

Preliminary Studies on the Ecology and Diversity of Zooplankton of Tinapa Lake Calabar, Cross River State, Nigeria

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Abstract: This is a report on the preliminary studies on the ecology and diversity of zooplankton of Tinapa Lake, an artificial lake in Calabar, Cross River State, Nigeria conducted in October, 2017. Zooplankton samples were collected using standard method. Zooplankton species were identified using standard schemes and atlases. Data were analyzed ecologically and numerically. Four stations were randomly selected in the lake for the study. 38 zooplankton species belonging to 5 taxa were recorded. These were Cladocera (9 species), Copepoda (11 species), Decapoda (2 species), Rotifera and Protozoa (8 species each). Copepoda were the most abundant of the zooplankton contributing 39.78% of the zooplankton population, with the least being Decapoda which constituted 5.09% of the zooplankton. Station 4 had the highest number of zooplankton with 375 individuals which contributed 38.15% of all the zooplankton from all the stations. High Margalef's index (5.241-5.736) was obtained for the zooplankton, indicating the lake unpolluted, stable and productive freshwater system. The ranges of the Shannon -Wiener, Pielou's and Simpson's Dominance indices, were also of ecological importance, portraying a stable zooplankton community in the lake ecosystem.

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Introduction

A lake is a body of relatively still fresh or salt water of considerable size localized in a basin, that is surrounded by land apart from a river, stream or other form of lotic water that serves to feed or drain the lake (Goldman & Horne, 1983). Lakes are inland and not part of the ocean and therefore are distinct from lagoons, and are larger and deeper than ponds (Goldman & Horne, 1983; Cunningham *et al.*; 2005; Cunningham & Cunningham, 2004).

In lakes, like stream and rivers, availability of oxygen, carbon (IV) oxide and sunlight for photosynthesis depend on a numbers of environmental factors which may, according to (Cunningham & Cunningham, 2004) include substances dissolved in the water (such as oxygen, nitrate, phosphate, potassium compounds and other by-products of agriculture and industry), suspended matter such as silt and microscopic algae, that affect water clarity and therefore, light penetration, depth, temperature, rate of flow, bottom characteristics (mudly, sandy, rocky bottom) internal convection currents and connection or isolation from, other aquatic ecosystems.

The zooplankton are so closely linked to the environment and they tend to respond to changes more rapidly than do larger aquatic animals such as fish (Davies and Ugwumba, 2013). These organisms have proved valuable indicators of apparent and subtle

alteration in the quality of aquatic environments (MOB, 2007a; Davies and Ugwumba, 2013). They are useful indicators of future fisheries health trophic levels (Godhantaraman, 2001; Davies and Ugwumba, 2013). Zooplankton biomass, abundance and species diversity are used to determine the conditions of the aquatic environment (MBO, 2009b; Davies and Ugwumba, 2013; Job *et al.*, 2017).

From the available literature, studies on lakes in Nigeria include those of Sambo *et al.* (2013), Ikongbeh *et al.* (2013). Ita (1993, 1996), Ahmed *et al.* (2013) and Offem *et al.* (2014). None of these studies reports on any aspect of the Tinapalake. The present investigation is a preliminary study on the ecology and diversity of zooplankton of the Tinapalake, an artificial lake in Calabar, Cross River State, Nigeria, with the specific objectives of providing the check- list and diversity of Zooplankton of the lake ecosystem.

Materials and methods

Study Area

The study area is Tinapa lake, an artificial lake in Calabar Cross River State, Nigeria located approximately at latitude 05.02° 49' N and longitude 08.13° 18'E at 26m above sea level within the Tinapa business and Resort Centre. The lake was created as a result of the dredging of the Calabar River in 2008 and serve as a direct entry route to the Calabar River from

the Tinapa Business and Resort Center by boat. The lake is about 7.63m deep, with the area characterized by tropical climate of wet and dry season periods. Human activities in the area include farming, sight – seeing / tourism, fishing, sand-mining and boat – building. Vegetation consists mainly of mangrove plants and *Nypa pam*. The common mangrove species include *Rhizophoraceinosa* and *Avicannia Africana* exploit by the fishing community for firewood building (Holzcohn *et al.*, 2002).

