



## Dynamics of Entomo-Faunal Diversity Indices of Rice-Fields Subjected to Different Agro-Chemical Inputs in Minna Metropolis, Nigeria

L.M. Salihu<sup>1\*</sup>, I.K. Olayemi<sup>2</sup>, Y. Garba<sup>3</sup>, I. Yahaya<sup>1</sup>, U.I. Hamza<sup>1</sup>, H.H. Ndayako<sup>1</sup>, S.L. Aliyu<sup>4</sup>,  
M. Nma-Estu<sup>5</sup> and A.Y. Gusau<sup>5</sup>

<sup>1</sup>Department of Biological Sciences, Ibrahim Babangida University, Lapai, Niger State, Nigeria

<sup>2</sup>Department of Animal Biology, Federal University of Technology, Minna, Nigeria

<sup>3</sup>Department of Biology Federal College of Education, Kontagora, Nigeria

<sup>4</sup>Department of Chemical Sciences, Federal Polytechnic, Bida, Nigeria

<sup>5</sup>Department of Biological Sciences, Federal Polytechnic, Bida, Nigeria

### ABSTRACT

Dynamics of entomo-faunal diversity of rice-fields subjected to different agro-chemical inputs during rainy season in Minna Metropolis was investigated in 2013. The densities of insects collected from rice-fields during the season ranged from 165 (30.11%) in site C to 211 (38.50%) in site B. Altogether, five insect Orders, viz; *Coleoptera*, *Odonata*, *Hemiptera*, *Decapoda* and *Orthoptera* were encountered during the period. The result further revealed that rice-field type A is more diverse in terms of species diversity among the rice-field types sampled, with a Simpson diversity index value of 0.6971. Furthermore, Shannon winner diversity indices also revealed that rice-field type C where both fertilizer and herbicide is applied is heavily polluted with an index value of 0.457. On the other hand, Simpson also revealed that Order *Coleoptera* is the most mature, stable and diverse insect order among the rice-field communities sampled, with an index value of 0.631 and the Order *Decapoda* recorded the least with an index of 0.364. On the whole, Fisher-alpha diversity indices have placed Order *Orthoptera* as the most spatial and temporally distributed order in the rice-field sampled. The findings of this study have placed the entomo-diversity of rice fields during the season in Minna, as influenced by the application of agrochemical inputs, in clearer perspective, more so, the finding will help in facilitating sustainable rice production in Minna and other areas with similar rice farming agronomic practices.

**Keywords:** Agro-chemical application, insect order, diversity indices, Berger-parker indices

### INTRODUCTION

Rice fields are generally considered as dynamic and highly 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) inhabiting the vegetative, water and soil sub-habitats. The wet phase of rice fields generally harbors varied groups of aquatic animals. Those that inhabit the vegetation are mainly arthropods such as insects and spiders. More so, many species of amphibians, reptiles, birds and mammals from surrounding areas visit rice fields for feeding and are generally considered

as temporary or ephemeral inhabitants (Bambaradeniyaet *al.*, 1998).

Rice production and consumption 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' of eateries in the remotest villages throughout the country. Rice is highly priced and widely accepted 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

Received 15 April, 2020

Accepted 3 July, 2020

Address Correspondence to:

[ismaikudi@gmail.com](mailto:ismaikudi@gmail.com), [ismaikudi@ibbu.edu.ng](mailto:ismaikudi@ibbu.edu.ng)

hectare of paddy) from a relatively limited area (Salihuet *al.*, 2017).

Agro-chemical practices such as application of Nitrogenous fertilizer could enhance aquatic insect larvae population in rice-fields (Yusuf and Olayemi, 2015). Furthermore, 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 (Yuanyuanet *al.*, 2016).

Though the use of agro-chemicals such as herbicide, insecticides and fertilizers, especially in rice farming is also known to increase yield per unit area and time (Renato *et al.*, 2011), such activities have widely resulted in the pollution of aquatic ecosystems, with particular negative effects on water quality. Moreby and Southway (1999) reported loss of diversity resulting from the de-structuring of physicochemical conditions and alteration of natural dynamics of biological communities in aquatic ecosystems. Rice agro-ecosystem provides ideal breeding habitats for aquatic organisms (Salihuet *al.*, 2017).

