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Research Article

A Study on the Diversity and Relative Abundance of Insect Fauna in Wukari, Taraba State, Nigeria

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ABSTRACT

A field survey was conducted in Wukari, Taraba State to assess the diversity and abundance of insect species in selected habitats (residential, open field made up of grassland and an agro ecosystem). Sampling were done biweekly using light, pitfall and yellow pan traps set in 3 replicates, 30m apart. Insects recovered were wet preserved in 70% ethanol except butterflies and moths. Representative samples were taken to the Insect Museum of Ahmadu Bello University Zaria for identification. A total of 4,501 insects spread across 9 orders, 34 families and 77 species were recovered. The most dominant order was Coleoptera with a relative abundance of (44.41%) and, the least was Orthoptera (0.84%). The most dominant insect species are *Heteronychus mossambicus* (11.44%) followed by *Termes* sp. (7.77%) and, *Goryphus* sp. (7.71%). *Chlaenius decipiens, Cheilomenes sulphurea, Copris* sp., *Cicindela* sp., *Pseudantheraea* sp., *Derobranchus geminatus, Glaurocara townsendi, Camponotus perrisi*, and *Gryllus bimaculatus* were the rare species with relative abundance of 0.02%. Species richness is based on number of individual insects measured. The highest species diversity was observed in the order Coleoptera (Shannon H' =2.547) while, Isoptera was the least (H' = 0.00). However, the highest species evenness was observed in the order Isoptera (E' = 1.00). Fisher-alpha (α) index of diversity shows that the agro ecosystem has the highest index of diversity (α = 14.24) while, the residential area had the least (α = 11.9). This study therefore, brings to the fore the diversity and abundance of insects in Wukari and underscores the need for a more intensive study and for sustainable actions to be taken in conserving beneficial rare species while, managing the abundant pestiferous ones.

Key words: Abundance, Diversity, Fisher-alpha (α), Insects, Jaccard's similarity index, Margalef (d), Shannon index (H').

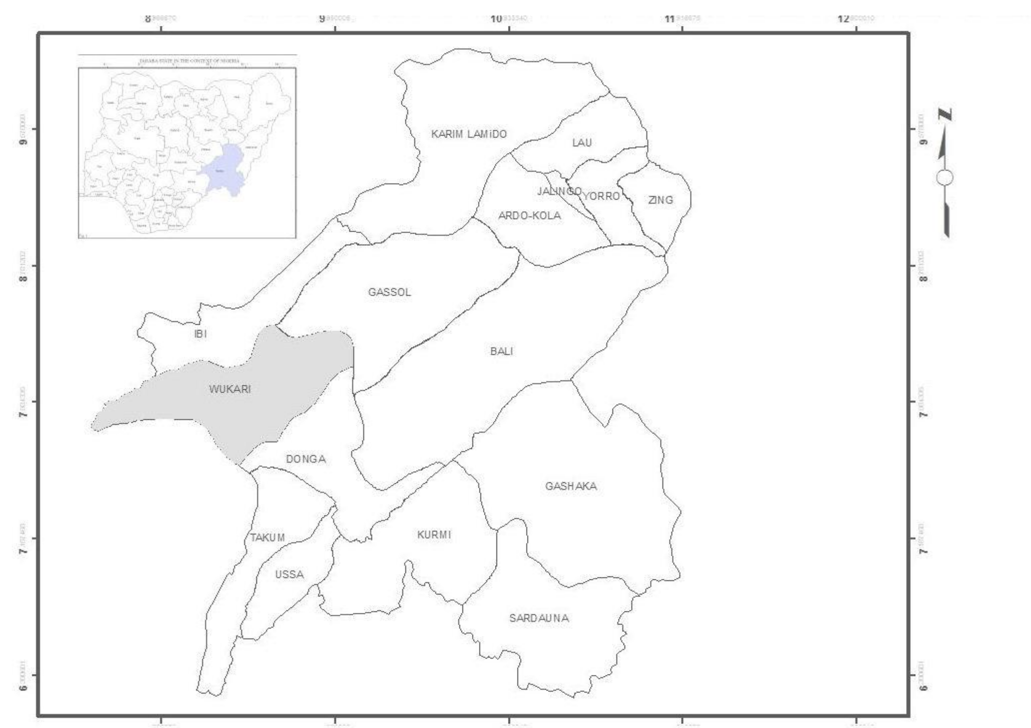
Introduction

Insects are important because of their diversity, ecological role, and influence on agriculture, human health, and natural resources (Berenhaum, 1995; Adetundan *et al.,* 2005; Premalatha *et al.,* 2011). They have been used in landmark studies in biomechanics, climate change, developmental biology, ecology, evolution, genetics, paleolimnology, and physiology. They make up more than 58% of the known global biodiversity. They inhabit all habitat types and play major roles in the function and stability of terrestrial and aquatic ecosystems (Godfray, 2002).

