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Natural Control on Insects Biodiversity Under Rehabilitation And Regenerated Secondary Forest Canopies, Sarawak, Malaysia

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Abstract: *Generally, Malaysia are still lacking of research regarding insects biodiversity or the insects order itself, except for certain order that were important for agriculture and forestry. The study on insects biodiversity been done at two different forest canopies Rehabilitation Forest and Regenerated Secondary Forest. The insects were captured using four types of methods such as pitfalls trap, light-trap, yellow-pan trap and sweep net. The trap installed within the study area and continuously monitored periodically for a period of 10 weeks.There were 4 insects order recorded in Rehabilitation Forest, come from order of Coleoptera (56%), Homoptera (22%), followed by Hemiptera and Lepidoptera with both order with 11%. With the Shannon-Wiener Index of Diversity (H')= 1.149 with the species evenness = 0.829.*

Keyword: Rehabilitation Forest, Regenerated secondary Forest, insects biodiversity, diversity index, species evenness, Sarawak

Abstrak: *Ketika ini, terdapat banyak definisi mengenai biodiversiti dan kebanyakkannya masih lagi kabur dan kurang jelas, dan konsep ini boleh menimbulkan keraguan. Kajian berkenaan biodiversiti serangga telah dilakukan di hutan yang terdapat di UPMKB dengan membuat perbandingan dua jenis kanopi hutan yang berbeza, iaitu Hutan Rehabilitasi dan Hutan Regenerasi Sekunder. Secara umumnya, Malaysia masih lagi kekurangan kajian berkenaan biodiversiti serangga mahupun order serangga, kecuali bagi beberapa order serangga yang berkepentingsn dalam bidang pertanian dan perhutanan. Lokasi kajian ini terletak di antara kawasan perumahan dan ladang kelapa sawit dan durasi kajian ini adalah sebulan. Kaedah penangkapan serangga adalah seperti berikut, 'pitfall trap', 'light-trap', 'yellow-pan trap' dan kaedah jaring serangga. Bagi kaedah perangkap, ia akan ditinggalkan setelah dipasang dan pemerhatian akan dilakukan secara berkala, jadi penggunaan jaring serangga adalah penting semasa proses mengumpul data perangkap di lapangan. Terdapat 4 order serangga yang direkodkan di Hutan Rehabilitasi, terdiri daripada order Coleoptera (56%), Homoptera (22%), diikuti oleh Hemiptera dan Lepidoptera masing-masing dengan 11%. Dengan Indeks Kepelbagaian Shannon-Wiener (H ') = 1.149 dan data kesamaan spesies = 0.829. Data ini merupakan petunjuk awal bagi menentukan biodiversiti serangga di Kampus Universiti Putra Malaysia Bintulu Sarawak.*

1. INTRODUCTION

Tropical rainforest in Malaysia are known for its richness in flora and fauna diversity. Diversity is often defined as the variety of all forms of life from the level of genes to species through broad scale of ecosystem (Purvis & Hector, 2000; Rasmann & Mooney, 2016). Based on (White and Martin, 2002), they mention that Malaysia has been recognized as the 17 mega-diverse among the countries in the world along with Madagascar, India, Peru, Ecuador, Venezuela, Mexico, China, Indonesia, Australia, The Democratic Republic of Congo, Papua New Guinea, Philippines, South Africa, United States, Colombia and Brazil). Therefore, with the previous records on higher diversity of insect in Borneo (Kato *et al.*, 1995; Nagamitsu and Inoue, 1997). Insects is the most diverse fauna in the world, currently among 1.5 million species of living organisms, insects represent 75%. Insect is a type of fauna that categorized under the Phylum Arthropoda, same with Chilopoda (Centipedes), Crustacea (Crabs, Shrimp) and Arachnida (Spiders).

