International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 3 Issue 7, July – 2019, Pages: 1-8

Quantifying Insects Richness Under Riparian and Rehabilitation Forest Canopies, Sarawak, Malaysia

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***Abstract**: Insects are the largest and more diverse group of organisms on Earth that can be found everywhere especially in the forests. Over the decades, as far as we know, until today there have been limited research were conducted an experiment on insects between Riparian and Rehabilitation Forest. The Riparian forest with coordinate 3 ° 12'33.6 "N 113 ° 05'40.4" E and Rehabilitation Forest with coordinate 03"12'16.7" N 113 "04'04.9" E which located at Bintulu, Sarawak, Malaysia. The study objectives were: identifying the insects order in two different canopies identifying and computing insect biodiversity index richness determine the efficiency of insect trapping. There are four sampling methods employed as 16 pitfalls, 1 light trap, 1 yellow-pan trap, and sweep net. The sampling duration were employed eight weeks at each location. Based on our findings on this research, the most efficient method is by using the sweep net because sweep net is the easiest way to catch the insects because it allows us to move around to catch the insects especially the flying one.*

Keywords: Permanent Sample Plot (PSP); Rehabilitation Forest; pitfall, sweep net.

1. INTRODUCTION

Forest insects are a primary source of much biodiversity in forests because they are highly important food sources for many animals and responsible for much of the nutrient cycling that allows trees and plants to grow. A significant number of insect species also directly prey on bark beetles and other insects and thus would be categorized by humans as beneficial. These include predatory beetles, wasps, hornets, and ants. Insects affect the nutrient and energy flow of ecosystems in many ways; most essentially as decomposers. Burnie (2005) noted that insects are attractive animals, they outnumbered humans by over a billions times, and they make up over a half of all the animal species on the earth. Furthermore, many insects are to be revealed, scientists believe; and have recognized more than one million species. Also, they categorized insects into groups known as orders. Within each order, they shared the same form and features. The major orders include Hymenoptera, Heteroptera, Hemiptera, Coleoptera and Lepidoptera. The insects are grouped together with other animals sharing the same characteristics the phylum Athropoda; except for some unique characters absent in other animals (Akunne, Ononye & Mogho, 2013).

Thus, most of the insects can be found everywhere especially in the forests. Tropical rainforests are one of the most species-rich and functionally important terrestrial ecosystems (Myers et al. 2000). For this study research is evaluated between two types of forest which is Riparian Forest and Rehabilitation Forest. As the research for this study between two types of forests, Riparian and Rehabilitation Forest. Riparian forests have positive effects on water quality and biodiversity. Riparian zones are among the most diverse and functionally important ecotones on Earth (Naiman *et al*. 1998). Insects are the most diverse group of organisms in freshwater streams and rivers. Thus, riparian habitat is the transitional zone between aquatic and terrestrial habitat that extends through areas adjacent to water bodies, into the soil and groundwater, and vertically into the canopy (Gregory et al. 1991). Rehabilitation Forest is to restore the capacity of degraded forest land to deliver forest products and services. Forest rehabilitation re-establishes the original productivity of the forest and some, but not necessarily all, of the plant and animal species thought to be originally present at a site especially on the insects biodiversity within that area like an ants in particular can be useful tools in biodiversity monitoring in a variety of ecosystems, where ant species richness is very high. Ant communities have been shown to respond significantly when their environment is altered therefore making excellent indicators of change. For example, ants have been used successfully to monitor minesite rehabilitation (Andersen 1993).

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In this study research, it is specifically having the objectives (1) to identify the insects order in two different canopies; (2) to compute the insect biodiversity index richness between two types of forests; (3) to determine which trap that are more efficient to use caught the insects.