Insects are closely associated with our lives and affect the welfare of humanity in diverse ways. At the same time, large numbers of insect species, including those not known to science, continue to become extinct or extirpated from local habitats worldwide (Miller *et al.,* 2001). The diversity of insect species is a function of the environmental condition (Yi *et al.,* 2012).

Wukari is a richly agrarian community in the North eastern part of Nigeria. The diversity and abundance of insects in Wukari has hardly been studied. Insect biodiversity studies conducted in Nigeria have largely been on the insects' diversity of specific orders and/or species of insects. Few have considered the insect community altogether (Meddler, 1980). Aside inadequate taxonomic knowledge, the ecological knowledge of insects in Nigeria is not well understood as distribution and abundance of many insect species in the country are unknown and their ecosystem services mostly assumed (Kato *et al.,* 2000). Anthropogenic activities have contributed to the movement and spread of invasive insects into the different habitats with many of them having Agricultural, Medical and Veterinary implications (Wardle *et al.,* 2002).

The current study is designed for the very first time to document diversity and abundance of insects in Wukari, Taraba State, Nigeria. This information is not only useful for Agricultural, Medical and Veterinary purposes, but will also probably for the very first time, give an insight into the insect species richness of wukari; an information that is very critical for management and conservation purposes (Mazon *et al.,* 2008).



Source: Satellite Maps (2015)

Figure 1. Map of Taraba State in Nigeria, showing Wukari

The habitats/locations that were sampled are;

1. Agro-ecosystem (A farm land of about ten (10) hectares used for all year round farming)
2. Open field (A Grassland community behind Federal University Wukari, football field)

3. Residential area (Hostel and Staff Quarters environment of Federal University Wukari).

Insect sampling/collection technique

The field survey was conducted from March to May, 2016. Insect's sampling was done biweekly using the following insects sampling techniques (Campos *et al.,* 2000);

1. Pitfall trap: This was used to collect ground dwelling insects (Axmacher *et al.*, 2004). A double cup design of pitfall trap with a length of 11cm and, 10 cm wide was used in which a hole is dug and two (2) containers are placed in a dug hole and soil is packed around it to the level of the rim of the inner container (Sabu *et al.,* 2010).

The inner cup was a removable container that allow for setting and servicing of the trap. The outer cup keeps the hole from back filling with soil. An elevated wooden tripod stand (5 cm above the ground level) was placed over the pitfall to keep off water, falling debris and small rodents. Water and 2% mild detergent were used as a killing agent (Winder *et al.,* 2001). The content of the trap was serviced after 48 hours. By pouring the content through a sieve and rinsed with gently running water and preserved in a container containing 70% ethanol.

2. Yellow pan trap: A yellow plastic dish of 6cm length and 12 cm wide containing a mixture of water with 2% mild detergent which breaks the surface tension of the water was placed 25cm above the ground level. Flying insects landing on the surface of the water were trapped (Roulston *et al.,* 2007; Saunder *et al.,* 2013). The trap was set up for a period of twelve (12) hours (6 am to 6 pm). Insects collected were poured into a sieve and rinsed with gently running water and then preserved in a container containing 70% ethanol.

3. Light trap: This was set by sinking two (2) nails into a tree, 10 cm apart with the bottom one at 3 m above ground level. The light source was tied on the first nail up, while the container of 17 cm length and 16.5 cm wide containing the mixture of water with 2% mild detergent was tied to the second nail just below the light source. Insects that fly onto the light source fall into the container and are trapped (Kato *et al.,* 2000). The trap was set in the evening (6 pm) and serviced in the morning (6 am). The insects collected were poured into a sieve and rinsed with gently running water and, preserved in 70% ethanol. All traps were set biweekly in three (3) replicates in each habitat and were spaced about 15 meters from each other (Frank, 2006).

Preservation of insects collected

All insects collected were preserved by immersion in 70% ethanol. However, insects like moths that have scales on their wings were preserved dry in a tight container containing Silica gel. Representative samples were preserved in the Biology Laboratory, Federal University Wukari, for future reference.

