ABUNDANCE AND DIVERSITY OF DIURNAL INSECTS IN RIVERS STATE UNIVERSITY FOREST ARBORETUM

Ukoima, H. N., Chukunda, F. A., Nimi, I. M &Amadi, N.
Department of Forestry & Environment Rivers State University, Nkpolu-Oroworukwu, Port Harcourt, Nigeria
Corresponding author: ukoima.hudson@ust.edu.ng/08037082778

Abstract
Field experiment was carried out at the Department of Forestry and Environment Arboretum, Rivers State University Port Harcourt between the month of January and February 2021 to investigate the abundance and diversity of diurnal insects. Samples were collected using pitfall trap, bait and camera. simple sampling method was used in data collection. Results showed that Diptera and Lepidoptera were found to be the most abundant and diverse order of insects, followed by Coleoptera, Lepidophtera and Hymenoptera. There was no significant difference in terms of abundance of the diurnal insects.However, there was significant difference ($p \leq 0.05$) between the various insects order that was collected from the field. This work is pioneering and identifies the roles of diurnal insects in plants pollinations and foragingpattern in Rivers State University Forest Arboretum.

Keywords: *Diurnal insects, Abundance, Diversity, Arboretum.*

Introduction

The evolutionary relationship of insects to other animal groups remains unclear. Although traditionally grouped with millipedes and centipedes possibly on the basis of convergent adaptations to terrestrialisation (Russell and Gregory, 2011) evidence has emerged favoring closer evolutionary ties with crustaceans. In the Pancrustacea theory, insects, together with Entognatha, Remipedia, and Cephalocarida, make up a natural clade labeled Miracrustacea. Insects form a single clade, closely related to crustaceans and myriapods. Other terrestrial arthropods, such as centipedes, millipedes, scorpions, spiders, woodlice, mites, and ticks are sometimes confused with insects since their body plans can appear similar, sharing a jointed exoskeleton. However, upon closer examination, their features differ significantly, most noticeably, they do not have the six-legged characteristics of adult insects (Malcolm, 1994). The higher-level phylogeny of the arthropods continues to be a matter of debate and research. In 2008, researchers at Tufts University uncovered what they believe is the world's oldest known full-body impression of a primitive flying insect, a 300-million-year-old specimen from the Carboniferous period (Researchers Discover Oldest Flying Insect 2008). The oldest definitive insect fossil is the Devonian *Rhyniognathahirsti*, from the 396 million-year-old Rhynie chert. It may have superficially resembled modern-day silverfish insect. This species already possessed dicondylic mandibles (two articulations in the mandible), a feature associated with winged insects, suggesting that wings may already have evolved at this time.

The origins of insect flight remain obscure, since the earliest winged insects currently known appear to have been capable fliers. Some extinct insects had an additional pair of winglets attaching to the first segment of the thorax, for a total of three pairs. As at 2009, no evidence suggests the insects were a particularly successful group of animals before they evolved to have wings. Carboniferous and Early Permian insect orders include both extant groups, their stem groups, (Garwood *et al.,* 2010) and a number of Paleozoic groups, now extinct. During this era, some giant dragonfly-like forms reached wingspans of 55 to 70cm making them far larger than any living insect. This gigantism may have been due to higher atmospheric oxygen levels that allowed increased respiratory efficiency relative to today. The lack of flying vertebrates could have been another factor. Most extinct orders of insects developed during the Permian period that began around 270 million years ago.

Many of the early groups became extinct during the Permian-Triassic extinction event, the largest mass extinction in the history of the earth, around 252 million years ago. (Rasnitsyn 2002) The remarkably successful Hymenoptera appeared as long as 146 million years ago in the Cretaceous period, but achieved their wide diversity more recently in the Cenozoic era, which began 66 million years ago. A number of highly successful insect groups evolved in conjunction with flowering plants, a powerful illustration of coevolution (Stein, 2005). Many modern insect genera developed during the Cenozoic, insects from this period on are often found

preserved in amber, often in perfect condition. The body plan, or morphology, of such specimens is thus easily compared with modern species.

Forests are among world's most important in terms of the area of land surface they cover (approximately 30% of all land, over 3.8 billion hectares) and the biodiversity they contain approximately 90% of terrestrial biodiversity, (FAO, 2000). Forests serve as a reservoir of biodiversity and serve as recreation and tourism centers. Invertebrates account for the greatest amount of biodiversity in forest ecosystems.Several studies from different parts of the world have provided evidence to support the view that deforestation and other forms of habitat disturbance can cause reduction insect abundance and species richness. (Eggleton*et al.,* 1995) in Cameroon. These studies brought about general consensus in the field of insect conservation that the most important factor maintaining diversity is maintaining appropriate habitat (Pullin 1995).

However, our understanding of the impact of deforestation and other anthropogenic activities on insect species richness and abundance in Nigerian forests is poor due to lack of published information. Although, appreciable attempts have been made to quantify the impact of deforestation on global species extinction, resulting in estimates of global species extinction rates of 1-10% species per status of insect diversity conservation in Nigeria (Reid 1992). These estimates have all been obtained by extrapolating from known relationships between species richness and habitat area. The fate of many species of organisms following forest disturbance is uncertain (Lugo 1988) and there is a need to measure directly the impact of deforestation and forest disturbance on insect diversity and abundance. There is also the need to quantify the impact of forest plantations and other land use activities on insect diversity and abundance (Laurence 2006).

Despite the fact that insects account for the greatest amount of biodiversity in forests, they are the least studied of all fauna (Cardoso *et al.,* 2011; Zou 2011). Research on the impact of tropical forest management practices on insects are currently limited to individual species (e.g. Eggleton 1995, 1996; Estrada and Fernandez *et al.,* 1999; Davis *et al.,* 2001). Knowledge of insect community response to disturbances in forests is scanty. Also, little is known about the population little is known about the population, dynamics and management potentials of many forest insects. The possibility of manipulating forest vegetation or harvest practices to maximize or sustain forest insect population in Nigeria is yet to be carefully investigated.