This studies are focused on the differentiation on the diversity of the insects within two types of forest in Sarawak, by comparing rehabilitation forest with regenerated secondary forest as the manipulated variable. Forest rehabilitation is defined as a coordination of efforts, supported by policy agents to bring back tree cover on formerly. Forested grasslands, brushlands, scrublands or barren areas through planting, seeding and assisted natural regeneration for the purposes (Will, 2010). Secondary forests are forests regenerating largely through natural processes after significant removal or disturbance of the original forest vegetation by human or natural causes at a single point in time or over an extended period, and displaying a major difference in forest structure or canopy species composition with respect to pristine primary forests. forests regenerating largely through natural processes on degraded lands. Regeneration could be enhanced by protection from chronic disturbance, site stabilization, water management and enrichment planting to facilitate natural regeneration (FAO,

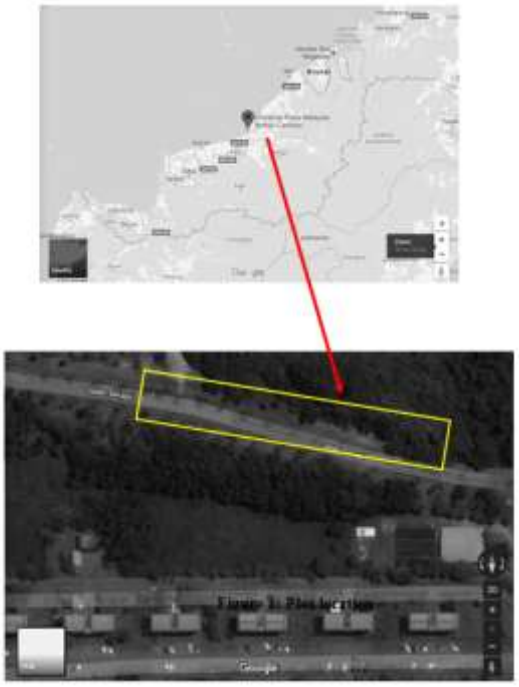
2003). Insects are essential to ecosystem functions as they become the main agent for nutrient cycling. And of course, insects are the agent for plant propagation, as they become the pollinator especially for butterflies (Lepidoptera) and bees (Hymenoptera) and also these insects also become the seed dispersal agent. The existence of insects has maintained the plant community composition and structure. Especially for phytogany insects such as Leaf-cutter ant (Hymenoptera) and grasshopper (Orthoptera). Insects are crucial in the food chain as they become the diet for birds, fish, reptiles and mammals. And among the insects' community itself, they create the chain for balancing its community structure through predation and parasitism.

Last but not least, we cannot doubt that insects are the benchmark for the biological conservation such as larger vertebrates, endangered mammals and birds or plant species. Mostly insects' studies were done by University and this situation needs the researcher and the farmer to collaborate to plan a strategy and prevention against pest invasion (Stoll, 1995). So, significant efforts should be done to preserve natural flora and fauna of an ecosystem in the forest especially in the university thus offering extraordinary opportunities for student learning (Eagan, 1992). Until today, there is no scientific study on insects' biodiversity in UPMKB, and in Malaysia itself, there are still poor study on many insects group except for attractive species such as butterflies, moth and stick insect, agricultural important insects as well as the insects that important to forestry (Cheng & Kirton, 2005). This studies is to identify the main insect order under 2 different canopies in this campus. Plus, it is to assess the efficiency of different types of method. Therefore, this data is important for us to compute insects' diversity richness in different forest canopies.

METHODOLOGY

Sampling sites

This research was carried out to analyse insect biodiversity and it was carried out from March to April 2019. The experiment was conducted at Rehabilitated Forest (Forest Nursery) in University Putra Malaysia Bintulu Campus, Sarawak. The method used in this research consists of five steps. The five stages are preliminary study, sample plotting, trap installation, insect identification and data analysis. The study was conducted at Rehabilitated Forest (Forest Nursery) in University Putra Malaysia Bintulu Campus, Sarawak with coordinates (**03 ° 12'16.7 "N 113 ° 04'04.9" E**) and the elevation for this area is 28m above sea level. This forest is located at the middle to the residential area and oil palm plantation. This area is about 0.21 acre.