2. METHODOLOGHY

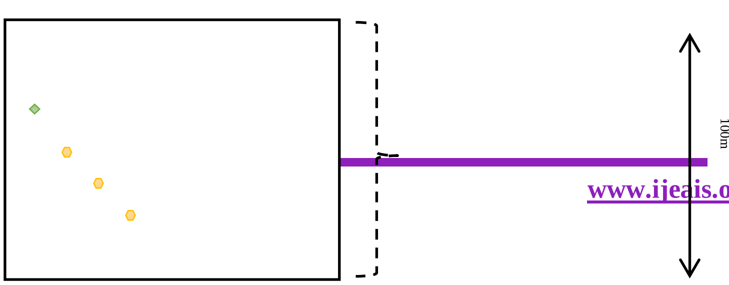
Riparian Forest

The study was conducted to analyze the insect richness between two types of forest and was carried out for two months, starting from March until April 2019. preliminary studies are conducted such as determine design sample plotting, trap installation, insect identification, and data analysis. This experiment was conducted at Permanent Sample Plot (PSP) which is Mixed Dipterocarp Forest and it is located at Borneo Ecological Science Technology (BEST), Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB), Malaysia. The location of the trap at the coordinate position 3 ° 12'33.6 "N 113 ° 05'40.4" E in UPMKB. The area is close to the area that has been developed. The estimated distance taken from the main road to the plot is at distance: 217.13 m (712.36 ft)

Figure 1 : Plot Location

DESIGN OF TRAP INSTALLATION: RANDOM

PSP area of 10,000m² / 1ha. Where there are ten plots in it. One part of the plot represents 10 parts of the sampling plot available. Where, the area is about 50mx20m / 0.1ha in size for one part of the plot. for one part of the plot.



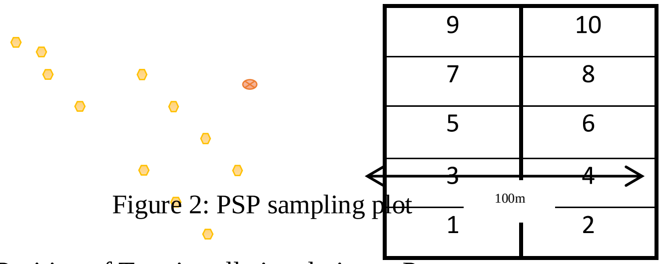


Figure 2: PSP sampling plot

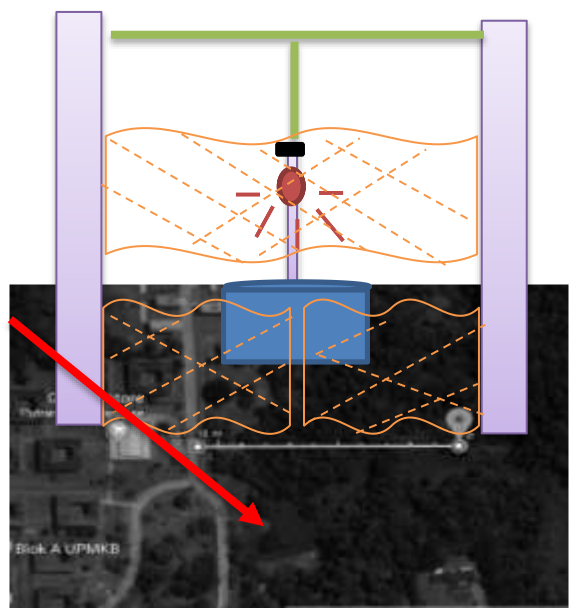
Position of Trap installation design at Permanent Sample at Plot 1 (PSP), UPMKB:

Indication:

1. 1 of Light Trap
2. 16 of Pitfall Insects Trap
3. 1 of Yellow Trap Method

Put insect trap based on: -

1. In areas with less people passing through
2. Area with wooden stumps
3. Near the flowering ginger plant
4. Near the water line
5. The area is not steep



Rehabilitation Forest

Figure 3: Light trap design

The study was conducted to analyze the diversity of insect biodiversity and it was carried out for two months, starting from March until April 2019. preliminary studies are conducted such as determine design sample plotting, trap installation, insect identification, and data analysis. This experiment was conducted at Forestry Nursery which is

Rehabilitated Forest in Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB), Malaysia. The location of the trapping at the coordinate position 03"12'16.7" N 113 "04'04.9" E. The area is close to the area that has been developed. This forest is located at the middle to the residential area and oil palm plantation, and this area wide is about 0.21 acre.