Rice farming is indispensable, but it comes with disadvantages in that it replaces the natural ecosystem diversity with a monoculture one, especially as some of the agronomic requirements of rice farming, impact negatively on other species in such ecosystem particularly the insect. Yet, the natural rich diversity altered by rice farming is needed for species preservation. Rice is widely grown in Minna and the impacts on species diversity especially the insects, have not been investigated, thus making it difficult to practice sustainable rice farming in a way to preserve flora and fauna diversity. In view of this, the research was conducted to determine dynamics of entomo-faunal diversity indices of rice-fields subjected to different agro-chemical inputs during rainy season in Minna Metropolis.

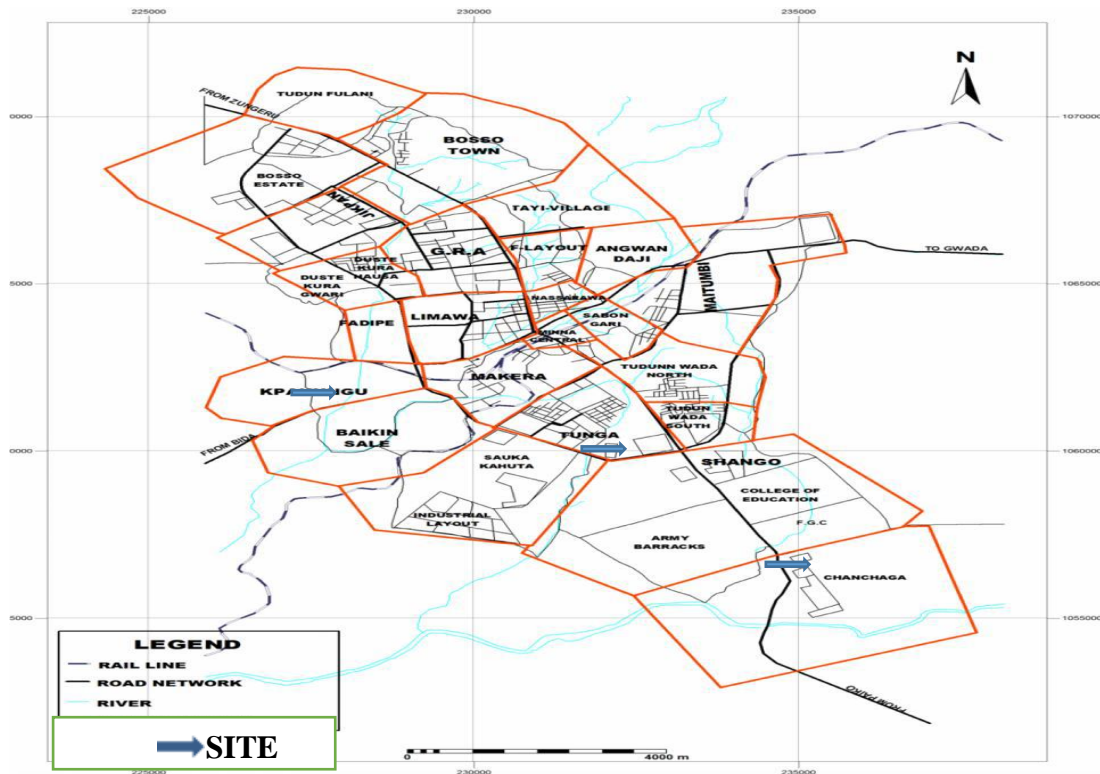
## METHODOLOGY

### Study Area

The study was carried out in Minna, the capital of Niger State, Nigeria. It is located within longitude 6°33'E and latitude 9°37'N, and 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°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 (Olayemiet *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 being the dominant (Akintayoet *al.*, 2011). Farming is the major pre-occupation of inhabitants of Minna and the 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 types and combinations of agricultural chemical inputs, i.e., chemical fertilizer, herbicides or both, commonly used in rice farms in Minna. Thereafter, guided by the result of the questionnaire test, three types of rice farming chemical input sites in the two rice fields categories (i.e., rain-fed lowland and irrigated ecosystem) were selected, each with three replicates. The three types of sites were named: Type A (rice fields with no chemical input serving as Control), type B (rice fields with only fertilizer application), type C (rice fields with both fertilizer and herbicide application). The sites were widely located at Fadikpe, Tunga and Chanchaga areas of Minna 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 Species

During the 2013 rainy season, Subber-sampler was used for insect specimen collection. The substratum of flooded rice fields was collected in the morning hours of 0900-1100hr attwo weeks interval during the months of May and June. The substratal material was transferred into plastic bowls and conveyed to the Post Graduate Laboratory, at the Department of Biological Sciences, Federal University of Technology Minna, the available insect were picked with forceps and preserved in 70% ethanol for identification (Fred, 2004). Identification was done using keys and charts described by Rawda *et al.* (2013); Vaibhao and Varsha, (2011) and Arimoro, and James (2008).

