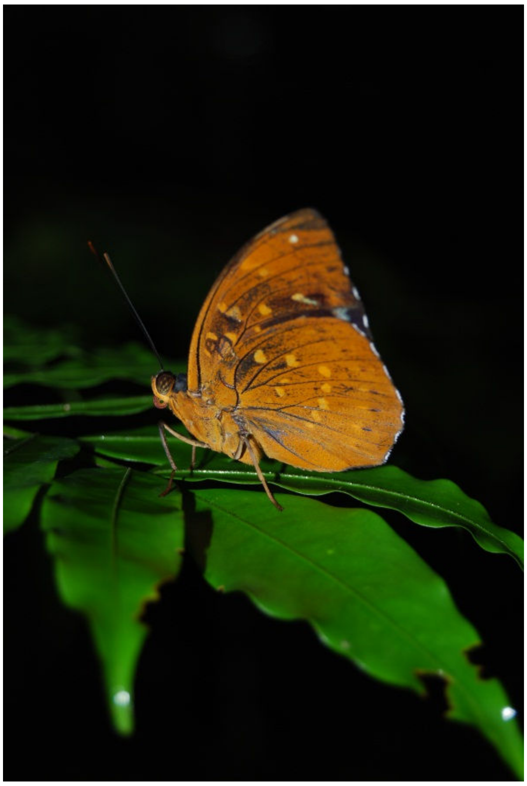
THE NOTTINGHAM TRENT UNIVERSITY

BSc (Hons) BIOLOGICAL SCIENCES

(ECOLOGY AND ENVIRONMENTAL MANAGEMENT)

UNDERGRADUATE PROJECT REPORT

TROPICAL BUTTERFLY DIVERSITIES WITHIN A BORNEAN RAINFOREST



***Lexias dirtea merguia* in Kerangas habitat (Picture by Jessica Smallcombe)**

by

SARAH NOLAN

N0179587

THE NOTTINGHAM TRENT UNIVERSITY

TROPICAL BUTTERFLY DIVERSITIES WITHIN A BORNEAN RAINFOREST

by

SARAH NOLAN

Project submitted in partial fulfilment of the BSc (Honours)

Biological Sciences

Summer 2011

DECLARATION OF OWNERSHIP
This submission is the result of my own work. All help and advice, other than that received from tutors, has been acknowledged and primary and secondary sources of information have been properly attributed. Should this statement prove to be untrue, I recognise the right and duty of the Board of Examiners to recommend what action should be taken in line with the University's regulations on assessment contained in the Handbook.

Signed:____________________________ Date:

Acknowledgements

I would like to give massive thanks to Dr Chris Terrell – Nield for recommending and encouraging such a wonderful experience to me plus his commitment to my project throughout the whole year.

To all of the Orangutan Tropical Peatland Project thank you for supporting my project and giving me the opportunity to carry out my own research. I must thank Jess Smallcombe for her supportive words, cuddles and strength to get me through the harder times. To Susan, Simon, Mark, Karen and Helen thank you for advising me through my project.

Thank you to Lis and the Ibu's for the food and my birthday cake, plus to Pac Bobby for collecting the ice and fresh food. Thank you to the Indonesian foresters who remained upbeat and worked hard for the whole project. Special thanks to Ari, Santi, Azis, Hanafi, Yanto and Iwan.

A big thank you to all of the volunteers for their help with my field work and overall support – Klara, Emily, Lilia, Ellie, Charlie, Charlotte, Kirsty, Marie, Laura and Kath.

I must thank Chloe Turner for her dedication to help with the statistical analysis and proof reading of my project.

The biggest thank you has to be shared between my mum, my dad, my sister Samantha and Ben for their continuous phone calls of encouragement during the expedition and unbelievable support and motivational talks during the write up of my project.

Abstract

Butterflies can be used globally as bio indicators of environmental change. Their biology and captivating appeal makes them ideal for this type of study. The purpose of the current study is to establish any differences in butterfly diversity between three unstudied unique habitats in the unprotected tropical rainforest in Bawan, Central Kalimantan of Indonesian Borneo. The aim is also to work towards protecting the forest from illegal logging and industrial interests. Indonesian Borneo is home to many different species of butterflies, yet research into Bawan forest has never been carried out, therefore leading a to high potential of new behavioural traits and possibly new species.

The survey was carried out using the Blendon Butterfly Trap design in three different sites: Kerangas Forest, Burnt Forest, and Mixed Peat Swamp Forest. The traps were set from 12th June 2010 to 22nd August 2010 and checked every day for 15 days. The trapping method was deemed reliable.

The results showed no significant difference in the number of individuals or species diversity across the three habitats. It was suggested that this was a result of the small spatial scale in which the different habitats were to each other. However there was a difference in flight morphology of certain species in different habitats. The most abundant and least specialised species was *Melanitis Leda*, which was present in all three habitats. The most recaptured species appeared in the Burnt habitat that had wide open spaces and no canopy cover, *Charaxes bernardas hierax*. Kerangas has the highest diversity and number of individuals of the three habitats, followed by the mixed peat swamp. The burnt area was the least diverse and had the fewest species.

Contents

List of Figures

List of Tables

1. Introduction, Review of Literature and Aims

1.1 *Introduction*

Endemic animals, thousands of invertebrate species, diverse plant life in tropical forests and many more magnificently unique organisms to find makes Borneo one of the most biodiverse places on the planet. The island is the third biggest island in the world, most of which is Indonesia, (MacKinnon, Hatta, Halim, Mangalik, 1996). Conservation International identified Indonesian as one of the 17 megadiverse countries. It has the second highest ratings next to Brazil for the number of endemic non fish vertebrate species, (Williams, 2001). The island comprised an array of habitats for the endemic and unique life forms. MacKinnon *et al.* (1996) describes several vicinities, from the limestone caves to the montane forest to the peat swamp. Unfortunately Indonesia had the world's highest deforestation rate in 2006 and lost over 30,000 square kilometres of forest, this is the third largest contributor to global warming after rainforest fires, (www1). These forests have up to 15,000 species of flowering plants and over 3,000 species of trees, (Williams, 2001). Borneo's remaining habitats have been neglected and damaged previously by commercial logging and other anthropogenic activities; currently however the areas are gaining higher protection, especially if endemic species are present. The WWF states that there are at least 222 species of mammals and 44 of these are endemic. Eight of the thirteen non – human primate species are endemic to Borneo. These include *Pongo pygmaeus*, *Hylobate albibarbis* and *Nasalis larvatus*. The other mammals include *Elephas maximus*, *Bos jarvanicus* and *Macaca fascicularis*.

The number of insect species within just one forest is difficult to comprehend when it is estimated that on one giant lowland dipterocarp forest tree there is a possible 1000 species. Some of the largest insects are found in Borneo, (Garbutt, 2006). This includes the group of butterflies known as the Birdwings. For example, *Trogonoptera brookiana* belongs to the Family Papilionidae and has a wingspan of 180mm (7 inches) it is found in lowland forests. Approximately 11,000 species of Lepidoptera are present within Borneo. These butterflies tend to be sensitive to their habitat and most are plant specific. Tropical rainforests in Borneo are so diverse that they can meet the requirements of all the species and even provide such specialized environments that 10% of Lepidoptera are endemic to the island. 60% of that 10% are actually found in Kinabalu, - approximately 600 species, (Garbutt, 2006). Garbutt continues to discuss the distribution by saying how 70% are limited to local regions around Borneo including the Malay Penisula, Java and Palawan.

There are several other families of butterflies present on Borneo island that commonly attract interest due to their habitat preference and behaviour. For instance, *Pachliopta aristolochia* and *Papilio helenus* have been described as 'conspicuous' as they wait at the forest edge for flowers to bloom. Whereas a mineral rich river bank gives a home to *Graphium doson*.

The Orangutan Tropical Peatland Project (OuTrop) works towards protecting tropical rainforests within Borneo. Their main site is based in The Sabangau Forest in Central Kalimantan. The research is predominantly on primates but many biodiversity surveys are carried out annually. OuTrop have developed a relationship with local authorities in Borneo, and with local people and other conservation organisations which all support the project and encourage its growth. The main aims of the biodiversity surveys are to prevent destruction by protection of rainforests and to encourage re generation.

<u>**1.2 *Review of Literature***</u>

As ecologists it is important to understand that all living organisms within ecosystems are valuable and beneficial (Sbordoni *et al.* 1985). They provide and maintain a balance to the ecosystem in which they belong. Therefore the destruction of rainforest habitats by means of illegal logging, fire and felling is of global concern. These actions create colossal losses of biodiversity. Tropical rainforest are at the centre of biodiversity (Hamer *et al*. 2003) offering a stable environment with constant weather conditions to all organisms present (Attenborough, 1984) and gradual or infrequent changes to the environment gradient will create a rift in the ecological processes that support the stability they offer. Vertebrate species have previously been used as indicators of environmental quality of tropical rainforests. However Hamer *et al*. (1997) suggests invertebrates, with their rapid responses, short life cycles and fast generation times are far better indicators. There are several successful insect orders that live in the tropical rainforests including Coleoptera, Diptera, Lepidoptera and Hymenoptera. These insects are used as indicator species to monitor the health of the habitat by assessing their presence and absence (Griffis and Wagner, 2001). Particular biological characteristics and overall charismatic appeal linked to Lepidoptera make them ideal indicators. The health of a habitat can also be monitored using butterflies that have a more prosaic behaviour (Vane – Wright, 2003). The taxonomy of Lepidoptera is well researched and they are recognised as valuable environmental indicators due to their rapid and sensitive responses to subtle habitat or climate changes (Hill *et al*. 2003). This results in limited dispersal and makes them more closely linked with their habitat during their feeding stages and oviposition as they are plant specific (Sbordoni and Forestiero, 1985). Their variability is also controlled by their environment. For instance the colouration of a butterfly is not always genetic. Ecophenotypes can be produced when the pupae of a butterfly is exposed to various temperatures that influence the duration of diapause, this can work in researchers' favour allowing easier identification (Sbordoni *et al*. 1985).

Not only are butterflies important indicators but they are also of cultural and historical significance. They have been known to represent the afterlife of Egyptians, evil spirits of South American Indians or in Japan the species *Sasakia charonda* is their national symbol.

1.2.1 *Life Cycle*

Butterflies undergo a complete metamorphosis from egg to adult. Their life cycle can be broken down into four stages. Initially there is an egg stage. Eggs are dispersed depending on their diet, once fertilised they are released by the adult onto plants for them to develop. If the species has a polyphagous diet then the eggs are dispersed whilst flying and are much smaller eggs than if the species has a monophagous diet. In this case the eggs are placed carefully on a more specialised plant which they will feed from. The embryo starts to develop within a few days using the micropyle to respire. The eggs vary in size number and shape depending on the species. For instance they can be spherical, hemispherical, rod or spindle shaped. The next development stage is the larva. Sometimes it is difficult to see and identify caterpillars because they are modified in various ways (Sbordoni *et al*. 1984). Some have a protective casing or large prothoraces that cover their heads. A caterpillars head holds several important structures, but lacks compound eyes which most other invertebrates have. The mouthparts have a very robust mandible and are generally toothed. They are vital to the caterpillar because during this larval stage of a butterfy's life cycle it is said that the larval stage is for consuming food, whilst the adults' purpose is breeding (Sbordoni *et al*. 1984). The digestive system of a caterpillar differs from a butterfly and tends to be short, wide and straight. An important structure to the caterpillar is the mandibular glands which produce a liquid that turns to a solid as it comes into contact with the air. It is made of two proteins, an inner core of fibroin and an outer sheath of sericin. This product helps with movement and more importantly it is used to develop the cocoons.

