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Diversity and Abundance of Insects Species in Makurdi, Benue State, Nigeria

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Abstract— **Insects are unique in their own way and contributes all types of services to the ecosystem. In order to develop effective global insects' conservation strategies there is the need to target species at local or regional scales. The current study was therefore designed for the very first time to document the diversity and abundance of insects in Makurdi, Benue State, Nigeria. Five sites reflecting different levels of disturbances and different land use covers were selected within Makurdi metropolis: Hudco Quarters North Bank (HQN), Benue State University Zoological Garden (BZG), Gyado Villa (GYV), High Level (HLV) and Akpehe (APH). Insects were collected from the months of October to November 2017. Three methods of insect collection were used; Pitfall method, Sweep net method and Hand Picking. Diversity indices were measured at each site using Simpson's, Shannon, Menhinick's and Margalef's indices, while similarity between sites and trapping methods was assessed using Sorensen's similarity index. There was no significant difference in the diversity of insect species between sites ($F(4, 50) = 0.000375$, $P>0.05$), However, GYV had the highest diversity index and Species Richness (d) but lowest dominance Index, while, APH had lowest species richness and highest dominance. When the indices were converted to Shannon Effective number of species (ENS) to show the true diversity, GYV had the highest value for ENS while BZG had a lowest value. This is an indication of dominance because where there is a high degree of dominance; the ENS value will be less than the species richness. The Order Odonata was the most dominant and it occurred at BZG than all the other sites. Sorensen's similarity index between sites was from 89% to 100%, an indication that all insects can occur at all sites. There was a significant difference between the trapping methods ($F(2, 17) = 6.7965$, $P<0.05$) with the sweep net having the highest average catch. However the similarity between trapping methods was approximately 67% between sweep net and pitfall while it was 53% between hand collection and sweep netting. This difference in the trapping method possibly accounted for the high numbers of winged insects in the collection. The ENS of the area was 7, this is low, but also an indication that more effort should be channeled into insect monitoring and conservation.**

Index Terms— **Diversity, Dominance, Species richness, Effective Number of Species, Insects.**

I. Introduction

Insects are unique in their own way and play an important ecological role for survival of life on earth, their diversity is indeed an intrinsic part of the earth's ecosystem [1]. The crucial functional roles insects' ensure delivery of various ecosystem services [2]. According to [3], ecosystem services are principally four types namely; provisioning services, such as production of fibre, clean water, and food; regulating services, obtained through ecosystem processes that regulate climate, water, and human diseases; cultural services, such as spiritual enrichment, cognitive development, reflection, recreation, aesthetics and finally, supporting services which include all other ecosystem processes, such as; soil formation, nutrient cycling, provisioning of habitat, production of biomass and atmospheric oxygen.

As members of the ecosystems, insects contribute all four types of services and the economic value of these ecological services provided by insects has been pegged to approximately $60 billion a year in the United States alone, and this is only a fraction of the value for all the services they provide [4]. Also insects have been used in landmark studies in biomechanics, climate change, developmental biology, ecology, evolution, genetics, paleolimnology, and physiology [5].

The tropics have been reported to be home to about 70% of the global biodiversity [6] and Nigeria is an afro-tropical country with her vegetation zones lying within the Guinea Forests of West African Biodiversity Hotspots [7]. It has also been identified as the region with the most severely threatened forests in the world and it is estimated to have lost about 55.7% of its primary forest mainly to anthropogenic activities [8].

There is currently a global interest in the estimation of insects' diversity of an area as it will aid in the development of conservation strategies, however, this will be more effective if it is targeted at local or regional scales [9]. This would possibly remove the ambiguity that may result when conservation efforts are approached globally with limited consideration for local scale dynamics that shape insect diversity loss and conservation needs [10]. There is also the need to have an understanding of the variation in insect species composition and relative abundance between different sites [11].