Identification of insect samples

All insects collected were taken for identification at the insect museum centre of Ahmadu Bello University Zaria, Kaduna State, Nigeria.

Data analysis

The following Biodiversity indices were computed using Past3 software;

a. Abundance of insect species.

b. Relative Abundance of insect species,

c. The Shannon Diversity Index (H') was used to compute the ecosystem diversity index.

d. Jaccard's Similarity Index.

Shannon index (H') was used in calculating t' to test for significant difference in diversity of insect species between the habitats surveyed.

Results

Diversity and abundance of insects in the study area

Table 1 show the diversity and abundance of insect species recovered in the selected habitats. A total of 4,501 insects belonging to 77 species, 34 families and 9 orders were recorded. The largest number of insect species (69) was recovered from farm land, and the least (56) were recovered from the open field. Across the habitats, *Heteronychus mossambicus*, had the highest abundance (515) followed by *Termes* sp. (350) and *Goryphus* sp. (347), the least abundant (rare) insect species include *Chaenius decipiens, Cheilomenes sulphurea* and, *Derobrachus geminatus*.

Table 1. Diversity and abundance of insect species in the study area

Order	Famiy	Genus/species	RA	OF	AG	Total
Coleoptera	Brentidae	*Cylas brunneus* Fab.	0	11	24	35
	Carabidae	*Arsinoe biguttata* Chaud.	16	37	49	102
		Aulacoryssus aciculatus Dej.	1	8	22	31
		Aulacoryssus sp.	12	18	27	57
		Callida decora Fab.	0	15	11	26
		Callida sp.	0	0	2	2
		Chlaenius decipiens Dufour.	1	0	0	1
		Cicindela sp.	0	1	0	1
		Dichaetochilus vagans Dej.	22	12	26	60
		Edagroma sp.	16	15	0	31
		Paussus sp.	2	1	5	8
	Cerambycidae	*Derobrachus geminatus* LeConte	0	0	1	1
		Paroeme nigripes Auriv.	58	69	57	184
	Chrysomelidae	*Stobiderus* sp.	10	13	47	70
		Aspidomorpha nigromaculata Herbt.	2	1	2	5
	Coccinellidae	*Cheilomenes sulphurea* Oliv.	0	0	1	1
	Curculionidae	*Alcidodes brevirostris* Boh.	7	3	3	13
	Curculionidae	*Colliuris* sp.	7	24	26	57
	Elateridae	*Melanoxanthus* sp.	40	0	1	41
		Prosephus sp.	43	51	32	126
	Hesteridae	*Hister* sp.	21	0	3	24

Contine: Table 1

Order	Family	Genus/species	RA	OF	AG	Total
Coleoptera	Scarabaeidae	*Anomala mixta* Fab.	38	70	42	150
		Copris sp.	0	0	1	1
		Heteronychus mossambicus Peringuey.	137	106	272	515
		Onthophagus sp.	35	79	85	199
		Serica sp.	7	59	47	113
		Schizonycha africana Castel.	51	9	31	91
	Tenebrionidae	*Derophaerus* sp.	0	11	2	13
		Disonycha sp.	15	28	55	98
		Tenebriodes sp.	37	0	34	71
Dictyoptera	Blattidae	*Blattella* sp.	2	8	7	17
		Deropeltis sp.	9	8	3	20
		Gyna costalis Walk.	8	22	3	33
Diptera	Asilidae	*Ommatius* sp.	0	5	2	7
	Calliphoridae	*Chrysomyia albiceps* Wield.	0	1	6	7
	Muscidae	*Morellia nilotica* Loew	0	0	2	2
		Musca domestica Lin.	25	25	27	77
		Musca sorbens Wied.	3	2	1	6
		Musca sp.	0	0	2	2
	Scarcophagidae	*Scarcophaga* sp.	0	3	0	3
	Stratiomiidae	*Acrodesmia pennicornis* Berri.	0	0	2	2
	Tachinidae	*Glaurocara townsendi* Emden.	0	0	1	1
		Latiginella rufogrisea Villeneuve	18	7	55	80

Contine: Table 1

Order	Family	Genus/species	RA	OF	AG	Total
Hemiptera	Flatidae	*Cryptoflata unipunctuntata* Oliv.	0	0	6	6
	Pentatomidae	*Aspavia acuminata* Mont.	1	0	2	3
		Piezodorus sp.	2	26	27	55
	Reduviidae	*Coranus lugubris* Stal.	1	0	4	5
		Oncocephalus sp.	1	3	3	7
Hymenoptera	Apidae	*Halictus* sp.	5	16	9	30
	Braconidae	*Apanteles* sp.	6	7	2	15
		Braunsia sp.	2	0	2	4
		Ipiaulax sp.	35	38	40	113
		Macrocentrus sp.	6	0	0	6
	Formicidae	*Camponotus maculatus* Fab.	118	41	16	175