Furthermore, no group of insect in the country has received significant attention and this makes it difficult to make knowledgeable decisions about out their population, diversity, the likely impact of forest disturbance on these insects and timely conservation strategies to the current losses. As a result, there is need for further studies on insect taxa globally especially in the areas listed as hotspots for biodiversity such as Nigeria (Lugo, 1988; Reid 1992).

The purpose of this research is to answer the question on the diversity and abundance of diurnal insects that are found around the forestry arboretum located in rivers state university, since the research done on insects has very height species richness in the forest and also they have found insects which use the forest floor and tree crowds as their habitat and home. The arboretum will be no different in anyway, therefore the need to study and understand the diversity and abundance of diurnal insects will help to further research on the conversation and perversion of the various insect species in the arboretum.

Specific objectives of the study are to determine abundance and diversity of diurnal insects at the Rivers State University forest Arboretum.

Materials and Methods

Study Area

The experiment was conducted at the Teaching and Research farm of Rivers State University (Forestry Arboretum unit) NkpoluOroworukwu Port Harcourt. The farm is situated on Latitude 4.46°N and Longitude 7.10°E with an elevation of 18m above sea level (Chukunda,*et al* 2014).

Materials
The Materials used are Pitfall Trap for the collection of ground dwelling insects, three types of baits (fruits - pawpaw placed in the center of the traps, meat -beef cubes placed on a Petri dish at the centerand artificial scentsplaced on filter paper and thumb tacked to the center of the platform). The same baits were used throughout the experiment and replaced as necessary to maintain freshness.

Cameras: This was used to take photos or video of the various insects captured within the forestry arboretum.

Large Screw Driver: was used to access difficult to collect locations, such as under bark, in logs, behind walls, dry dirt.

Sampling Technique
The traps were checked during the morning and afternoon hours. No specific tree was utilized as a control, the total number of specimens were recorded form each site, separated by time of collection, and by bait type and placing them in bags according to tree and trap each insect was found in. Specimens were brought to the laboratory for identification. Species were separated based on morphological features and later identified using field guides.

Experimental Design/ Statistical Analysis
This study makes use of simple random sampling method, every tree in the arboretum had an equal channel of becoming part of the research, each trap was 50m apart from each other.

The diversity indices of the taxa during the weeks of collection were determined using the palaoritological statistics software 3.18. The species richness on number of taxa and the abundance of individual for each week of collection was calculated. Insect species diversity was quantified by Simpon's index, Shannon- Weiner index, Dominance, Evenness, Brillouin, Menhinick, Margalef, Equitability test, Fisher alpha, Berger-Parker and chao-1.
Simpon's index

$$\mathbf{D} = \frac{ni\,(ni-1)}{N\,(N-1)}$$

Where:
ni= the total number of organisms of each individual species of insects
N= the total number of organisms of all species of insects

Menhinick Formula $$R = \frac{S}{\sqrt{N}}$$

Where, R= Menhinick's (1964) insects species index
S= Number of insects
N= Total number of individauls insects

Abundance Formula $$= \frac{Total\ number\ of\ Individual\ species\ sof\ insects}{Total\ number\ of\ insects\ population}\ X\ 100$$

Results
The results on the abundance of Diurnal insects found in the Rivers State University Forest Arboretum are presented in Figures 1-10 and Plates 1-10 respectively. Results of insects collected from week 1-4 showed that Diptera samples had thirteen (13) insect species and the most abundant was blue butterfly (34%) in the fourth week followed by Rhinophoride (28%) in the first week of collection and the least was yellow fever mosquito and common green butterfly (10%) within the week two. Coleopteran significantly had eleven (11) species with rain beetle (35%), Strapis (28%) and Ground beetle (26%) occurrence in the field results obtained.

The order Lepidoptera, there were nine (9) Diurnal insect species found as seen in Figure 2 and Plates 2a and b. The most frequently captured were papilodemodocus and myrina in all the weeks. However, Hymenoptera order had nine (9) Diurnal insects with the Bullet ants frequently occurred followed by furmicinae (sugar ant) and the least was Apocrita.

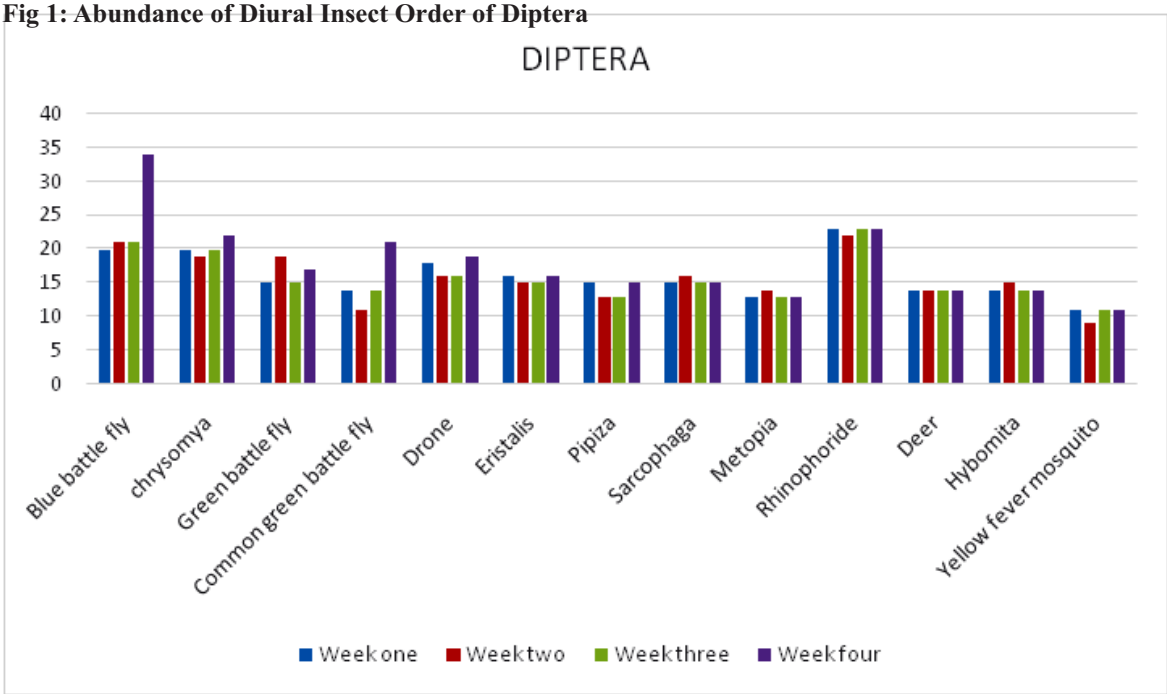
Whereas in the order of Spodoptera seven (7) specific Diurnal insects were captured and the most frequent were Chomoidea, Bombycidae, Cossidea and Miller. Blathodea had four (4) specific species with Blathidae having the highest frequency of occurrence followed by Ectobundae. The Odonata order had four (4) Diurnal insects