DESIGN OF TRAP INSTALLATION: BASELINE AND RANDOM

There were two types of trap installation design that been applied in this area. One is using the baseline method, and one is by randomizing 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, it was set up 5m from the baseline. And the light-trap was set up at the middle of the baseline and for 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 (Andy, 2019)

What can be found, the method used for both types of installation design trap is to cover the entire forest area. It is used to identify any variety of insect species available. However, a small restored forest area, it is likely to help in monitoring forest health and maintenance ecosystems. We need them to carry out essential processes like pollinating plants, recycling nutrients, sustaining the food chain and keeping forests develop.

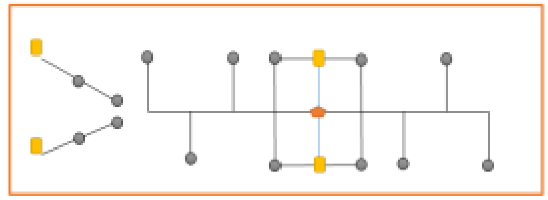
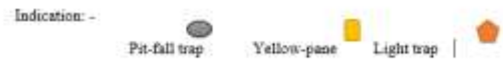


Figure 4: Trap installation design



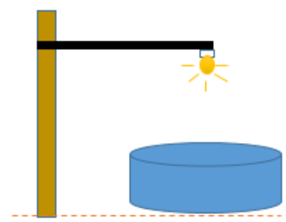


Figure 5: Light trap design

Shannon – Wiener index of Diversity (H')

Shannon-Wiener index of diversity A measure derived from information theories developed by Claude E. Shannon and Norbert Wiener and published in 1949 by Shannon and Warren Weaver, which is used by ecologists when a system contains too many individuals for each to be identified and examined. A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness at the number of species present, and they also take the relative abundances of different species into account. Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure. According to Spellerg & Fedor (2003), Shannon and Wiener Index can be calculated with the following formula:

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

H = The Shannon – Wiener Index of Diversity

P_i = Fraction of the entire population made up of species, *i*

S = Number of species
∑ = Sum from species 1 to species S

3. RESULT AND DISCUSSION

Identifying the insect order in two different canopies

Figure 6: Dorsal view of *Tacua speciosa* showing its yellow collar.

Based on the research that we conducted in rehabilitation forest and riparian forest in UPMKB, Sarawak, we found that there are five type of insect orders that are dominant under those two type of canopies. The insect orders in rehabilitation forest are Coleoptera, Lepidoptera, and Hemiptera, while in riparian forest we got Lepidoptera, Hymenoptera, Coleoptera and Phasmatodea**.** For rehabilitation forest, there are nine insects that were caught. The first one is *Tacua speciosa* from the order of Hemiptera and the family of Cicadidae. It was caught by using sweep net. This species is the only species in its genus and the largest cicada in Borneo. It can be easily identified with a yellow strip on its collar and a turquoise colour on its abdomen. The wingspan can reach about 15–18 cm with a head-body length of 4.7–5.7 cm. This species can be found in Borneo, Sumatra, Java, Singapore and in the Peninsular Malaysia.

Figure 7: Dorsal view of *Orientopsaltria* spp.

The second insect is also from the order of Hemiptera, which is *Orientopsaltria* spp. This species comes from the largest family of cicadas which is Cicadidae. This species has a golden-green abdomen, have prominent eyes set wide apart, short antennae, and membranous front wings. The male produces their din by rapidly vibrating a drum-like membrane located on each side of the body. They typically live in trees, feeding on watery sap from xylem tissue and laying their eggs in a slit in the bark. This insect was caught by using sweep net.

