in Borneo. The study found that reptile diversity was slightly higher in primary rainforest while secondary rainforest showed a higher diversity of amphibians. We also caught several species of reptile that were out of their home ranges according to the available identification resources.

4.2 INTRODUCTION

There is not a lot of literature available on the reptile ecology of Borneo that can be directly related to this study. 289 species of reptile have been recorded from Borneo as a whole, however much of the previous research has been concentrated in the Mt. Kinabalu National park area and not in the low land rainforest therefore outlining the importance of this project (Das, 2006 and Lloyd et al 1968). Nevertheless Danum valley is known to be home to at least 75 species of reptile, including; skinks, monitors, geckos, agamids, hard and soft shelled turtles and several species of snake including the longest species recorded the reticulated python.

Borneo is thought to be home to around 242 species of amphibian in 41 genera (Whitten et al, 2004). As with reptiles there is not much literature to be found directly related to this study and no research had been conducted on this taxa in the Danum Valley conservation Area before. Amphibians are thought to be represented in Danum Valley by approximately 60 species including the rare Wallace's flying frog and the Bornean horned frog.

4.3 MATERIAL AND METHODS

The investigation involved a herpetological study coupled with a bird diversity study in the same time duration. 15 days of data recording were allowed for the primary forest between the 29th June and 13th July, followed by 15 days for the secondary rainforest between the 19th June and 3rd August. 2-4 days prior to data recording were spared for digging pitfall traps and setting up transect lines.

The 500m^2 plots of rainforest selected for studying (i.e. the sects of primary and secondary rainforest) where the point samples were taken were chosen randomly in areas that typically represent the regions primary or secondary forest respectively (in terms of tree composition and canopy height). For example, there were areas which we could not use due to dense vegetation. Using a random number generator between 0-360^o we determined the bearing along which the transect was followed. See appendix for GPS co-ordinates of transects.

Selection of the forest plots and indeed the pitfall transects was random to the greatest extent possible. However, the positioning of transects and thus the point sample sites were influenced by some degree by accessibility. On occasion challenging topography or extreme density of vegetation prohibited the location of transects in exact straight lines.

A team measured reptile and amphibian diversity along five transects in primary rainforest and subsequently along five transects in secondary rainforest.

Setting up transects involved digging holes in the ground at 5 metre intervals for a distance of 45 metres, thus 10 holes in each transect was dug. The length of each transect was measured using tape, and were made along as straight a line as possible in the environment.

In each dug hole 5 litre buckets were placed with soil tightly packed around the outside to ensure animals would fall into the buckets. Before palcing the buckets into the pits, 6 holes of 1cm diameter were burnt through the floor of the buckets using an iron rod. The purpose of which was to prevent the buckets flooding due to rain and thus drowning of animals.

Along the line of each transect a polyester sheet was placed vertically standing at 1m in height. The bottom of the sheet was dug into the soil between pitfalls. This would ensure animals would not be able to migrate through to the opposite side of the sheet, but instead would follow the sheet along to the pitfall where it would fall and be trapped.

Each morning a team would check each pitfall trap in each transect for any reptiles and amphibians. If caught the species would be identified and recorded noting the transect found in. Animals were not taken back to the lab but would be replaced to the surrounding area of the transect found in . Any litter such as dead leaves, branches and soil found in buckets would also be removed, in order to prevent pitfalls from clogging up and thus minimising the possibility of the traps flooding. The team members would also remove arthropods and any small mammals caught in the traps.