Sampling stations

Four sampling stations station 1, station 2, station and station) were selected randomly for the studies. Station 1 it the entrance of the Calabar River water into the lake, station 2 is 50 meters from station, while station 3 is at the sampling point of the motorized boats and status, the extreme and of the lake opposite the mouth of the Calabarriverie where the River flows into the lake (Fig 1).

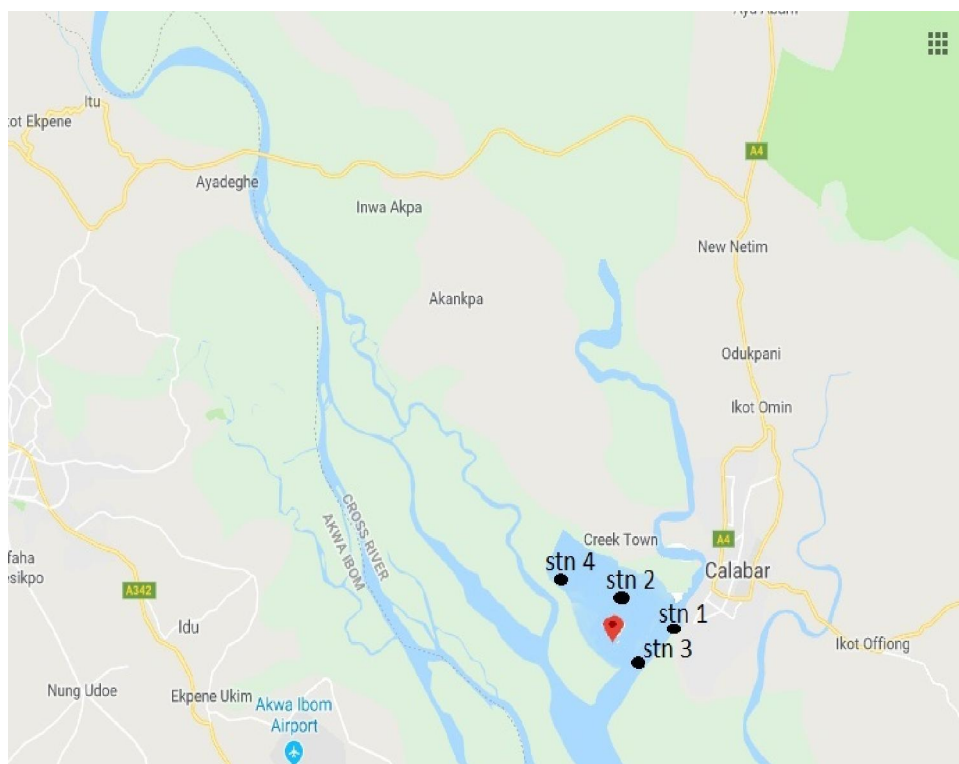


Fig. 1: Map of Calabar River, Nigeria showing Tinapalake and the sample stations

Identification of Zooplankton species

Descriptive keys of Needham and Needham (1962), Maosen (1972), Kasturirangan (1983), Han (1978), Durans & Leveques (1980), UNESCO (1978), Sverdrup *et al.* (2006), Egborge (1972) and Adoni Wiafen Frid (2000) *et al* (1985) Alfred *et al* (1973) Newell & Newell (1977), plankton upto species level where practicable.

Relative abundance (%Ra)

To calculate the relative abundance (%), the total number of each species (n) was counted to know the total number of all individuals (N) following Job *et al* (2011) *et al* (2017), Job & Ekpo (2012) Job & Asuquo (2009) and Eyo *et al* (2003) Udoh *et al* (2015) relative abundance was calculated based on the formula:

$$\%Ra = \frac{n}{N} \times 100 \quad (1)$$

Where

n = the total number of individuals in each of the zooplankton taxonomic group and N= the total number of all zooplankton individuals in all the taxonomic groups.

