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Abundance and Diversity of Zooplankton within the Itu Bridge –End Area of the Cross River System in Southern Nigeria

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Abstract: The zooplankton community in relation to abundance and diversity within the Itu Birdge – End Area of the Cross River system in Southern Nigeria was studied for nine months (February – October, 2018). Zooplankton samples were collected by filtration method using a – 100 litre bucket and a standard plankton net of 55µm mesh. 20L of surface water was filtered and concentrated to 10mls and preserved in 4% buffered formaldehyde solution in properly labeled sample bottles. Samples were stored in plastic boxes and transported to the Biological Oceanography Laboratory, University of Calabar, Calabar, Nigeria for analysis using standard texts and atlases. The zooplankton community consisted of 25 species spread into five taxonomic groups. These were Cladocera with 7 species, copepoda with 6 species, Protista with 5 species, Rotifera with 4 species and Protozoa with 3 species. Total of 123 (18.36%) Copepoda were recorded, with 376 (56.12%) of Cladocera, 57 (8.51%) of Protista, 67(10.0%) Rotifera and 47 (7.01%) Protzoa giving an abundance pattern of: Cladocera > Copepoda > Rotifera > Protista > Protozoa. Monthly zooplankton abundance ranged between 51 (7.45%) in July – 99 (14.45%) in February. Margalef's index ranged between 0.74 – 2.01 for the Copepoda, with a range of 1.07 – 1.43 for the Cladocera, 0.62 – 1.86 for Protista, 0.51 – 1.24 for Rotifer and between 0.12 – 0.91 for the Protozoans, Shannon- Wiener index ranged between 0.69 – 1.08 for the Copepoda, 1.34 – 1.73 for the Cladocera, 0.21 – 0.72 for the Protista, 0.28 – 0.96 for the Rotifera and 0.0 – 0.75 for the Protozoans. Significant relationship ($p<0.05$) existed between months of sampling and Zooplankton abundance and diversity within the area.
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Key words: Abundance, Diversity, Zooplankton community, Itu Bridge – End Area, Cross River System, Southern Nigeria.

1. Introduction

Zooplankton are ecological important groups of aquatic organisms that occupy a wide range of habitats (Castro and Huber,2005; Okorafor *et al.,* 2013; Antai and Joseph, 2015; Job *et al.,* 2017). Plankton generally constitute essential biotic components which influences the efficiency of an aquatic ecosystem such as energy flow, through various trophic interactions (Park and Shin, 2007; Job *et al.,* 2011; Antai and Joseph, 2015; Ekanem *et al.,* 2018; Ada and Job 2018). For example among the zooplankton, the Copepoda have been shown to be the major link between phytoplankton and first level carnivores, while arro norms (chaetognatha) are the common carnivores in Zooplankton Tse *et al.,* 2007; Job and Asuquo, 2009 and Antai & Joseph, 2015).

According to FAO (2006), the species composition, diversity, biomass, period and season of abundance of Zooplanktonic organisms may differ in different water bodies and geographical location, hence the need to study as many water bodies possible.

Studies on Zooplankton in the Nigerian river system from available literature include those of Onyebuchi *et al.,* (2019) in Ivo River Basin, Ude *et al.,* (2011) in Echara River, Antai and Joseph (2015), Agouru and Audu (2012) in river Benue, Dimowo (213) in River Ogun, FAO (2006) in Inland waters, Okorafor *et al., (* 2013), Yakubu *et al.,* (1998) in the Nun River Ezekiel *et al.,* (2011) in the Soimbreiro river, Eni *et al.,* (2014) in the Calabar River, Job *et al.,* (2017) in the Calabar river, Eyo *et al* (2013) in the Great Kwa River, Ikonmi and Anyanwu (2010) in ogba river, Akin – Oriola (2003) in Ogunpa and Ona rivers, Ekwu and Sikoki (2005) in the Cross River estuary, Offem *et al.,* (2009) in the Cross River system, Ajay *et al.* (2005) in the Calabar and Cross rivers, Egborge (1972) in river Oshun, Egborge and Chigbu (1988) in Ikoba River and Uttah *et al.* (2008) in the Calabar River, Iman *et al* (2011) in the Jakara –

Getsi River and Oku *et al.,* (2013). None of these studies has reported on the zooplankton within the Itu Bridge –End Area of the Cross River system Nigeria, which is the focus of the present study.