4.4 RESULTS

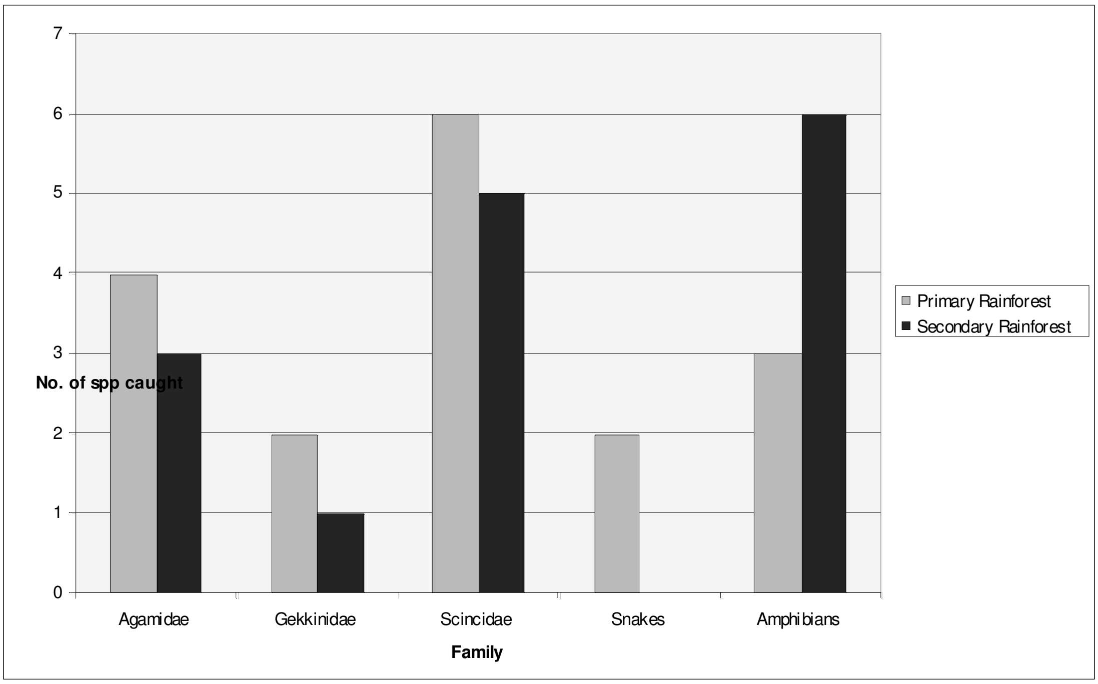

Figure 1: Bar chart comparing reptile family and amphibian diversity in both primary and secondary rainforest.

Figure 1. shows that the diversity of reptiles is consistently higher in primary rainforest than secondary rainforest. Skinks were the most diverse catch; with six different species in primary rainforest and five species in secondary rainforest. The least diverse category were the snakes where only two specimens (two species) were caught during the entire study, both of these in primary rainforest. The data we collected for amphibians shows that there is a reversal in this trend. We caught a total of 3 amphibian species in primary rainforest compared with six species in the secondary rainforest. We believe that this could by largely due to the varied weather conditions encountered during the two sets of transects.

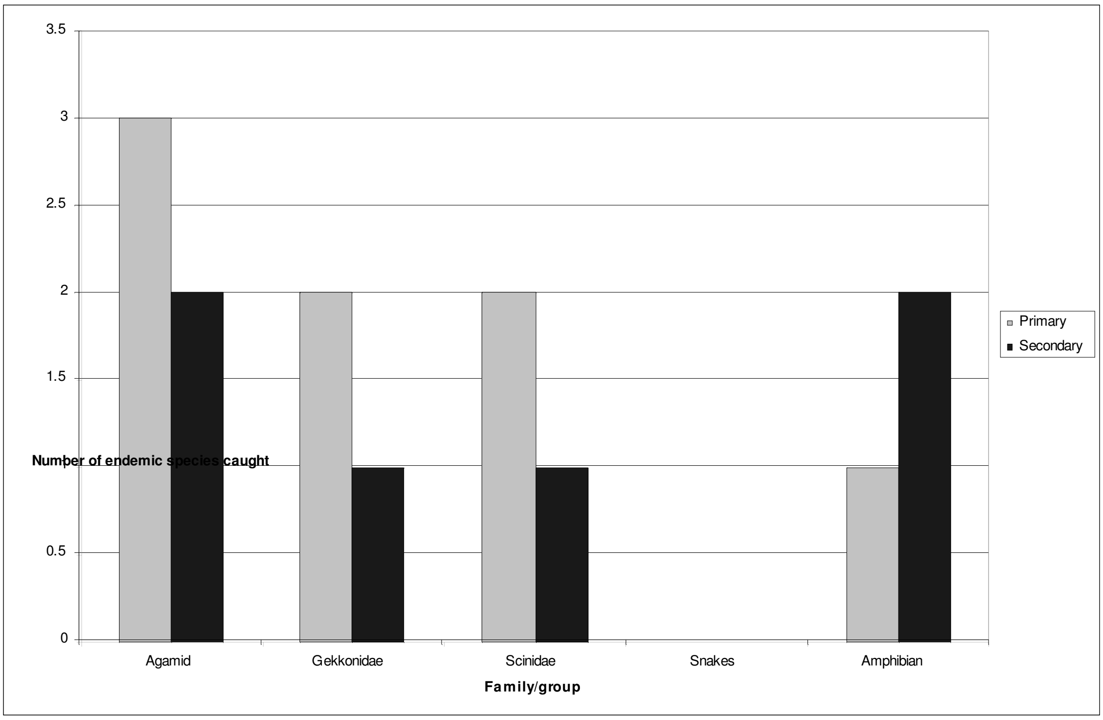

Figure 2: A bar chart to show the number of endemic species caught in both primary and secondary rainforest. Categorised as Agamidae, Gekkonidae, Scinidae, Snakes and generalised Amphibians.

