



## Abundance and Diversity Indices of Aestivating Insect in Rice-Field Soil Exposed to Different Agro-Chemical Practices in Minna Metropolis, Nigeria

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### ABSTRACT

Abundance and diversity indices of aestivating insect in soil exposed to different agro-chemical practices in Minna Metropolis, during dry season of the year 2013 was investigated. The result revealed three insect Orders namely, Hymenoptera, Coleoptera and Hemiptera with the following abundance 45 (56.25%), 25 (31.25%) and 10 (12.50%) across the rice-field categories sampled. However, category A (No agro-chemical application), B (Only fertilizer application) and C (Both fertilizer and herbicide application) recorded 35.00, 38.75 and 26.25 % respectively, for all the insect orders. Only order Hymenoptera was recorded across the 3 rice-field categories sampled. Furthermore, Simpson and Margelef diversity indices revealed that category B is the most diverse with an index value of 0.666 and 0.582 respectively. In terms of Insect Order diversification, Simpson, Shannon and Margelef diversity indices revealed no diversity recorded for Order Hemiptera across the rice-field community during the aestivation period. Although, the 3 diversity indices above have all place Order Hymenoptera as the most diverse compare to others. Berger-parker diversity indices also revealed had the lowest dominance and Hymenoptera had the highest with index value of 1.000 and 0.466 respectively. The findings of this study have buttressed insect aestivating process in rice-fields during arid season in Minna, as influenced by the previously retained soil agrochemical inputs, in clearer perspective, more so, the findings have also established the baseline implication of agro-chemical practices as one of the anthropogenic factors, influencing sustainable increase in aquatic insect population in rice-field ecosystem in Minna and other areas with similar rice farming agronomic practices.

**Keywords:** Agro-chemical practices, insect diversity, Aestivation, Fisher-alpha diversity

### INTRODUCTION

Aestivation is typically defined as a summer or dry season dormancy. The word derives from the Latin for summer (*aestas*) or heat (*aestus*). Arid conditions that restrict water and food availability are the common trigger for aestivation, often but not always accompanied by hot summer temperatures (Storey and Storey, 2012). 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. The crucial functional roles insects' ensure delivery of various ecosystem services (Adelusiet *al.*, 2018). Rice fields are commonly considered as dynamic and noticeably disturbed ecosystems as

a results of inherent routine agricultural practices (including ploughing, drainage, fertilizer and pesticide applications, harvesting and desiccation brought about by the wet and dry climate cycles) which may affect the diversity of the aquatic community (Che-Salmahet *al.*, 1998). The fauna of rice fields are dominated by micro-meso and macro-invertebrates (especially arthropods) that are capable of aestivating either at egg, larval, pupal or adult stage when they

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lack suitable medium for survival, such as vegetative environment, availability of water and soil sub-habitats.

Rice manufacturing and intake in Nigeria cut across cultural, religious, ethnic or geographical boundaries. It is available in five star hotels in the big cities and towns as well as in the 'most local' restaurants in the remotest villages throughout the country. Rice is extraordinarily priced and extensively ordinary for festivities (Salihu *et al.*, 2017). Niger state is one of the major rice-producing states in Nigeria. The state has the highest average yield (on average 3 tons (t) per hectare of paddy) from a relatively limited area (Salihu *et al.*, 2017).

Agro-chemical practices such as application of Nitrogenous fertilizer could enhance aquatic insect larvae population in rice-fields during the faring season (Yusuf and Olayemi, 2015). However, application of synthetic Nitrogen fertilizers to rice fields could result in rise in concentration of Ammonia-Nitrogen and subsequent increase in Nitrate-Nitrogen level in the rice-field water which can increase the density of aquatic insects, as well as, increasing their aestivating potentials against extreme conditions (Yuanyuan *et al.*, 2016).

Rice farming is essential, but it comes with dangers in that it replaces the natural ecosystem range with a monoculture one, especially as some of the agronomic necessities of rice farming, effect negatively on other species in such atmosphere specifically the insect. Yet, the natural rich diversity altered by rice farming activity is observable year round or when there is continuous water source to the natural earlier mentioned ecosystem, although, the activities of the agrochemical application also play a significant role on the survival of aestivation aquatic insects in rice-field. Rice is widely grown in Minna and the impactsof agro-chemical application on aestivating insect speciesand their diversity indices have been neglected, thus making it difficult to practice year round sustainable rice farming in a way to preserve flora and fauna diversity, hence the need for this study.

