ZOOPLANKTON DIVERSITY OF THE LOWER RIVER NIGER AT AGENEBODE, EDO STATE. NIGERIA.

***[1] ADENIYI, A. O., [1] A. O. AKINWOLE, [2] A.O. ABIODUN-SOLANKE, AND [3]J.O. OSHOKE**
*[1]Department of Aquaculture and Fisheries Management, University of Ibadan. Ibadan, Nigeria.
[2]Nigerian Institute of Oceanography and Marine Research, Victoria Island, Lagos,
[3]Nigeria Federal University, Dutsin-ma, Katsina State, Nigeria.
Corresponding Author: osasadeniyi@gmail.com

ABSTRACT
The Zooplankton diversity of the Lower River Niger at Agenebode town in Edo State was assessed. The river was stratified into three zones; downstream (DNS), midstream (MDS) and upstream (UPS) based on the hydrological features. Plankton samples were collected using a plankton net of 76µm mesh size with a mouth diameter of 12.50cm. Samples were analyzed using the drop-count method under the light microscope. A total of 2,897 zooplanktons were recorded belonging to 3orders, 10families, 13genera and 20 species, with order: copepod (1605, 55.40%) dominating in abundance. The family: Cyclopidae had the highest number of species (55.06%) of the total zooplankton while Brachionus falcatus falcatus was the most abundant species. Spatially, the DNS had the highest zooplankton abundance (1054, 36.38%) while MDS (890, 30.72%) had the least. There was no significant difference in zooplankton abundance amongst the sampling zones, however, there was a significant difference between DNS and the other two zones. There was a significant difference seasonally in the distribution and abundance of zooplankton obtained in the Lower River Niger at Agenebode. Zooplankton abundance in the wet season was higher than in the dry season with August recording the highest number of 496 species. The zooplankton assemblage of Lower River Niger belongs to three major taxonomic groups, Cladocera, Copepoda, and Rotifera, however, it was dominated by the copepods.
Keyword: Assemblage, Biota, Plankton, Spatial Variation

INTRODUCTION

Zooplankton plays an important role in the energy and material transfer in water bodies as the consumers of phytoplankton (Adedeji *et al.,* 2013). Zooplankton is also known as a valuable source of amino acids, lipids, fatty acids and essential minerals and enzymes needed by aquatic organisms for effective normal growth and survival. Several studies have also indicated improved performance of fish larvae fed natural indigenous live zooplankton (Ovie *et al.,* 1993; Adeyemo *et al.,* 1994; Adedeji *et al.,* 2013 and Abdul *et.al*., 2015). According to Adedeji *et.al.* (2013), both live and frozen zooplankton have also been used in commercial and experimental aquaculture.

Zooplankton consists of macro and microscopic animals, comprising representatives of almost all major taxa, particularly the invertebrates (Anamunda, 2015). The zooplankton are ubiquitous. Their variability over space and time in any aquatic ecosystem is their most characteristic feature. Zooplankton can be categorized as herbivorous and carnivorous based on their nature of feeding; herbivorous zooplankton feed on phytoplankton and in turn constitute important food items to other aquatic animals in the higher trophic levels including fish (Haven, 2002; Anamunda, 2015) thereby, play a vital role in the aquatic food chain. The occurrence and abundance of Ichthyo-plankton, fish eggs, and fish larvae) facilitate the location of probable spawning and nursery ground of fishes.

The livelihood of the residents of Agenebode, a major fishing commercial town, and adjoining communities depends on the Lower River Niger for both domestic and fishing activities. Despite this river's support to the artisanal fishing, transportation, domestic use and cultural ethics of these surrounding communities, there is a paucity of scientific information on the zooplankton diversity of the Lower River Niger at Agenebode. The objective of this study, therefore, was to investigate the spatial and seasonal variations of the abundance and distribution of zooplankton of the Lower River Niger at Agenebode, Edo State, Nigeria.

MATERIALS AND METHODS

Study Area

Agenebode is located on latitude $7^0$03'15N to $7^0$09'15N and longitude of $6^0$39'42E to $6^0$45'00E (Figure 1). It is a serene, water-side town bounded by Ivioghe, Egor, Emokweme villages, and the River Niger in Edo State, and the headquarters of Etsako-East Local Government Area of Edo State, Nigeria.