identified and the most frequent occurring insect in the field was Darners. Orthoptera had three (3) insect species; Jersulem cricket (37%) as the highest followed by Gyloidea (20%) and the least was Diestrammena.

In the heteroptera order, there were two (2) insects identified namely; Assassin bugs and Ambush bugs though the first were mostly found though Dictyoptera had only two (2) insects found and identified. The termite was predominately found compared to Mantis.

The results on diversity of the insect order found in the Rivers State University Forest Arboretum (Table 4.1). Results showed that Simpson's Diversity Index of the Diurnal insects revealed that there was significantly ($P \leqslant 0.05$) diversity among the various insect order. However, Hymenoptera was the most diverse followed by the order Diptera.

Fig 1: Abundance of Diural Insect Order of Diptera



A

Plates 1 (a): Green Battle Fly

B

(b): Rhinophorid Fly

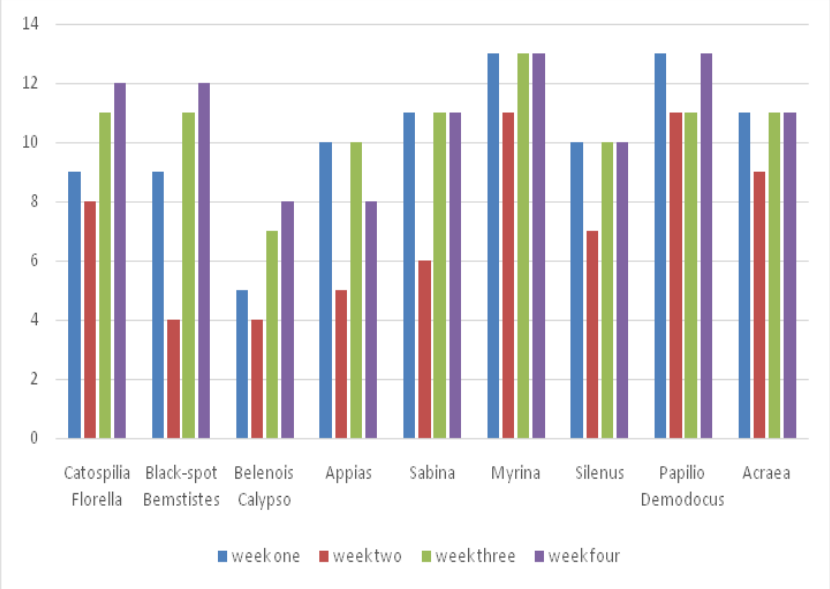


Fig 2: Abundance of Diural Insect Order of Lepidoptera

A **B**

Plates 2 (a): Myrina butterfly
(b): PapilioDemodocus butterfly

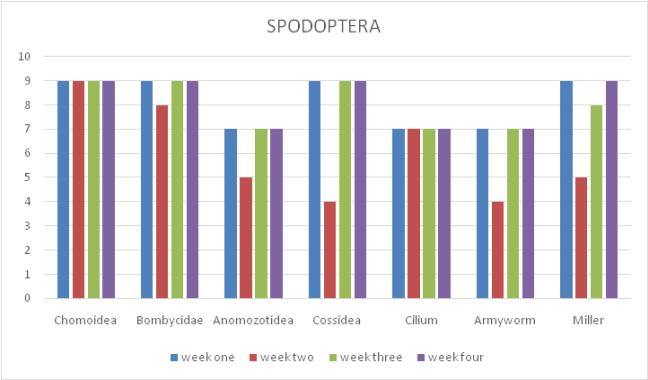


Fig 3: Abundance of Diural Insect Order of Spodoptera

A

B

Plates 3 (A): Choreutidae moth **(B)** Bombycidae moth

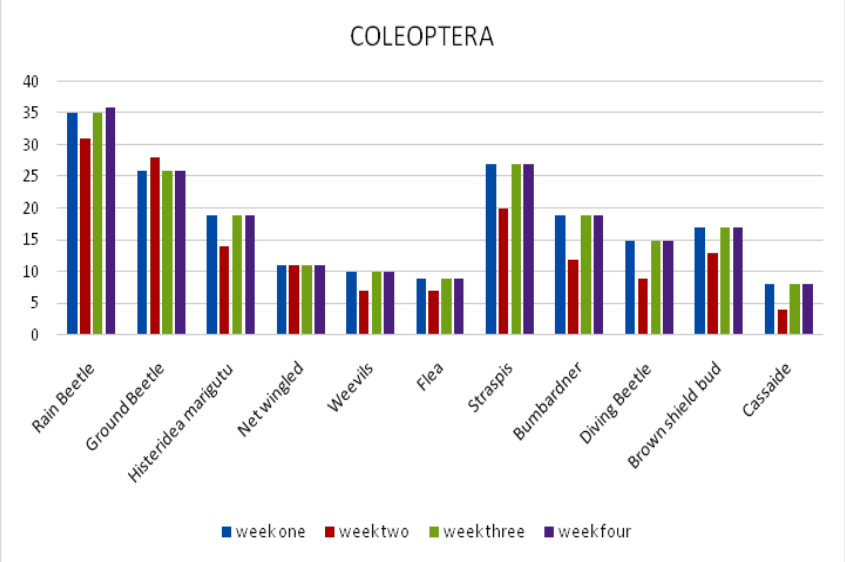


Fig 4: Abundance of Diural Insect Order of Coleoptera

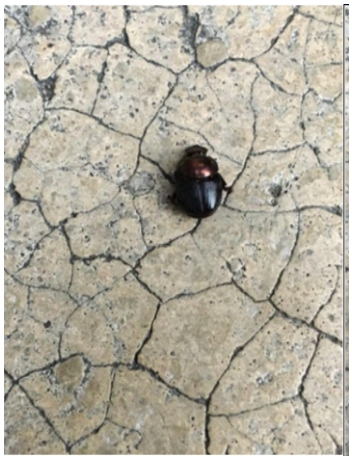


Plate 4 (a): Photograph of Rain Beetle4 **(b):** Photograph of Ground Beetle

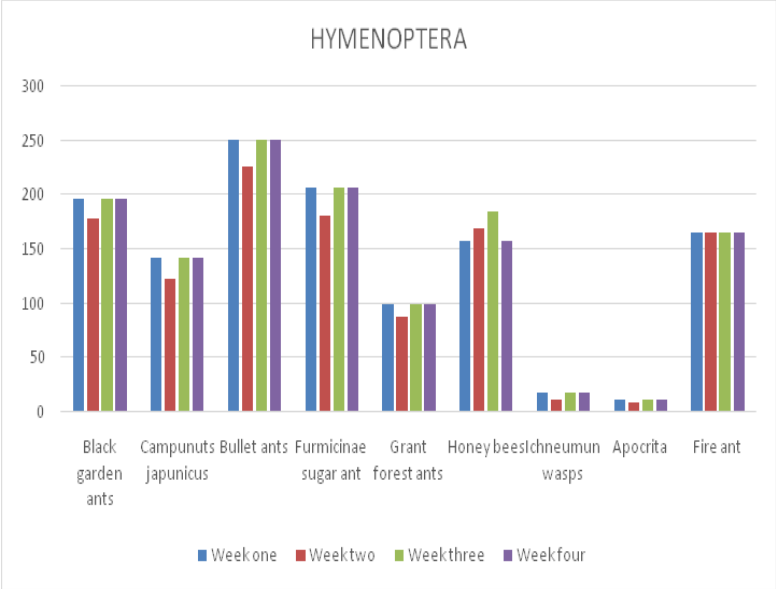


Fig 5: Abundance of Diural Insect Order of Hymenoptera

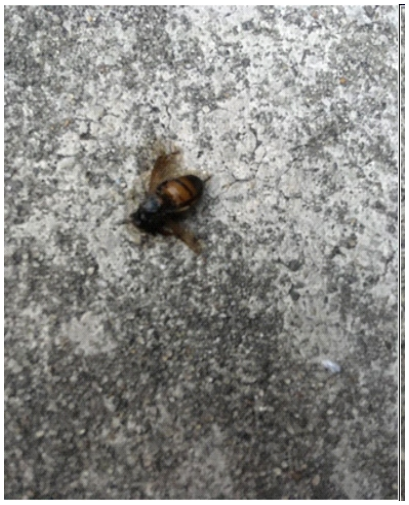
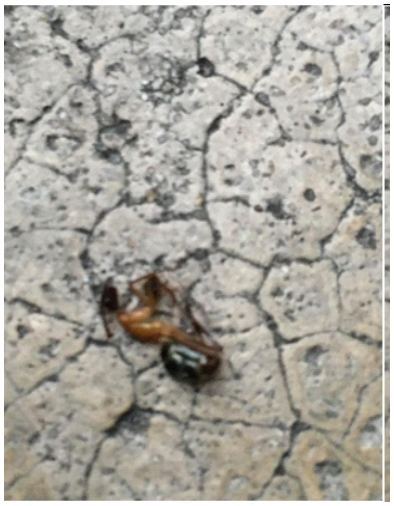