2. Materials and Methods

2.1 Study area

The study area is the lower Cross River, a tropical freshwater fluvial system draining the rainforest belt of Akwa Ibom and Cross River States, Nigeria and is described in King (1998). There are two seasons in the area (dry) (November – March) and rainy (April – October). At Ayadehe bridge (Itu Local Government Area) $5^0$12'N, $7^0$59'E, where samples for this study were collected. The river experiences tidal variations which are most pronounced in the dry season (King, 1998). The river flow becomes unidirectional during the peak of rains (July – October), with the current velocity increasing from 0.4 – 0.6ms^{-1} in the dry season to 0.7-1.5ms^{-1} during the rains (King, 1998). The average depth has been reported by Etim and Brey (1994) to be 4m in the dry season and 14m in the Wet season. Water temperature of the study are according Etim and Enyenihi (1991), varies between 22^0C and 30^0C. The river is hydro dynamically relatively homogenous stretching about 25km to the north and 25km to the South of It (Etim and Enyenihi, 1991; Etim and Brey (1994). The river is vertically homogenous in most physico-chemical parameters with annual variation in pH 6.8-7.2, salinity, 0.2 – 0.6% and total hardness ranging between 10-20mgCaCo$_3$L^{-1} (King, 1998).

2.2 Field Studies

2.2.1 Collection of Samples

Zooplankton samples were collected by filtration method, using a – 20 litre bucket and a standard plankton net of 55µm mesh as recommended by Ashutosh *et al.* 2010 and Job *et al.,* 2017). The 20l of surface water was concentrated to 10mls and preserved in 4% buffered formaldehyde solution in properly labeled sample bottles. Samples were stored in plastic boxes and transported to the Biological Oceanography Laboratory, University of Calabar, Calabar, Nigeria, for analysis.

2.3 Laboratory Studies

In the laboratory, each sample was and well stirred to mix using a glass rod and allowed to sediment as recommended by Egbai & Job (2017). Samples were then observed under a compound microscope (model: Olympus CHOO545 Tokyo, Japan) of x 10, and x 40 objectives following Job *et al* (2011, 2017). The Zooplankton species were identified based on their respective morphological features using the schemes of Jeje & Fernando (1980), Han (1978), Needham & Needham (1962) and Marine Biology Organization (2007a).

2.3.1 Data analysis

Data were analyzed empirically and ecologically.

2.3.2 Empirical data analysis

Individual species (n) of the zooplankton in each sample was enumerated to find the total number of all individuals (N) in the group. This was used for the determination of the relative abundance ($\%_{Ra}$), using the formula:

$$\%_{Ra} = n\,(100)/N \qquad 1$$

N

where n = number of individual species

and N= total number of all the individual species in the group (Job *et al.*, 2011., Job *et al* 2017; Job & Ekpo 2017, Egbai & Job, 2017; Ekanem *et al* 2018; Ada & Job, 2018)

2.3.3 Ecological data analysis

These were performed using Margalef's and Shannon – Wiener indices

2.3.3.1 Margalef's Index (d):

Margalef's Index (d) windows the pollution index of the system studied (Ali *et al* 2003). and is given by the formula:

$$d = S\text{-}1/\ \ln N \qquad 2$$
(Margalef 1965, 1978

where S = total number of species

ln = the nature or niperian longarithm ($\log_e$)

and N = total number of individuals samples (Margalef, 1965, 1978, Ogbeibu, 2005, Job *et al* 2017, Job Ekpo, 2017 Egbai & Job, 2017; Ekanem *et al.,* 2018).

2.3.3.2 Shannon- Wiener Index (H): This index is sensitive to the number of species present in the sample (Shannon-Weaver, 1949; Ogbeibu, 2005, Job *et al.,* 2017), and is given by the formula:

$$H = N\log N - \Sigma fi\log fi/N \qquad 3$$

where N = total number of all individual in the assemblage, group, phyla or class (as the case may be

fi = total number of individual species or group of species.

2.4 Statistical Analysis

The distribution and abundance of the zooplankton in relation to sampling months was compared using the single factor analysis of variance (ANOVA) at 0.05 level of significance (SAS, 2003).

3. Results

Species composition, species Richness, abundance and distribution.

The species composition of the zooplankton is presented in Table 1. Altogether 25 species of the zooplankton spread into 5 taxonomic groups were identified. The most diverse group in terms of species composition was the Cladocera with 7 species. This was followed by Copepoda with 6 species Protista, with 5 species, Rotifera, with 4 species and Protozoa, with 3 species.

Among the Cladocera, *Alona monachata* was observed in all months during the period of study. Some species of the zooplankton were either absent in one month or present in another. The only species that was present throughout the month of study was *Alona monochata* (a cladocera), while *Philomedes globoso* (another Cladocera), was observed in every other month except September.

Each species also showed varied abundance in each of the month of sampling.