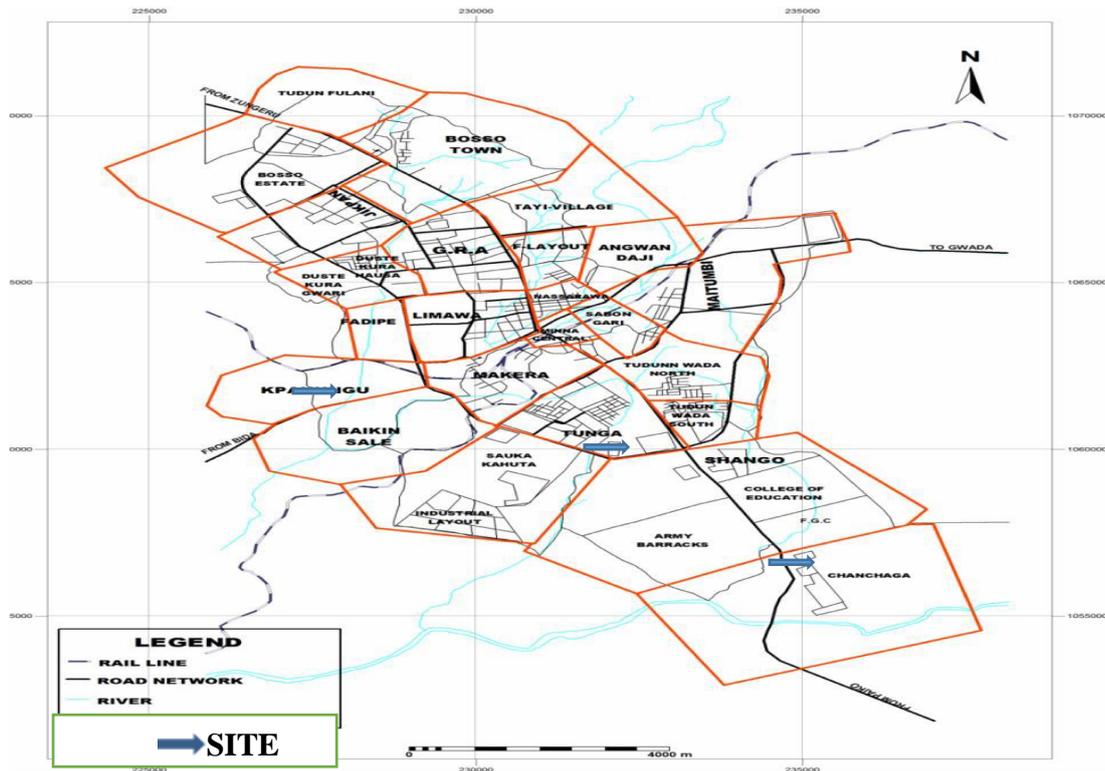
## METHODOLOGY

### Study Area

The study was carried out in Minna, the capital of Niger State, Nigeria, located within longitude 6<sup>o</sup>33E and latitude 9<sup>o</sup>37N, on a land area of 88km<sup>2</sup>and having a population of about 1.2 million inhabitants. Minna has a typical tropical climate with mean annual temperature of 30.2<sup>o</sup>C, relative humidity of 61% and rain-fall of 1334mm. The climate in the area has two distinct seasons: rainy season (April - October) and a dry season (November - March), completely devoid of rains. Its vegetation is typically grass-dominated savannah with scattered short trees (Olayemi *et al.*, 2009). Basically, four types of wetland rice ecosystems are present in Minna, which include irrigated, rain-fed lowland, upland and wetland rice ecosystem, with the irrigated rice environment been the dominant (Akintayo *et al.*, 2011). Farming is a major pre-occupation of the inhabitants of Minna and environs, with the area particularly famous for rice production; being a staple food of the people.

### Selection of Rice Fields Habitats

A questionnaire was administered to farmers to determine the category and combinations of agro-chemical inputs, i.e., chemical fertilizer, herbicides or both, commonly used in rice farms in Minna. The results of the questionnaire test was used as guide in selecting the rice-field categories, twocategories of rice-fields exposed toagro-chemical input were selected, with a control category where no agro-chemical application. The two rice-fields categories were category A (rice field with no agro-chemical input serving as Control), category B(rice field with only fertilizer application), category C (rice field with both fertilizer and herbicide application). The study sites were widely located at Fadikpe, Tunga and Chanchaga areas of the metropolis (Fig. 1).