### 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 Highlight results for percentage insect densities and distribution in cultivated rice-fields subjected to various agricultural chemical inputs, during 2013 rainy season in Minna. The highest insect density collected from the rice-fields during the season was 36 (20.93%), 40 (18.95%) and 31 (18.78%) insects per sample during the third, second and first weeks, respectively; for rice fields types A, B and C respectively. The densities of insects were higher in type B rice fields (i.e., rice field with fertilizer application) than the other two types of rice fields (type A and C i.e., where there was no application of any agro-chemical in input and where both fertilizer and herbicide were applied, respectively) during the season. The higher percentage density could be attributed to the application of chemical fertilizer to the rice-field by farmers, and these results is similar to the work of Lu and Heong (2009), who reported that rice plants fertilized with high levels of Nitrogen attract more brown plant-hoppers (BPH) than nitrogen-poor plants, and also improve the insect's survival and reproduction in the field. Weekly variations in the percentage densities of insects among the types of rice-fields were

observed; although such variations were low between rice-field types A and B in weeks 1 and 3, as well as, types A and B in week 3 and 4. This variation could be due to different agro-chemical input practices by the farmers; this is

similar to observation made by Idowu *et al.* (2004), who reported that aquatic invertebrates recorded during his study were influenced by anthropogenic activities in the area.

Table 1 Weekly Insect density inhabiting rice-fields subjected to various agro-chemical inputs during 2013 rainy season in Minna.

Rice Field Types	Weekly Densities (Insect / sample)						Aggregate
	1	2	3	4	5	6	
A	30 (17.44)* (33.33)**	25 (14.53) (28.41)	36 (20.93) (36.00)	35 (20.35) (35.35)	17 (19.88) (20.99)	29 (16.86) (32.22)	172 (100) (31.39)
B	29 (13.74) (32.22)	40 (18.95) (45.45)	36 (17.06) (36.00)	36 (17.06) (36.36)	38 (18.01) (46.91)	32 (15.17) (35.56)	211 (100) (38.50)
C	31 (18.78) (34.44)	23 (13.94) (26.14)	28 (16.97) (28.00)	28 (16.97) (28.28)	26 (15.76) (32.09)	29 (17.58) (32.22)	165 (100) (30.11)
Aggregate	90 (16.42) (100)	88 (16.06) (100)	100 (18.25) (100)	99 (18.07) (100)	81 (14.78) (100)	90 (16.42) (100)	548 (100) (100)

Type A: rice fields with no agro-chemical application; type B: rice fields with fertilizer application; type C: rice fields with fertilizer and herbicide applications

\* are percentage proportion of insect density within a particular type of rice field

\*\* are percentage proportion of insect density across the various rice field types

Table 2: Entomo-fauna Diversity Indices of Rice-fields subjected to different agricultural chemical inputs during 2013 rainy season in Minna.

Diversity Indices	Rice Field Type A	Rice Field Type B	Rice Field Type C
Taxa (S)	5.000	5.000	3.000
Simpson (1-D)	0.697	0.649	0.228
Shannon (H)	1.310	1.168	0.457
Evenness( $e^H/S$ )	0.741	0.642	0.526
Menhinick	0.381	0.344	0.233
Margalef	0.777	0.747	0.391

Table 3: Aquatic Insect Order Diversity Indices of Rice-fields during 2013 rainy season in Minna.

Diversity Indices	Coleoptera	Odonata	Hemiptera	Decapoda	Orthoptera
Taxa (S)	3.000	3.000	3.000	2.000	2.000
Simpson (1-D)	0.631	0.571	0.572	0.364	0.500
Shannon (H)	1.047	0.930	0.930	0.551	0.693
Evenness( $e^H/S$ )	0.949	0.845	0.845	0.867	1.000
Menhinick	0.173	0.240	0.375	0.400	1.000
Margalef	0.350	0.396	0.480	0.310	0.721
Fisher_alpha	0.463	0.526	0.652	0.511	1.592
Berger-Parker	0.481	0.525	0.515	0.760	0.500