Moulting is necessary for caterpillars as they cannot continuously grow. The nitrogen – containing polysaccharide named chitin makes the caterpillar relatively stiff and inextensible. The integument is originally soft allowing the caterpillar to expand until it develops its rigidness. The caterpillar takes in as much food and air as possible until it hardens then the moult will occur so it can then be soft again and continue to grow. This can happen between 3 and 5 times before it reaches the next development stage. These growth patterns are referred to as instars (Scoble, 1992).

The pupa is the next stage and this is found in shaded areas. There are two basic pupa structures, firstly the excrate which occurs in primitive groups and has free adult appendages. Secondly, the obtect which is the pupa of most Lepidoptera. Here, the appendanges are firmly attached to the body. The pupa has reduced activity, only being able to stretch the abdomen slightly and adjust its position. Excretion and waterloss is minimized during this stage of development. Transformation takes place internally and externally and involves histolysis followed by histogenesis. However, histolysis and histogenesis begin during the larval stage. The external changes include the division of the body into a head, thorax and abdomen. The wings are also developed here but are hidden. The transformation from pupa to adult is known as emergence. In certain instances the cocoon needs to be split. This is sometimes done by forcing water into the head and thorax creating a swelling which rips away the casing. It can also be done chemically there is a release of a highly alkaline substance which causes the split or it can be pierced open by sharp features on the body.

As the adult is emerging the legs are first, delicately followed by the abdomen and then the wings need time to unfold fully. The butterfly hangs backwards and lets the blood pump through the veins. Eventually the blood pressure will drop and the veins will harden ready for the adult to fly.

1.2.2 *Distribution*

Lepidoptera are found all over the world, but due to the huge changes of environmental conditions many are disappearing or threatened. The International Union for the Conservation of Nature and Natural Resources (IUCN) and the World Wildlife Fund (WWF) work closely in conserving protected species. Currently a 'Programme of Priorities for the Conservation of Lepidoptera' discusses projects to protect some the special species. *Polyommatus bellargus*, *Hamearis lucina*, and *Erynnis tages* are just a named few from the Priority Species in the UK Biodiversity Action Plan.

There are approximately 127 families and 165,000 species of Lepidoptera (McGavin, 2000), it is not known how many of these are extinct. The decline may be linked to excessive collecting, deterioration of habitat and even man's increased pace and intensity on changes in the environment. Butterflies are affected by damage to the Earth's vegetation. Some, being monophagous or oligophagous, are very sensitive to the disappearance of their food plants. Most Lepidoptera species are found in the tropics where there has recently been a large decrease in forest area (Sbordoni *et al*. 1985).

Previous research from Cleary (2003) and Ramos (2000) has shown it to be difficult to conserve just the species without conserving the whole natural environment. This is especially the case for Lepidoptera, because they are so sensitive to their environment.

1.3 *Aims*

To assess the differences and similarities in species diversity between three different habitats.

To assess the quality and health of the habitats by using the butterfly survey.

To identify any morphological characteristics based on the habitat type.

To provide evidence for protection on the Bawan forest in order to save it from destruction.

2. Methodology

2.1 *Study Area*

The butterfly survey was just one of the many biodiversity surveys being carried out by The Orangutan Tropical Peatland Project (OUTROP) and Centre for the International Cooperation in Management of Tropical Peatlands (CIMTROP). All field work took place in Bawan Forest situated approximately 45 minutes away from Bawan village by car. Bawan is 65km North of Palangka Raya, Central Kalimantan, Borneo, (Figure 1). The forest itself has never had an intense biodiversity survey carried out. Therefore, there is no previous butterfly data for this forest or a true estimate of the forest size. However, due to recent threats, illegal logging and fires to the forest, a study was put together in order to gather information about the remaining pristine forest. It is hoped that this will help to protect the forest from any anthropogenic destruction, by emphasising its ecological importance.

The study aims to look at the butterflies present in the three different forest types within Bawan Forest.

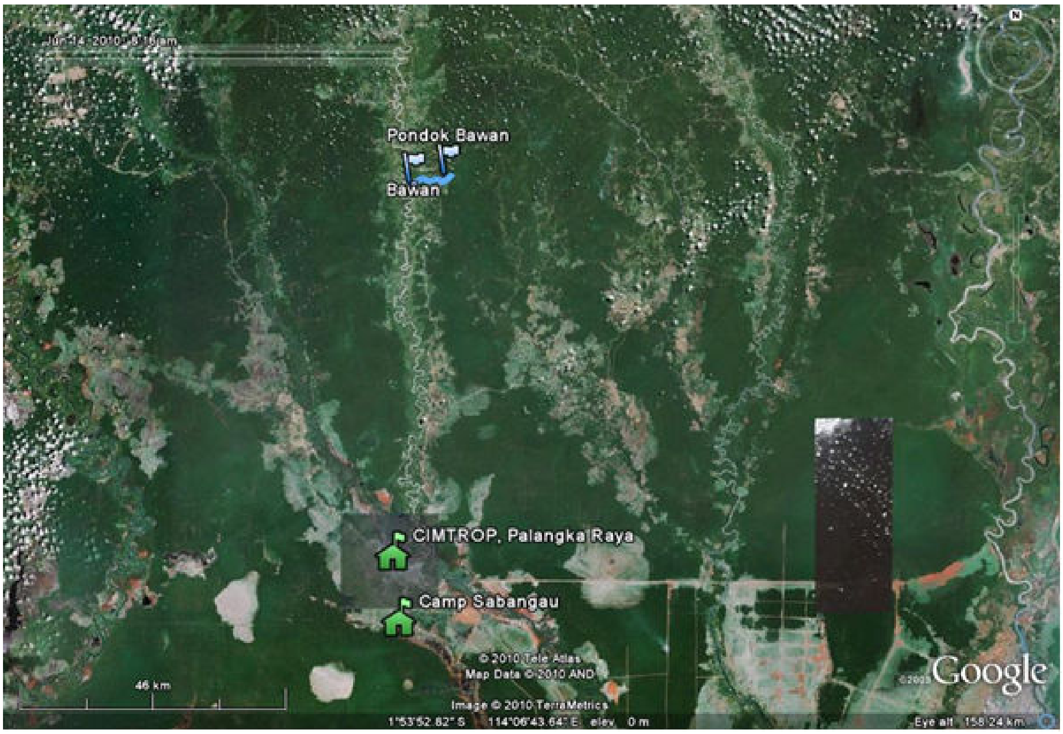


Figure 1. Map showing the location of Bawan village and the camp (Pondok Bawan) in relation to Palangka Raya. (Googlemaps, 2010)

Borneo is situated on the equator and the whole island lies within the 'ever wet' zone. The temperature remains relatively constant throughout the year, during the study the average daily temperature was 27.5^{o}C. The rainfall measurements imply that rainfall was the main climatic variable, the average daily measurement was 12.3 mm however there were several days with no rain at all and other times when the rainfall was very heavy.

It is possible to suggest that Bawan forest was previously a sandstone beach that has been eroded. It would have got to this state by an uplift of land or the falling of sea level. The forest has experienced extreme trauma from natural fires and illegal logging, these have established a mosaic habitat pattern.

2.1.1 *Habitat Descriptions*

Study Site 1: Kerangas

This survey took place along a transect located 50 m from base camp. The traps were at a minimum of 50m away from each other. It appears that a high quality kerangas forest covers a large proportion of the area with a high abundance of dipterocarp species and other trees that give a high canopy. Both large and small dipterocarp species had buttresses surrounded by little shrub layer and low leaf litter. The more dominant species were *Eugenia palembanica* and *Ilex hypoglauca.* The organic soils were dominated by termites, but it must also be noted that there were several beetle species that were of secondary importance. Kerangas forests tend to have a high detritivore biomass due to large individual detritivores such as the beetles. According to the data from the peat depth survey this habitat had a relatively shallow peat layer of 10.7 cm. There was low light intensity as the canopy was closed in most areas.

Study Site 2: Burnt

The traps for this survey site were positioned in a similar layout as study site 1 but it was difficult as not many live trees were still standing. This transect started 250m away from camp. Along the forest edge and moving through the forest there are severe cases of newly burnt areas which lead to a few pioneer species but mainly a low shrub layer. The previous habitat here was Kerangas which is easily degraded by felling and burning. Within this habitat there were several fallen trees, burnt trees still standing and charcoaled plant matter. The fire created a Padang formation; shrubs and scattered trees over a sparse grass layer. It is possible for the habitat to revert back to the original Kerangas; the time it takes to do so depends on the level of disturbance and at Bawan this will take a very long time after such high disturbance. The soils had clearly degenerated showing a surface humus layer that had been eroded and oxidised from the fire. All of the peat layer had been lost and there were only a few living trees still standing. This whole habitat had high light intensity and wide open spaces with low vegetation.

Study Site: 3 Mixed Peat Swamp

This survey was the furthest from camp starting at starting at 600m from camp and ending 1km away. Dispersed further into the forest were areas of mixed peat swamp. The average peat depth here was 55.3 cm. The soil was permanently water logged which did not encourage or support the life of micro-organisms that would normally decompose leaf litter. They could not survive in the anaerobic conditions and high sulphide concentrations, therefore leaving the organic matter to build up forming the deep peat layer. This habitat had a relatively low canopy of approximately 20 metres throughout. There was a decrease in tree girth and several of the trees supported pneumatophores in order to obtain oxygen in the water conditions. These shallow, aerial and buttressed roots caused the trees to be very unstable and little wind or gentle movement towards the thin trunk would cause them to fall. Throughout the study many trees did fall and one fallen tree caused damaged to a trap. This was later rectified. The terrain was uneven, with many weak points and hollow areas.

A map showing the layout of the transect can be found in the Appendix.

2.2 *Survey Techniques*

75% of butterflies on the island of Borneo are represented by the guild of fruit-feeding Nymphalid butterflies, (Hamer *et al*. 2003) therefore the surveying techniques aimed towards trapping that guild.

The traps were operated for 30 days during 12.07.10 – 21.08.10. 9 traps were deployed in each habitat for 15 days at a time; the extra days were used for setting up the traps. Setting up of the traps did require an Indonesian capable of climbing trees, but in general a minimum of 2 people for 4 hours a day was sufficient. Once the traps had been positioned they were baited with two heaped tea spoons full of banana bait mixture which consisted of homogenised rotting bananas, two spoons of sugar and alcohol. During each sampling period the traps were checked and emptied daily at between 8.30 am - 12.30 pm. The old bait was cleared and fresh mixture was placed in the dish. The trap design was based on the Blendon© style bait trap, (Figure 2). The idea behind the trap is that butterflies fly to the trap, walk to the middle of the dish to feed then as they try to fly away they are caught in the cylinder netting. Butterflies tend to fly in an upward motion rather than at a gradient, this is the principle of the trap.

All butterflies were captured by hand from the traps whilst either resting on the netting or hanging from the top of the trap. It was important for the butterflies not to be flying whilst being caught as this could cause damage. Once caught the butterfly was positioned to be marked and photographed. This meant holding the butterfly between the index finger and thumb at the thorax. Handlers had to be firm yet careful not to apply any pressure to the abdomen. Using callipers the body length was measured and the wing span to aid later analysis. Once individually marked by marker pen the butterflies were released and the photographs were later used to identify the species.

Figure 3. *Amathusia ochraceofusca ochraceofusca* caught in Kerangas with a mark.

Figure 2. Butterfly trap baited and hanging in the Kerangas forest

2.3 *Statistical Analysis*

Initially a species count and individuals caught count was taken. This led onto further analysis of the Shannon Index Value. It is a measure of species diversity and takes into account the abundance and evenness of the species present. It was calculated for each site.

The statistical analysis programme Biodiversity Professional was used to calculate this value and all other statistical calculations.