		Camponotus perrisi Forel.	0	1	0	I
		Camponotus vestitus Smith	5	5	2	12
		Camponotus sp.	65	24	33	122
		Dorylus sp.	7	4	1	12
	Ichneumonoidae	*Goryphus* sp.	125	100	122	347
Isoptera	Termitidae	*Termes* sp.	104	36	210	350
Lepidoptera	Arctiidae	*Eilema* sp.	76	63	52	193
		Metatarcta sp.	12	12	8	32
		Ovenna sp.	95	95	108	298
		Spilosoma sp.	25	23	15	63
	Geometridae	*Heterocrita* sp.	50	30	39	119
	Saturniidae	*Pseudantheraea* sp.	1	0	0	1

Contine: Table 1

Order	Family	Genus/species	RA	OF	AG	Total
Mantodea	Amorphoselidae	*Amorphoscelis* sp.	23	15	16	54
	Mantidae	*Empusa* sp.	1	1	1	3
		Hoplocorypha nigerica Beir.	3	9	12	24
		Pygromantis sp.	0	4	23	27
Orthoptera	Acrididae	*Eurycorypha* sp.	0	1	1	2
		Gastrimargus amplus Sjost.	2	1	2	5
		Oedaleus nigeriensis Uvarov.	1	5	1	7
		Stobbea sp.	2	0	18	20
	Gryllidae	*Gryllus bimaculatus* De Geer	0	0	1	1
		Gymnogryllus sp.	1	0	1	2
		Scapsipedus marginatus Afz & Bra	1	1	0	2
		Total	**1,421**	**1,283**	**1,797**	**4,501**

RA – Residential Area
OF – Open Field
AG – Agroecosystem

Relative abundance of insects in the study area

Table 2. Show the relative abundance of the insect species in the selected habitats *Heteronychus mossambicus*, had the highest relative abundance of (11.44%) followed by *Termes* sp. with (7.78%) and *Goryphus* sp (7.71%). Insect such as *Chaenius decipiens*, *Cheilomenes sulphurea, Copris* sp., *Cicindela* sp. and *Derobrachus geminatus* have the least abundance of (0.02) each.

Table 3 shows the pooled relative abundance of insects based on orders. The Coleopteran insects have the highest relative abundance (46.42%) followed by Hymenoptera (18.59%) and the least is Orthoptera (0.84%). The diversity indices shows that Coleopteran insects have the highest diversity index (H'= 2.547) and species richness (d = 2.65). Isoptera have the least (H'= 0) and (d = 0). Isoptera was noted to have the highest evenness index (E'= 1) and have no equitability.

However, Dictyoptera which have the second highest evenness after Isoptera, have evenness (E') of 0.9484 and the highest equitability of 0.9614. Diptera have the least evenness and equitability; (E'= 0.372) and (J= 0.5706).

Table 2. Relative abundance of insect species recovered from selected habitats in Wukari

Order	Genus/ Species	Relative Abundance (%)
Coleoptera	*Anomala mixta*	3.33
	Alcidodes brevirostris	0.28
	Aulacoryssus aciculatus	0.68
	Aulacoryssus sp.	1.26
	Aspidomorpha nigromaculata	0.11
	Arsinoe biguttata	2.27
	Chlaenius decipiens	0.02
	Cheilomenes sulphurea	0.02
	Callida sp.	0.04
	Copris sp.	0.02
	Cicindela sp.	0.02
	Callida decora	0.58
	Colliuris sp.	1.26
	Cylas brunneus	0.78
	Derobrachus geminatus	0.02
	Dichaetochilus vagans	1.33
	Disonycha sp.	2.17
	Derophaerus sp.	0.28
	Egadroma sp.	0.68
	Hister sp.	0.53
	Heteronychus mossambicus	11.44
	Melanoxanthus sp.	0.13
	Onthophagus sp.	4.42
	Paussus sp.	0.18
	Prosephus sp.	2.8
	Paroeme nigripes	4.09
	Strobiderus sp.	1.56
	Serica sp.	2.51
	Schizonycha africana	2.02
	Tenebriodes sp.	1.58
Dictyoptera	*Blattella* sp.	0.38
	Deropeltis sp.	0.44
	Gyna costalis	0.73