Plate 5 (A): Bullet ants



5 (b): PHoneybees

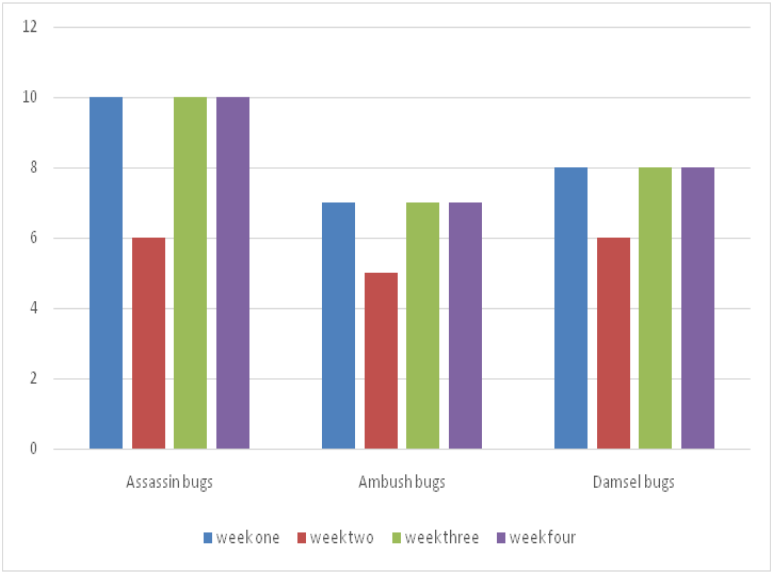


Fig 6: Abundance of Diural Insect Order of Heteroptera

A

B

Plate 6 (A): Assassin bug

(B) Damsel bug

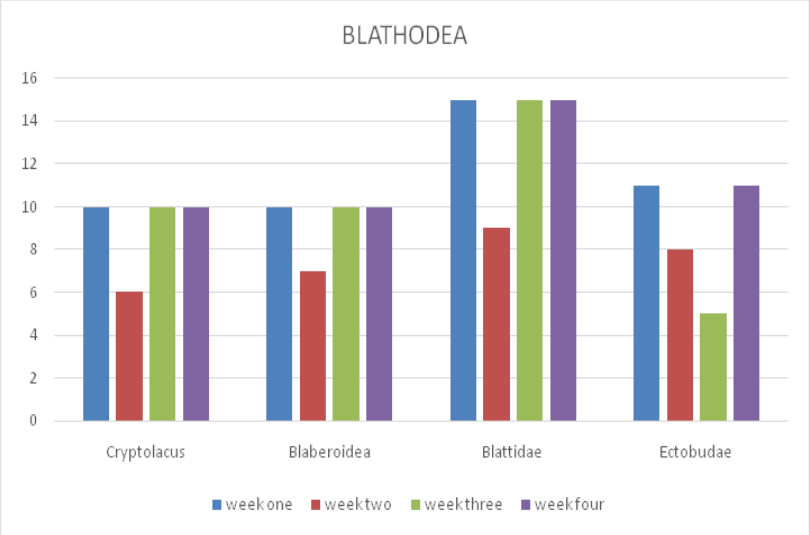
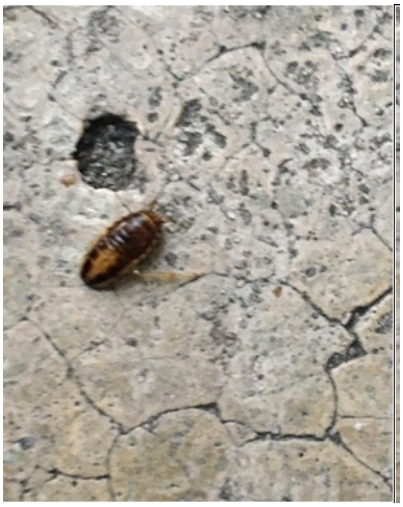