Selection of Sampling Stations

Spatial stratification was adopted according to Southwood and Henderson (2000), in which, the river was delineated into three zones; according to their hydrological features. Two stations were selected in each zone (Figure1). Sampling points were marked with the use of Global Positioning System-GPS (Microstar IV Carl Zeiss®)

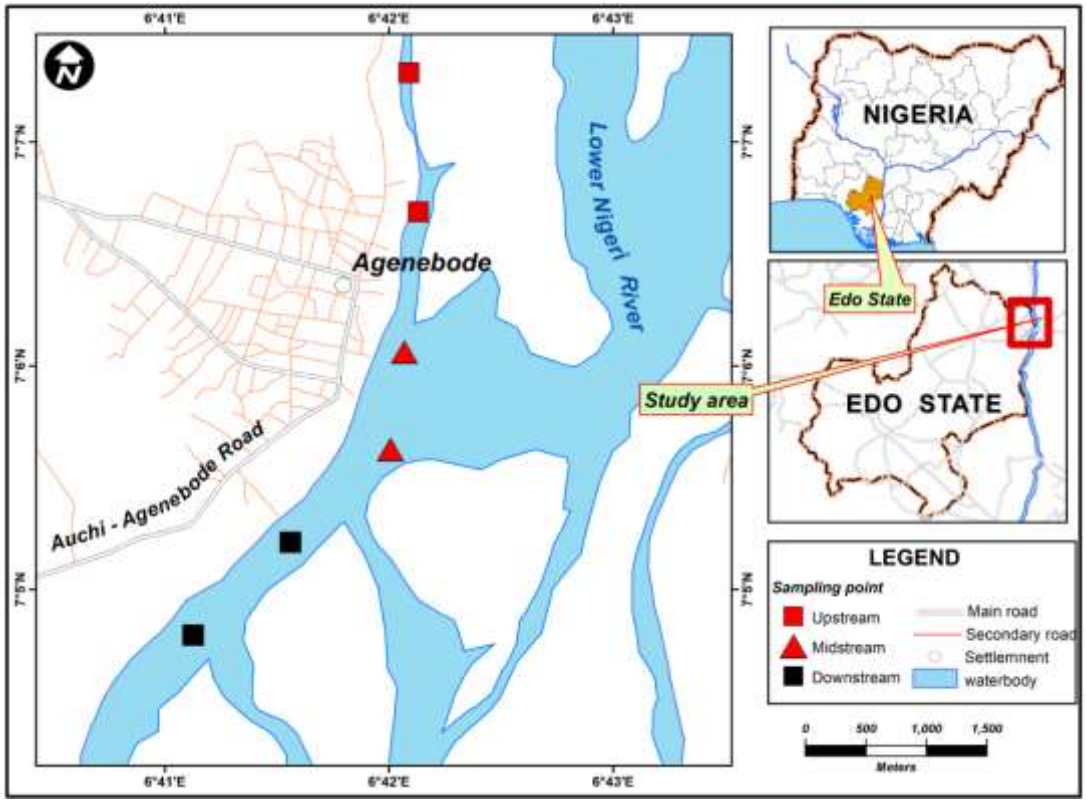

Figure 1: Map of Study Area Showing Sampling Stations

Collection of Samples

Water sampling was carried out for 21months (covering two wet seasons and two dry seasons) and collected bimonthly in the early hours of the morning from 6 am to 8 am) at a depth of 20cm below the water surface according to USEPA, (2014) procedures. Plankton samples were collected using No. 20 silk bolting zooplankton net of 76µm mesh size and mouth diameter of 12.50cm. The plankton net was towed along the river at the sampling sites from the boat for five minutes, the net was rinsed into the attached bottle and the content in the attached bottle was poured into the sample bottles and preserved in 4% formalin (Zabbey *et al*., 2008); this was kept undisturbed on a flat surface for over 24hours. The sample volume was later reduced to 25ml by siphoning with a pipette fitted with a flexible rubber tubing of 5mm diameter. The tip of the pipette fitted to prevent accidental loss of organisms during siphoning (Ovie and Ajayi, 2009). Two drops of Rose Bengal stain was added to the water sample for zooplankton and kept in the laboratory for microscopic analysis.