Continue: Table 2

Order	Genus/Species	Relative Abundance (%)
Diptera	*Acrodesmia pennicornis*	0.04
	Chrysomyia albiceps	0.15
	Glaurocara townsendi	0.02
	Latiginella rufogrisea	1.78
	Musca sorbens	0.13
	Musca sp.	0.04
	Musca domestica	1.71
	Morellia nilotica	0.04
	Ommatius sp.	0.15

	Scarcophaga sp.	0.07
Hemiptera	*Aspavia acuminata*	0.07
	Coranus lugubris	0.11
	Cryptoflata unipunctata	0.13
	Oncocephalus sp.	0.15
	Piezodorus sp.	1.22
Hymenoptera	*Apanteles* sp.	0.33
	Braunsia sp.	0.09
	Camponotus perrisi	0.02
	Camponotus vestitus	0.26
	Camponotus maculatus	3.89
	Camponotus sp.	2.71
	Dorylus sp.	0.27
	Goryphus sp.	7.71
	Halictus sp.	0.67
	Iphiaulax sp.	2.51
	Macrocentrus sp.	0.13
Lepidoptera	*Eilema* sp.	4.29
	Heterocrita sp.	2.64
	Metatarcta sp.	0.71
	Ovenna sp.	6.62
	Pseudantheraea sp.	0.02
	Spilosoma sp.	1.40
Mantodea	*Amorphoscelis* sp.	1.20
	Hoplocorypha nigerica	0.53
	Pygromantis sp.	0.60
	Empusa sp.	0.07

Continue: Table 2

Order	Genus/Species	Relative Abundance (%)
Isoptera	*Termes* sp.	7.78
Orthoptera	*Eurycorpha* sp.	0.04
	Gastrimargus amplus	0.11
	Gryllus bimaculatus	0.02
	Gymnogryllus sp.	0.04
	Oedaleus nigeriensis	0.15
	Scapsipedus marginatus	0.04
	Stobbea sp.	0.44

Table 3. Relative abundance of insect orders recovered from selected habitats in Wukari, Taraba State

Order	Relative Abundance (%)	Community Dominance (%)	Shannon Index (H^I)	Evenness (E^I)	Margalef (d)	Equitability (J)
Coleoptera	46.41	11.65	2.547	0.6082	2.65	0.8367
Dictyoptera	1.55	36.29	1.056	0.9484	0.4708	0.9614
Diptera	4.13	36.05	1.314	0.372	1.722	0.5706
Hemiptera	1.68	50.52	1.086	0.4936	1.144	0.606
Hymenoptera	18.59	25.72	1.625	0.4618	1.486	0.6778
Isoptera	7.78	100	0	1	0	Nil
Lepidoptera	15.68	29.13	1.384	0.6651	0.7622	0.7724
Mantodea	2.4	36.27	1.127	0.7715	0.6407	0.8129
Orthoptera	0.84	23.02	1.465	0.6182	1.638	0.7525

Diversity indices of insects in the study area

Table 4a shows that agro ecosystem have the highest relative abundance of insects (39.91%), while the open field have the least (28.51%). The Fisher – alpha diversity indices shows that the farm has the highest index of diversity (14.24) while, the residential has the least (11.9)
The open field have the least species richness (d = 7.685) but, has the highest diversity (H' = 3.345), evenness (E'= 0.5617) and, equitability (J = 0.8565). However, the agro ecosystem have the highest species richness (d = 9.074).
The t- test analysis on the Shannon diversity index shows there is a significant difference ($P < 0.05$) between RA and OF, RA and AG in terms of species diversity. However, there is no significant difference ($P > 0.05$) between OF and AG in term of species diversity (Table 5).
Table 6 shows the Jaccard similarity index values. The levels of species similarity between the habitats surveyed are high as they are all above 0.5. However, the highest similarity index was observed between residential area and the agroecosystem (0.718).