Fig 7: Abundance of Diural Insect Order of Blathodea

A



B

Plates 7 (A) Blathodae

(B) Ectobudae

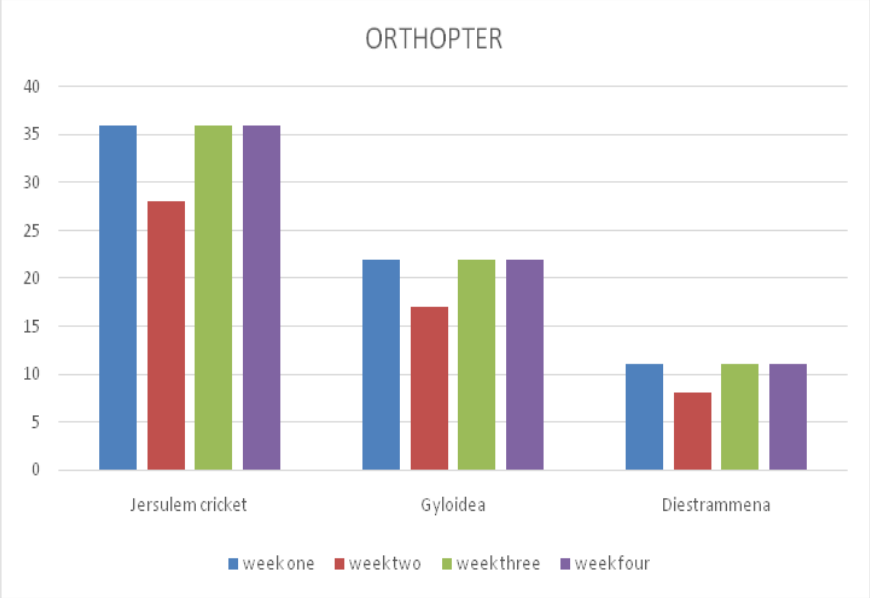


Fig 8: Abundance of Diural Insect Order of Orthopter

A

Plates 8 (A): Jerusalem cricket

B

(B): Grasshopper

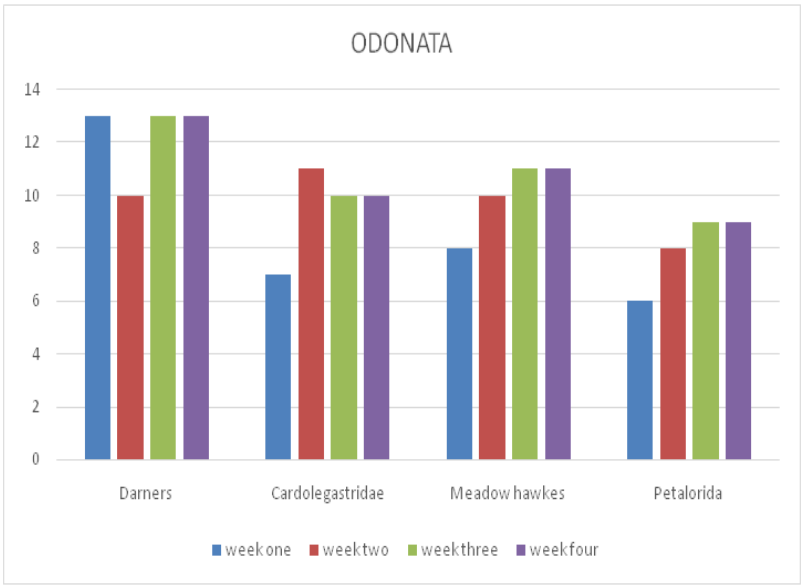


Fig 9: Abundance of Diural Insect Order of Odonata

A

B

Plates 9 (A): Darners

(B): Cardolegastridae

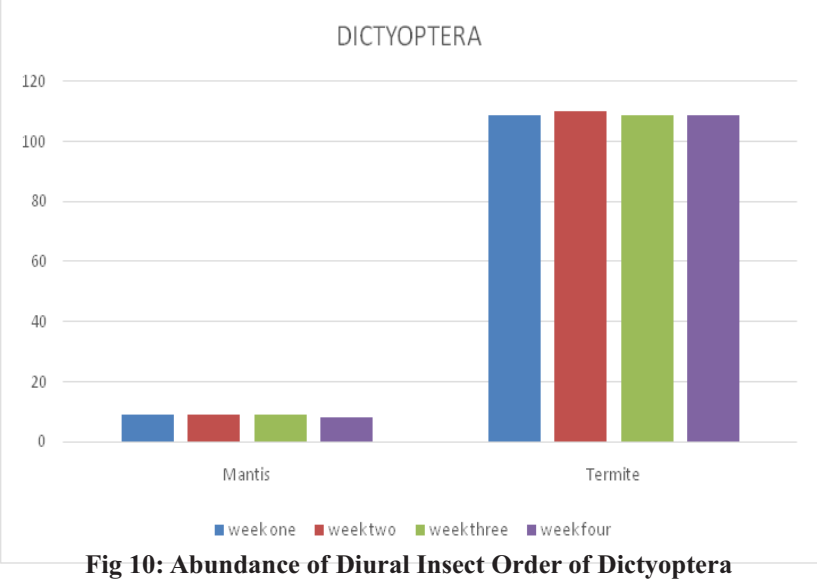


Fig 10: Abundance of Diural Insect Order of Dictyoptera

Plate 10 (a): Mantis

A

(A) Mantis

B

(B): Termite

Table 1: Diversity Index of Diurnal Insects Order in Rivers State University Forest Arboretum

	Diptera	Lepidoptera	Spodoptera	Coleoptera	Hymenoptera	Heteroptera	Blathodea	Orthoptera	Odonata	Dictyoptera
Taxa_S	4	4	4	4	4	4	4	4	4	4
Individuals	67	39	30	68	546	31	44	87	42	229
Dominance_D	0.2515	0.2571	0.2533	0.2526	0.2503	0.2508	0.2562	0.2525	0.2517	0.25
Simpson_1-D	0.7485	0.7429	0.7467	0.7474	0.7497	0.7492	0.7438	0.7475	0.7483	0.75
Shannon_H	1.383	1.371	1.379	1.381	1.386	1.385	1.373	1.381	1.383	1.386
Evenness_e^H/S	0.9971	0.985	0.993	0.9946	0.9993	0.9984	0.9868	0.9948	0.9965	1
Brillouin	1.289	1.231	1.209	1.288	1.368	1.218	1.244	1.304	1.249	1.351
Menhinick	0.4887	0.6405	0.7303	0.4851	0.1712	0.7184	0.603	0.4288	0.6172	0.2643
Margalef	0.7135	0.8189	0.882	0.711	0.476	0.8736	0.7928	0.6718	0.8026	0.5521
Equitability_J	0.9979	0.9891	0.9949	0.9961	0.9995	0.9988	0.9904	0.9963	0.9975	1
Fisher_alpha	0.9328	1.117	1.24	0.9287	0.5848	1.223	1.069	0.8658	1.087	0.6884
Berger-Parker	0.2836	0.2821	0.2667	0.2647	0.2582	0.2581	0.2727	0.2644	0.2619	0.2533
Chao-1	4	4	4	4	4	4	4	4	4	4

Discussion

Results on the diversity of the various order of insects collected are shown in Table 1.The results showed that there were significant differences ($p \leq 0.05$) in the insects collected. Insects such as Lepidoptera, Odonata and Coleoptera were very active when the weather is hot but less active during the cold weather which supports the work done by Ukoima*et al.,* (2016). Insects such as the honey bee and spodoptera were present as floral visitors in the arboretum as documented by Ukoima*et al.,* (2016) and Chukunda*et al.,* (2016).