For each habitat type a species cumulative frequency by day graph was established to verify the sampling methods.

All of the animals recorded were marked; therefore using the Manly and Parr analysis method the estimated population for each day in each habitat could be calculated and compared to the observed.

An unmatched T – test was carried out to compare the average number of individuals at each site. This was further analysed by a Spearman's rank correlation, to determine if any of the sites were significantly similar to each other and ranked in order of similarity.

A test for association between butterfly species in selected habitats was calculated using 2 x 2 chi squared test.

The final analysis investigated flight morphology. It used the wingspan and thorax measurements of the most encountered species.

3. Results

3.1 Initial Findings

In total 195 individuals of 33 species were caught and marked, the results are shown in table 1-3 below.

Table 1. Main findings from Kerangas

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Total Individual	3	10	11	8	3	5	3	5	4	2	6	2	3	5	1	70
Total Species	3	9	8	6	3	4	3	4	4	2	5	2	3	5	1	62
Shannon Wiener	1.585	3.122	2.845	2.406	1.585	1.922	1.585	1.922	2	1	2.252	1	1.585	2.322		1.937929

- 24 species were recorded and 70 individuals were caught and marked measured.
- At the start of the trial the Shannon index reached over a score of 3, making it the most diverse day.
- Figure 11 shows the rapid species accumulation within the first three days of the trial.
- The greatest numbers of individuals were caught on Day 2 and Day 3.
- Day 15 was not calculated as only one species and one individual was captured.
- The Shannon Weiner index value was higher than the other two sites.
- Figure 5 shows a full species list for the Kerangas forest and how less than half of species were only captured once.
- Even fewer species were captured more than twice.

Table 2. Main findings from the Burnt habitat

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Total Individual	2	7	9	2	4	7	3	6	2	4	5	4	2	7	2	66
Total Species	2	4	7	2	4	5	3	6	2	4	3	4	2	3	1	52
Shannon Wiener	1	1.664	2.725	1	2	2.128	1.585	2.585	1	2	1.371	2	1	1.449		1.679091

- 18 species were recorded and 66 individuals were caught and marked and measured
- Day 3 showed the most diversity with a Shannon Wiener value of 2.725.

- Day 3 also showed the greatest number of individuals caught.
- Day 15 was not calculated as only one species and one individual was present.
- Figure 11 shows a slow increase in species accumulation taking over 5 days to reach over ten different species.
- Yet, Table 2 shows high numbers of the individuals caught.
- *Melanitis leda* was the more dominant species in the habitat.
- Figure 4 confirms how *M. leda* is the most dominate of all the habitats.
- The species richness reached a plateau at day 12 (Figure 11).
- Over half of the species were encountered two times or less.
- The main four species were *M. leda, Zexuidia auerlius auerlius, Melanitis* spp and *Charaxes bernardas hierax*.

Table 3. Main finding from the mixed peat swamp habitat

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Total Individual	7	10	3	3	7	2	4	3	3	2	4	5	3	1	3	60
Total Species	6	8	3	3	4	2	3	2	3	2	4	4	3	1	3	51
Shannon Wiener	2.522	2.922	1.585	1.585	1.842	1	1.5	0.918	1.585	1	2	1.922	1.585		1.585	1.682214

- 15 species were recorded and 60 individuals were caught, marked and measured.
- Day 2 showed the highest number of individuals caught.
- Day 8 had the lowest diversity with a Shannon Wiener value of 0.918.
- Day 14 was not calculated as one species and one individual was captured.
- For 5 days the diversity was 1.585, here three species were caught and three individuals.
- The main species in this habitat were *M. leda, Lexias pardalis dirteane and Z. auerlius auerlius.*
- Two of the main species were common with the burnt area.
- There were few individuals but this habitat had almost the same diversity as the burnt area.
- Figure 11 shows how species richness reached its plateau very early on in the trial at day 6 with 15 species.

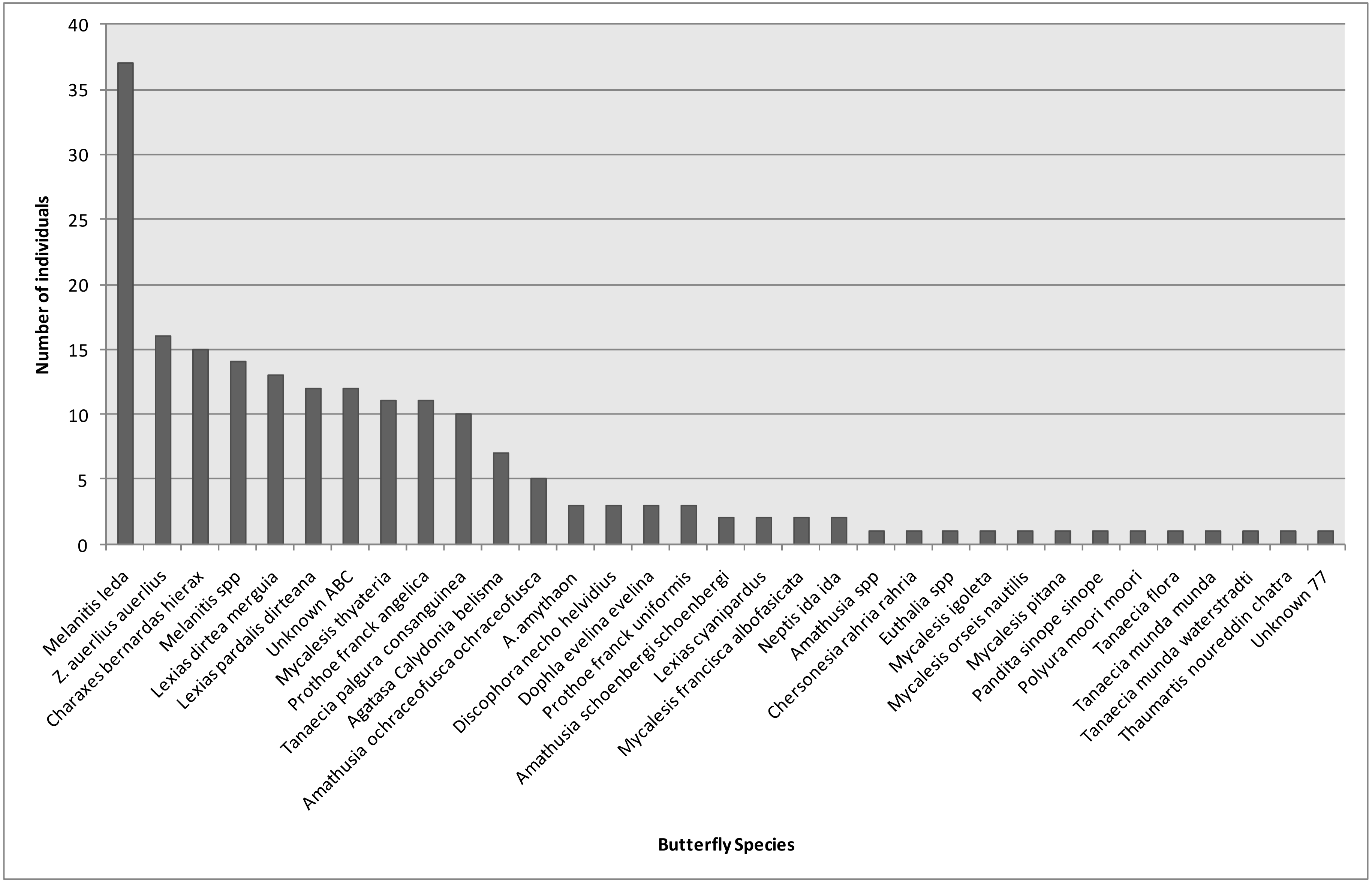


Figure 4. A full species list of butterflies found and the numbers of each found in all three habitats.