Insect sampling

There were 16 pitfalls, one light trap and four yellow-pan traps in each area. Determination of trap installation is done by two methods; base line and random method. Base line method with light trap in centre of each quadrant. Traps for diurnal insects are performed with yellow-pan trap, pitfall, and sweep net. Filled with liquids (liquid soap with water) into a yellow pan trap to breaks the surface tension of water. All these traps are installed in the forest area then abandoned. Interval sampling was performed once every 3 days with 7 times the sampling of insects. for nocturnal insects used light trap traps, it is installed at 6.00 pm. Other traps are also installed at 06.00 pm like yellow-pan trap, pitfall.

Design of trap installation; Baseline and Random

There were two type of trap installation design that been apply in this area. One is using the baseline method, and one is by randomize method. Both of this design was set up to cover up the whole area of the forest. The length of the baseline is 80m and the trap interval is 10m. For pitfall and yellow-pane trap, is was set up 5m from the baseline. And the light-trap was set up at the middle of the baseline and for the random method, it was set up 10m after the last trap. However, the trap installation in the manipulated variable which is Regenerated Secondary Forest is using random design.

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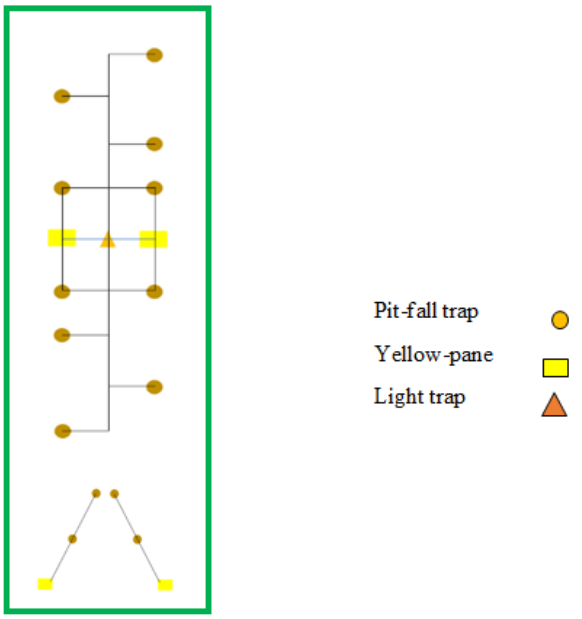


Figure 2: Trap installation design

Insect Preservation and Handling

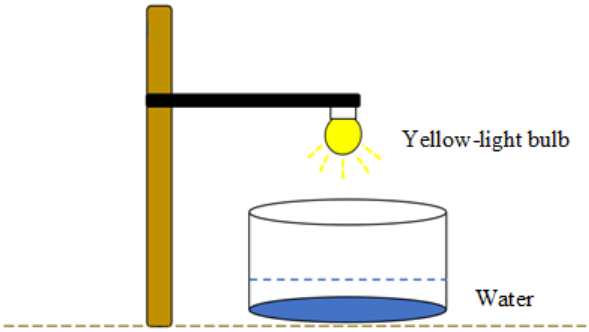


Figure 3: Light trap design. The basin or container is filled with a little of water with a drop of liquid soap on it to form a soapy water (soap act as surfactant)

The insects specimen that been collected were dried and pinned up with different pin sizes according to different insects sizes. But before it was totally dry, first the insects body parts were set up properly eg: wings, legs, antennae. The set up process need to be done slowly and carefully to ensure there is no damaged done to the insects specimen. A perfect specimen collection requires a complete set of insects body parts so that it can identified easily and can be used as a reference in the future. By then, all the specimen will store systematically in the insects collection box.

ANALYSIS OF DATA

Insect Identification

The morphological identification has been done by determining its taxonomy level such as Order, Families, Genus and lastly Species with the aids of reference such as BugGuide.Net and other references. In addition, the captured insects were stored as insect specimen inside the specimen box as for records and future reference.