Our data showed some interesting results relating to endemism in the different taxa. Our results suggest that throughout the reptilian group, the number of endemic species caught is directly affected by habitat. For the three reptile groups that we caught endemic species, there were almost double the numbers of endemic species found in primary rainforest over those in secondary rainforest (figure 2). This is suggestive that the endemic species we caught are unable to re-establish populations in forest which has been previously logged, in this case eighteen years ago. This trend is reversed for the various frog and toad species that were captured; where two endemic amphibian species were recorded in secondary rainforest compared to just one in primary rainforest. This is possibly accountable to external factors such as weather conditions which are discussed later and also the possibility that amphibians find it easier to re-establish in disturbed habitats.

Table 2: List of all species caught, showing endemism, expected distribution and showing discrepancies of animal distribution, specifying what aspect does not match our findings. (Das, 2006).

Species	Endemic	Expected Distribution	1°	2°	Correct?
Aphaniotis ornata		lowland r/forest, mid hills	y	y	y
Draco cornutus		plains and mid hills	y		y
Gonocephalus bornensis	E	primary mid hills up to 1100	y		y
Gonocephalus liogaster		lowland r/forest	y	y	y
Gonocephalus mjobergi	E	2134-2250, only montane forest	y	y	(altitude)
Cyrtodactylus ingeri	E	riparian forest 500-800	y	y	(altitude)
Cyrtodactylus pubisculus	E	lowland r/forest	y		y
Dasia grisea		lowland dipterocarp	y		y
Mabuya multifasciata		throughout Borneo up to1800	y	y	y
Mabuya rudis		lowland and mid hills up to1300	y	y	y
Sphenomorphus cyanolaemus		lowland primary r/forest	y		y
Sphenomorphus haasi	E	lowland forest (N/W Borneo only)	y		(N/E)

Sphenomorphus multisquamatus	E	lowland forest and peat swamps	y	y	y
Sphenomorphus sabanus	E	lowlands and sub-montane		y	y
Gongylosoma longicauda		lowland r/forest	y		y
Ramphotyphlops braminus		tropical/subtropical	y		y
(amphibians):					
Bufo divergens (toad)		Prim, old Secondary, below 700		y	y
Calluella smithi	E	Prim, low elevation		y	(secondary)
Chaperina fusca		All	y	y	y
Kalophrynus pleurostigma		Prim, low elevation	y	y	(secondary)
Leptobrachium abbotti	E	Prim, old Secondary, below 1000		y	y
Leptolalax dringi	E	Prim, old Secondary, between 200 &1800	y		Y
Rana chalconota		All		y	y

Figure 3 shows the total number of each amphibian species that were captured throughout the study in both primary and secondary rainforest. With exception to *C. fusca*, where 13 individuals were recorded in secondary rainforest, the numbers caught were relatively low, with only one or two individuals for each species being recorded in each habitat.

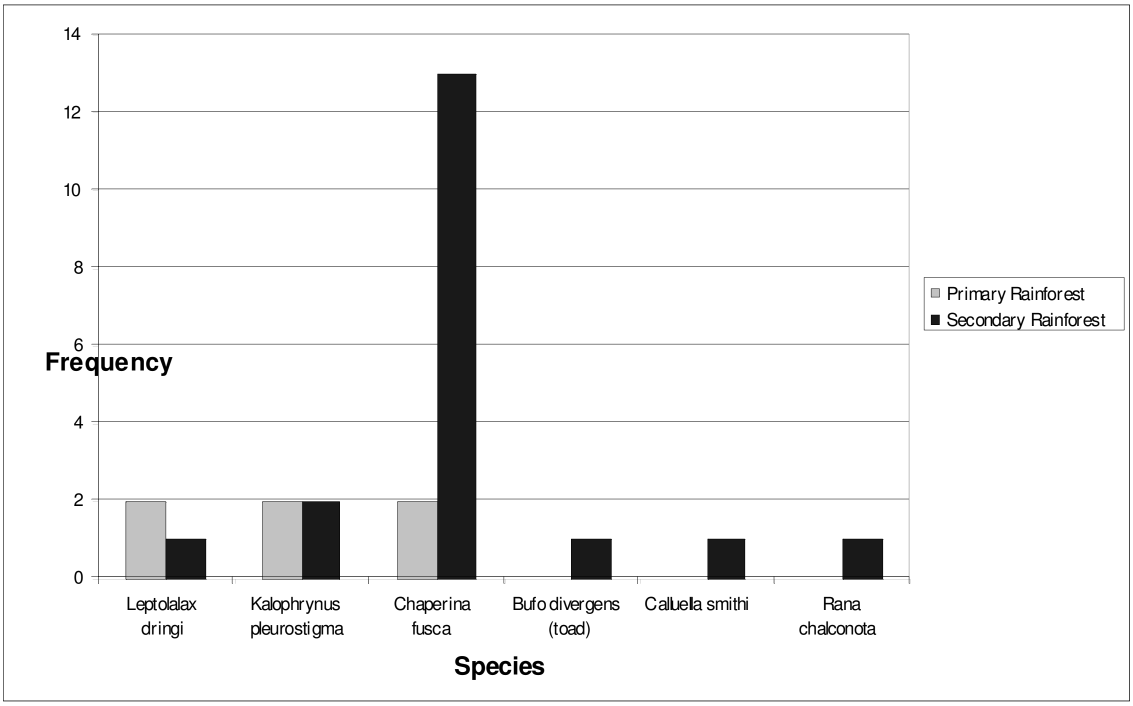

Figure 3: Bar chart showing the frequency of different amphibian species caught within both primary and secondary rainforest.

