Original Article

Spatial Distribution of Lake-water Insects in Minna, North central Nigeria: Bio-indication of Water Quality

Mohammed, A. Z., Sidiq, O. L., Olayemi, I. K*. and Ayanwale, A. V.

Department of Biological Sciences, Federal University of Technology, Minna, Nigeria

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ABSTRACT

This paper reports on a study to elucidate the ecological state and water quality of fresh water lakes in Minna, Nigeria, and generate baseline information for their sustainable management. Aquatic entomo-faunal indicators of water quality were assessed for spatial variations in species composition and relative abundance among four lakes in the area, following standard procedures. The results indicated the occurrence of 16 insect species, belonging to five Orders; in order of abundance, Coleoptera > Hemiptera > Diptera > Odonata > Orthoptera, in the lakes. The dominant insect species encountered included, *Locris ruben* (23.23%), *Chironomus* sp. (14.81%), *Helochares* sp. (14.13%), *Orectogyrus* sp. (12.23%), *Epilachna similis* (11.96%), etc. The total numbers of insects collected from the four lakes varied significantly ($P < 0.05$), ranging from 4.89% in Bosso Pyata lake to 51.49% in Bosso Gabas lake. Likewise, the proportional distribution of the individual insect species within a lake differed significantly ($P < 0.05$). The most versatile taxa were Diptera and Odonata, being present in all lakes while, Orthoptera was the most restricted, recovered only from Bosso Gabas and Tagwai lakes. While all five insect Orders encountered during the study period were present in Bosso Gabas and Tagwai lakes, Bosso Pyata lake was the least productive, harbouring only two Orders. These results were discussed from the ecological standpoint of probable pollution status of the lakes, and it is hoped that the findings will guide the managers of the lakes in taking informed and justifiable actions.

Key Words: Aquatic Insects, Bio-indicators, Fresh Water, Minna and Pollution

***Corresponding Author:** kaylatiyemi@yahoo.com

INTRODUCTION

Insects are the most successful and versatile faunal group, constituting more than 80% of described animal species (Pfadt, 1985). They are widely distributed in every conceivable habitat with the exception of the marine ecosystems, and are particularly important in fresh water food chains (Foil, 1998; Chae *et al.*, 2000). Also, certain aquatic insect species including, members of the Orders Ephemeroptera, Plecoptera, Tricoptera, Diptera, etc, because they live relatively long and are capable of integrating temporal environmental conditions, may serve as good indicators of aquatic pollution; and have been used over the decades in fresh water bio-monitoring programs and assessment of environmental impacts (Arimoro and Ikomi, 2008).

While some aquatic insect species are sensitive to and hence, are limited by pollution, others thrive even in extremely degraded environments (Merritt and Cummins, 1996; Bauernfeind and Moog, 2000). The responses of aquatic insects to pollution are usually manifested as nil species occurrence, reduced relative abundance of individuals or species relative predominance, depending on the tolerance limits of the species. To this end, significantly spatial variations in species composition and densities of entomo-indicators of fresh water pollution within localities have been reported. According to Popoola and Otalekor (2011), such variations in distribution of aquatic insects may be attributed to the degree of anthropogenic interference in the ecological balance of fresh water bodies. Poor anthropogenic practices have resulted in the discharge of untreated wastes and chemical-laden agricultural run-offs in to fresh water ecosystems, with the consequent effects of reducing their water quality (Arienzo *et al*., 2001; Azrina *et al*., 2005). This development results in unhealthy changes in physico-chemical properties of the water bodies thus, influencing the species composition and relative abundance of the inherent entomo-fauna.

Traditionally, water quality monitoring of aquatic ecosystems entails the collection of water samples for physic-chemical analysis in the laboratory. This approach is expensive and can not detect non-point source pollution problem (Swaminathan, 2003); it is therefore, regarded as inadequate to fully characterize aquatic pollution status or reliably detect adverse impacts (Mandavile, 2002). To this end, the use of aquatic insects as biological water quality monitoring tools have been widely reported (Hardensen, 2002; Ogbeibu and Oribhabor, 2002; Compin and Cereghino, 2003; Arimoro *et al*., 2007; Paparisto *et al*., 2009).

In Nigeria, significant spatial variation in aquatic entomo-diversity have been reported (Ugbogu and Akinya, 2001; Tyokumbur *et al*., 2002; Zabbey and Hart, 2006), probably, indicative of differential pollution status of the water bodies assessed. With increasing rates of fresh water pollution in Nigeria, coupled with the high costs of the use of physic-chemical analysis in detecting and monitoring fresh water pollution, there is an urgent need to promote the use of entomo-indicators as integral tools for the management of fresh water pollution in the country. However, the success of this strategy depends largely on a good understanding of the composition and distribution of aquatic insect species in different eco-geographic zones of the country. Presently, there is a general dearth of information on the bio-diversity of aquatic insects in Nigeria. This study was, therefore, carried out to elucidate the species composition, relative abundance and spatial distribution of lake fresh water entomo-fauna in Minna, Northcentral Ni.