The order of Hymenoptera had the highest percentage of relative abundance of 59.83% of the total insects collected, followed by Diptera 10.41% and it is in line with the work done by Michael (2006) who showed that there are differences in diversity and species richness of insects found at day and night. This work also revealed three domineering insect order namely, Hymenoptera, Diptera, Coleoptera in the arboretum as supported by the research done by Stork (2018). The three commonly occurring insects in the arboretum were the bullet ants, furcininae sugar ants and black garden ants all in the order of Hymenoptera.

Some of the insectss are parasitic in nature though play important roles in ecology which also support the work done by (Vincent, 2012) and that done by Chukunda*et al.,*2016. Hysmenoptera had the highest percentage of relative abundance 38.46% of the total insects collected. It was follow by the order Orthopterai with 28.20% of the total insects collected. It was observed that there were significant differences ($p<0.05$) in diversity and species richness of insect found at night and day, diurnal insects exhibited higher species richness and diversity.

Conclusion

This study showed the diversity of insects within the order and the abundance of the order in the arboretum and what kind of baits or tools that can be used to attract the various order of insects. In terms of diversity Diptera had more diversity within the individuals species. Hymenoptera was the most abundant.

Acknowledgement

With special thanks to Dr. S.O.N Dimkpa for identifying the insects collected from the Rivers State University Forest Arboretum.

References

Cardoso P., Erwin T.L., Borges A.V & Paulo T.R (2011). *The seven impediments in invertebrate conservation and how to overcome them."* Archived 19 May 2011.