Figure 8*:* Dorsal view of *Dysdercus cingulatus.*

The third insect is also a Hemipteran. It is *Dysdercus cingulatus* from the family Pyrrhocoridae. The locals called it as Cotton stainer bug. This true bug has a white collar and three black spots. *D. cingulatus* is slightly larger and the femora have varying amounts of black which make it different with *D. koenigii* which has completely red femora. Like other true bugs, Dysdercus cingulatus sucks fluids from its host plants, which make it as a crop pest. As this develops, the insect thrusts its rostrum between the carpels and sucks fluids from the still soft seeds inside. Microorganisms are admitted in the process and may make the boll contents rot or the lint become discoloured. Meanwhile, the seeds wither, the fibres may fail to expand and the boll may abort. When the seeds of a host plant ripen and it becomes unsuitable, the adult insects migrate to new host plants of the same or different species. While away from their hosts, they feed on nectar and fruit of non-host plants, and can survive for several days without food. The distribution of this species is in Nepal, Sri Lanka, northeastern India, Bangladesh, Thailand, the Philippines, Sumatra, Borneo, Papua New Guinea and northern Australia. It was caught by using sweep net.

Figure 9*:* Ventral view of *L. staudingeri,* showing its abdomen.

The next insect is *Leucopholis staudingeri* from the order of Coleoptera, family of Scarabaeidae. The local name is Cockchafers. It was caught by using sweep net. It has a brownish stout body, with lots of grey dots on it. The clubbed antennae on its head can be used to sense odours. They are good in digging because of the front legs which are broad and are adapted to do so. *L. staudingeri* has elytra which cover the hind body and protect the hindwings. The elytra are like a hard shell structures which will be raised before it fly. This species usually can be found in Borneo.

Figure 10: Side view of rhinoceros beetles show that the horn resembles rhino's horn.

The fifth insect comes from the same family as *L. staudingeri,* which is Scarabaeidae and is Coleopteran. The scientific name is *Scapanes australis,* while the locals called it as rhinoceros beetle because of the horn resembles rhino's. The body is fully black with two enormous frontwardly directed horns, front recurved horn with small inner tooth near apex of frontal horn. This beetle is a major pest to young coconut trees. Adults bore a gallery into the upper trunk destriying the growing bud and curtailing development of the palm. The beetles will also attack and damage betelnut palm (*Areca catechu*) and banana plants (*Musca* spp.). *S. australis* also attacked young oil palms. Damage took the form of holes in the frond base, midribs of fronds chewed through, ends of fronds V-cut, and stunting and twisting of the growing point sideways with the leaflets of emerging fronds compressed and deformed. In a few cases the young palm was killed. This species is native to the Melanesian region. It was caught by using sweep net.

Figure 11: Dorsal view of *Asota producta.*

The last species that was caught in rehabilitation forest, UPMKB was *Asota producta. A. producta* is a species of noctuoid moths in the family Erebidae, order of Lepidoptera. It is found from Sri Lanka and India to Sundaland. This species is widely distributed throughout Africa, India, Sri Lanka, Myanmar, the Malayan region and tropical parts of the Australian region. The wingspan is 60–71 mm. Forewing has a basal orange patch which extending further along the costa with an extra black spot on the costa. Some subspecies have darker orange and brown colors. Larva has large head. There is a series of dorsal tubercles from forth to terminal somite. Purplish brown with sparse hairs, the thoracic somites pale above. Some pale lateral spots present. There is a dorsal

black line with oblique dorsal streaks found on somites seven to ten. It was also caught by using sweep net.