Total of 376 (56.12%) Cladorera were recorded with,123 (18.36%) of Copepoda, 67 (10.0%) of Rotifera, 57 (8.51%) of Protista and 47 (7.01% of Protozoa giving a distribution pattern of: Cladecera > Copepoda > Rotifera > Protista > Protozoa (Table 1a).

Margalef's and Shannon – Wiener indices calculated for each of the zooplankton groups showed varied values and ranges. Monthly zooplankton abundance ranged between 51 (7.45%) in July – 99 (14.45%) in February. Margalef's index ranged between 0.74 – 2.01 for the Copepoda, with a range of 1.07 – 1.43 for the Cladocera, 0.62 – 1.86 for Protista, 0.51 – 1.24 for Rotifer and between 0.12 – 0.91 for the Protozoans, Shannon- Wiener index ranged between 0.69 – 1.08 for the Copepoda, 1.34 – 1.73 for the Cladocera, 0.21 – 0.72 for the Protista, 0.28 – 0.96 for the Rotifera and 0.0 – 0.75 for the Protozoans.

Table 1: Species composition, abundance and diversity of zooplankton with Itu Bridge –End Area of Cross River System, Nigeria (February – October, 2018)

Taxonomic list										
Copepoda (Crustaceae)	Feb	March	April	M ay	June	July	Aug.	Sept	Oct	Marginal total
Cyclops glenius	4	3	-	3	2	-	3	2	4	
Paracyclops fimbriatus	-	5	1	2	1	-	-	4	6	
Paracalanus parnis	4	-	7	3	2	5	3	2	-	
Mesochia suifunensis	-	1	3	-	3	1	-	-	5	
Eucalanus elonga	-	3	2	2	1	-	3	2	1	
Mesochra sulfunensis	7	-	4	6	3	2	5	3	-	
Total abundance (N)/100ml	15	12	17	16	12	8	14	13	16	123
Number of species (S)	3	4	5	5	6	3	4	5	4	
Margalef's Index (d)	0.74	1.20	1.41	1.44	2.01	0.96	1.14	1.56	1.08	
Shannon-Wiener Index (H)	1.08	0.88	1.02	0.99	0.69	0.72	0.97	0.85	1.05	
Cladocera (Crustacea)										
Alona monachata	11	13	9	10	9	8	6	9	7	
Podon polyphemides	13	8	-	11	6	4	-	7	9	
Bosmina coregoric	-	14	12	-	9	8	3	9	10	
Daphnia pulex	10	9	-	6	-	4	7	-	4	
Philomedes globoso	7	8	6	5	6	5	8	-	5	
Evadne nordmanuc	3	11	5	-	7	4	-	9	8	
Daphnia magna	7	-	9	6	3	-	5	3	-	
Total abundance (N) $100ml^{-1}$	51	63	41	38	41	33	29	37	43	376
Number of species (S)	6	6	5	5	6	6	5	5	6	
Margalef's Index (d)	1.27	1.21	1.07	1.09	1.35	1.43	1.19	1.11	1.33	
Shannon-Wiener Index (H)	1.62	1.73	1.53	1.49	1.49	1.38	1.34	1.47	1.52	
Protista										
Difflugia corona	3	1	-	2	2	1	2	3	1	
Nebella collavis	1	3	4	-	3	3	-	2	1	
Centropages disoxides	-	2	-	1	-	-	3	-	-	
Avcella vulgaris	1	-	-	2	1	-	2	1	-	
Diffugia accominata	2	-	1	3	1	1	-	3	2	
Total Abundance (N)/100ml	7	6	5	8	7	5	7	8	4	57
Number of species (S)	4	3	2	4	4	4	3	3	3	
Margalef's Index (d)	1.54	1.11	0.62	1.44	1.54	1.86	1.03	0.96	1.44	
Shannon-Wiener Index (H)	0.50	0.54	0.52	0.60	0.50	0.21	0.64	0.72	0.24	
Rotifera	1	2	3	1	2	3	1	2	3	
Lecane bulla	3	1	5	2	-	-	3	4	-	