Makurdi is a richly agrarian community in the North Central part of Nigeria; the people are engaged in subsistence agriculture and nomadic farming. They are also engaged in other anthropogenic activities such as logging, subsistence agriculture, collection of fuel Wood for energy etc. This has made the vegetation fragmented in addition to modification by road and house constructions [12].

The current study was therefore designed for the very first time to document the diversity and abundance of insects in Makurdi, Benue State, Nigeria. This information is not only useful for agricultural, medical and veterinary purposes, but

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will also probably for the very first time, give an insight into the insect species richness of Makurdi; an information that is very critical for management and conservation purposes.

II. MATERIALS AND METHODS

A. Study Area

The study was carried out at Makurdi, Benue State, Nigeria. The state derives its name from River Benue the second largest river in the country and it is located in the central region of the country lying between latitude 7^0 13' and 7^0 49' North and longitude 8^0 15' and 8^0 42' East in the Guinea Savannah vegetation zone of Nigeria. The State belongs to the Koppen's Aw climate group and it experiences two distinct weather conditions, dry season which starts from October to March and wet season which starts from April to September. It has a mean temperature of 28°C, which sometimes rises to about 37°C. Rainfall ranges between 12,000-20,000mm. The state covers an area of about 34,059 square kilometers with a population of over 4.2 million people [13]. The vegetation of Benue State still possesses relics of the guinea savanna with coarse grasses and numerous species of scattered trees. According to [14], dense forests are very few and far apart in the state and exist either as village forest, gallery forest and forest reserves. In these forests typical rain forest tree species found are trees such as *Khaya senegalensis*, *Daniella oliveri*, *Isorbelina doka*, *Parkia biglobosa, Prosopsis africana, Vitellaria paradoxa, Burkea Africana* [12]. Five sites reflecting different levels of disturbances and different land use covers were selected within Makurdi metropolis: Hudco Quarters North Bank (HQN), Benue State University Zoological Garden (BZG), Gyado Villa (GYV), High Level (HLV) and Akpehe (APH) (Figure 1). BZG and HQN were considered as relatively undisturbed sites (even though in reality all the sites have some measure of human disturbances) as these two sites are protected, GYV is a semi urban area with human habitation interspersed with natural vegetation, and HLV and AKP are areas of high human activities. Insects' collection was from the months of October to November 2017.