MATERIALS AND METHODS

Description of Study Area

The study was carried out in and around Minna area of North Central Nigeria. Minna is the capital city of Niger state, located within longitude 6^0 33´ E and latitude 9^0 27´ N, covering a land area of 88km^2 with an estimated human population of 1.2 million. Minna enjoys a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20^{0}C, 61.00% and 1334.00mm, respectively. The climate presents two distinct seasons; a rainy season between May and October and a dry season (November - April). The vegetation in the area is typically grass-dominated savannah with scattered trees.

Sampling of Aquatic Insects

Insect specimens were collected from the four lakes (i.e., Bosso Gabas, Bosso Pyata, Maizube and Tagwai lakes) bi-weekly, during the rainy season of 2009, between the hours of 0800 and 1200. Surface-dwelling insects were collected using a dip-net with Nytex® netting of 500 µm mesh. The contents collected were subsequently emptied into a labeled bucket, containing water from the sampling site. The net was properly checked for insects clinging to the mesh. Also, the shores were searched for 30 minutes where insect specimens were handpicked from specific microhabitats, with the aid of forceps. For the bottom-dwelling species, a Suber Sampler was used to collect sediments from the substratum. The sediments collected were emptied into labeled polythene bags and taken to laboratory for washing and sorting.

Processing, Preservation and Identification of Insect Specimens

In the Laboratory, the samples were washed and screened separately through a sieve with mesh size of 0.5 mm to eliminate the excess sediments while, detritus were handpicked off the collections. The large specimens were sorted by naked eyes while that of the smaller ones was done under a dissecting microscope. The specimens were then preserved in 70% alcohol. The specimens were subsequently identified to species level, where possible, using standard aquatic insect taxonomic keys (Dejoux *et al*., 1994; Heckman, 2002).

Data Analysis

For each lake, the total number and relative proportions of insect species collected was calculated. ANOVA was used to test for the significance of statistical differences among means of insect species densities in each lake while the Chi square test was used to assess such differences among total numbers of specimens collected from the four lakes.

RESULTS

Entomo-faunal species composition and relative abundance of the four lakes investigated are presented in Table 1. On the whole, a total of 736 insect specimens, comprising 16 species from five Orders were collected from the lakes during the study period. The five insect fauna, in order of species and relative density abundance included Coleoptera (54.35%; represented by nine species), Hemiptera (26.22%; 3 species), Diptera (15.63%; 2 species), while Odonata (2.85%) and Orthoptera (0.95%) were represented by a species each (Table 2). Statistical analysis revealed significant ($P < 0.05$) differences among the proportional relative abundance of the taxonomic Orders. Likewise, the proportional distribution of the individual species within a lake varied significantly ($P < 0.05$).

The three taxonomic Orders represented by multiple species were each significantly dominated by certain insect types. While, *Orectogyrus* sp (24.00%) and *Helochares* sp (20.00%) dominated the Order Coleoptera, the Hemipterans and Dipterans were respectively dominated by *Locris ruben* (86.40%) and *Chironomus* sp (86.05%). *Locris ruben* was the dominant species in three of the lakes namely, Bosso Gabas, Maizube and Tagwai lakes (range = 15.69% in Tagwai lake to 28.50% in Bosso Gabas) while *Chironmus* sp dominated in Bosso Pyata lake (Tab. 1).

Figure 1 highlights the distribution and relative abundance of the taxonomic Orders among the four lakes. The five taxa were encountered in Bosso Gabas and Tagwai lakes, while Orthoptera was the only Order missing in Maizube lake. Bosso Pyata lake on the other hand, supported only Diptera and Odonata species. Consistently, where present, Coleoptera was the most abundant taxon, followed by Hemiptera and Diptera. However, in terms of spread, the Orders Diptera and Odonata were the most versatile, being present in all lakes while, Orthoptera was the most restricted (i.e., encountered only in two of the lakes namely, Bosso Gabas and Tagwai.

DISCUSSION

The five insect Orders encountered in the lakes during the study period is consistent with the findings of Popoola and Otaleko (2011), who collected the same species number and more-or-less same set of species of insects, from a reservoir in the southern part of the country. However, elsewhere especially outside Nigeria, studies on fresh water entomo-fauna revealed the occurrence of higher species number and types (Hafeez *et al*., 2000; Martinoy *et al*., 2006 Wahizatul *et al*., 2011). Also worthy of note, is the general absence of the EPT (i.e., Ephemeroptera, Plecoptera and Tricoptera) insect Orders in the Nigerian studies compared with those reported outside the country. The EPT entomo-fauna are often regarded as the most diagnostic of water quality (Paparisto *et al*., 2009). These findings, therefore, probably indicate that the four lakes examined in this study were in poor states of health.