From the research that we conducted in riparian

Figure 12: The dorsal view of *Faunis gracilis*.

forest which located at Permanent Sample Plot BEST Project, there are five insects that we caught. Firstly, it is from the order Lepidoptera, which is from genus and species *Faunis gracilis*. It was caught by using sweep net. *Faunis gracilis* is a butterfly in the family brush-footed butterflies, Nymphalidae. It was described by Arthur Gardiner Butler in 1867. The distribution is in Sumatra and Malaya in the Indomalayan realm. *Faunis* is a genus of Asian butterflies in the family Nymphalidae. They are among the butterflies commonly known as fauns. They are relatively small-sized amathusiins, subtly colored in soft browns and violets, and range from China to the Philippines and Sulawesi. Larvae

Figure 13: The side view of *C. longicalcar*. The antennae, legs and wings are yellow in colour.

can be found on Musa, Smilax, and Pandanus host plants. Many forms, whether species or subspecies, are restricted to islands and are probably vulnerable. This butterfly ressembles very much its larger cousin *F. canens* and it can be distinguished by its smaller size and two ringed black ocelli with white centre on its hindwings.

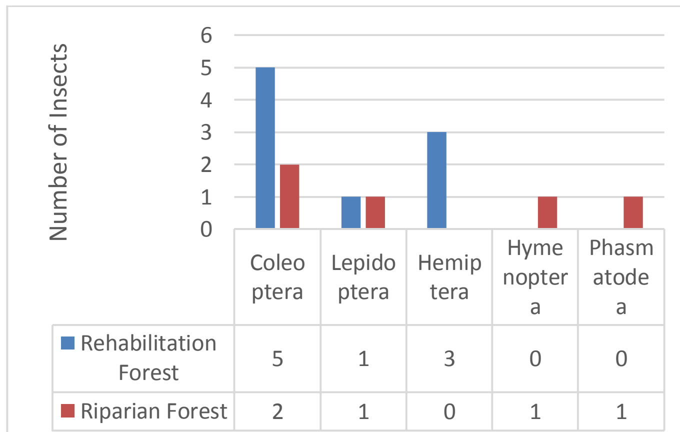
The second insect is from the species *Chorinaeus longicalcar* in the order Hymenoptera from family Ichneumonidae (Ichneumon Wasps). The Ichneumonidae are a parasitoid wasp family within the order Hymenoptera. Unlike other parasites, parasitoids kill their hosts. Ichneumonids are important parasitoids of other invertebrates; common hosts are larvae and pupae of Coleoptera (beetles), Hymenoptera (wasps and relatives), and Lepidoptera (moths and butterflies). About 25,000 species have been described worldwide. Estimates of the total species range from 60,000 to over 100,000 – more than any other hymenopteran family. C. longicalcar has two long pair of antennae with many segments which is yellow in colour with black end. It is also having two pairs of yellow wings and three pairs of yellow legs with a slender waist, a pair of large compound eyes on the side of the head and three ocelli on top of the head. This wasp was seen flying around its nest which is located inside the bark of a dead tree. It was caught by using sweep net.

Figure 14: The dorsal view of *Marmessoidea annulata,* showing its long antennae, three pairs of legs with elongate and cylindrical body.

The third insect which was caught by using sweep net is from the order Phasmatodea. The Phasmatodea are an order of insects whose members are variously known as stick insects, stick-bugs, walking sticks or bug sticks. They are generally referred to as phasmatodeans, phasmids, or ghost insects. The species that we got from this catches was from species *Marmessoidea annulata* which is also called as Yellow and Brown Flying Stick. Marmessoidea is an Asian genus of stick insects in the family Diapheromeridae and subfamily Necrosciinae. It has blueish head, green thorax and reddish legs. The antennae are long with stripes of dark brown and light brown in colour. The body is elongate and cylindrical, resembling sticks, two pairs of reddish wings, the forewings are short and hardened, forming a protective cover over part of the larger membranous hindwings, capable of full flight. Even when fully winged they are weak, clumsy fliers, usually flying for short bursts. Phasmids have chewing (mandibulate) mouthparts, long or short, segmented antennae and two moderately long cerci at the end of their abdomen.

Computing the insect biodiversity index richness between two type of forest

The research shows that order Coleoptera has the highest percentage number of insects compared to another order between this two type of forest. Hemiptera is the second highest in percentage number of insects followed by Lepidoptera, Hymenoptera and Phasmatodea. This is because beetles constitute the largest and most diverse order of insects on earth, making up about 30% of all animals. There are over 300 000 species of beetles worldwide. Meanwhile at the same time Hemiptera (true bugs) shows the largest population size in Borneo, which make it also has high percentage number of insects.