Source: Salihu *et al.* (2017)

Figure 1: Map of Minna and Environs show rice field sampling sites

### Collection, Preservation and identification of Insects Aestivating in Rice-Fields Soil

The dry season collection was done late in the season for six weeks (March-April, 2013) when all stagnant rain pools in the rice fields have dried up. Soil samples were collected by excavating the soil at a shallow depth of 3cm (30 x 30cm), at five randomly selected points, in each sampling site. 2kg of soil was transferred into plastic bowl (30cm in diameter and 40cm deep) and flooded with 2.0 liters of borehole water in the Post Graduate (PG)Laboratory of the Department of Animal Biology Department, Federal University of Technology, Minna. Each rice field was represented with five replicate bowls covered with mosquito net to prevent insect from escaping after they have emerge and to prevent oviposition by wild insects. The soil sample was collected in the early hours of 9 – 11 am, and emergence was observed on daily basis for 6 weeks. The emerged insect specimen were collected, recorded and preserved in 70% ethanol (Fred, 2004). Identification was done using standard keys and charts described by Rawdaet *et al.* (2013); Vaibhao and Varsha (2011); Arimoro, and James, (2008); Bouchard (2004).

### Data Analysis

Data collected during the study periods were processed into percentage a proportion using EXCEL programme, and Diversity indices was also computed on the different rice-fields as well as the insect orders identified using PAST statistical package for Ecological Studies.

### RESULTS AND DISCUSSION

Table 1 Show the results on distribution and abundance of insect orders aestivating in flooded rice-field soil previously subjected to different agro-chemical inputs in Minna. Three insect Orders were encountered during this period and listed below in pattern of decreasing abundance: Hymenoptera 45 (56.25%) > Coleoptera 25 (31.25%) > Hemiptera 10 (12.50%). The insect Orders showed considerable abundance variation among the different types of rice fields. The above insect Orders were frequently encountered aestivating in the soil during dry season. Their presence and abundance may be due to their unique adaptation to the prevailing arid conditions in the dry soil of rice-fields, though; some of them serve as bio-indicators of water quality in aquatic ecosystem.

This agrees with the earlier work reported by Hu *et al.* (2007), that aquatic bugs especially Belostomatidae are often collected in large numbers that allow their utilization as bio-indicators.

Diversity indices of aestivating insect in flooded rice-fields soil previously subjected to different agro-chemical inputs in Minna, during the dry season is presented in table 2. Three categories of rice-fields was selected and termed as Category A: rice fields with no agro-chemical application; Category B: rice fields with fertilizer application; Category C: rice fields with fertilizer and herbicide applications. The three categories of the rice-fields recorded different number of species richness with category B recording the highest and category C had the least (Taxa (S) = 3.000 and 1.000) respectively. On the other hand, Simpson Diversity indices that measure the dominance level of a community, had revealed that Category B is more diverse with Simpson index value of 0.666 followed by A with index value of 0.497 and category C did not record any diversity. Shannon Winner Diversity index recorded similar pattern as explained above, revealing that rice-field category B is more diverse and stable followed by A with an index value of 1.098 and 0.690 respectively. More so,

Evenness diversity index revealed that all the three categories of the rice-fields recorded almost the same level of rare species distribution in the three communities with Evenness index value of 0.997, 0.999 and 1.000 for rice-field category A, B and C respectively. However, Margelef Diversity indices that measure variable of species in the community in terms of richness only. The Margelef diversity index revealed that Category B recorded the highest richness and C recorded the least with margelef index value of 0.538 and 0.218 respectively. More so, Mechnick Diversity indices which also estimate the richness of a community revealed that there is no single richness in rice-field category C, and Category B recorded the highest richness with Mechnick index value of 0 and 0.582 respectively. the low richness abundance and diversity of aestivating in rice-field category C could be due to the influence of previous application of herbicide in the rice field, this agrees with the report of Acostaaet *al.* (2017), who attributed the variations in the composition of species associated with rice agro-ecosystems in different places to be as a result of differences in climate and geographical characteristics of the locations where the studies were conducted, as well as, and the most important, the influences exerted by native natural areas surrounding different agronomic farming systems approach.

Table 1: Distribution and abundance of insects Orders in flooded rice-fields soil previously subjected to different agro-chemical inputs in Minna.