Table 2 shows results on Entomo-fauna diversity indices of rice-fields subjected to different agricultural chemical inputs during 2013 rainy season in Minna. Of the three types of rice fields studied viz: rice fields with no chemical application i.e type A; rice fields with fertilizer application i.e., type B and rice fields with fertilizer and herbicide applications i.e., type C. Rice field type A and B has the same number of species richness though the two are higher than type C rice field. Taxa (S) index value of 5.000, 5.000 and 3.000 respectively. Simpson Diversity Index is used to assess the dominance of a community. The index ranges from 0 to 1, of which mature and stable communities have high index value i.e., rice field type A (0.6971) is more diverse in terms of species diversity among the rice field types even though they are having the same level of species richness with type B (0.6497) and type C recorded the least (0.2288) because low diversity usually show value close to zero. This was similar to the report of Dash, (2003). More so, Shannon-Winner Index which usually varies from 0 -5. According to this index, as values increase the more stable the environment is, i.e less than 1 are characterized to be in heavily polluted condition and vice versa, having recorded 1.31, 1.168 and 0.4573 for rice field type A, B and C respectively, this implies that rice field type C is heavily polluted and type A which has no agrochemical inputs is less polluted. This is in agreement with the report of Shah and Pandit (2013) However, Evenness diversity index ranges between 0 to 1, the closer the index value is to 0, the more rare species are present in a community. Therefore, Evenness diversity indices revealed that rice field type C recording more rare species than others with Evenness index value of 0.5266 and type A recorded least rare species of index value of 0.7411.

Margalef index has no limit value and it shows variation depending upon the number of species. Thus, it is used for comparison of the site (Gorelick, 2006.) and takes only one component of diversity (i.e., species richness) into consideration. The advantage of the index is that it compares the richness of different study sites. In the present investigation, the value of Margalef diversity index was between 0.3917 at rice field type C to 0.7771 at rice field type A. More so, Mechnick diversity index is like Margalef index but attempts to estimate species

richness also. In the present investigation, the value of Mechnick index ranged from 0.2335 in rice field type C to 0.3812 in rice field type A. The low diversity associated with rice field type C as described by Simpson, Shannon, Margalef and Mechnick indices, may be attributed to lesser number of species and environmental degradation due to regular application of both fertilizer and herbicide in such habitat, beside other biotic factors, this is in agreement with the result of Shah and Pandit (2013), whom intensively worked on the application of diversity indices to crustacean community of Wular lake, Kashmir Himalaya.

Results on aquatic insect order diversity indices of rice-fields community during 2013 rainy season in Minna are presented on table 3. The rice-fields sampled harbored five insect orders as follows Coleoptera, Odonata, Hemiptera, Decapoda and Orthoptera. The first three orders had the same number of richness with Taxa (S) index value of 3.000 and the last two also had the same with a Taxa (S) index value of 2.000. Simpson diversity index revealed that Order Coleoptera is the most mature, stable and diverse insect Order in the rice-field community sampled with an index value of 0.631 and the least stable and diverse Order is Decapoda with an index value of 0.364. More so, Shannon Winner diversity index revealed that Order Decapoda is heavily affected by the pollution level in the rice field community while Order Coleoptera is less affected because they record the least and highest Shannon index value of 0.551 and 1.047 respectively. Although, Evenness diversity indices revealed that Order Orthoptera is the least rare species and Order Hemiptera is the rarest species with Evenness index value of 1.000 and 0.845 respectively. However, Menhinick diversity index revealed that Order Orthoptera is richer in terms of diversity with Menhinick index value of 1.000 and Coleoptera had the least richness with an index value of 0.173. While Margalef diversity index was similar to Menhinick with the richest Order to be Orthoptera and the least was Order Decapoda with Margalef index value of 0.721 and 0.310 respectively. On the other hand Berger-parker diversity index was highest for Decapoda (0.760) and the lowest is Order Coleoptera (0.481) in the rice-field community, although the higher the Berger-parker index value, the higher the diversity and lower the dominance, which implies that Decapoda has the

highest diversity with low dominance, which is contrary to the previous diversity indices of Simpson, Shannon explained earlier. Although, Fisher-alpha diversity indices is the only diversity that revealed spatial and temporal distribution pattern of species in a community, during the study period, the highest value of Fisher-alpha index was 1.592 for Order Orthoptera and the least was 0.481 for Order Coleoptera. This simply implies that Order Orthoptera was having the highest spatial and temporal distribution, meaning its diversity in the rice-field community was both with time and also across the different location in the rice-field community, while Order Coleoptera might be concentrated in a particular place and only at a particular period. This contradicts the findings of Andrea *et al* (2002) who worked on temporal and spatial diversity and distribution of Arboreal Carabidae (Coleoptera) in a Western Amazonian rain forest and placed Coleoptera far higher than previously thought by many research report.