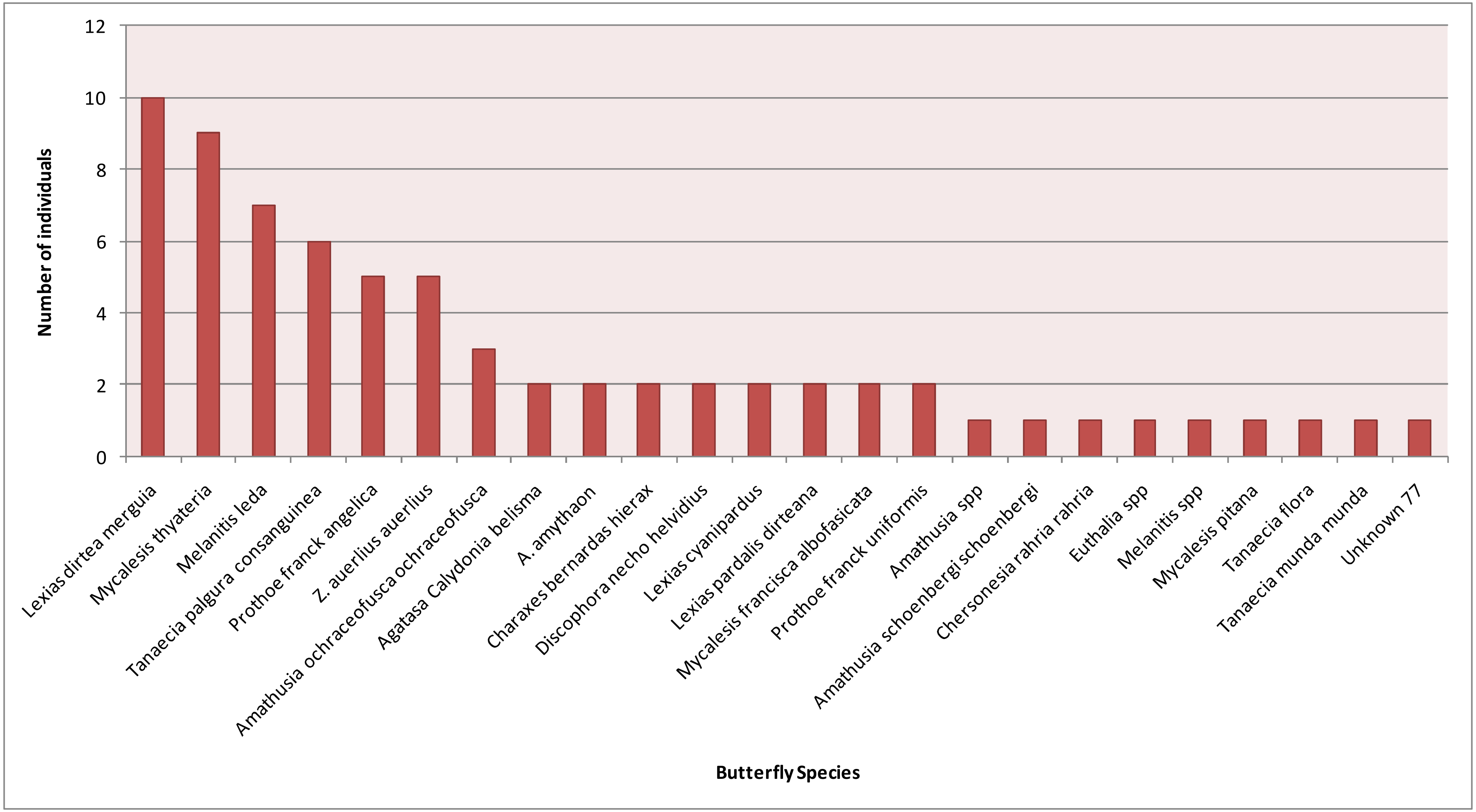


Figure 5. The number of each species found in the Kerangas Habitat type

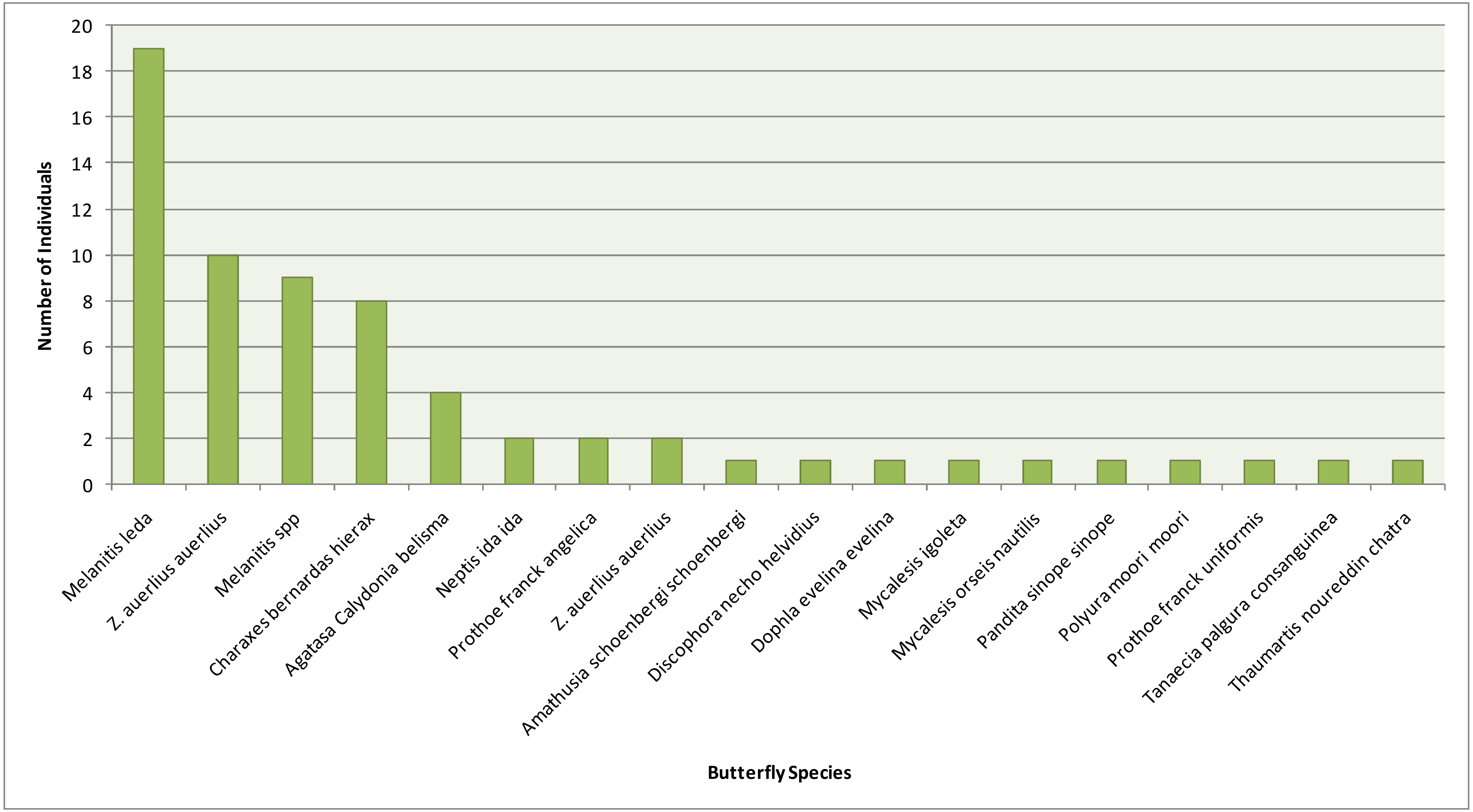


Figure 6. The number of each species found in the burnt habitat type

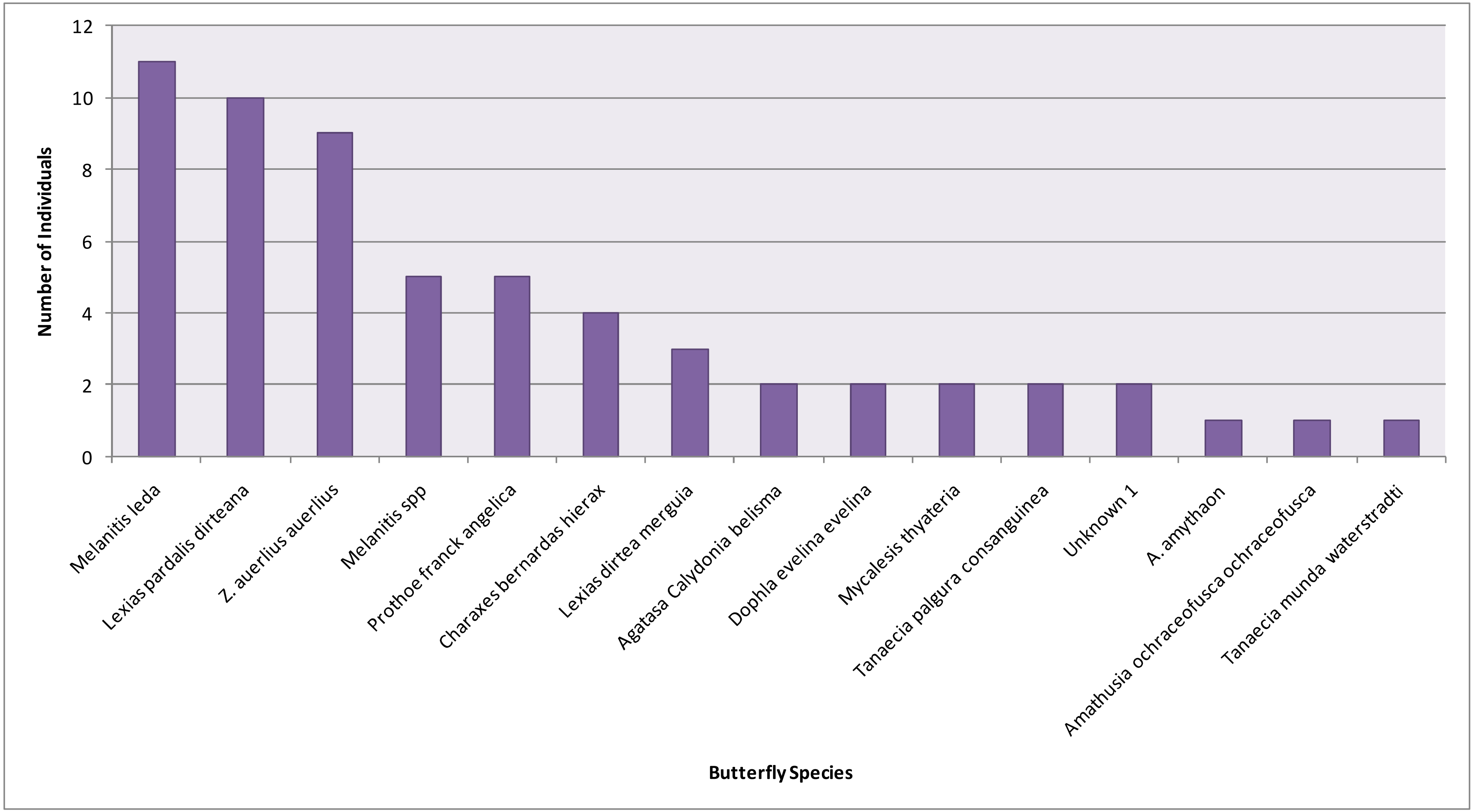


Figure 7. The number of each species found in the mixed peat swamp habitat type.

3.1.1 Species Diversity

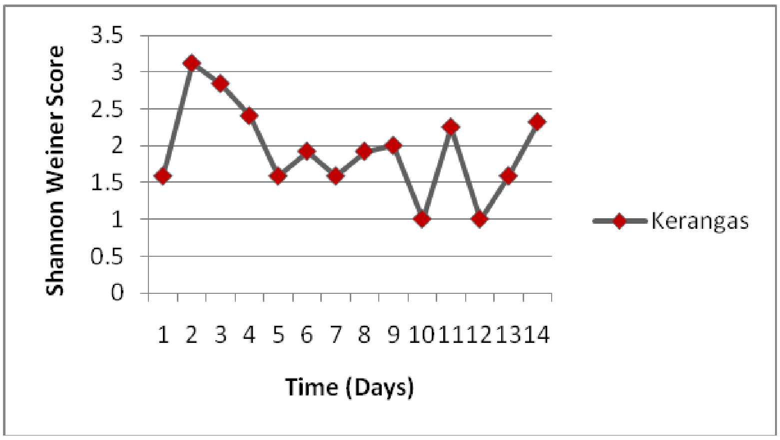


Figure 8. The Shannon Weiner score for each day the traps were checked in Kerangas habitat

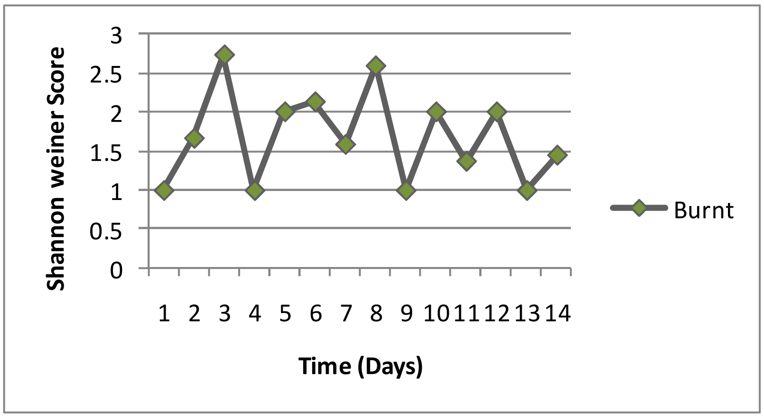


Figure 9. The Shannon Weiner score for each day the traps were checked the Burnt habitat

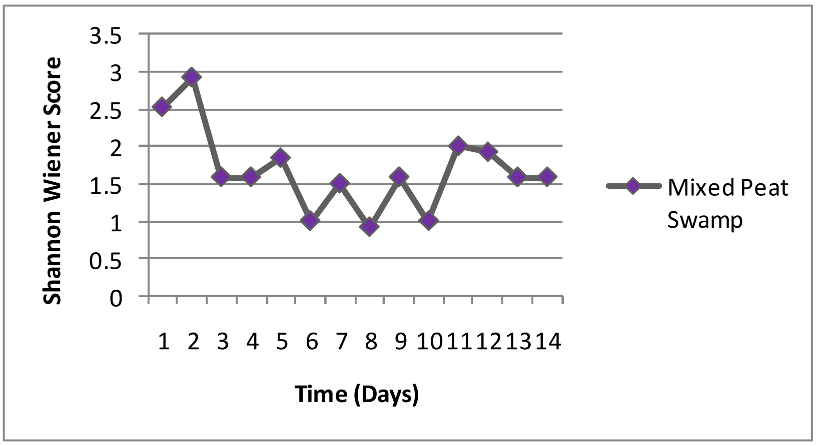


Figure 10. The Shannon Weiner score for each day the traps were checked in the Mixed Peat Swamp Habitat

Figure 8 and 10 show the highest diversity on day two with a Shannon index value of 3.1 for Kerangas and 1.7 for Mixed Peat Swamp. Figure 8 to 10 all have the highest diversity during the first three days, yet the Shannon Weiner score in the Burnt habitat does peak again on day 8 with a value of 2.5, (Figure 9).