Figure 4: *Tacua speciose* Cicada (yellow-strip)

Figure 5: *Scapanes australis* Rhinoceres beetles

Shannon-Wiener Index of Diversity (H')

The diversity index was interpreted by many ecologists to indicate the diversity itself in a particular habitat or ecosystem. And these measurements are categorized into three classes, which are species diversity, species richness and species evenness. Species diversity refers to the different number of species and the number of the species itself in the insect community. While species richness refers to the present of the distinct species in one area. The species richness of certain area is shown by the present of species where the more species present. However, a single species richness does not determine the diversity of the area. So, it should be evaluated with the species evenness. Evenness can be defined as the distributions of individuals over species. It is positively to consider that species richness and species evenness is two independent characteristics of biological communities that form its own diversity (Heip, 1974). In addition, species diversity should be assessing through species richness, species abundance and species evenness

(Spellerberg & Fedor, 2003). Shannon and Wiener Index of species diversity is commonly used to ascertain the species diversity (Izsák & Papp, 2000). According to Spellerberg & Fedor (2003), Shannon and Wiener Index can be calculated with the following formula;

Shannon-Wiener Index of Diversity (H')

$$H = \sum_{i=1}^{s} Pi\ (In)\ Pi$$

H = The Shannon-Wiener Index of Diversity
Pi = fraction of the entire population made up of species, *i*
S = Number of species
$\sum$ = sum from species 1 to species S

RESULTS AND DISCUSSION

Major Insects Order and Order Percentage in Rehabilitation Forest

During the sampling study on the insects biodiversity, the total of insects caught and identified in the study plot is 9, comes from 4 order; Coleoptera (beetles): 5, Hemiptera (stainer-bug): 1, Homoptera (cicada): 2 and Lepidoptera (moth): 1. Meanwhile, for the compared plot, a total of 3 different orders were collected, the following orders and number of insects per insect order were observed; Hymenoptera (Black ants): 20, Coleoptera (Beetles): 10 and Blattodea (Bark cockroach & Oriental cockroach): 2. As we can see, there are 4 insects order in Forest Nursery area compared with 3 insects order in Regenerated Secondary Forest. This data shows a slight difference in species variety in both areas. But we clearly see that Coleoptera are the common insects order in both areas. In other words, Coleoptera is the common terrestrial insects that can inhabit different types of forest canopies. Plus, the Coleoptera order are dominated by scarab scavenger beetles, as it appears in both sides. Ecologically, this beetles are a scavenger and it is a decomposer for any fauna species where its show that it is easily adapt to any forest types. The total number of insects caught were analyses as in Figure 6 below. The following percentages of insect orders were recorded in Forest Nursery Area. The highest percentage of insects order was recorded from order of Coleoptera (56%), Homoptera (22%), followed by Hemiptera and Lepidoptera with both order with 11%. Meanwhile, the Regenerated Secondary Forest records a higher differences in order percentage; Blattodea (6%), Coleoptera (31%) and Hymenoptera (63%). We can see the differences between both sites, one is from the dominancy of insects order and another is the number of insects per order. Total percentages of these insects order based on different forest canopies are shown in Figure 7. This percentage shows that the number of insects in Forest Nursery is fewer than the Regenerated Secondary Forest.