Table 4 a. Diversity indices on insect species recovered from the selected habitats in Wukari

Location	Relative Abundance (%)	Fisher – alpha (α)
Residential Area	31.57	11.9
Open Field	28.51	11.95
Agro ecosystem	39.91	14.24

Table 4 b. Diversity indices on insect species recovered from the selected habitats in Wukari

Location	Community Dominance (%)	Shannon Index (H')	Evenness (E^{I})	Margalef (d)	Equitability (J)
Residential Area	4.96	3.316	0.4835	7.714	0.8202
Open Field	4.23	3.345	0.5617	7.685	0.8568
Agro ecosystem	5.78	3.344	0.4107	9.074	0.7898

Table 5. P value for T-test showing the level of difference in insect diversity between the study habitats

	RA	AG	OF
RA		0.005 *	0.0002 *
AG			0.45 NS
OF			

RA –Residential Are, **AG-** Agro ecosystem, **OF -** Open Field
* **-** Significantly different at 5% level of significance
NS – Not Significantly different at 5% level of significance

Table 6. Jaccard similarity index values

	RA	AG	OF
RA	**1**	**0.718**	**0.6911**
AG		**1**	**0.689**
OF			**1**

RA –Residential Area**, AG –** Agro ecosystem**, OF-** Open Field
* **-** Significantly different at 5% level of significance

Economic importance of insects in the study area

Table 7 shows that 2 of the overall dominant insect species are beneficial serving as natural enemies of insect pests and soil formation and aeration and protein source for man. Table 8 shows that the rare species are made up of beneficial and pestiferous insect species.

Table 7. Economic importance of dominant insect species in the study area

Insect Species	Economic importance
Heteronchyus mossambicus	Pest of crops
Goryphus sp.	Parasitoid
Termes sp.	Entomophagy/Soil formation

Table 8. Economic importance of rare insect species in the study area

Insect Species	Economic importance
Cicindela sp.	Predator
Chlaenius decipiens	Predator
Camponotus perrisi	Predator
Cheilomenes sulphurea	Predator
Copris sp.	Decomposer
Derobranchus geminatus	Pest of crops
Gryllus bimaculatus	Pest crops
Pseudantheraea sp.	Pest of crops
Glaurocara townsendi	Parasitoid

Discussion

Diversity and abundance of insects in the study area

A total of 9 orders, 34 families and 77 insect species were found in the habitats surveyed in Wukari. A total of 4,501 individual insect species was collected during the survey period using pitfall, light and yellow pan traps. Different trapping methods were used to attract different kinds of insects. This is in line with the report of John, 1989 who reported that using a combination of traps gives better species richness data.

The most abundant insect overall was *Heteronychus mossambicus* followed by *Termes* sp. and *Goryphus* sp. Insects species such as *Chlaenius decipiens, Cheilomenes sulphurea, Copris* sp., *Cicindela* sp. *Pseudantheraea* sp., *Derobranchus geminatus, Glaurocara townsendi, Camponotus perrisi*, and *Gryllus bimaculatus* were rarely found.

Relative abundance of insect orders in the study area

Overall, Coleoptera was the most abundant (46.41%) insect order in the study area. This was followed by Hymenoptera (18.59%), Lepidoptera (15.68%) and the least; Orthoptera (0.84%). This agrees with the report of Tscharntke and Brandl, 2004 who acknowledges coleopterans as the most predominant insect order.

Diversity indices of insect orders

Diversity indices shows that Coleoptera is the most diverse (Shannon H' = 2.547) and has a high evenness and equitability indices (0.6082 and 0.8367) with the report of (Bradshaw et al., 2009) on high diversity of coleopterans in tropical environments.

Diversity indices on selected habitats

Overall, the agro ecosystem was notably the highest in terms of species diversity (α = 14.24) and richness (d = 9.074). The least is the residential area; (α = 11.9) and (d =7.714). Therefore as plant species increases, insect species also increase. This agrees with the reports (Gaston, 1991; David *et al.,* 1994; Cheng *et al.,* 2007) that substantiated that plants and insects interact by way of mutualism and phytophagy. The highest similarity was observed between the agro ecosystem and residential area with 71.8% overlap. However, the t'-test statistical analysis shows no significant difference in species diversity between the open field (grassland) and the agro ecosystem. This can be understood from the standpoint that, both communities are highly plant based and plants have been believed to co-evolve with their insect herbivores (David *et al.,* 1994; Tscharntke *et al.,* 2004). They are also found where there is a favorable condition for their survival (Samways, 2007; Adetundan *et al.,* 2013).

Economic importance of insects in the study area

Each insect plays an ecosystem service and contributes to the stability of the ecosystem. The dominant and rare species were noted to cut across beneficial and noxious species. This is in agreement with (Maina *et al.,* 2012).

Conclusion

The survey has shown that Wukari is rich in insect biodiversity. It has also documented probably for the very first time, the insect fauna in wukari. This information will assist all stakeholders to optimize the beneficial amidst them 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.

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