4.5 DISCUSSION

Over the one month of data collection we caught seventeen species of reptiles and seven species of amphibian. The data collected suggests that secondary rainforest has a negative impact on reptile diversity; this is justified by the number of species that we caught. Yet the primary rainforest proved to be less favourable for the amphibian species than in the secondary rainforest. It is however, highly likely that weather conditions during the recording of secondary rainforest could have had a huge impact on our amphibian collection. Within this count, seven of the Reptilian were endemic along with three amphibians.

4.5.1 Distribution

Of all 24 species that we caught, six species; three reptiles and 3 amphibians were found to oppose the modest amount of literature available to us; (it should be noted that the lack of literature was of no individuals fault, there is simply very little published data on reptiles of Borneo). Table 2 shows these species. While the possibility of false identification could play a factor, we are certain that our identification is 100% correct and that due to the scarcity of studies that have been carried out across the island of Borneo, these animals have never been recorded at such elevations or indeed at Danum Valley. The most surprising find was that of Gonocephalus mjoberji, which has only been documented at altitudes of 2134-2250m above sea level, the highest altitude recorded for that genus (Das, 2006). The transects at Danum Valley were situated between 154-217m (above sea level). These important findings help to show that the reptiles of Sabah remain an area of study where existing data most certainly needs to be followed up with more rigorous studies. This could help to create a reliable data source in relation to species, habitats and home ranges. Other species we found outside the published distribution were the reptiles Cyrtodactylus ingeri and Sphenomorphus haasi, the former as found to be below the stated altitude and the latter was stated to only be in the North West of the island, and Danum Valley is North East. The two amphibians Calluella smithi and Kalophrynus pleurostigma were both found in secondary rainforest where the available data suggested that these should be indicators of primary rainforest (Das, 2006).

We encountered several problems which have limited the effectiveness and reliability of this study. The key problems were:

Lack of man power. Due to financial restraints on our expedition, we could not afford to hire any Research Assistants from Danum Valley. To coincide with this, several members of our team pulled out of the expedition unexpectedly, only a few months from our departure date. This severely limited how much data we could collect.
Lack of repetition. Ideally we would have had ten transects running at a time in each environment, instead of just five. This would have enabled us to run the studies of primary and secondary rainforest simultaneously; this would have also freed up time to double the number of transects we could do. A longer study duration would have been a more obvious solution to this problem. It was thought that two months would be sufficient to attain a reliable quantity of data; however this proved to be difficult with such a small team.

Variable weather conditions. Data collections for primary and secondary rainforest were done back to back, this unfortunately led to variations in weather conditions. During our data collection for primary rainforest, the weather was largely dry, with several days of very little precipitation. In stark contrast to this, our data collection for secondary rainforest coincided with heavy rains. We believe that this had a particular impact on our collection of amphibians where many more amphibians were collected in secondary rainforest. Had we been able to run the study simultaneously, this would not have been a problem. This would perhaps have given a fairer comparison of amphibian and indeed reptile populations in both primary and secondary rainforest.

Other problems we encountered were that during data collection in the secondary rainforest, heavy rain led to several buckets flooding. As mentioned previously, all the buckets were punctured several times to allow for drainage; however due to the saturation of the soil, some buckets could not drain. Amphibians, especially Chaperina fusca, appeared to thrive with this aspect (figure 3); we even found some frog spawn in two of the flooded buckets.

Our sample sites between primary rainforest and secondary rainforest were hugely variable. The transects established in secondary rainforest happened to fall by a series of water bodies. As a result, two of the transects intersected small streams. To overcome these obstacles, it was necessary to cut large holes in the plastic sheeting. This enabled the free flow of water and any debris, without washing the transect downstream.

As well as causing a delay in transect construction; dead fall also had a direct impact on data collection. On several occasions, we found dead fall on our transects, causing a potential 'bridge' for reptiles and amphibians to evade the pitfall traps.

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CHANGES TO PERSONNEL

Naomi Julien led the expedition until March 2007, when unforeseen circumstances forced her to withdraw from the team, when Toby Nowlan took over as expedition leader.