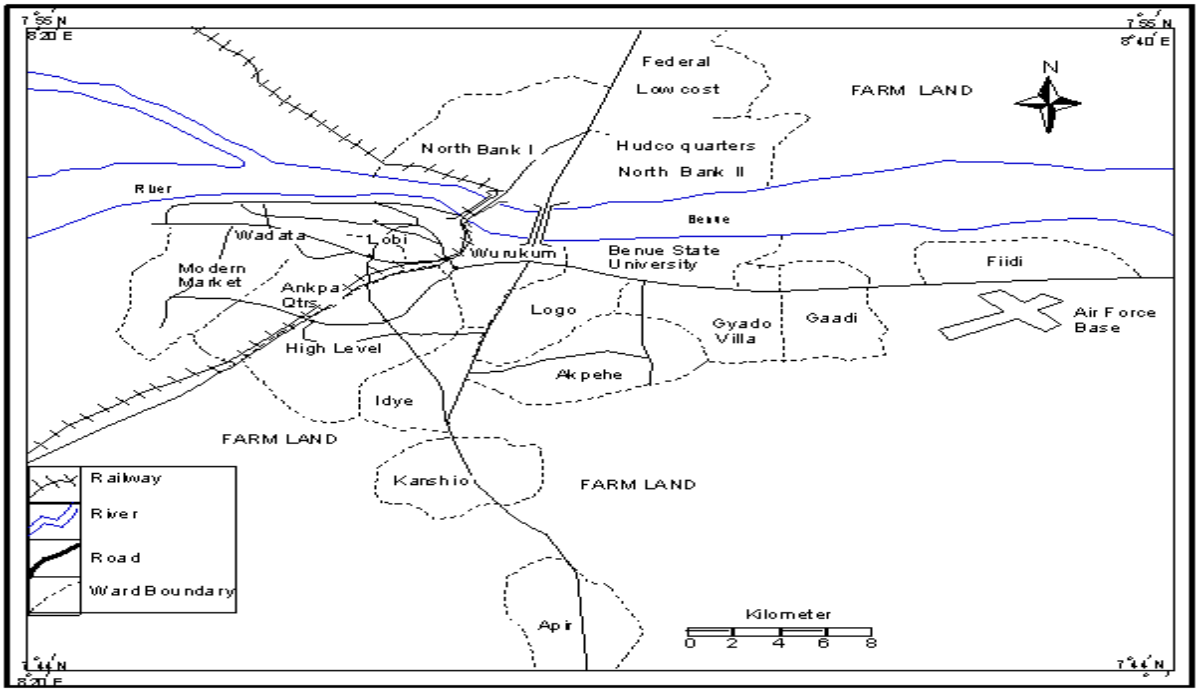

Figure 1: Map of Benue State showing sampling sites

. III. EXPERIMENTAL DESIGN AND DATA COLLECTION

A. Pitfall method

Three (3) pitfalls where dug at random locations within each site of study. A suitable wide-mouthed container was sunk in the soil so the opening is leveled with the ground surface. A cover was placed over the open top of the container to exclude rain and small vertebrates while allowing insects and mites to enter. It was inspected after 24 hours, and desired specimens where removed and placed in 70% alcohol.

B. Sweep net

Sweep nets where used in this research work to collect insects at random locations within the study sites. Insects caught were transferred into the container with 70% alcohol for identification.

C. Hand picking method

This method was used to capture insects that are not harmful to human when caught with bare hands. Various insects were collected with this type of method at the various sites of study. Insects collected were then placed in the 70% alcohol containing jar for identification.

IV. DATA ANALYSIS

All data were collected from the month of October to November 2017 and was subject to Analysis of Variance (ANOVA). Other analyses used were diversity indices which were calculated using the following:

A. Shannon diversity index (H') of birds species and this was calculated using equations as shown by [15].

Shannon Diversity Index $H' = -\sum Pi \ ln \ Pi$ (1)

Where: $\sum$ is summation

P_i is the proportion of individuals found in the ith species.

ln is the natural log

The Shannon Weiner index (H') is a quantitative measure that reflects how many different types (such as species) there are in a dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types.

B. Simpson's Dominance Index (D) as shown by [16] is a measure of diversity which takes into accounts both richness (the number of species per sample) and evenness (abundance of the different species making up the richness of an area) as:

$$D = \frac{\sum_{i=1} ni\ (ni-1)}{N\ (N-1)} \quad (2)$$

Where: D = Dominance index

n_i = number of individual in the i^{th} species

N = total number of entities in the dataset.

C. Margalef's Species Richness Index (d) as shown by [17] and it is the simplest measure of biodiversity and is simply a count of the number of different species in a given area calculated using the formula:

$$d = \frac{S-1}{lnN} \quad (3)$$

Where d = Margalef richness index

S = number of species

ln = natural log

N = number of individuals in the sample

D. Effective Number of Species (True Diversity): This is the conversion of diversity indices into true diversity values so as to give a true picture of the diversity at the sites and for the Shannon diversity index, the Effective number of Species also known as the Shannon Effective Number of species will be calculated using the formula by [18]

$$ENS = \exp(-\sum_{i=1}^{S} p_i \ln p_i) \quad (4)$$ Where:

$(-\sum_{i=1}^{S} p_i \ln p_i)$ is the Shannon index

E. Sorensen's Similarity Index (Ss): The Sorensen index, also known as Sorensen's similarity coefficient, is a statistic used for comparing the similarity between communities [19]. It mainly uses abundance, presence-absence data, but not the incidence of species. It can be expressed in percentages and calculated as:

Ss = 2a/ (2a+b+c) × 100

Where: a = the number of species found at the first and second sites

b = species found only at the first site

c = species found only at the second site

V. RESULTS

A total of one thousand and forty two (1042) insects distributed between 11 orders were collected Blattodea 16(1.5%), Coleoptera 46(4.4%), Dermaptera 9(0.9%), Diptera 137(13.1%), Hemiptera 83(8.0%), Hymenoptera 146(14.0%), Isoptera 11(1.1%), Lepidoptera 143(13.7%), Mantodea 3(0.3%), Odonata 255(24.5%), and Orthoptera 193(18.5%). However, there was no significant difference in the abundance of insect species between sites ($F_{(4, 50)}$ =2.352697, P=0.067). Insect species checklist collected in Makurdi Benue State Nigeria is presented in Table 1.

There was no significant difference in the diversity of insect species between sites ($F_{(4, 50)}$ =0.000375, P=1.0), However, Gyado Villa (GYV) had the highest diversity index and Margalef's Species Richness (d) but had the lowest dominance Index, while Akpehe (APH) had lowest species richness and highest dominance. It was also noticed that BZG had a low diversity index, high dominance index, but the Shannon effective number of species (ENS) of GYV was higher than BZG even though they had equal number of species (Table 2). The reason for the higher diversity (ENS) of GYV over BZG is an indication of dominance because where there is a high degree of dominance, the Shannon effective number of species will be less than the species richness as seen at all the sites especially at BZG. The Order Odonata being the most dominant Order in the whole collection was highest at BZG compared to other sites. The Overall diversity, taking the study sites is 1. 98, this gives an ENS of 7.25

Table 1: A checklist of insects collected at Makurdi Benue State, Nigeria from October to November 2017

Order	Species	Common name
Blattodea	*Periplanata americana*	Cockroach
Coleoptera	*Chondroplyga dorsalis*	Dung beetle
	Amblytelus spp.	Forage beetle
Dermaptera	*Forficula spp.*	Earwig
Diptera	*Musca domestica,*	House fly,
	Tabanus spp.	fruit fly
	Culex sp.	
	Anopheles sp	Mosquito
	Aedes sp	
Hemiptera	Coreidae	Leaf-footed bug
Hymenoptera	*Apis spp.*	Honeybee,
	Bombus latreille	bumblebee
	Formica spp.	Wasp
		Ant

Isoptera	*Macrotermes nataiensis*	Termite
Lepidoptera	*Papilio paramedes*	Palamedes
	Danaus plexipppus,	Swallowtail
	Neophasia menapia	Monarch,
	Thorybes pylades,	Pine white
	Antochton cellus	Northern cloudwing,
	Acraea bonasia	Golden-banded skipper
	Cricula sp	Orange-streak acraea Moth
Mantodea	*Mantis religiosa*	Praying mantis
Odonata	Aeshnidae (Family)	Dragonfly
Orthoptera	Acrididae (Family)	Leafhopper
	Pygomorphidae (Family)	Meadow grasshopper
	Tettigonidae (Family)	Katydid
	Acheta domesticus,	House cricket,
	Gryllus bimaculatus	Field cricket

Table 2: Diversity indices of insect species between sites

	Sampling sites				
Diversity Indices	**BZG**	**HLV**	**GYV**	**APH**	**HQN**
Total Number of Individuals (N)	374	117	216	174	161
Number of Orders (n)	11	9	11	9	9
Shannon Diversity Index (H')	1.943	1.950	1.961	1.959	1.960
Simpson's Dominance Index (1-D)	0.837	0.849	0.824	0.854	0.849
Margalef's Species Richness Index (d)	1.688	1.679	1.860	1.551	1.574
Shannon Effective Number of Species [exp(H')]	6.98	7.02	7.11	7.09	7.10