Determination of Plankton Composition

Samples were analyzed qualitatively and quantitatively to determine zooplankton composition, using a binocular microscope (Microstar IV Carl Zeiss®) calibrated at different magnifications (x10, x40 and x100). The supernatant of the fixed zooplankton samples was carefully decanted to 400ml. 1ml of the water sample was analyzed with the aid of a Sedgwick Rafter counting chamber, using the drop count method (Lackey, 1938). For each 1ml of water sample, at least ten transacts were examined comprehensively with each transact at the right angle to the first. The number of subsamples taken was dependent on the examining of 2 to 3 successive subsamples without any addition of non-encountered species when compared to the already examined subsamples in the same sample. The species were identified using relevant texts/keys (Wickstead, 1965; Newell and Newell, 1966; Wiafe and Frid, 2001). Data were analysed using both descriptive (means and standard deviations) and inferential statistics (One-way ANOVA, t-test and correlations).

RESULTS

A total of 2,897 zooplankton species were recorded during this study, consisting of three orders, ten families, thirteen genera and 20 species with the order copepod (with 1605 individuals) dominating in terms of abundance representing 55.40% of the total individual species (Table1). Among the zooplankton identified, *Brachionus falcatus falcatus* of order Rotifera was the most abundant with 635 individuals representing 33.33% of the total while *Alona eximia, Moina reticulate, Diaphanosoma sp, Thermocyclops hyalinus,* and *Thermocyclops taihokuensis* were least with 5

species each in abundance. Spatially, DNS had the most abundant zooplankton (with1054 individuals) followed by UPS (953 individuals) and MDS (890 individuals) representing 36.38%, 32.90%, and 30.72% respectively. Moreover, the family: Cyclopidae was most (55.06%) abundant while the family: Chydoridae recorded the least (0.17%) (Tables 2 and 3). There was no significant difference ($P< 0.05$) among the sampling stations using (Table 4).

Zooplankton species composition and abundance in the wet season were higher than in the dry season, with August recording the highest of 496 while the least was in June with 101, the month of April recorded the highest with 444 and least of 150 for April in the dry season (Figure 2).

Table 1: Spatial Abundance of Zooplankton in the Lower River Niger at Agenebode with Rank

TAXONOMY	SPECIES	DNS	MDS	UPS	TOTAL Abundance	%
ORDER CLADOCERA						
BOSMINIDAE						
	Bosmina longirostris	30	71	64	165	4.63
	Bosminopsis deitersi	38	9	10	57	1.7
CHYDORIDAE					0	
	Alona eximia	0	5	0	5	0.13
DAPHNIDAE					0	
	Ceriodaphnia cornuta	15	5	0	20	0.54
MOINIDAE					0	
	Moina micrura	42	28	3	73	2.5
	Moina reticulate	5	0	0	5	0.13
SIDIDAE					0	
	Diaphanosoma excisum	62	25	46	133	3.72
	Diaphanosoma sp	2	2	1	5	0.13
ORDER COPEPODA					0	
CYCLOPIDAE	*Eucyclops serrulatus*	29	13	43	85	2.29
	Mesocyclops bodanicola	60	70	41	171	5.39
	Microcyclops varicans	20	22	15	57	1.72
	Thermocyclops hyalinus	5	0	0	5	0.13
	Thermocyclops neglectus	216	230	163	609	17.42
	Thermocyclops taihokuensis	5	0	0	5	0.13
	Tropocyclops prasinus	200	212	251	663	20.6
HARPACTICOIDA	*Nauplius larva of copepod*	4	6	0	10	0.27
ORDER ROTIFERA					0	
BRACHIONIDAE	*Brachionus calyciflorus anuraciformis*	54	30	94	178	4.79
	Brachionus falcatus falcatus	257	158	220	635	33.33
	Brachionus sp.	4	4	0	8	0.23
LECANIDAE	*Lecane sp*	6	0	2	8	0.22
TOTAL		**1054**	**1605**	**953**	**2897**	**100**

Table 2: Spatial Distribution of Zooplankton Families in Lower River Niger at Agenebode.