Ecological Diversity of m the zooplankton

In this study, the following diversity indices of the zooplankton were determined; margarlef's index (d), Shannon- W Siener diversity index (H), Pielou's Evenness inde (E) and Simpson's Dominance index (C). Margalef's index (d) was determined using the

$$d = \frac{S-1}{\ln(N)} \quad (2)$$

Where S is the total number of species, 'N' is the total number of individuals and ln is the natural or Naperian logarithm (\log_e) (Margalef 1965, 1978; Ogbeibu, 2005, Job *et al.*, 2017).

Shannon – Wiener Diversity Index (H) (

This index is given by the formula:

$$H = \frac{N \log N - \sum_{i=1}^s \log f_i}{N} \quad (3)$$

Where N is the total number of the zooplankton for station and f_i the total number of species at a particular station (Shannon 1949)

Pielou’s Evannes index (E)

This represents the ratio of the observed diversity (H) to the maximum diversity (H_{max}) and is given mathematically as:

$$\frac{H}{\text{Logs}} \quad (4)$$

Where H is Shannon –Wiener index and 3, the total number of species (Ogbeibu, 2005).

Simpson’s Dominance Index (D)

Simpson’s Dominance index © which usually varies from 0 to 1, gives the probability that two

individuals drawn at random in a population belong to the same species: (Simpson, 1949, Ogbeibu, 2005). The index is expressed as:

$$D = \sum_{i=1}^s \frac{ni(ni - 1)}{N_1(N_1 - 1)} \quad (5)$$

Where n_i is the number of individuals in the n th species and N_1 , the total number of individuals. The reciprocal form (D^1) of Simpson’s index which is defined as the number of very abundance species, ensures that the index D^1 increases with increasing diversity (Ludwig and Reynold, 1988, Magurran, 1988, Ogbeibu, 2005).

Statistic analysis

The relationship between zooplankton abundance (n) and sampled stations was analysed using analysis of variance (ANOVA) at 0.05 level of significance (df-3).

Table 1: Taxonomic list of the zooplankton of Tinapa lake Calabar Cross River State, Nigeria (February – July, 2017)

		Station 1	Station 2	Station 3	Station 4	Marginal total
	Taxonomic composition	Number of individual (n)	n	n	n	
A	Cladocera					
1.	Pondonpolyphemoides	5	6	7	5	
2.	Peniliaaavirostris	4	-	10	6	
3.	Evadnespinifera	8	9	-	11	
4.	E. tergestina	-	4	6	7	
5.	Daphnia rosea	9	5	11	13	
6.	D. Pulex	-	7	9	15	
7.	D. Longispina	5	8	7	18	
8.	Bosminalongirostris	3	-	5	9	
9.	Polyphemisintermedius	-	6	4	-	
	Total abundance (n0)	34	45	59	84	222
B.	Copepoda					
10.	Peudocalanas elongates	11	14	13	18	
11.	Diaphannosoexcism	10	9	-	13	
12.	Limnocalanusmoerarus	4	2	-	6	
13.	Calanuscalanus	5	7	4	10	
14.	Eucalanus elongates	-	4	8	13	
15.	Oithonarana	13	13	15	21	
16.	Cyclopinalongicornis	11	10	14	18	
17.	Cyclops strenuous	9	7	-	12	
18.	Diaptomusgracilis	13	-	4	-	
19.	D.siciloides	10	8	-	14	
20.	Pseudodiaptomushossei	12	10	9	18	
	Total abundance (N)	98	83	67	143	391
c.	Decapoda					
21.	Caridiongordoni	3	1	-	18	
22.	Pasiphae tarda	-	6	8	14	
	Total abundance (N)	3	7	8	32	50
		Stn 1	Stn2	Stn3	Stn 4	Marginal total
D.	Rotifera	n	n	n	n	
23.	Brachionusfalcatus	5	3	-	7	