There was a significant difference between the trapping methods ($F_{(2, 17)} = 6.7965$, P=0.007) with the sweep net having an average catch of 109 insects (Figure 2). The similarity index between the methods was approximately 67% between sweep net and pitfall while it was 53% between hand collection and sweep netting (Table 3)

Figure 2: Average number of insect collected between the tree trapping methods

Table 3: Sorensen's similarity indices between the trapping methods

Trapping Methods	**S_S**
Hand Collection and Sweep Net	53.3
Hand Collection and Pit Fall	60
Sweep Net and Pit Fall	66.7

V. DISCUSSION

The overall most abundant insect order was Odonata, and it occurred more at BZG than all the other sites, probably because the site shares its boundaries with the River Benue and its proximity to the water body makes it a good habitat for Odonates as Odonates distribution is determined by fresh water habitats ranging from permanent running waters and

lakes to small rain pools *[20] also* Odonates are known to thrive best in habitats characterized by either sparse or dense vegetation and water bodies[21], [22]. They act as bio-indicators of the health of an area and their life cycle depends on water. The site BZG is a protected site with reduced human activities this may be one of the reasons for the higher numbers of Odonates found there.

However, even though BZG and GYV had equal number of insect orders, species richness and the diversity of BZG was lower than GYV, as GYV had 7 equally common orders like any other community and BZG had only 6 equally common orders, even though this values were not significantly different it clearly shows that insects may still thrive where there is human activity, that the absence of human activities in an area is not necessarily the guarantee of high biodiversity especially for insects. Some human activities have been known to positively influence insect diversity but then the argument remains that an area with high human activities will only lead to unevenness in the distribution of insect species hence the dominance that was noticed at the BZG. This agrees with [23] who said that many animals and plant species have adapted to the new stresses, food sources, predators and threats in urban and suburban environments, where they thrive in close proximity to humans. In another research involving 25 business parks as study sites 90 bird species were identified including 18 that were listed as endangered by IUCN, the researcher concluded that business parks are of value to biodiversity [24]. But analysing diversity can be misleading, as it can be measured over different geographical scales. If the same human-dominated local settings were replicated everywhere, species that do not like the conditions would disappear together with their ecological niches. Maintaining high local diversity without reducing regional or even global diversity therefore requires careful planning to avoid repeating the same urban or suburban landscapes everywhere [25].

That, there was no significant difference between species abundance and diversity between the sites, also the similarity index between sites was from 89% to 100% is an indication that all sites have same distribution in species composition of insects because all sites occupy same geographic location [26], [9]. The overall Shannon effective number of species at Makurdi was 7.25, this is an implication that on average, the area has 7 equally common species as any other area and looking at this holistically it shows that the insect diversity of Makurdi Benue State is low compared to other areas [27]-[29] . This may be because of the high agricultural activities in the area, majority of the indigenes are farmers and there is an upsurge in the use of chemicals as herbicides and pesticides as these have been known to have negative effects on non target species which insects are the unfortunate culprits [30], [29] .

The trapping methods used in this study may have also had an influence on the species composition of the sites, different methods trap different types of insects and using various methods to trap insects increases the diversity of insects [31]. There was a highly significant difference between methods which meant that different methods trapped different types of insects, however, the similarity index between the methods was above 50% the lowest been between hand collection and sweep net, this difference may be in the number of individuals in the sample but the type of insects sampled were about half the same for both methods. On the average, the sweep net method trapped more insects than the other two methods, and this method is biased towards flying species hence, the high numbers of winged insects in the sample collected.

In conclusion, the present survey has shown that Makurdi has a low insect biodiversity. It has also documented probably for the very first time, the insect fauna in Makurdi. This information will assist all stakeholders to optimize the beneficial insects, while managing noxious species. Further studies should be conducted using other sampling techniques and by also expanding the geographical scope of the study. There is need to also expand the duration of the study as seasonal variations affect population dynamics of insects. Routine insect abundance and diversity monitoring should be encouraged. Finally, conservation laws in the state should be enforced to ensure the sustainability of insects.

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