ZOOPLANKTON FAMILY	BOS	CHY	DAP	MOI	SID	CYC	HAR	BRA	LEC	TOTAL	%
DNS	68	0	15	47	64	535	4	315	6	**1054**	**36.38**
MDS	80	5	5	28	27	547	6	192	0	**890**	**30.72**
UPS	74	0	0	3	47	513	0	314	2	**953**	**32.90**
Total	**222**	**5**	**20**	**78**	**138**	**1595**	**10**	**821**	**8**	**2897**	**100**
%	**7.66**	**0.17**	**0.69**	**2.69**	**4.76**	**55.06**	**0.35**	**28.34**	**0.28**	**100**	

BOS – Bosminidae; CHY– Chydoridae; DAP – Daphnidae; MOI– Moinidae; SID–Sididae; CYC– Cyclopidae; HAR– Harpacticoida; BRA– Brachionidae; LEC- Lecanidae.

Table 3: Distribution of Dominant, Sub-Dominant and Non-Dominant Families of Zooplankton at the Sampling Stations.

Dominance	DNS (%)	MDS (%)	UPS (%)
A: Dominant * Families (15% and above)	Cyclopidae (41.60) Brachionidae (41.88)	Cyclopidae (57.77) Brachionidae (28.45)	Cyclopidae (45.34) Brachionidae (43.68)
B: Sub- dominant** Families (7-14%)	-	Bosminidae (7.07)	-
C: Non-Dominant*** Families (less than7%)	Bosminidae (5.64) Chydoridae (0.00) Daphnidae (1.05) Moinidae (4.67) Sididae (4.46) Harpacticoida (0.28) Lecanidae(0.42)	- Chydoridae (0.44) Daphnidae (0.44) Moinidae (2.47) Sididae (2.83) Harpacticoida (0.53) Lecanidae (0.00)	Bosminidae (6.33) Chydoridae (0.00) Daphnidae (0.00) Moinidae (0.26) Sididae (4.10) Harpacticoida (0.00) Lecanidae (0.17)

Key:* Taxa/individuals constituting 15 % and above of the total taxa or individuals as Dominant,
**Taxa/individuals constituting 7- 14 % of the total taxa or individuals as Sub-Dominant,
***Taxa/individuals constituting less than 7 % of the total taxa or individuals as Non- Dominant (Slack *et al.*, 1977 and 1979)

Table 3: Differences in the Zooplankton Distribution among Sampling Stations

	DNS			MDS			UPS			P-value
	Mean ±SE	Min	Max	Mean ±SE	Min	Max	Mean ±SE	Min	Max	
Zooplankton Abundance	71.75±29.30[a]	0	543	56.60±21.30[b]	0	288	57.35±23.43[b]	0	407	0.889