Except for Coleoptera, which had nine species, the few insect Orders encountered in the lakes were represented by relatively equally few a

Table 1: Species composition and relative abundance of entomo-faunal communities of freshwater lakes in Minna, Northcentral Nigeria.

Order	Species	Bosso Gabas Lake		Bosso Pyata Lake		Maizube Lake		Tagwai Lake		Aggregate	
		No.	%	No.	%	No.	%	No.	%	No.	%
Coleoptera	*Attagenus* sp	3	0.79^{a*}	0	0.00^{a}	0	0.00^{a}	3	1.47^{b}	6	0.82^{a}
	Coleostoma sp	31	8.18^{b}	0	0.00^{a}	0	0.00^{a}	16	7.84^{c}	47	6.39^{c}
	Epilachna similis	37	9.76^{b}	0	0.00^{a}	21	17.95^{c}	30	14.71^{d}	88	11.96^{d}
	Helochares sp	40	10.55^{b}	0	0.00^{a}	18	15.38^{c}	46	22.55^{e}	104	14.13^{d}
	Hydrocanthus	4	1.06^{a}	0	0.00^{a}	0	0.00^{a}	0	0.00^{a}	4	0.54^{a}
	Orectogyrus sp	48	12.66^{b}	0	0.00^{a}	17	14.53^{c}	25	12.25^{d}	90	12.23^{d}
	Paederus sabaeus	0	0.00^{a}	0	0.00^{a}	0	0.00^{a}	12	5.88^{c}	12	1.63^{a}
	Sternoloplus solieri	34	8.97^{b}	0	0.00^{a}	7	5.98^{b}	5	2.45^{b}	46	6.25^{c}
	Yola sp	3	0.79^{a}	0	0.00^{a}	0	0.00^{a}	0	0.00^{a}	3	0.41^{a}
Diptera	*Chironomus* sp	37	9.76^{b}	30	83.33^{c}	18	15.38^{c}	24	11.76^{d}	109	14.81^{d}
	Culex sp	6	1.58^{a}	0	0.00^{a}	0	0.00^{a}	0	0.00^{a}	6	0.82^{a}
Hemiptera	*Laccotrephes steindacneri*	9	2.37^{a}	0	0.00^{a}	2	1.71^{b}	3	1.47^{b}	14	1.90^{a}
	Locris ruben	108	28.50^{c}	0	0.00^{a}	31	26.50^{d}	32	15.69^{d}	171	23.23^{e}
	Ochterus marginatus	8	2.11^{a}	0	0.00^{a}	0	0.00^{a}	0	0.00^{a}	8	1.09^{a}
Odonata	*Brachythenis wilsoni*	7	1.85^{a}	6	16.67^{b}	3	2.56^{b}	5	2.45^{b}	21	2.85^{b}
Orthoptera	*Atractomorpha* sp	4	1.06^{a}	0	0.00^{a}	0	0.00^{a}	3	1.47^{b}	7	0.95^{a}
Aggregate	16	379 $(51.49)_{d**}$	100.00	36 $(4.89)_{a}$	100.00	117 $(15.90)_{b}$	100.00	204 $(27.72)_{c}$	100.00	736 (100.00)	100.00

*Values followed by same superscript alphabet in a column, for species, are not significantly different at $P = 0.05$.
**Values in parenthesis are percentage distribution of total insect specimens collected from the four lakes, and when followed by different subscript alphabets are significantly different at $P = 0.05$.

Table 2: Relative abundance of entomo-faunal communities of freshwater lakes in Minna, Northcentral Nigeria.

Taxonomic Order	Bosso Gabas Lake		Bosso Pyata Lake		Maizube Lake		Tagwai Lake		Aggregate	
	No.	%	No.	%	No.	%	No.	%	No.	%
Coleoptera	200	52.77[d*]	0	0.00[a]	63	53.85[e]	137	67.16[c]	400	54.35[d]
Diptera	43	11.35[b]	30	83.33[c]	18	15.38[c]	24	11.76[b]	115	15.63[b]
Hemiptera	125	32.98[c]	0	0.00[a]	33	28.21[d]	35	17.16[b]	193	26.22[c]
Odonata	7	1.85[a]	6	16.67[b]	3	2.56[b]	5	2.45[a]	21	2.85[a]
Orthoptera	4	1.06[a]	0	0.00[a]	0	0.00[a]	3	1.47[a]	7	0.95[a]
Aggregate	379	100.00	36	100.00	117	100.00	204	100.00	736	100.00

[*]Values followed by same superscript alphabet in column are not significantly different at $P = 0.05$.