	Coleoptera	Lepidoptera	Hemiptera	Hymenoptera	Phasmatodea
Rehabilitation Forest	5	1	3	0	0
Riparian Forest	2	1	0	1	1

Figure 15: This graph shows that Coleoptera has the highest number of insects in both forest.

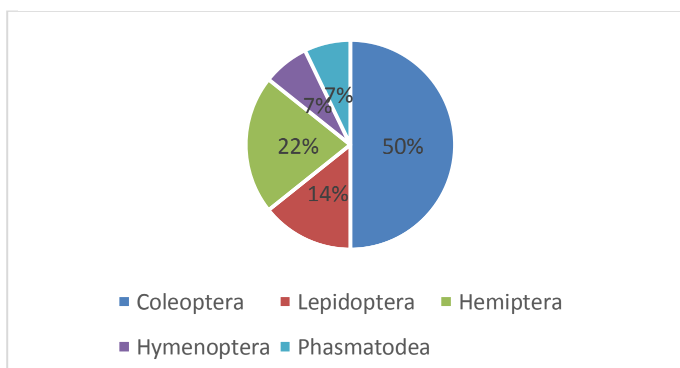


Figure 16: This graph shows that order Coleoptera is dominating the forest while Hymenoptera and Phasmatodea both have low population in rehabilitation forest and riparian forest in UPMKB.

As we know, species richness is the number of species found in a community or ecosystem. Species diversity is a

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measurement of species richness combined with evenness, meaning it takes into account not only how many species are present but also how evenly distributed the numbers of each species are. Based on our findings in rehabilitation forest and riparian forest in UPMKB, we found that riparian forest has the higher species richness compared to rehabilitation forest with 59% and 41% species richness respectively. This is because of the presence of water, which is necessary for the live of insects. Insects are more attracted to a place that has more water and food to stay alive especially in drought season. Meanwhile, species evenness is higher in rehabilitation forest which is 72% compared to riparian forest which is 28%. It means that the species are evenly spread in rehabilitation forest than in riparian forest.

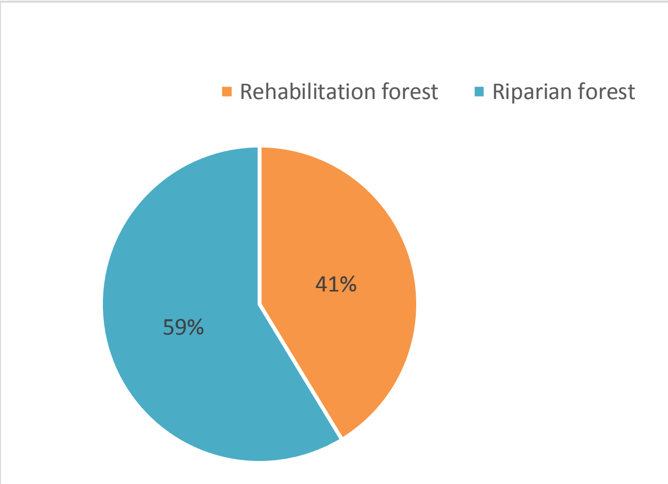

Figure 17: This graph shows that riparian forest has 59% species richness compared to rehabilitation forest which is 41%.

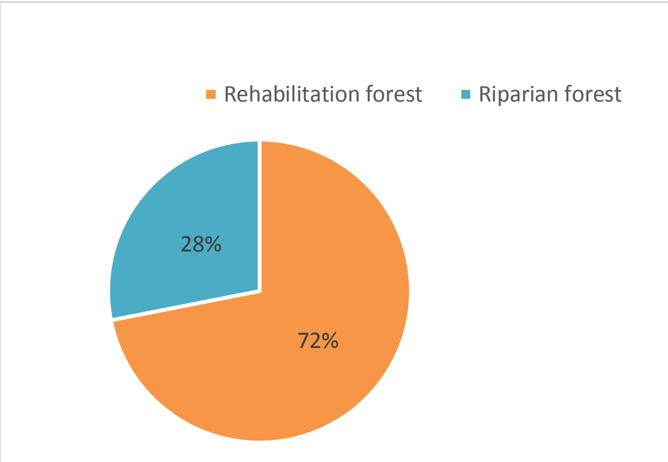

Figure 18: This graph shows that insects are evenly spread in rehabilitation forest compared to riparian forest.