24.	<i>B.calyciflorus</i>	4	7	6	11	
25.	<i>B.patulus</i>	-	-	7	9	
26.	<i>Lecane bulla</i>	6	7	3	10	
27.	<i>L.closterocerca</i>	3	3	5	7	
28.	<i>L.lana</i>	4	5	3	8	
29.	<i>Asplanchnagiradi</i>	5	-	4	7	
30.	<i>Keratellacochlearis</i>	2	4	6	9	
	Total abundance	29	36	34	63	162
E.	Protozoa					
31.	<i>Loinotusifasciola</i>	6	5	-	2	
32.	<i>Arcellamitrata</i>	4	-	4	8	
33.	<i>Oikomonassp</i>	-	6	5	7	
34.	<i>Vorticella mayerii</i>	8	-	9	11	
35.	<i>Eucllypha ciliate</i>	5	3	-	6	
36.	<i>BodoCauclatum</i>	7	-	9	-	
37.	<i>Arveliavulgaeris</i>	-	6	6	8	
38.	<i>Spirostonumambiguum</i>	9	5	8	11	
	Total abundance (N)	39	25	41	53	158
	Overallabundance	203	196	209	375	982

Results

Zooplankton species composition of the Tinapalake

The species composition of the zooplankton of the Tinapa lake ecosystem are presented in Table 1. Total of 38 species of the zooplankton, belonging to 5 taxa were identified. These were *Cladocera* (9 species), *Copepoda* (11 species), *Decapoda* (2 species), *Rotifera* and *Protozoa* (8 species each). Among the *Cladocera*, *Pondonpolyphemoides*, *daphnia rosea* and *D. longispina* were recorded at all the stations, while among the copepod, 5 species (*Pseudocalanuselongatius*, *calanus*

Cyclopinalongicornis and *Pseudodiaptomushossei*) occurred at all the stations during the study were *Brachionuscalayciflorus*, *Lecane bulla*, *L. Closterocerca*, *L.Lana* and *Keratellacochlearis*. Only 1 species (*spirostanumambiguum*) of protozoa, out of the 8 species recorded during the study, was found to occur at all the stations in the lake. Every other species was observed to be station- specific. The numerical (N), relative abundance (% μ) and the ecological indices of the zooplankton taxa of the Tinapa lake during the study, are presented in Table 2.

Zooplankton Taxa	Station 1	Station 2	Station 3	Station 4	N/%N
Cladocera	34	45	59	84	222(22.58)
Copepoda	98	83	67	143	391(37.78)
Decapoda	3	7	8	32	50 (5.09)
Rotifera	29	36	34	63	162(16.48)
Protozoa	39	25	41	53	158(16.07)
N/%N	203(20.65)	196(19.94)	209(21.26)	375(38.15)	983
Number of species (S) from all taxa (S)	30	30	29	35	
Margalef's Index (d)	5.458	5.494	5.241	5.736	
Shannon-Wiener Index (h)	2.089	2.066	2.117	2.429	
Pielou's Evenness Index (E)	1.414	1.398	1.447	1.573	
Simpson's Dominance Index (D)	0.021	0.022	0.018	0.0084	
Min-Max of individuals Sampled	2-13	1-14	3-15	2-21	
Averaged number of individual sampled	40.6	39.2	41.8	75.0	

Numbers in parenthesis represent relative abundance per station and taxa station 1 had 203 zooplankton representing 20.65% of the zooplankton at that station, with 196 (19.94%) at station 2, 209 (21.26%) at station and 375 (38.15%) at station 4.

For the respective zooplankton taxa, Cladocera has 222 individuals from all stations combined. This represented 22.58% of the overall taxa population of the zooplankton in the lake. Copepoda had 391 individuals, representing 39.78% of the zooplankton,

with 50 (5.09%) decapoda, 162 (16.48%) Rotifera, and 158 (16.07%) Protozoa, resulting in a distribution pattern of:

Copepoda>Cladocera>Rotifera>
Protozoa>Decopoda.