Chukunda, F.A., Ukoima. H. N., Abere, S.A &Ebere, N (2016). Abundance and diversity of insect visitors to flowers of *Moringa oleifera* at Forestry and Environment arboretum. *Research Journal of Forestry,* 3 (2), 1-8.

Davis, A.J., Holloway, J., Huijbregts, H., Krikken, J &Sotton S.L (2001) *"Dungbettes as indicators of change in the forest of northern borneo.*

Eggleton, P., Bignell, D.E., Sands W.A., Waite B., Wood T.G & Lawton J.H., 1995. The species richness of termites under forest levels disturbance in mbalmayo forest Reserve, southern Cameroon. *"Enhancement of symbiosis between butterfly caterpillars between butterfly caterpillars and ants by vibrational communication".Science. 248 (4959), 1104–1106.*

Erwin, T. L., Pimienta, M. C., Murillo O. E &Aschero V. (2004). *Mapping patterns of biodiversity for beetles across the western Basin: a preliminary case for improving conservation strategies". Proceedings of*

the California Academy of Sciences 56, 7285
Estroda, C & Fernandez, F (1999) *"Diversity of ants (hymenoptera gradient of a cloud forest cnarino Colombia).*
Food and Agriculture Organization (FAO) 2000. *"Global Forest Resources Assessment. FAO paper"*. Available from http://www.fao.org/docrep/004/y1997e00.htm.
Garwood, R. J., Sutton, M. D. (2010). "X-ray microtomography of Carboniferous stem-Dictyoptera: New insights into early insects".Biology Letters. 6(5), 699–702.
Laurance W.F., 2006 *"have we overstated the topical biodiversity crsis? Tands in ecology and evolution"*. (34).
Lugo, A.E (1988) *"estimating reductions in the diversity of tropical forest species"*.
Malcolm W. B. (1994). "Evolution of insect flight". Archived from the original on 18 February 2021.
Rasnitsyn, A.P &Quicke, D.L.J. (2002). "History of Insects". Kluwer Academic Publishers.
Reid W.V (1992) *"How many species will there be? In whitemore T.C. and Sayer J.A. tropical deforestation and species extincition"*.
Russell, G & Gregory, E (2011). "Early terrestrial animals, evolution and uncertainty". Evolution: Education and Outreach. 4(3), 489–501.
Stein, J. C (2005). "Coevolution and Pollination". University of Cincinnati. Archived from the original on 30 March, 2021.
Stork, N. E. (2018*)* "How many species of insects and other terrestrial Arthropods are there on Earth?". *Annual review of entomology.* 63(1): 31-45.
Ukoima, H. N., Chukunda F. A., Abere, S. A &Ebere, N (2016). Diversity and abundance of insect visitors to flower of *Irvingagabonensis* at Forestry and Environment Arboretum. *EntomologyandApplied Science Letters,* 3 (2), 1-9.
Zou V., Feng J., Xre D & Sang W (2011). *"insects diversity, addressing an important but strongly neglected research topic in china*
Aizen, M.A &Feinisinger, P. (2002) "bees not be? Responses of insects pollinator and habitat fragmentation" 23 **
Ashworth, L., Aguilar, P.L., Gelrtto, L &Aizen, M.A (2004). "Why do pollination generalist and specialist plant species show similar reproductive suscepatibity to habitat fragmentation?"Journal of Ecology, 92. **
Bart G & Dave L (2003). P5A.6 "Fine-Scale Vertical Structure of a Cold Front As Revealed By Airborne 95 GHZ Radar" Archived 7 October 2008 at the Wayback Machine. University of Wyoming. Retrieved on 26 April 2009. **
Bonneton, F., Brunet, F.G., Kathirithamby J. &Laudet, V. (2006). "The rapid divergence of the ecdysone receptor is a synapomorphy for Mecopterida that clarifies the Strepsiptera problem". Insect Molecular Biology. 15 (3): 351–362. **
C.B.N (2001). *"Annual report and statement of account for the year ended 31st December 2001"*, 142. **
Cardoso P., Erwin T.L., Borges A.V & Paulo T.R (2011). *The seven impediments in invertebrate conservation and how to overcome them."* Archived 19 May 2011.
Chapman, R. F. (1998). "The Insects; Structure and Function (4th ed.)". Cambridge, UK: Cambridge University Press. **
Chukunda, F.A., Ukoima. H. N., Abere, S.A &Ebere, N (2016). Abundance and diversity of insect visitors to flowers of *Moringa oleifera* at Forestry and Environment arboretum. *Research Journal of Forestry,* 3 (2), 1-8.
Davis, A.J., Holloway, J., Huijbregts, H., Krikken, J &Sotton S.L (2001) *"Dungbettes as indicators of change in the forest of northern borneo.*
Dudley, R (1998). "Atmospheric oxygen, giant Paleozoic insects and the evolution of aerial locomotor performance". Journal of Experimental Biology.201 (8), 1043–1050. **
Eggleton, P., Bignell, D.E., Sands W.A., Waite B., Wood T.G & Lawton J.H., 1995. The species richness of termites under forest levels disturbance in mbalmayo forest Reserve, southern Cameroon. *"Enhancement of symbiosis between butterfly caterpillars between butterfly caterpillars and ants by vibrational communication".Science. 248 (4959), 1104–1106.*
Emma, T.L., Pimienta, M.C., Murillo, O.E &Aschero, V (2004). Mapping patterns of biodiversity for beetles across the western Amazon basin."Journal of Experimental Biology. **
Erwin, T. L., Pimienta, M. C., Murillo O. E &Aschero V. (2004). *Mapping patterns of biodiversity for beetles across the western Basin: a preliminary case for improving conservation strategies". Proceedings of theCalifornia AcademyofSciences* 56, 7285
Estroda, C & Fernandez, F (1999) *"Diversity of ants (hymenoptera gradient of a cloud forest cnarino Colombia).*
Food and Agricultural Organization (FAO) 2005. *"Towards sustainable forest management"*. Available from www.mongabay.com **
Food and Agriculture Organization (FAO) 2000. *"GlobalForestResourcesAssessment. FAO paper"*. Available from http://www.fao.org/docrep/004/y1997e00.htm.
Garwood, R. J., Sutton, M. D. (2010). "X-ray microtomography of Carboniferous stem-Dictyoptera: New insights into early insects".Biology Letters. 6(5), 699–702.
Gilliott, C (1995). "Entomology (2nd ed.)". Springer-Verlag New York, LLC.