Determining which type of traps that is more efficient

Based on our observation, sweep net is the most efficient type of trap. This can be proved by the number of insects caught by each of the trap. Sweep net caught the highest number of insects in both two canopies, followed by pit fall, light trap and yellow-pan trap. Sweep net is the easiest way to catch the insects because it allows us to move around to catch the insects especially the flying one.

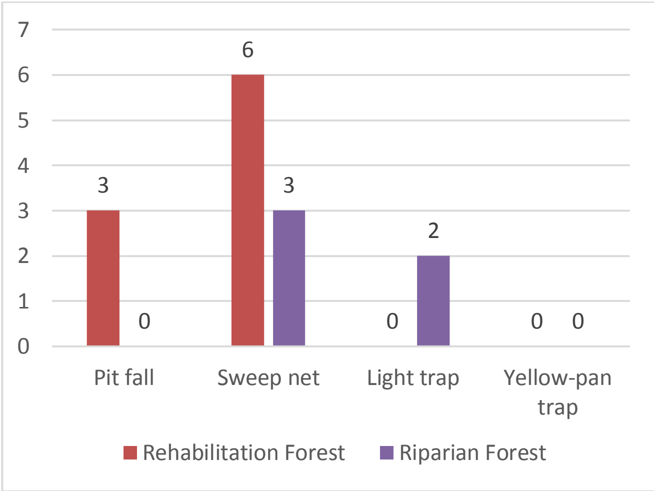

Figure 19: This graph shows that sweep net has the highest catches followed by pit fall, light trap and yellow-pan trap.

4. CONCLUSION

This study research successfully recorded overall fourteen insects with a total eleven different types of species found in the Permanent Sample Plot (PSP) at the BEST Project and also at the Rehabilitation Forest at the Taman Perhutanan UPMKB. The insect are *Faunis gracilis* from the order Lepidoptera, *Chorinaeus longicalcar* from order Hymenoptera, *Leucopholis* spp. from order Coleoptera and order Phasmatodae which the species is *Marmessoidea annulata* were found at the PSP. Thus, at the Rehabilitation Forest, the insects that was found is *Tacua speciose*, *Orientopsaltria* spp, *Dysdercus cingulatus* from the order of Hemiptera, *Leucopholis staudingeri* and *Scapanes australis* and *Hybosorus* spp. from the order of Coleoptera and the last which is *Asota producta* from the order Lepidoptera. This result was shown by using different types of method such as pitfalls, light trap, yellow-pan trap, and sweep net. Based on our observation, sweep net is the most efficient type of trap. This can be proved by the number of insects caught by each of the trap. Sweep net caught the highest number of insects in both two canopies, followed by pit fall, light trap and yellow-pan trap. Sweep net is the easiest way to catch the insects because it allows us to move around to catch the insects especially the flying one. The presence of countless number of insects orders with balanced coexistence of pollinators agent, decomposers, prey and predators both terrestrial insect orders showed healthy.

5. Acknowledgment

This paper and the research behind it would not have been possible without the exceptional support of our lecturer, Dr. Geoffery James Gerusu. His enthusiasm, knowledge and exacting attention to detail have an inspiration and kept our work on track and the comments that greatly improved until the final draft of this paper. We also thank to Mr. George Empin Bala for constructing the method and materials that have been used during this research and also thank our classmates who provided the data and assisted the research for Riparian and Rehabilitation Forest at Bintulu, Sarawak.

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