In relation to stations of sampling, station 4 had more zooplankton density followed by station 3, 1, and 2, resulting in a distribution pattern of:

Station 4 > Station 3 > Station 1 > station 2.

At station 1, 34 Cladocera were identified, with 45 at station 2, 59 at station 3 and 84 at station 4. Copepoda contributed total of 98 individuals at station 1, with 83 at station 2, 67 and 143 at station 3 and 4, respectively. Total of 3 Decopoda were recorded at station 1, with 7 at station 2, 8 at station 3 and 32 at station 4. At station 1, 29 and 39 Rotifera and Protozoa were respectively recorded, with 36 and 25 at station 2, 34 and 41 at station 3, with 63 and 53 individual of the Rotifera and protozoa, respectively at station 4 (Table 2).

An overview of the ecological indices of the zooplankton composition of the Tinapa Lake are also presented in Table 2. The ecological indices indicate an unpolluted Lake ecosystem Margalef's index was high and ranged between 5.241 (station 3) – 5.736 (Station 4), with a range of between 2.066 (Station 2) – 2.429 (Station 4) for Shannon-Wiener index, 1.398 (Station 2) – 1.573 (Station 4) for Pielou's Evenness index and between 0.0084 (Station 4) – 0.022 (station 1) for Simpson's dominance index.

The ranges of the number of zooplankton individuals sampled per station were 2-13 (station1); 1-14 (station 2), 3-15 (station 3) and 2-21 (Station 4) r represented by an average of 40.6 (2-13). (Station 3) and 75 (2-21) (station 4).

Discussion

The species composition of the zooplankton of the Tinapa Lake depicts the Lake as a typical eutrophic freshwater system and were well distributed at each sampling station except for most of the species which were station – specific. Five zooplankton taxa (Cladocera, copepod, Decapoda, Rotifera and Protozoa) were the major zooplankton in the lake ecosystem during the study, with the copepod being the most abundant. The results of the study, with the copepod being the most abundant. The results of the study agree with those of Etim et al (2010), Onepena & Oyo (2008), Egborge (1987), Davies & Ugwumba (2013), Udoh et al. (2015), Endongan & Ertan (2016) Ajuonu et al. (2011) and Job et al (2017) who reported the abundance of copepod in the zooplankton during their respective studies. The results of the present study however disagree with those of Ude et al. (2011), Ogbuagu & Ayoade (2012) and Offem et al (2011) who respectively recorded high abundance of

Cladocera in the zooplankton of River Ogun, River Echare and Lake Ikori all freshwater systems in Nigeria. They attributed the high abundance of the Cladocera to the influence of anthropogenic activities carried out around the aquatic systems, which they maintained was evidenced by high concentration of pollution indicators, typically nutrients and trace elements which according to them were above acceptable limits giving rise to the decimation of the copepod.

In the Mandovi estuary, India, Selvakumar et al. (1986) reported high abundance of copepod in the zooplankton of the estuary, attributing it to the ability of the copepods to show a complex pattern in their distribution. In their studies, Etim et al (2010), Onyemax & Oyo (2008), Egborge (1987), Davies & Ugwumba (2013), Udoh et al (2015), Ajuonu et al (2011) and Job et al. (2017) whose results are similar to that of the present study they respectively attributed the abundance of copepod in the zooplankton, to the ability of the copepods to exhibit high reproductive capacity and become recruited into the standing stock of the zooplankton population.

The occurrence of some of the zooplankton species at all the stations and the absence at others, may be unconnected to the ability of these species to adapt to the prevailing ecological conditions of the stations milieu. According to Hart (1999), the presence or absence of a species, species group or taxa in a particular habitat is influenced by the prevailing ecological setting in the habitat. Davies et al (2009) asset that some planktonic species may be distributed only within restricted zones in the aquatic habitat, while others may reside only in other zones of the ecosystem, depending on adoptive capability of the individual organism.