One-way ANOVA at $p < 0.05$

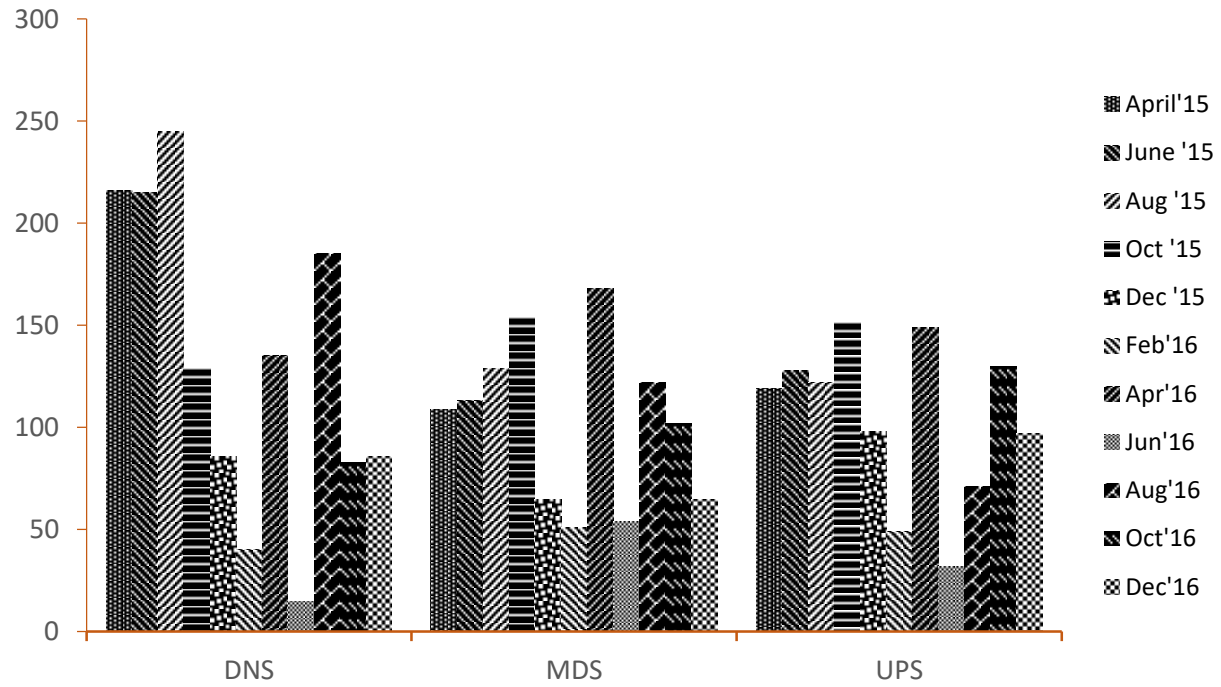

Figure 2: Monthly Distribution of the Zooplankton in the Lower River Niger at Agenebode, Edo State, Nigeria.

Zooplankton Diversity Indices

Using the Shannon-Weiner (H) zooplankton diversity index of the Lower River Niger for the period of study spatially, ranged from 1.87 to 1.97 at UPS and MDS respectively and was highest (2.00) at DNS. The Simpson index of Diversity (1 – D) fluctuated between 0.79 and 0.82 for UPS, DNS and MDS respectively with MDS recording the highest (0.82). However, the equitability values recorded for DNS and MDS were

0.68 and 0.71 respectively while UPS had the highest (0.73). The result of the Margalef index of species richness was 2.48 for DNS, 2.13 for MDS and 1.70 for UPS (Table 4).

Table 4: Spatial Diversity Indices of the Zooplankton of Lower River Niger

Zooplankton Indices	DNS	MDS	UPSw
Taxa_S	19	16	13
Individuals	1435	1132	1147
Dominance_D	0.2085	0.1846	0.2086
Simpson_1-D	0.7915	0.8154	0.7914
Shannon_H	2.002	1.968	1.865
Evenness_e^H/S	0.3897	0.4471	0.4964
Menhinick	0.5016	0.4756	0.3839
Margalef	2.476	2.133	1.703
Equitability_J	0.68	0.7097	0.727

DISCUSSION

From this study, 13 zooplankton genera comprising of 20 species were recorded; Adukwu *et.al,* (2019) recorded 32 genera comprising of 20 species in Goronyo Reservoir in Sokoto State, Nigeria while Zabbey, (2008), recorded 9 genera consisting of 24 species in Imo river, Niger-Delta. The qualitative order of domination of the zooplankton in this study where Copepods was highest followed by Rotifera and Cladocera least were at variance with Adukwu *et.al.* (2019) who reported the dominance of the rotiferans in Goronyo Reservoir, and what had earlier been observed in Imo River in Nigeria by Zabbey *et al.* (2008), who reported that cladocerans consisted of 30.03% of the total individual organisms. The abundance of the Rotifera species (*Brachionus falcatus falcatus)* over some other zooplankton was perhaps due to the capacity to survive and thrive in the environments predominant with seasonal variations. Certain rotifers are described to be primary consumers that forage on several phytoplanktons while some are known as unaggressive hunters that consume on bacterial and debris substances (Abdul *et.al*. 2015)

The species richness of zooplankton was low. The index of diversity ranged from 1.865 to 2.002, this result was high when compared with the works of Zabbey *et al*. (2008), who determined a range of 1.24 to 1.99 and Ogamba *et al*. (2004), in Elechi Creek Complex, all in the Niger Delta. Zabbey *et.al.* (2008), also reported zooplankton mean Margalef's diversity of 0.882different from that of the current study of 1.104. This could be ascribed to many factors like geo-ecological, geo-hydrological and temporal differences apart from anthropogenic influences which must have exerted selective effects on the zooplankton community.

CONCLUSION

The taxonomical composition and abundance of zooplankton of Lower River Niger studied indicated that three taxonomical groups were comprised of 10 families, 13 genera and 20 species. The most dominant zooplankton family was the Copepods while the Cladocerans were least and *Brachionus falcatus falcatus* species belonging to the Rotiferans dominated in the river.

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