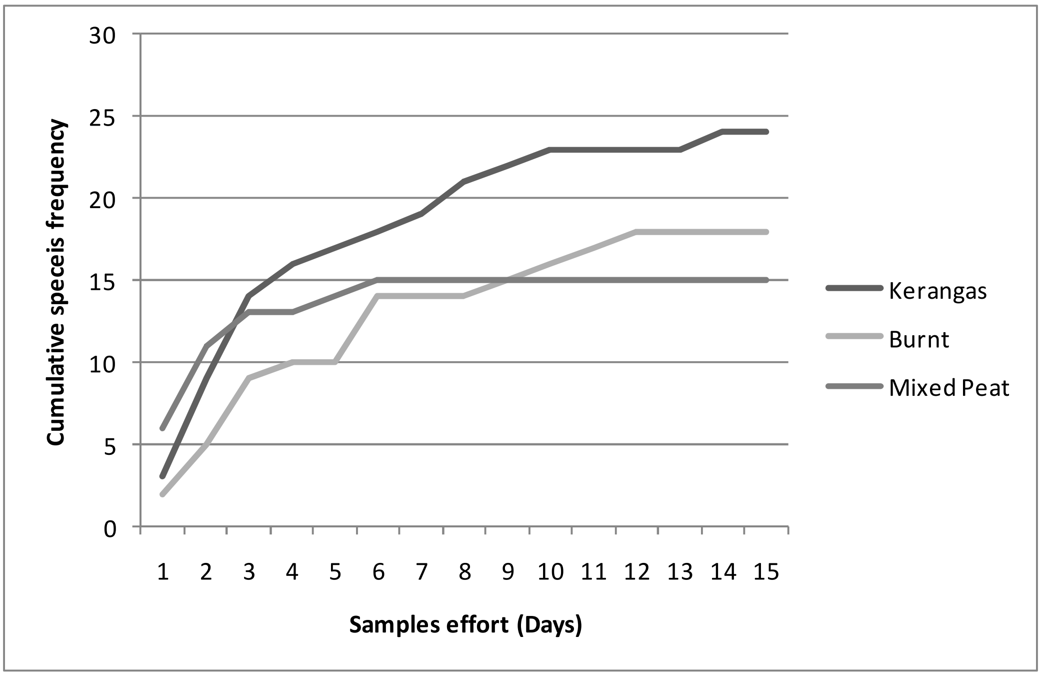


Figure 11. Cumulative frequency of all species encountered across all three habitat types

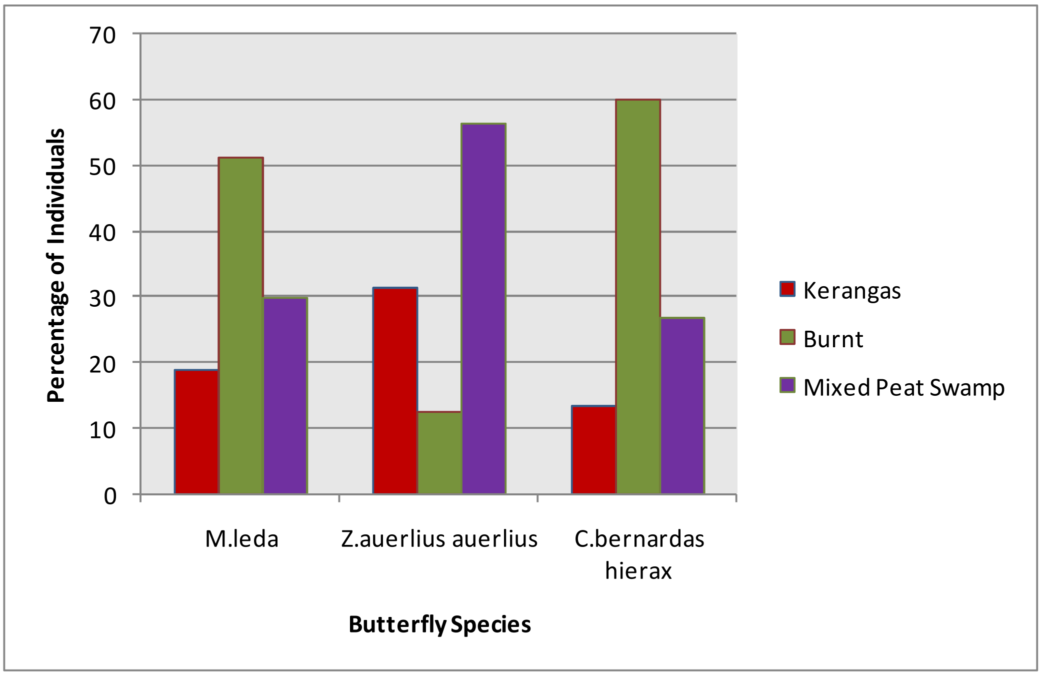


Figure 12. The percentage abundance of the three most popular species from all three habitat types

3.1.2 ***Manly and Parr analysis***

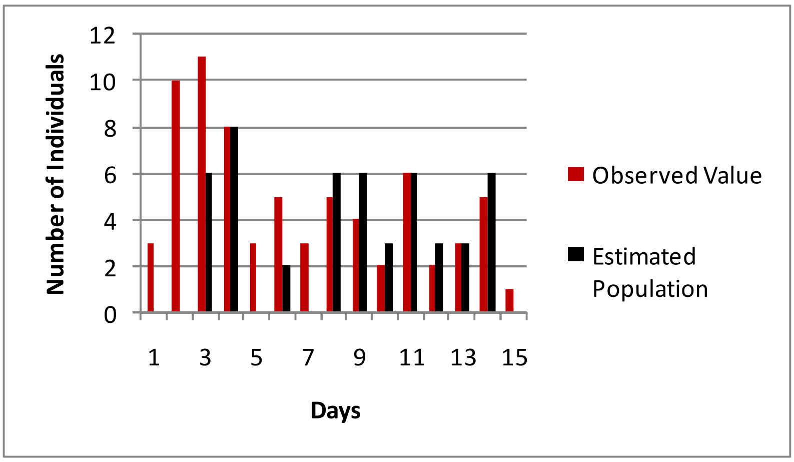


Figure 13. The number of individuals observed and estimated in Kerangas habitat for 15 days

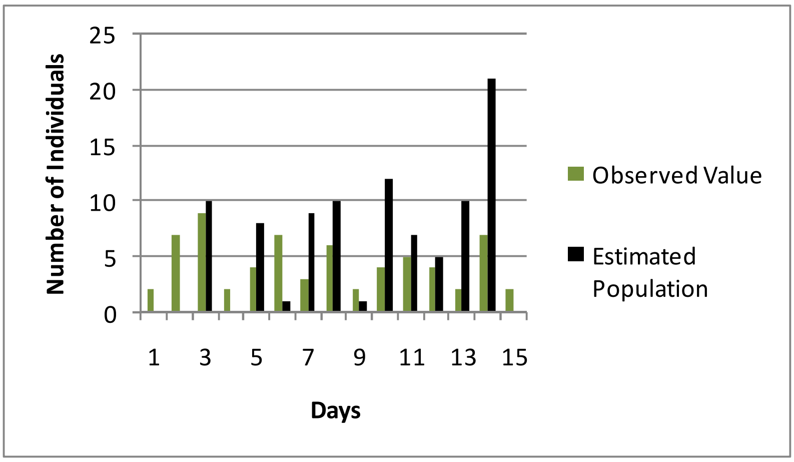


Figure 14. The number of individuals observed and estimated in Burnt habitat for 15 days

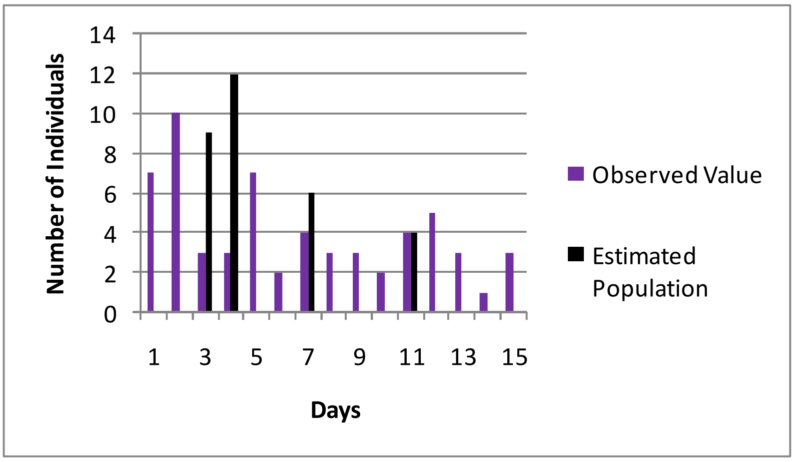


Figure 15. The number of individuals observed and estimated in Mixed Peat Swamp habitat for 15 days

3.1.3 ***Statistical Analyses***

T – test

This was done using e-stats and it compares the butterflies that are present in both areas being assessed. The null hypothesis is that the average difference between the two sites is zero.

Table 4. The results comparing all three sites with each other using a paired t-test.

First site	Kerangas	Burnt	Mixed Peat Swamp
Second site	Burnt	Mixed Peat Swamp	Kerangas
P – value	0.592	0.231	1.055
Difference in Mean	0.75	0.333	1.083

- The table shows there is no reason to reject the null hypothesis for relationships between any of the sites.
- The largest difference is between Kerangas and Burnt.
- The least different is mixed peat swamp and Kerangas.
- The difference in the means of each site show how different they are in terms of abundance of species in these sites.
- All of these results are showing that the butterflies that are present in both areas when the survey was carried out are different in terms of abundance.

Spearman's rank correlation

The hypothesis for the spearman's rank correlation is that the two sites that are being observed will be similar.

Table 5. Spearman's rank correlation between all three sites together

	Kerangas	Burnt	Mixed Peat
Kerangas	1	*	*
Burnt	0.0223	1	*
Mixed Peat	0.5917	0.4598	1

- Kerangas and the Burnt habitat types are the least similar at 0.0223.
- Mixed Peat Swamp is similar to both but more similar to Kerangas.
- The result do show a positive correlation between Mixed Peat Swamp and Kerangas, however it is not statically significant but the rank figure of 0.5917 is on the margin of significance. The critical value of Rs is 6.0.

<u>Chi squared test</u>

The null hypothesis: There is an association between butterfly species in the two assessed habitat types.

Table 6. The observed Chi^2 test results from Kerangas and Burnt habitat types

Observed	Kerangas	Burnt	Total
Present	10	14	24
Absent	8	1	9
Total	18	15	33

Table 7. The expected Chi^2 test results from Kerangas and Burnt habitat types

Expected	Kerangas	Burnt	Total
Present	13.091	10.909	24
Absent	4.909	4.091	9
Total	18	15	33

Table 8. Calculation of the Chi^2 value

		O-E = d	d - 0.5	$(d - 0.5)^2$	$(d - 0.5)^2/E$
R1	C1	10 - 13.091	2.591	6.713	0.513
R2	C2	14 - 10.909	2.591	6.713	0.615
R3	C3	8 - 4.909	2.591	6.713	1.367
R4	C4	1 - 4.091	2.591	6.713	1.641
				X^2 (2dp)	4.14

Table 9. Denotes which results will be significant and the outcome of the hypothesis

Significance level	5%	2%	1%	0.1%
Chi^2 crit	3.84	5.41	6.64	10.83
Reject Null Hypothesis	Yes	No	No	No

The calculated value for Chi^2 (χ^2 calc 4.14) is greater than the critical value (χ^2 crit = 3.84). Therefore the results are statically sound. There is a significant association (χ^2 = 4.14, p = 0.05) between the distribution of butterfly species in the Kerangas and Burnt habitats.