The abundance of copepod in the zooplankton in this study may be interplayed by the principle of retention mechanism at each station and samples collection technique. In this study, zooplankton samples were collected within few centimeters of the water column (surface water). Such technique according to Davies et al. (2009), takes into account, the retention mechanism of the organisms sampled. As hypothesized by Krumme and Liang (2004), for copepods resident in the Euro do Meico (a macrotidal mangrove channel in northern Brazil) enhances station not influenced by swift current, to retain current dependent organisms at particular habitat/ or station.

In this study station 4 was generally observed not be effectively influenced by current hence, the high densities of the zooplankton. The principle of retention mechanism, coupled with the generally high reproductive capacity of the copepod, may be the only possible premise for the observed high abundance of the copepod in the Tinapa Lake zooplankton.

The results of the present study being the outcome of the preliminary investigations on the ecology and diversity of zooplankton of the Tinapa Lake ecosystem also agree with those of Davies *et al* (2009) during their studies on the effects of tides on zooplankton community of a tributary of upper Bonny Estuary, Niger Delta, Nigeria. However, in Davies *et al* (2009) report, zooplankton taxa such as Ostracoda, Euphasiacea and Branchiura which were absent in the present study were listed among the zooplankton taxa of the tributary. According to Hart (1999) investigation conducted in different ecotones are likely to reveal differential results. The high Margalef's index in this study indicates an ecological stable and productive Lake ecosystem. According to Ali *et al* (2003), Margalef's index values less than 1 indicate heavily polluted environment, values between 1-3 window moderately polluted environment, while values greater than 3 portray clean ecological system. Offem *et al* (2011) recorded high Margalef's index values for the zooplankton of Ikworilake, in Southeastern Nigeria and concluded that the lake is ecologically fit for enhanced fish growth and survival.

In Tinapa Lake, in addition to the high Margalef's index values which characterize highly productive system (Adieral 2003; Mason, 1988; Salam *et al.*, 2000; Margalef 1965, 1978, Job *et al* 2017, Egbai & Job 2017, and Job & Ekpo, 2017), the ranges of the Simpson's dominance, Shannon-Wiener and Pielou's indices, indicate a zooplankton community with a stable and even distribution. Similar observation was made by Ogbeibu & Edutie on the Rotifers (2000) in Ikpoba River, Nigeria, Job *et al* (2017) on the Zooplankton in the Calabar River, Nigeria.

Conclusion

This study provides information on the ecology and diversity of zooplankton of the Tinapa Lake, as artificial lake in Calabar, Cross River State, Nigeria. 38 zooplankton species belonging to 5 taxa namely Cladocera (9m species), Copepoda (11 species), Decapoda (25 species) Rotifera (8species) and Protozoa (8 species) were recorded in this study which represented a preliminary report on the zooplankton of the Lake. The most abundance zooplankton taxa was the copepod (391 by number, 39, 78% the least being Decapoda (50.5.05%) station 4 had the most abundant number individuals (375 38.5%) of the zooplankton with the least recorded at station 2 (196:19.84%).

Margalef's Index calculated for the zooplankton ranged between 5.241 – 5.736, with Shannon-Wiener ranging between 2.0066-2.429, Pielou's index ranged between 1.398-1.573 while Simpson's sampled zooplankters were between at station 1-14 at station 2, 3-15 at station 3 and 2-21 at station 4, while average

number of fanirus sampled was 40.6 (station 1), 39.2 (station 2), 41.8 (station 3) and 75.0 (station 4). Altogether, 222 (22.5%) Cladocera were sampled, with 391 (39,78%0 copepoda, 50 (5.09%) Decopoda, 162 (16.4*%) Rotifera and 158 (16.07%) protozoa. The Ecological index values of this study portray Tinapalake as an ecological stable and productive highway system with a rich zooplankton community. Job & Ekpo (2017) on the macrobenthos of the Calabar River system Nigeria and Ofem *et al.* on the zooplankton of Lake Ikwori and Udoh *et al* (2015) on the microcrustacean of Uwanse Stream, Cross River State, Nigeria.

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