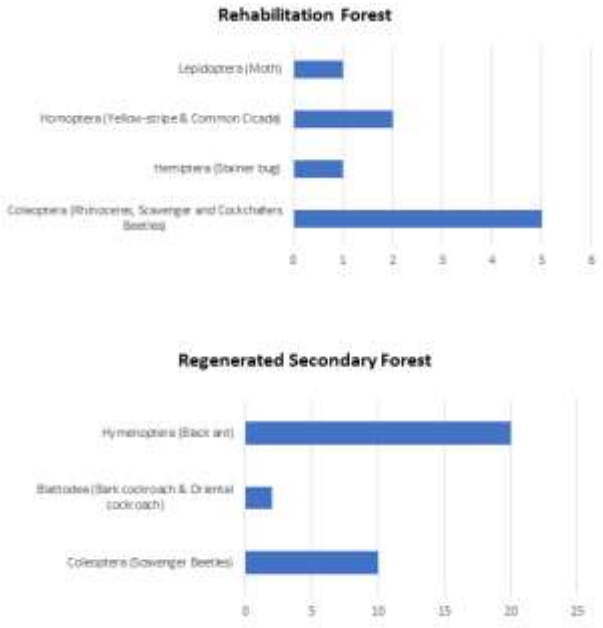
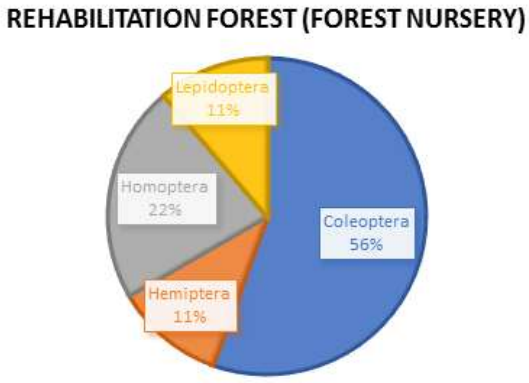
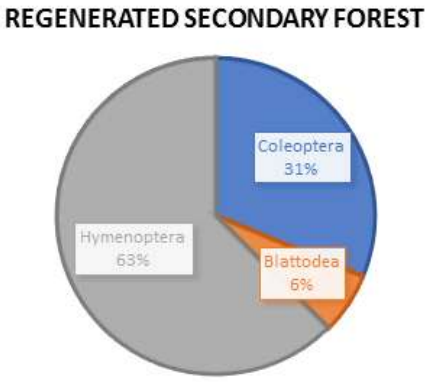


Figure 6: The Total Number of Insects Trapped based on Insects Order





Shannon-Wiener Index of Diversity (H') and Species Evenness

Figure 7: The Total Number of Insects and the Percentage of Insect Orders

Based on the results of diversity index value for both site, it shows that Rehabilitated Forest (Table 1.a) have a higher *Shannon-Wiener Index of Diversity (H')= 1.149* compare to the second site (Table 2.b) with *Shannon-Wiener Index of Diversity (H')= 0.83.* High values of H would be representative of more diverse communities. So it means that the study site is more diverse than the second site. A community with only one species would have an H value of 0 because P_i would equal 1 and be multiplied by ln P_i which would equal zero. If the species are evenly distributed, then the H value would be high. So the H value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the community. Generally, the diversity index for Rehabilitation Forest is 1< H' <3, which means that the diversity is moderate and positively increase. As for the Regenerated Secondary Forest, the diversity index is 0< H' <1 and it shows a slightly low species distribution. Despite of that, the species evenness index for site 1 is 0.829 and the second site is 0.755. Note that species evenness ranges from zero to one, with zero signifying no evenness and one, a complete evenness. Even though that both site have a slight differences for species evenness index, but we can conclude that the second site which is Regenerated Secondary Forest is tend to be dominated by one species as the index is low. Based on the data given, it shows that the area is dominated by Coleoptera especially the Hybosoridae family. But what we can observe that, the index recorded in UPMKB is low compare to the other areas in Borneo that has been recorded by Chung et al., (2016). This may be affected by the forest canopies and biodiversity of the forest itself.

Table 1: Shannon-Wiener Index of Diversity (H') and Species Evenness in Rehabilitated Forest

No.	Insect Order	(n)	(n/N) Relative Abundance	ln(n/N)	n/N*In(n/N)
1	Coleoptera	5	0.556	-0.587	-0.326
2	Hemiptera	1	0.111	-2.198	-0.244
3	Homoptera	2	0.222	-1.505	-0.334
4	Lepidoptera	1	0.111	-2.198	-0.244
	N	9			
	Species Richness (S)	4			
	Number of individuals	9			
	Shannon-Wiener Index of Diversity (H'):	1.149			
	Species Evenness (H'/ln(S)):	0.829			

Table 2: Shannon-Wiener Index of Diversity (H') and Species Evenness in Regenerated Secondary Forest