Brachionus caliaflorus	2	4	-	3	1	-	2	-	3	
Lecane ohioensis	-	4	2	-	3	2	-	3	1	
Brachionus quadridentata	6	-	5	3	1	1	2	-	1	
Total abundance (N)/100ml	11	9	12	8	5	3	7	7	5	
Number of species (S)	3	3	3	3	3	2	3	2	3	
Margalef's Index (d)	0.83	0.91	1.21	0.96	1.24	0.91	1.02	0.51	1.24	
Shannon-Wiener Index (H)	0.91	0.79	0.96	0.72	0.41	0.28	0.64	0.76	0.41	
Protozoa										
Arcella vulgaris	2	-	3	2	3	1	3	-	4	
Oikomonas Sp	-	1	2	1	-	1	2	5	3	
LIonotus fasciola	3	2	-	4	3	-	-	2	-	
Total Abundance (N) 100ml^{-1}	5	3	5	7	6	2	5	7	7	47
Number of species (S)	2	2	2	3	2	2	2	2	2	
Margalef's Index (d)	0.62	0.91	0.62	1.02	0.56	0.12	0.62	0.51	0.51	
Shannon-Wiener Index (H)	0.58	0.27	0.58	0.64	0.68	0.0	0.58	0.75	0.75	
Overall abundance (N)	99(14.45)	93(13.58)	88(12.85)	77(11.24)	71(10.36)	51 (7.45)	69 (10.07)	72(10.51)	75 (10.95)	685

Numbers parenthesis represent relative abundance (%)

Table 1a: Summary of the abundance of the major zooplankton groups during the period of study (February to October, 2018) (Pooled Data)

Major Zooplankton group	Abundance (n)	%n
Copepoda	123 (18.36)	18.36
Cladocera	376 (56.12)	56.12
Protista	57 (8.51)	8.51
Rotifera	67 (10.0)	10.0
Protozoa	47 (7.01)	7.01
Overall Total	670 (100.0)	100.0

Numbers in parenthesis represent relative abundance (%)

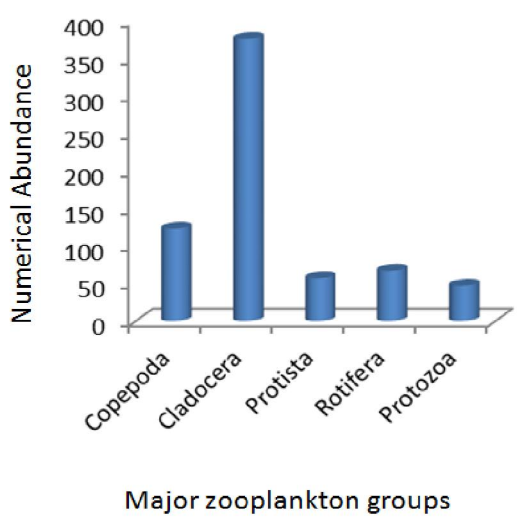

Fig. 2 Numerical abundance of the major zooplankton groups within Itu Bridge-end area of the Cross River System during the period of study (Feb. – Oct. 2018)

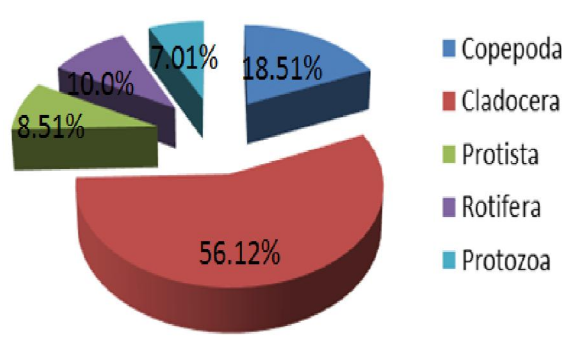

Fig. 2a Relative abundance of the major zooplankton groups within Itu Bridge-end area of the Cross River System during the period of study (Feb. – Oct. 2018)

Table 2: Summary of the ecological parameters of the zooplankton within the Itu Bridge –End Area of Cross River system, Nigeria (Pooled Data) Feb – Oct., 2018)

Copepoda									
Ecological parameters	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Total Abundance (N)/20L	15	12	17	16	12	8	14	13	16
Number of species (S)	3	4	5	5	6	3	4	5	4
Margalef's Index (d)	0.74	1.20	1.41	1.44	2.01	0.96	1.14	1.56	1.08
Shannon-Wiener Index (H)	1.08	0.88	1.02	0.99	0.69	0.72	0.97	0.85	1.05
CLADOCERA									
Total Abundance (N)/20L	51	63	41	38	41	33	29	37	43
Number of species (S)	6	6	5	5	6	6	5	5	6
Margalef's Index (d)	1.27	1.21	1.07	1.09	1.35	1.43	1.19	1.11	1.33
Shannon-Wiener Index (H)	1.62	1.73	1.53	1.49	1.49	1.38	1.34	1.47	1.52
PROTISTA									
Total abundance (N)/ 20L	7	6	5	8	7	5	7	8	4
Number of species (S)	4	3	2	4	4	4	3	3	3
Margalef's Index (d)	1.54	1.11	0.62	1.44	1.54	1.86	1.03	0.90	1.44
Shannon-Wiener Index (H)	0.50	0.54	0.52	0.60	0.50	0.21	0.64	0.72	0.24
ROTIFERA									
Total Abundance (N)/20L	11	9	12	8	5	3	7	7	5
Number of species (S)	3	3	3	3	3	2	3	2	3
Margalef's Index (d)	0.83	0.91	1.21	0.96	1.24	0.91	1.02	0.51	1.24
Shannon-Wiener Index (H)	0.91	0.79	0.96	0.72	0.41	0.28	0.64	0.78	0.41
PROTOZOA									
Total Abundance (N)/20L	5	3	5	7	6	2	5	7	7
Number of species (S)	2	2	2	3	2	2	2	2	2
Margalef's Index (d)	0.62	0.91	0.62	1.02	0.56	0.12	0.62	0.51	0.51
Shannon-Wiener Index (H)	0.58	0.28	0.58	0.64	0.68	0.0	0.58	0.75	0.75