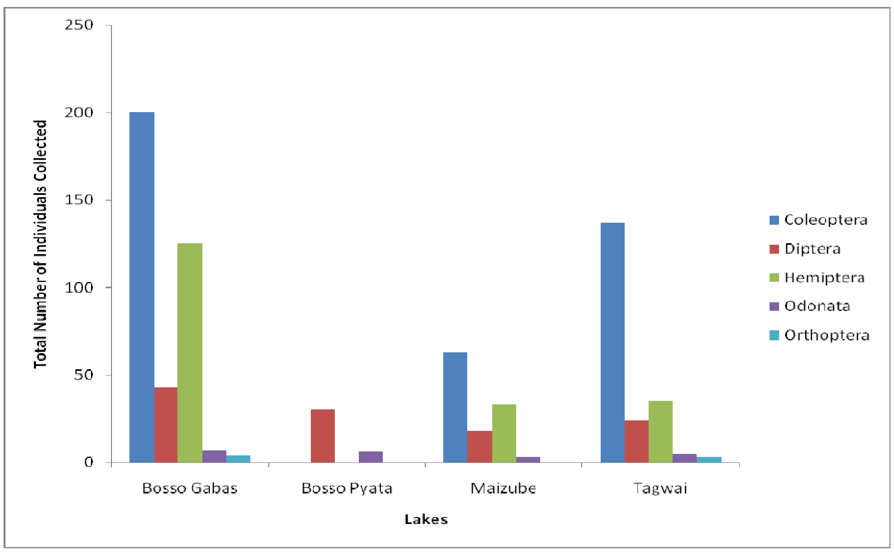

Figure 1: Patterns of distribution of insect Orders in freshwater lakes in Minna, Northcentral Nigeria.

species. For example, two of the Orders, i.e., Odonata and Orthoptera, were represented by a species each while, Diptera had two species. These results contrasted sharply with those obtained elsewhere. In Malaysia, most of the entomo-faunal taxonomic Orders encountered in two freshwater bodies of Hulu Terengganu were represented by at least five families, with the Odonates comprising nine families (Wahizatul *et al*., 2011). Similar, results were obtained by Hafeez *et al*. (2000) while monitoring water pollution near Islamabad using bio-indicators; the results showed that the Dipterans accounted for 12 of the 38 insect *Genera* encountered. To this end, the authors concluded that the quality of the two water bodies can be considered as high based on the diversity and abundance of the inherent aquatic insects. Thus, the relatively few species inhabiting the four lakes investigated in Minna, could be further indicative of their poor water quality.

The significant variation in the total number of species and individuals of insect specimens recovered from the four lakes, probably, suggests differential levels of pollution of the four lakes. Earlier, physic-chemical analysis of two of the lakes, i.e., Bosso Gabas and Bosso Pyata, revealed significantly higher nutrient concentrations and Chemical Oxygen Demand in the former than latter lake (Mohammed *et al*., 2011). The significantly varied proportional distribution of the individual insect species within a lake observed in the four sites may be indicative of species tolerance capacity of the prevailing physico-chemical properties of the water bodies. According to Bauernfeind and Moog (2000), the distribution pattern of aquatic insects is greatly influenced by variations in physic-chemical parameters, since some species are highly susceptible to pollution while others may be more tolerant of environmental deterioration.

The significant preponderance of certain species over others in each of the five Orders recovered from the sites may reflect the species of each site may reflect the species of each Order best adapted to surviving and proliferating under the prevailing conditions. However, the dominance of *Locris ruben* in three of the lakes, and *Chironomus* sp in the fourth lak, indicate that the two species can tolerate polluted waters. Traditionally, *Chironomus* sp, thrives better than other insect species in water bodies with low values of Dissolved Oxygen concentration (Emere and Nasiru, 2007), often indicative of poor water quality resulting from various anthropogenic interference (Yakub, 2004). In Malaysia, Ali *et al*. (2003) found Dipteran species including Chironomus sp dominating in heavily organic-impacted water bodies.

If the significant variations in numbers of insect species and individuals recorded in the four lakes truly reflects their levels of pollution then, Bosso Pyata lake, supporting only two insect Orders and a paltry <5% of all collected species may be considered the most polluted while Bosso Gabas lake is the least polluted and distantly followed by Tagwai lake.

CONCLUSION

The lake freshwater habitats in Minna are characterized by vary low entomo-faunal numbers of species and individuals. Pollution sensitive insect species, especially, members of the EPT bio-indicators were conspicuously absent in specimen collections from these lakes. Instead, such collections were significantly dominated by renowned pollution-tolerant species namely, *Locris ruben* and *Chironomus* sp. Thus, it may be concluded that the lake freshwater bodies in Minna are significantly polluted; though physic-chemical analysis will help validate this submission. It is hoped that the findings of this study will provide the managers of these lakes with baseline data to take informed and justifiable actions, to reverse the present probable poor health of the water bodies in order to ensure sustainable exploitation.

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