3.1.4 *Flight Morphology*

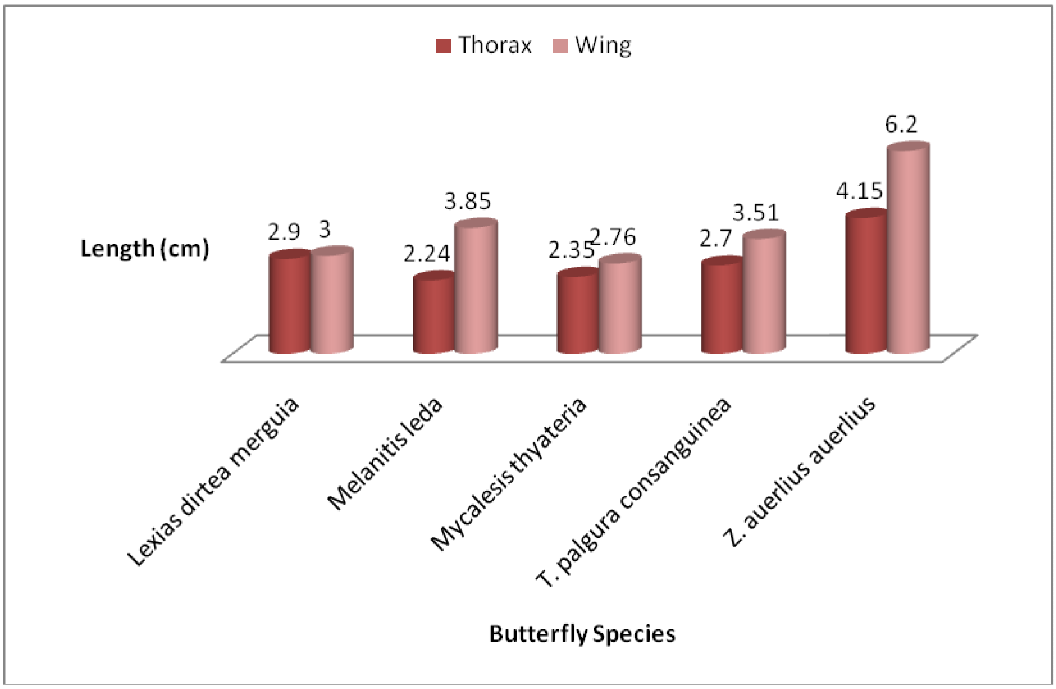


Figure 16. Average thorax length of species encountered 5 times or more and their associated wingspans in Kerangas habitat

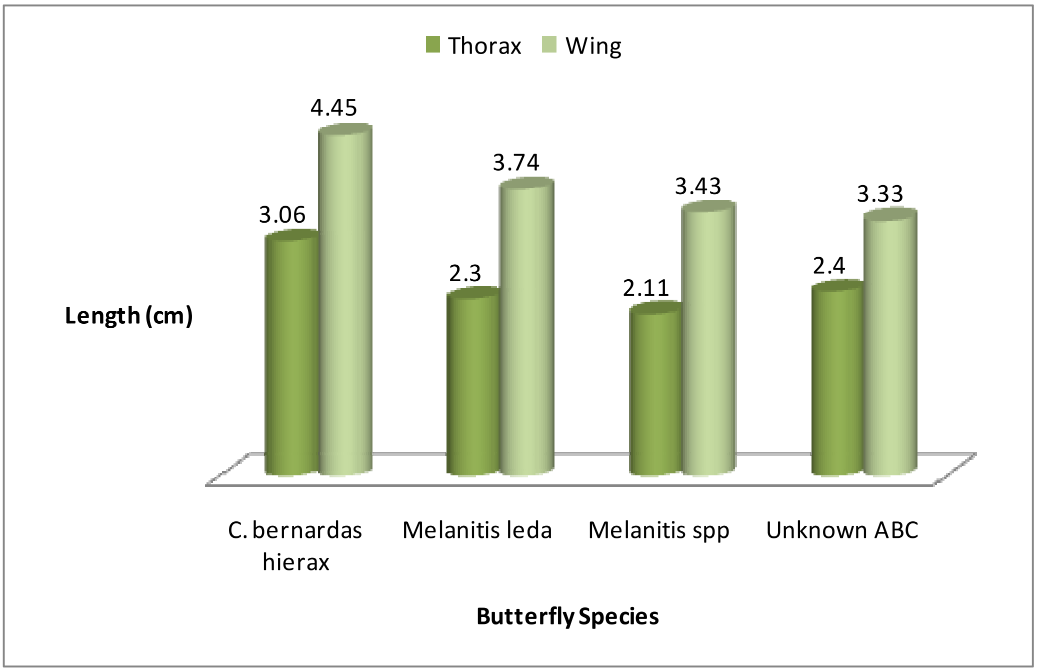


Figure 17. Average thorax length of species encountered 5 times or more and their associated wingspans in Burnt habitat

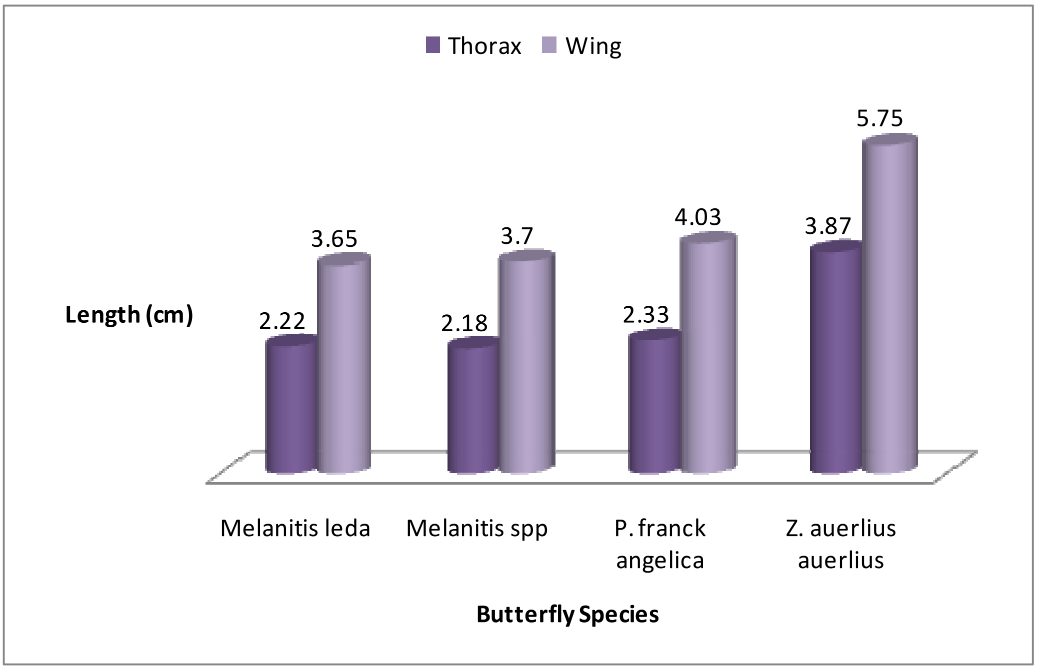


Figure 18. Average thorax length of species encountered 5 times or more and their associated wingspans in mixed peat swamp habitat

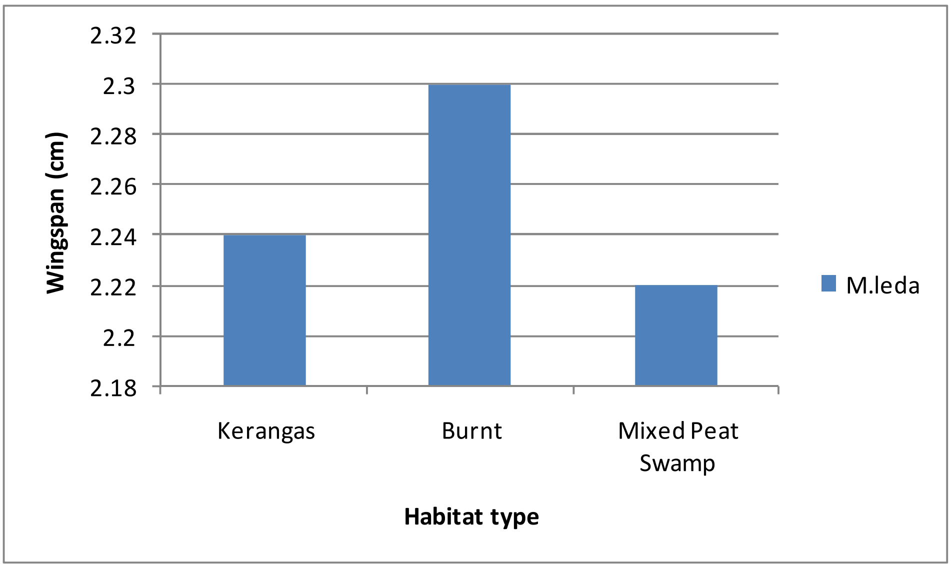


Figure 19. Differences in the average wingspan of *M.leda* caught in all habitat types

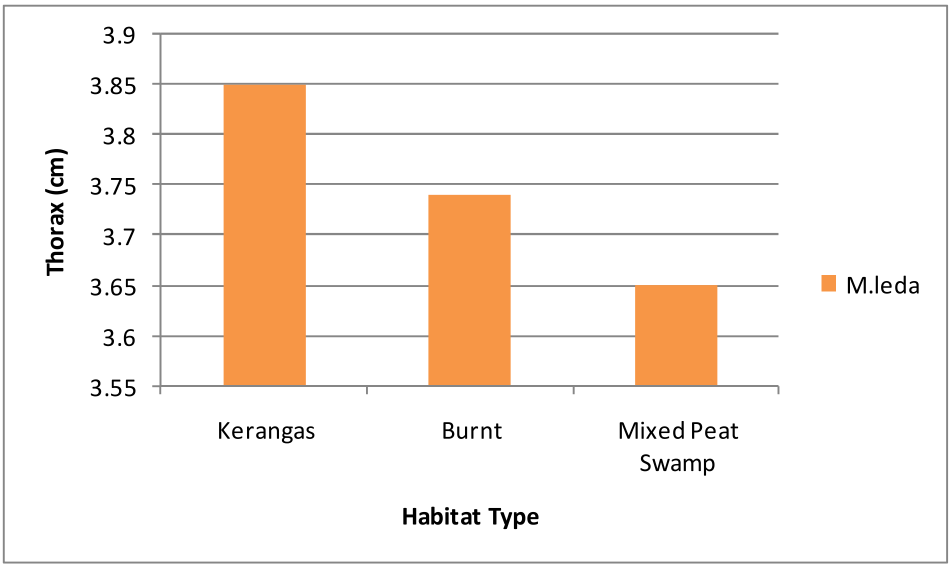


Figure 20. Differences in the average thorax length of *M.leda* in all habitat types

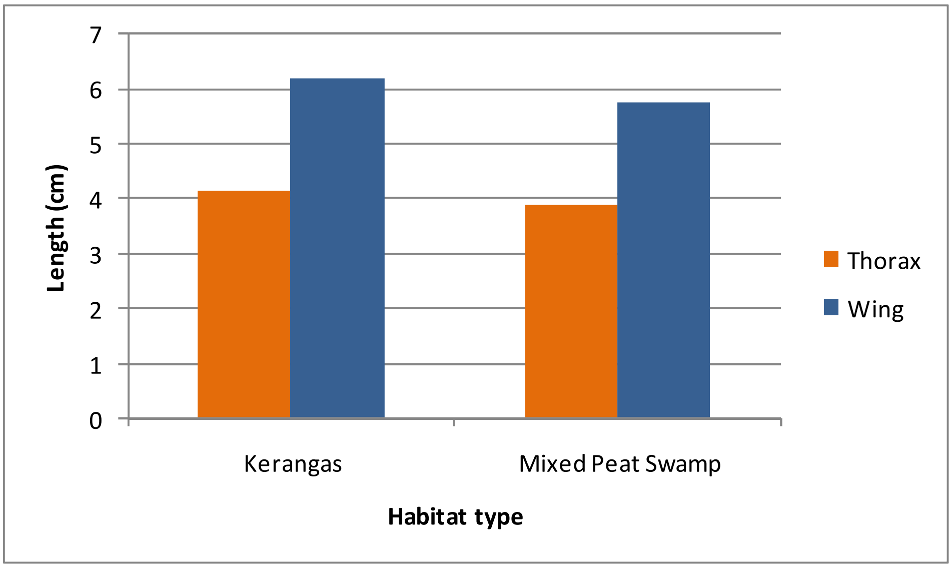


Figure 21. A comparison of Wing and Thorax lengths of *Z. auerlius auerlius* present in two different habitat types

4. Discussion

4.1 ***Sampling Data***

This study utilised the method of trapping butterflies rather than transect walks and visual observations due to weather conditions and the observers' ability to recognise butterfly species. Trapping allowed for time to be taken in identifications and more observations to be made. The measurements of the body and wing were later used to investigate flight morphology.