4. Discussion

The species composition of the zooplankton provides information which has a strong ecological implication on the river system. The low number of copepod species points at the direction of an environment which is polluted. Apart from the few species number of the copepod, the few number of individuals is also a strong indication that the environment is threatened by pollution. In an unpolluted open tropical water system, copepods are usually the most abundant (Ajuonu *et al.,* 2011; Okorafor *et al.,* 2013 Imoobe, 2014 Job *et al.,* 2017) same is applicable in temperate aquatic systems (Sameoto, 1984); but when the system is affected by an element of pollution, the reverse may be the case (Offem *et al.,* 2011; Dimowo, 2013) with the system dominated by the water flees (Cladocera) as was the case in this study.

The low values of Margalef's index generally obtained in all the months of study is also an indication of polluted system. As previously reported elsewhere (Yakubu *et al*.,1998; Dimowo,2013; Offem *et al* 2011; Job *et al* 2017). Margalef's index less than 1.0 windows highly polluted environment, with values ranging between 1.0-3.0 indicating moderately polluted system, while values greater than 3.0, signify clean environment (Ali *et al.,* 2003; Margalef 1965, 1978). The low ranges of the Shannon-Wiener indices are also strong indication of poor distribution and diversity of the zooplankton community within the Itu Bridge-End Area the river system. Similar observations were made by Okorafor *et al.,* (2013) in the Calabar river Nigeria, Job *et al.,* (2017) in the Calabar River, Nigeria and Dimowo (2016) in River Ogun, Nigeria, which they related scenario to pollution arising from anthropogenic activities carried out around the water resource.

The Itu Bridge-End Area of the Cross River system is characterized by various human activities including farming, sales and use of petroleum products and dumping of domestic wastes into the river system. The interplay of these and related activities are known to generally impact on the water quality not only of tropical but, temperate water bodies (FAO,2006; Francis *et al*.,2007; Dhanam *et al*.,2016; Job *et al* 2017), thereby influencing the structure of biotic community including that of the zooplankton which by nature, have short life cycle and respond swiftly to and environmental stress, causing the attenuation in their structure, abundance, distribution and diversity (Mann,2000; Goldman and Horne,1983; Imam *et al.,2011;* Job and Asuquo,2009). This scenario tends to favour the abundance of some groups and species groups of the zooplankton, while others are attenuated (Dimiwo,2013; Ezekiel *et al*.,2011; Job *et al* 2017). This might have been the premise for the abundance of the Cladocera within the area during the period of study.

Conclusion

In this study, the results of the investigatin on the zooplankton revealed five zooplankton groups (Copepoda, Cladocera, Protista, Rotifera and Protozoa). The information obtained from the zooplankton species composition and ecological indices (Margalef's and Shannon-Wiener) point in the direction of a polluted system. This was clear in the reduced species of copepods and increased composition of the Cladocera species (water fleas).

The low Margalef's and Shannon-Wiener indices were all pointers to a polluted environment. Based on the foregoing, it is therefore recommended that the inhabitants of the area abd users of this section of the Cross River system, ensure proper handling and disposal of wastes generated from their daily activities. The control of used and / or spent petroleum products are srongly advocated as this river system is a good source of food fish for cheap protein.

According to Dugbeon *et al* (2006), Job *et al* (2015), Job *et al* (2017) and Job Ekpo (2017, the conservation and proper management of water ecosystem is critical to the interest of the entire mankind, as long as biodiversity constitutes valuable natural resources in economical, cultural aesthetic, scientific and educational term. It is in view of this that the results from this study are expected to serve as a background database for future reference in the management of this area of the Cross River system Nigeria.

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