Grabowska, M., Godlewska, E., Schmidt, J &Daun-Gruhn, S (2012). "Quadrupedal gaits in hexapod animals – inter-leg coordination in free-walking adult stick insects".Journal of Experimental Biology. 215 (24), 4255–4266. **

Gullan, P.J & Cranston, P.S. (2005). "The Insects: An Outline of Entomology (3rd ed.)". Oxford: Blackwell Publishing. **

Huffaker, C. B & Gutierrez, A.P. (1999). *"Ecological entomology".* John Wiley and Sons, Inc. New York, USA.**

Ikawa, T., Okabe, H., Hoshizaki, S. Kamikado, T & Cheng, L. (2004). "Distribution of the oceanic insects Halobates (Hemiptera: Gerridae) off the south coast of Japan". Entomological Science. 7 (4), 351–357. **

Imeht N &Adeubola N. (2001). "The effects of poverty in conservation of biodiversity; the Nigeria experience" (23). **

Jockusch, EL; Ober, KA (September 2004). "Hypothesis testing in evolutionary developmental biology: a case study from insect wing. Journal of Heredity".95(5), 382–396. **

Johnson, K. P., Yoshizawa, K & Smith, V. S. (2004). "Multiple origins of parasitism in lice". Proceedings of the Royal Society of London. 271. **

Kendall, D. A. (2009). "Classification of Insect". Archived from the original on 20 May 2009. Retrieved 20 May 2009. Retrieved 9 May 2009. **

Laurance W.F., 2006 *"have we overstated the topical biodiversity crsis? Tands in ecology and evolution".* (34).

Lo, N., Tokuda, G., Watanabe, H., Rose, H., Slaytor, M., Maekawa, K., Bandi, C & Noda, H (2000). "Evidence from multiple gene sequences indicates that termites evolved from woodfeeding cockroaches".Current Biology.10(13): 801–804. **

Logo, A.E (1988) *"estimating reductions in the diversity of tropical forest species".* **

Longino, J. 2004. *"Arboreal ant species richness in primary forest, secondary forest, and pasture habitats of a tropical montane landscape".Biotropica*, 36(3): 402-409. **

Malcolm W. B. (1994). "Evolution of insect flight". Archived from the original on 18 February 2021.

Merritt, R. W. Cummins, K. W & Berg M. B. (2007). "An Introduction to the Aquatic Insects of North America (4th ed.)". Kendall Hunt Publishers. **

Oliveria C.M., Auad A.M., Mendes S.M. &Frizzas M.R. (2014). *"Crop losses and the economic impact of insects pests on Brazilian Agriculture".Crop Prot.,* 56,5 0-54 **

Pullin A.S (1995). *"Ecology and conservation of butterflies".* Chapman and Hall, London 363

Rasnitsyn, A.P &Quicke, D.L.J. (2002). "History of Insects". Kluwer Academic Publishers.

Refinetti, R. (2006). "Variability of diurnality in laboratory rodents". Journal of Comparative Physiology A. 192(7), 701–714. **

Reid W.V (1992) *"How many species will there be? In whitemore T.C. and Sayer J.A. tropical deforestation and species extincition".*

Rice, C.M., Ashcroft, W.A., Batten, D.J., Boyce, A.J., Caulfield, J.B.D., Fallick, A.E., Hole, M.J., Jones, E., Pearson, M.J., Rogers, G., Saxton, J.M., Stuart, F.M., Trewin, N.H & Turner, G. (1995). "A Devonian auriferous hot spring system, Rhynie, Scotland". Journal of the Geological Society,152(2): 229–250. **

Rosmoser, W. S. &Stoffolano, J. G 1998. *"The science of entomology".* WCB/McGraw Hill, Boston, Massachusetts, USA.**

Russell, G & Gregory, E (2011). "Early terrestrial animals, evolution and uncertainty". Evolution: Education and Outreach. 4(3), 489–501.

Spitzerk., N.V., Tonner M &Lep S.J (1993)." Habitat preferences, distribution and season ability of the butterflies (Lepidopapiliondea)". **

Stein, J. C (2005). "Coevolution and Pollination". University of Cincinnati. Archived from the original on 30 March, 2021.

Stork, N. E. (2018*)* "How many species of insects and other terrestrial Arthropods are there on Earth?". *Annual review of entomology.* 63(1): 31-45.**

Terry, M. D & Whiting, M. F (2005). "Mantophasmatodea and phylogeny of the lower neopterous insects" .Cladistics. 21(3): 240–257. **

Ukoima, H. N., Chukunda F. A., Abere, S. A &Ebere, N (2016). Diversity and abundance of insect visitors to flower of *Irvingagabonensis* at Forestry and Environment Arboretum. *EntomologyandApplied Science Letters,* 3 (2), 1-9.

Whiting, M.F (2002). "Mecoptera is paraphyletic: multiple genes and phylogeny of Mecoptera and Siphonaptera" .ZoologicaScripta.31(1): 93–104. **

Wing S&Yates, D. (2008). Birds migrate together at night in dispersed flocks, new study indicates. Archived 22 Jun 2012 at WebCite University of Illinois at Urbana–Champaign. Retrieved on 26 April 2009. **

Zou V., Feng J., Xre D & Sang W (2011). *"insects diversity, addressing an important but strongly neglected research topic in china*