The study focused on the guild of fruit feeding nymphalid butterflies which represent approximately 75% of nymphalid species in Borneo (Hill *et al*. 2001). Due to restricted captures the identification of more common species made checking the traps a faster process. Sparrow *et al*. 1994 explains how inexperienced workers can effectively be trained to identify and use field guides. Trapping within such a diverse area is the most useful and viable method with less than 5% of butterflies escaping (Hill *et al*. 2001) and no evidence of patterns occurring. All of the observation made came from trapping butterflies. An attempt at hand netting was made before the trial started in a disturbed location with understory re - growth, but it proved too difficult for enough butterflies to show a true representation of the habitat. The technique is viable if a longer sampling effort is maintained, for instance a study in the lowland rainforest of Sabah lasted for over 1,060 trapping days (Hill *et al*. 2001) and the results proved sound.

Even though this study was for a short period of time evidence of the recapture of *Charaxes bernardas hierax* suggest that some butterflies develop recognition of the traps and their food source. Once individual *of Charaxes bernardas hierax* was recaptured a total of 10 consecutive days and 11 days in total. A similar event occurred with an individual of *Bassarona dunya* which was recaptured every day for 11 days (J. Tungah, unpublished). This may suggest that individuals have the ability to become "Trap Happy".

4.2 ***Species Diversity***

During the study a total of 196 individuals of 33 species were recorded. The results do not represent a large fraction of the forest because the study was short term and took place in only one season. Nevertheless, the study is viable according to the confidence of the identification from the observer and Hamer *et al.* (2000) who confirms less than 5% of butterflies escape from the traps. More species and individuals were counted in the pristine Kerangas forest, (Table 1). The founder effect was experienced in all three habitats. This could be due to the use of trapping and restricting other members of the population to gain access, allowing for fewer individuals of various species to exploit the traps. There was a second peak in the diversity on day 8 in the burnt habitat, however during this day and the two previous, the abundance of individuals had plateaued. This could also confirm the founder effect.

The Shannon Index does take into account relative abundance, consequently affecting the diversity to a lower score in the burnt habitat. There were high numbers of *M. leda* encountered. This species has already been seen in Figure 4 as the most abundant of all the species.

There were no significant differences in the diversity of species across the period of the trial or even within the habitats. The least diverse was the burnt area however this was only a small difference from the diversity of the peat swamp. The species diversity has not been affected by the length of the survey. However to gain a better understanding of the difference a longer survey would be necessary.

Even though there were differences of individuals and species number, none are statistically significant and this is discussed later in terms of disturbance with a small spatial scale.

4.3 *Species Accumulation*

A rapid increase in species accumulation at the start of the trial was noted at all three sites, (Figure 11). The steepest gradient and smoothest curve came from species accumulation in the Kerangas forest. Presenting only common species would prevent jagged lines and offer a smoother curve (Sparrow *et al*. 1994). The mixed peat swamp habitat showed an initial high diversity (Shannon Index score, Day 1 = 2.5, Day 2 = 2.9). However this did plateau within a week resulting in the least number of species from all the sites. The accumulation was not consistent in the burnt habitat as it plateaued twice within a short period of time (Figure 11). Further sampling would be required to know the true stopping point of increase. The last habitat to stop accumulating species was Kerangas. Yet, considering this as a valid stationary point would be a weak assumption, as it only lasted for one day and was at the end of the trial. It is not possible to tell if this would have continued or was following the pattern of the burnt area. Further sampling could validate this stationary accumulation. It is especially necessary for the Kerangas habitat to further the sampling effort in accordance to Table 1 and Figure 8 which show the greatest diversity and abundance of all three habitats, suggesting a much larger species pool.

4.4 Flight Morphology

The species that were encountered 5 or more times had their thorax and wingspan measurements compared and analysed. An overall look at the flight morphology graphs (Figure 16, 17, 18.) shows how butterflies with wingspans of over 3.5cm preferred a closed canopy. This contradicts Hill *et al.* (2001) previous study that indicates open canopies have more mobile butterflies. The more mobile butterflies have better flight apparatus which positively correlates with the thorax size to flight speed (Hamer *et al*. 2006). The recorded differences of the thorax were not statistically significant, (Burnt vs Kerangas, $U = 9$, Burnt vs Mixed Peat Swamp, $U = 5$; $P > 0.05$. Mann Whitney U Test). The wingspans measured differently in each habitat however they were not significant either, (Burnt vs Kerangas, $U = 7$, Burnt vs Mixed Peat Swamp, $U = 8$; $P > 0.05$. Mann Whitney U Test). Larger thorax sizes in a closed canopy could suggest the butterflies there were stronger fliers and able to move around the dense forest. With the exception of *M. leda* the butterflies under a closed canopy have a stronger flight speed according to their thorax lengths.

This led on to further comparisons of flight apparatus of the species *M. leda*. It was present in all three habitats with the highest abundance. There were differences in relative thorax (Figure 19) and wingspan (Figure 20). The larger wingspan in an open space was not expected because as Betts and Wootton, (1988) explains those size wings are for slower, agile fliers. *M. leda* are dusk fliers therefore the exposed sunlight should create a presence for light loving butterflies with a more rapid erratic flight mode. The individuals with the larger thorax from *M. leda* were present in the Kerangas forest which could be relative to the vegetation structure of the habitat. The Kerangas forest had a very high canopy and it would be necessary for butterflies to fly higher for their food. The sizes of *M. leda* in the mixed peat swamp can be expected as the quality of the habitat was poor in terms of food and light it also had the lowest canopy height therefore a big thorax is not needed.

Flight morphology is not only associated with habitat quality it has also been related with types of feeders (carrion or fruit) and also sexual dimorphism, (Hamer *et al*. 2006). These aspects were not covered as all sampled butterflies were fruit feeders and there is no other data from this rainforest for Carrion feeders. Also due to complication of sample size, gender was not considered.

Hill *et al.* (2001) has proposed light intensities as an indirect influence on butterfly distribution by the development of the host plant quality. The results do show a change in morphology in accordance with canopy cover; for instance, much larger thorax sizes were associated with the Kerangas and Mixed Peat Swamp, therefore suggesting that stronger fliers are more closely associated with shaded areas. The wingspan of the butterflies in the more open areas all had relatively the same size therefore imply this habitat influences the butterflies' morphology.

There were no strong statistically significant differences in the size or number of butterflies in the three habitats. It is well known that butterflies are used as indicators of habitat quality, however it must be remembered that the disturbed areas and poor quality of habitats were surrounded by pristine forest. Hamer *et al.* (2000) discusses scale dependency. As the spatial scale of disturbance decreased the diversity of butterflies were less responsive to disturbed areas. None of the habitats proved to be significantly similar however the rank between Kerangas and Mixed Peat were on the margin of significance at 0.5917. When analyses were made to compare the butterflies present there were still no significant statistics and this could be based on the principal of how close all the sites were to each other. The main problem with this assumption is that this spatial scale dependency could differ among taxa in relations to mobility (Hamer *et al.* 2000).

4.5 *Dispersal rates and behaviour*

Recapture rates were found to be over double in the more disturbed habitats compared to the undisturbed. There were a total of 81 recaptures and approximately half of which were from the burnt habitat. Less than half of the species caught were recaptured from the burnt area. The majority of the recaptures were from the same species of butterfly. However this species was not the most abundant. Not only were the recaptures from the same species but one individual of *Charaxes bernardas hierax* was recaptured 11 times in the same trap. This was the case in the other recaptures from different habitats. For example in the Kerangas forest *Z. aurelius aurelius* was recaptured 5 times all of which were the same individual. This same behaviour from the species was present in the mixed peat swamp. *P. franck angelica* was not always recaptured in the original trap however the same individual was associated with traps in the local area and traps nearby. A pattern developed between species with a lower abundance and being recaptured but not in the original trap.

The lower recapture frequencies showed a preference for the Mixed Peat Swamp, 9 of the 15 species caught in this habitat were recaptured a total of 18 times. This was the lowest of all the habitats.

There were several interesting individual behaviours that have been discussed however it must be remembered that certain species cannot be used as indicators of habitat quality. *M. leda* for instance has such a widespread flight path and broad-based distribution it would be invalid to consider this species as an indicator of habitat quality. It is clear to see from Figure 4 that *M. leda* has the highest abundance across all habitat types, making it not specialised. Also Figure 14 expresses the observed value of individuals and expected values of each day, on day 14 7 individuals of *M. leda* were caught, 3 of which were recaptures. The estimated population calculated for that day should have been over double the observed value (O = 7, E = 21). This could suggest that with further sampling efforts an increase in abundance would be recorded.

It was difficult to estimate the population of the mixed peat swamp because individuals were only captured once; however from the populations that were estimated only day 11 matched the actual observed value. This problem persisted with the other habitats. However, the useful results were seen in Figure 13 which shows only slight differences in the observed to the expected. This could suggest that the trapping method was sufficient and that the Kerangas habitat was sampled fairly.

5. Conclusion and Recommendations

5.1 *Conclusion*

The three different habitats of Bawan forest that were compared showed that fire disturbance and habitat quality does affect the butterfly species diversity and number of individuals present. However these differences were not statistically significant. It was suggested that because the habitats were close together the butterflies were only subtly affected and could respond and move through the lower quality habitat freely to the pristine forest. From reading published work by people who have studied scale dependency effects of habitats on species, the outcome is not unusual. Hamer *et al.* (2000) found that as the scale decreased, the diversity increased.

It was proven in this study that the most beneficial method of surveying butterflies in Bawan is to trap them. This allows for misidentifications to be at a minimum, as there is plenty of time to photograph the specimen and use keys. It also allows inexperienced observers to feel confident in their finds. Trapping of the butterflies also opened up the opportunity to carry out further investigations into morphology.

The flight morphology proved to be non-significant between habitats. However, there were differences within *M. leda* depending on which habitat it was found in. This did not apply for all butterfly species, for instance *Z. auerlius auerlius* was found in both Kerangas and Mixed Peat Swamp and its wingspan and thorax were approximately the same. The strong fliers had larger thoraxes and were present in the Kerangas forest, whilst more agile slow fliers were present in the burnt area.

To gain protection for Bawan forest and prevent all illegal logging and coal mining activity the results of this study will be combined with all other on-going surveys of Bawan. This data includes orang-utan nest surveys, gibbon density surveys, amphibian diversity and moth surveys. Producing such a report will emphasise the high biodiversity of the forest at Bawan and its importance.