Insect Orders	Rice fields Categories (Insects per sample)			
	A	B	C	Aggregate
Coleoptera	15 (60.00)* (53.57)**	10 (40.00) (32.25)	0 (0.00) (0.00)	25 (100) (31.25)
Hemiptera	0 (0.00) (0.00)	10 (100) (32.26)	0 (0.00) (0.00)	10 (100) (12.5)
Hymenoptera	13 (28.87) (46.43)	11 (24.44) (35.48)	21 (46.67) (100)	45 (100) (56.25)
Aggregate	28 (35.00) (100)	31 (38.75) (100)	21 (26.25) (100)	80 (100) (100)

Category A: rice fields with no agro-chemical application; category B: rice fields with fertilizer application; category C: rice fields with fertilizer and herbicide application

\* are percentage proportion of insect orders across the various rice field categories

\*\* are percentage proportion of insect orders within a particular category of rice field

Table 2: Spatial diversity indices of aestivating insect in flooded rice-fields soil in previously subjected to different agro-chemical inputs in Minna

Diversity Indices	Rice Field Category A	Rice Field Category B	Rice Field Category C
Taxa (S)	2.000	3.000	1.000
Simpson (1-D)	0.497	0.666	0.000
Shannon (H)	0.690	1.098	0.000
Evenness( $e^H/S$ )	0.997	0.999	1.000
Menhinick	0.378	0.538	0.218
Margalef	0.300	0.582	0.000

Table 3: Aestivating Insect Order diversity indices in flooded rice-fields soil in Minna.

Diversity Indices	Coleoptera	Hemiptera	Hymenoptera
Taxa (S)	2.000	1.000	3.000
Simpson (1-D)	0.480	0.000	0.639
Shannon (H)	0.673	0.000	1.059
Evenness( $e^H/S$ )	0.980	1.000	0.960
Menhinick	0.400	0.316	0.447
Margalef	0.310	0.000	0.525
Fisher_alpha	0.511	0.276	0.723
Berger-Parker	0.600	1.000	0.466

Table 3 showed result on aestivating insect Order diversity indices in flooded rice-field soil in Minna during the dry season. The flooded rice-fields soil sampled revealed three Order of aestivating insects as follows; *Coleoptera*, *Hemiptera* and *Hymenoptera*, with *Hymenoptera* having the highest species richness and the least was *Hemiptera* with Taxa (S) index value of 3.000 and 1.000 respectively. Simpson, Shannon and Margalef diversity indices revealed no diversity for Order Hemiptera in the rice field community sampled during the study period, while the diversity indices above placed Hymenoptera as the most diverse compare to the Order *Coleoptera*. This result agrees with the report of Forbes *et al.* (2018), and reported that Beetles (*Coleoptera*) are not the most species-rich order of insect instead, another order of insects, called Hymenoptera, is more specious, and massively diverse. Evenness Diversity Indices revealed that Hemiptera is the rarest species in the rice-field community with Evenness index value of 1.000. Although, Mechnick Diversity indices revealed that diversity potentials across the three Orders, with Mechnick index value of 0.400,

0.316 and 0.447 for *Coleoptera*, *Hemiptera* and *Hymenoptera* respectively, with *Hemiptera* being the least. On the other hand Berger-parker diversity index revealed that Order *Hemiptera* is more diverse but having lower dominance, while Order *Hymenoptera* is less diverse with high dominance. The Berger-parker index values are 1.000 and 0.466 respectively. Finally Fisher-alpha diversity indices revealed that Order Hymenoptera is more spatially and temporally distributed and the most diverse within the rice-field and Order Hemiptera is had the least with Fisher-alpha index value of 0.725 and 0.276 respectively. This agrees with the research of Anbalagan *et al.* (2015), who worked on diversity and abundance of Hymenoptera families in vegetable crops in north-eastern district of Tamil Nadu, India, and reported that Hymenoptera is one of the few mega diverse insect orders he encountered during his study period.

### Conclusion

The previously retained regular application of agrochemicals residues in rice-fields soil, as a result of improving agronomic requirements in

rice fields prior or during farming had an influence on the distribution of insect species aestivating in such rice-fields. Rice-fields where both fertilizer and herbicide applications were previously practiced recorded the lowest insect abundance; where no chemical was previously applied on the soil recorded moderate abundance; and rice-fields where only chemical fertilizer was previously applied to the soil recorded the highest insect abundance aestivating during the dry season. Order Hymenoptera recorded the highest dominance and Hemiptera recorded the least based on diversity indices carried out. Conclusively, previous agro-chemical application (herbicide) in rice-fields soil and similar ecosystem could affect the integrity of aestivating insect.

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