### Conclusion

Regular application of agrochemicals as one of the agronomic requirements in rice farming had an influence on the distribution and diversity of insect species in the rice fields. Rice-fields where both fertilizer and herbicide applications were practiced recorded the lowest insect density, as well as, diversity; where no agrochemical was applied recorded moderate density, and was having most diverse insect population; and rice fields where only chemical fertilizer was applied recorded the highest insect density, though with slight lower diversity compare to rice-field type A during the study period. Therefore, application of herbicide in rice-fields could affect the occurrence, distribution and diversity of insect Orders. The highest insect densities were attained by Coleoptera and the lowest was Orthoptera.

### REFERENCES

- Akintayo, O.I., Rahji, M.A.Y., Awoyemi, T. T. & Adeoti, A. I. (2011). Determinants of Yield Gap in Lowland Rice Production in North Central Nigeria. *Agrosearch*, 1(2), 1-10.
- Arimoro, F. O. & James, B. H. (2008). *Pictorial representation of macro-invertebrate of Delta State, Nigeria*. South Africa, Albanil Meseum, 48 p.
- Andrea, L., Terry, L. E. & Jon, D.W. (2002). Temporal and Spatial Diversity and Distribution of Arboreal Carabidae (Coleoptera) in a Western Amazonian Rain Forest, *Biotropical*, 34 (3), 376-286.
- Bambaradeniya, C.N.B., Fonaseka, K.T. & Ambagahawatte, C.L. (1998). A preliminary study of fauna and flora of a rice field in Kandy Sri Lanka. *Ceylon Journal of Biological Sciences*, 25, 1-22
- Che-Salmah, M.R., Hassan, S.T.S., Abu-Hassan, A. & Ali, A.B. (1998). Influence of physical and chemical factors on the larval abundance of *Neurothemistullia* (Drudy) (Odonata: Libellulidae) in a rice field. *Hydrobiologia*, 389, 193-202.
- Dash, M.C. (2003). *Fundamental of Ecology*. 2nd Edition Tata McGraw-Hill publishing company limited, New Delhi, 34 p
- Fred, G.T. (2004). *Curator of Malacology, Florida meseum of natural history of Florida*. Florida, Geinesville, 1 p.
- Idowu, R.T., Inyang, N.M. & Eyo, J.E. (2004). The physicochemical parameters of an African Arid Zone Man made Lake. *Animal Research International*, 1(2), 113-119.
- Moreby, S.J. & Southway, S.E. (1999). Influence of autumn applied herbicides on summer and autumn food available to birds in winter wheat fields in southern England. *Agriculture, Ecosystems and Environment*, 72, 285-297.
- Olayemi, I.K., Ande, A.T., Isah, B. & Idris, A.R. (2009). Epidemiology of malaria in relation to climatic variables in Minna, Nigeria. *African International Journal of Medical Sciences*, 2, 5-10.
- Rawda, M.B., Iman, E.H. & Mohammed, T. (2013). Biodiversity and seasonal fluctuation of aquatic and semi aquatic insect in Rashid stream, Kafr El Zayat. *Egypt Academic Journal Biological Science*, 6 (1), 47-66.

- Salihu, I.M., Olayemi, I.K., Ukubuiwe, A.C., Garba, Y., Gusau, A.Y., Nma-Etsu, M., Usman M.D. (2017). Influence of Agrochemical Inputs on Suitability of Physicochemical Conditions of Rice-Fields for Mosquito Breeding in Minna, Nigeria. *Journal of Mosquito Research*, 7 (17), 134-141
- Shah, J.A. & Pandit, A.K. (2013). Application of diversity indices to crustacean community of Wular Lake, Kashmir Himalaya *International Journal of Biodiversity and Conservation*, 5(6), 311-316.
- Vaibhao, G.T. & Varsha, S.Z. (2011). Diversity, abundance and species composition of water Beetles (Coleoptera: Dytiscidae, Hydrophilidae and Gyrinidae) in Kolkas Region of Melghat Tiger Reserve, Central India. *Academic Journal of Entomology*, 4 (2), 64-71.
- Yusuf, G. & Olayemi, I.K. (2015). Spatial variation in physicochemical characteristics of wetland rice fields mosquito larval habitats in Minna, North-Central Nigeria. *International Conference on Agricultural, Ecological and Medical Sciences*. 3, 53-56
- Yuanyuan, L., Xiaohou, S., Wenlu, G., Liang, R., Jie, L., Jinlan, W. & Qijin, W. (2016). Nitrogen-Decreasing and Yield-Increasing Effects of Combined Applications of Organic and Inorganic Fertilizers under Controlled Irrigation in a Paddy Field. *Journal of Environmental Studies*, 25(2), 673-680