5.2 *Recommendations*

It is possible that the study will be an annual survey process therefore here are some suggestions that may help for it to be carried out again:

- A longer surveying time could produce more patterned results with statistical significance.

- Changing the bait of the traps to a more native food could increase the abundance and diversity butterfly species.

- Checking the traps more than once a day could produce more detailed results on the activities of the butterflies and their flight paths.

- Creating a survey during the wet season could be of interest to see if the butterflies change their preference of habitat type.

- Further investigation on flight morphology of species present in all three habitats needs to be carried out, to produce an understanding of the variation in the size of thorax and wingspan within the same species.

6. Bibliography and Appendices

6.1 References

Barlow, J., Overal, W.L., Araujo, I.S., Gardner. T.A., Peres, C.A., (2007). *The value of primary, secondary and plantation forests for fruit feeding butterflies in the Brazilian Amazon*. Journal of Applied Ecology; 44, 1001 – 1012.

Benedick, S., Hill, J.K., Mustaffa, N., Chey, V.K., Maryati, M., Searle, J.B., Schilthuizen, M., Hamer, K.C. (2006) *Impacts of rain forest fragmentation on butterflies in northern Borneo: Species richness, turnover and the value of small fragments.* Journal of Applied Ecology; 43, 967 – 977.

Charrette, N.A., Cleary, D.F.R., Mooers, A.O. (2006). *Range – restricted, specialist Bornean butterflies are less likely to recover from ENSO – induced disturbance.* Ecology; 87 (9), pp. 2330 – 2337.

Clearly, D.F.R. (2003*). An examination of scale of assessment, logging and ENSO – induced fires on butterfly diversity in Borneo*. Oecologia; 135:313 – 321.

Clearly, D.F.R., Genner, M.J. (2004). *Changes in rain forest butterfly diversity following major ENSO – induced fires in Borneo*. Global Ecology and Biogeography 13, 129 – 140.

Cleary, D.F.R., Mooers, A.O., Eichhorn, K.A.O., Tol, J.V., Jong, R., Menken, S.B.J. (2004*) Diversity and community composition of butterflies and odonates in an ENSO – induced fire affected habitat mosaic: a case study from East Kalimantan, Indonesia.* OIKOS; 105, 426 – 446.

DeVries, P.J., Walla, T.R. (1999) *Species diversity in spatial and temporal dimensions of fruit – feeding butterflies from two Ecuadorian rainforests.* Biological Journal of the Linnean Society.

Hamer, K.C., Hill, J.K. (2000) *Scale dependant effects of habitat disturbance on species richness in Tropical Rainforest*. Conservation Biology; Vol 14, No 5.

Hamer, K.C., Hill, J.K., Benedick, S., Mustaffa, N., Chey, V.K., and Maryati, M. (2006*) Diveristy and ecology of carrion – and fruit feeding butterflies in Bornean rain forest.* Journal of Tropical Ecology 22:25 – 33.

Hamer, K.C., Hill, J.K., Benedick, S., Mustaffa, N., Sherratt, T.N., Maryati, M., Chey, V.K. (2003) *Ecology of butterflies in natural and selectively logged forests of northern Borneo: the importance of habitat heterogeneity.* Journal of Applied Ecology; 40, 150 – 162.

Hamer, K.C., Hill, J. K., Lace, L.A., Langan, A.M. (1997) *Ecological and Biogeographical Effects of Forest Disturnbacne on Tropical Butterflies of Sumba, Indonesia.* Journal of Biogeography, Vol. 24, No.1.

Hill, J.K., Hamer, K.C., Dawood, M.M., Tangah, J., Chey, V.K., (2003) *Rainfall but not selective logging affect changes in abundance of a tropical forest butterfly in Sabah, Borneo*. Journal of Tropical Ecology 19:35-42. Cambridge University Press.

Hill, J.K., Hamer, K.C., Lace, L.A., Banham, W.M.T., (1995) *Effects of selective logging on tropical forest butterflies on Buru, Indonesia.* Journal of Applied Ecology 745-760.

Hill, J.K., Hamer, K.C., Tangah, J., Dawood, M. (2001). *Ecology of tropical butterflies in rainforest gaps*. Oecologia 128:294 – 302.

Kendrick, R.C. (2006). *First South East Asian Lepidoptera Conservation Symposium.* Kadoorie Farm and Botanic Garden.

Ramos, F.A. (2000) *Nymphalid butterfly communities in an Amazonian forest fragment.* Journal of Research on the Lepidoptera.

Sbordoni, V., and Forestiero, S. (1985). *The World of Butterflies: An illustrated encyclopedia*. Book Club Associate: Arnoldo Mondadori Editore S.p.A and Blandford Press.

Spitzer, K., Jaros, J., Havelka, J., Leps, J. (1997) Effect of small – scale disturbance on butterfly communities of an Indochinese montane rainforest. Biological conservation; 80.

Vane – Wright, D., (2003) *Butterflies.* The Natural History Museum, London.

Walpole, M.J., Sheldon, I.R., (1999) *Sampling butterfly in tropical rainforest: an evaluation of a transect walk method.* Biology Conservation; 87:85 – 91.

Willott, S.J., Lim, D.C., Compton, S.G., Sutton, S.L. (1998) *Effects of Selective Logging on the butterflies of a Bornean Rainforest.* Conservation Biology; Pages 1055 – 1065, Vol. 14, No 4.

Website References:

www1: http://news.mongabay.com/2007/0206-unep.html (02.02.11)

http://www.opwall.com/Expeditions/Indonesia/Indonesian%20research%20programme/Dissertations/Forest%20Suggested%20Reading/2011%20Forest%20Suggested%20Reading/IN204%20Forest%20Disturbance%20and%20Butterfly%20Communities.pdf (4.12.10)

http://www.opwall.com/Expeditions/Indonesia/Indonesian%20research%20programme/Projects/Suggested%20Reading/IN101%20Biodiversity%20monitoring.pdf (5.1.11)

http://books.google.co.uk/books?id=m-CEnf3DabIC&pg=PA55&lpg=PA55&dq=Lepidoptera+of+borneo+butterflies&source=bl&ots=U5msvRgptb&sig=uLS-LJvoiKqjdOPP5or6jyXAmD4&hl=en&ei=x0SDTaDfNcSYhQes8Yy4BA&sa=X&oi=book_result&ct=result&resnum=4&ved=0CDAQ6AEwAzgK#v=onepage&q=Lepidoptera%20of%20borneo%20butterflies&f=false (14.2.11)

Appendix

6.2 Full Species list tables

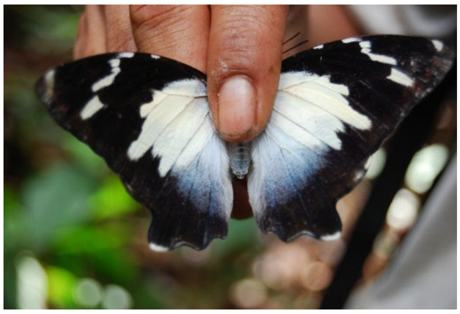
	Habitat 1			Habitat 2			Habitat 3			
Species	Present	Total	Recapture	Present	Total	Recapture	Present	Total	Recapture	
Agatasa Calydonia belisma	1	2	2	1	4	2	1	1	1	
Amathusia spp	1	1	0	0	0	0	0	0	0	
A. amythaon	1	2	1	0	0	0	1	1	0	
Amathusia ochraceofusca ochraceofusca	1	3	3	0	0	0	1	2	0	
Amathusia schoenbergi schoenbergi	1	1	0	1	1	0	0	0	0	
Charaxes bernardas hierax	1	2	0	1	9	19	1	4	2	
Chersonesia rahria rahria	1	1	0	0	0	0	0	0	0	
Discophora necho helvidius	1	2	1	1	1	0	0	0	0	
Dophla evelina evelina	0	0	0	1	1	0	1	2	1	
Euthalia spp	1	1	0	0	0	0	0	0	0	
Lexias cyanipardus	1	2	0	0	0	0	0	0	0	
Lexias dirtea merguia	1	10	2	0	0	0	1	3	2	
Lexias pardalis dirteana	1	2	0	0	0	0	1	10	2	
Melanitis leda	1	7	0	1	19	9	1	11	5	
Melanitis spp	1	1	0	1	8	2	1	5	0	
Mycalesis francisca albofasicata	1	2	1	0	0	0	0	0	0	
Mycalesis igoleta	0	0	0	1	1	0	0	0	0	
Mycalesis orseis nautilis	0	0	0	1	1	1	0	0	0	
Mycalesis pitana	1	1	0	0	0	0	0	0	0	
Mycalesis thyateria	1	9	1	0	0	0	1	2	0	
Neptis ida ida	0	0	0	1	2	0	0	0	0	
Pandita sinope sinope	0	0	0	1	1	0	0	0	0	
Polyura moori moori	0	0	0	1	1	0	0	0	0	
Prothoe franck angelica	1	4	2	1	2	4	1	5	2	
Prothoe franck uniformis	1	2	1	1	1	0	0	0	0	
Tanaecia flora	1	1	0	0	0	0	0	0	0	
Tanaecia munda munda	1	1	3	0	0	0	0	0	0	
Tanaecia munda waterstradti	0	0	0	0	0	0	1	1	0	
Tanaecia palgura consanguinea	1	7	0	1	1	1	1	2	1	
Thaumartis noureddin chatra	0	0	0	1	1	0	0	0	0	
Z. auerlius auerlius	1	5	5	1	2	1	1	9	2	
Unknown 77	1	1	0	0	0	0	0	0	0	
Unknown ABC	0	0	0	1	10	2	1	2	0	
Totals		70			66			60		196

6.3 Butterfly species identification photographs

Plate A

Agatasa calydonia belisma

Plate B



Agatasa calydonia belisma

Plate C

Amuthusia spp

Plate D

Amathusia ochraceofusca ochraceofusca

Plate E

Amathusia schoenbergi schoenbergi

Plate F

Amathusia schoenbergi schoenbergi

Plate G

Charaxes bernardas hierax

Plate H

Charaxes bernardas hierax

Plate I

Chersonesia rahria rahria

Plate J

Discaphora necho helvidius

Plate K

Dophla evelina evelina

Plate L

Dophla evelina evelina

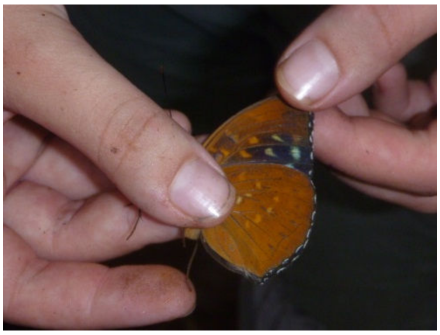
Plate M

Euthalia spp

Plate N

Lexias cyanipardus

Plate O



Lexias dirtea merguia

Plate P

Lexias dirtea merguia

Plate Q

Lexias pardalis dirteana

Plate R

Melanitis leda

Plate S

Melanitis leda

Plate T

Melanitis spp

Plate U

Mycalesis francisca albofasiata

Plate V

Mycalesis pitana

Plate W

Tanaecia munda waterstradti

Plate X

Tanaecia palguna consanguinea

Plate Y

Pandita sinope sinope

Plate Z

Polyura moori moori

Plate Aa

Prothoe franck angelica

Plate Ba

Tanaecia flora

Plate Ca

Tanaecia munda waterstradti

Plate Da

Tanaecia palguna consanguinea

Plate Ea

Thaumantis noureddin chatra

Plate Fa

Zeuxidia auerlius auerlius