No	Insect Order	(n)	(n/N) Relative Abundance	ln(n/N)	n/N*In(n/N)
1	Blattodea	2	0.063	-2.765	-0.173
2	Coleoptera	10	0.313	-1.1620	-0.363
3	Hymenoptera	20	0.625	-0.4700	-0.294
	N	32			
	Species Richness (S)	3			
	Number of individuals	32			
	Shannon-Wiener Index of Diversity (H'):	0.83			
	Species Evenness (H'/ln(S)):	0.755			

Method Efficiencies

Each method that been listed are suits for both diurnal and nocturnal insects, and each method have its own advantages and disadvantages. A comparison have been made for each method for both area and the results are shown in Figure 8. Terrestrial insects from Hymenoptera and Coleoptera order were commonly caught using pitfall trap (Rizali, 2002). It is proved by the data obtained in the Regenerated Secondary Forest where all the insects caught by the pitfall trap. As for the Rehabilitation Forest, the sweep net method seems to be the best and the most efficient method. Unfortunately, not even a single insects been captured by the light trap and yellow-pan trap for both area.

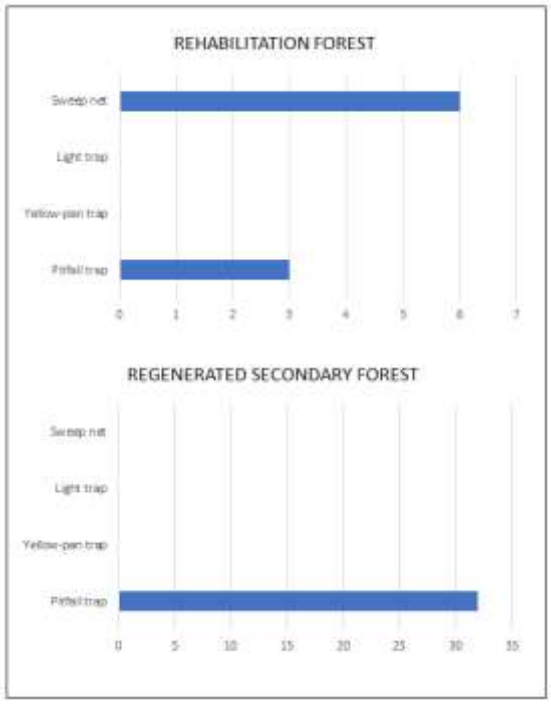


Figure 8: Method efficiencies in both study sites

Observations

Besides of the insects that were captured by the trap, there were also other insects that we've observed and record in Rehabilitation Forest area. Those insects are common in such area: Hymenoptera (weaver ant); Diptera (fly and mosquito). It means that the area actually also been inhabited by other insects that are not included in the data above. However, this data can be used as a reference for other study in the future.

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CONCLUSION

Based on the results, this study successfully recorded a total of 4 insect orders with 9 insects inventory in Rehabilitation Forest. The insects order are Coleoptera, Hemiptera, Homoptera and Lepidoptera. Meanwhile, the Regenerated Secondary Forest records 3 insect order with 32 insects inventory. The *Shannon-Wiener Index of Diversity (H')= 1.149* with the species evenness = 0.829 shows that site 1 is more to diversity compare to the evenness of the insects species. And for the second site, the *Shannon-Wiener Index of Diversity (H')= 0.83* with the species evenness = 0.755 showing that the area is mostly dominated by one insect order. The research on species diversity or any kind of species richness allows ecologists to view the balance of communities (Walker, 1988). The biological interaction between species diversity or richness and community stability is quite complex and hard to be understand. Stability can be defined as the potential of a system to undergo the recovery process to an equilibrium state after disturbance, or some persistent of the system (May 1976). Ecosystem is the main factor that affecting insects abundance. As for Rehabilitation Forest area, the study site is located near to the roads and the oil palm plantation. Most likely the insects are more to the oil palm area compare to the study sites. And most likely why the light trap is unable to attract any insects within the area is because of the existence of other light source from the residential area and the light from the main roads. Despite of that, the abundance of scavenger scarab beetles *(Hybosorus spp.)* in both site and shows its dominancy emphasize that the scavenger types of insects inhabits in most types of forest. We cannot deny its importance in decomposing the organic matter from other form of insects, reptiles or small mammals.

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