Journal of Fisheries International 3 (4): 105-111, 2008
ISSN: 1817-3381

Zooplankton of Lower Sombreiro River, Niger Delta, Nigeria

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Abstract: The zooplankton and Physico-chemical characteristics of the lower Sombreiro river, was studied from August 2005-July2006 using standard methods. A total of 17 species from 6 taxonomic groups were recorded during the study period. The species with the highest number (248, 12.1%) was *Paracyclops fimbriatus*, while *Mysis* sp. had the lowest number (25, 1.2%). The highest number of zooplankton (262, 12.7%) was observed in May and the lowest (59, 2.9%) was recorded in September. *Mysis* sp. was not recorded between April and September. *Halteria* sp. was absent in July. Other species were observed in all the months. The family Copepoda was the highest (45.5%) group followed by Cladocera (23.4%), Euphausicea (10.3%), Protozoa (11.9%), Rotifera (7.8%) and Decapod Crustaceae (1.2%) was the least. More zooplankton was recorded in the wet season (1267), with 61.6%, than the dry season (790), with 38.4%. All species were observed in both seasons. In the wet season, *Meganicliphanes norvegica* had the highest record (159), while *Paracyclops fimbriatus* was the highest in number (95) for the dry season. *Mysis* sp. was the least recorded for both seasons, as 9 individuals were recorded for the wet season and 16 for the dry season. Station 1 had the highest record (631, 30.7%), while station 4 had the lowest (376, 18.3%). All the species were observed in all the stations, with the exception of *Mysis* sp. that was absent in station 4. The analysis of variance for the seasons and stations for number of zooplankton recorded showed that there was significant difference (F = 14.10, d.f = 604, p = 0.05) between the stations. There was, however, no significant difference between seasons and also none for the combined effects of seasons/stations.The distribution showed that station 1 differed significantly from the rest. Station 3 also differed significantly from others. Stations 2 and 4 did not differ significantly. Shannon-Wiener information function (H) showed that, the highest value was in January (1.085) and the least (0.875) in September. There was variability between the months. Equitability (Evenness) index (E), October had the highest value (0.994) and February, the lowest (0.882). The variations were minor through out the study period. Margalef's species richness index (d) showed appreciable fluctuations. The lowest value (2.595) was observed in April. The highest value (4.212) was recorded in October. There was hardly any sharp variation from one month to the next. Simpson's dominance index (c) showed that January had the highest value (0.183). August had the lowest (0.089). The trend was relatively smooth.The catch increased with higher conductivity, lower dissolved oxygen, relatively faster flow rates and more rainfall. The abundance seemed to decline with lower conductivity, higher turbidity, higher dissolved oxygen and slower flow rates. The temperature did not show much difference between the 2 extreme percentage collections. The correlation between zooplankton collected and turbidity was negative.

Key words: Zooplankton, species composition, abundance, physico-chemical characteristics, Sombreiro river, Niger delta, Nigeria

INTRODUCTION

Plankton is recognized worldwide as bio-indicator organisms in the aquatic environment (Yakubu *et al*., 2000). According to Boyd *et al.* (2000), plankton blooms may indicate presence of mineral ions. Populations of planktonic ciliates often develop in organic-rich, oxygen-depleted and polluted waters (Wetzel, 1983).

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Plankton abundance increases productivity of water, as they form the basic food source in any aquatic environment (Russell-Hunter, 1970).

The stretch of the Sombreiro River is one of the most important river systems in the Niger Delta providing nursery and breeding grounds for a large variety of fish species (Ezekiel *et al*., 2002). The water body also serves as the only source of water in the area. Due to efforts at speedy industrialization and recreational activities, the Sombreiro River is fast becoming degraded (Ezekiel, 2001). Fishing is carried out indiscriminately with various traditional and modern gears.

Yet, reports available on the plankton population are from water bodies other than Sombreioro River including Lake Kotto and Lake Soden in West Cameroon (Green, 1960); Eleyele reservoir, Ibadan (Imevbore, 1965); River Osun (Egborge, 1972); Lagos Lagoon (Nwankwo and Oji, 1986) and River Sokoto (Green, 1960). Others include Nkisa and Orashi rivers, Rivers State (Yakubu *et al*., 2000), Elechi Creek, Port Harcourt Luubara Creek, Rivers State (Kosa, 2007), Oginigba Creek, Port Harcourt (Chindah and Pudo, 1991), Bonny river (Chindah, 2003), New Calabar river (Nwadiaro and Ezefili, 1989; Chindah, 1998), Oguta Lake (Nwadiaro and Oji, 1986) and Bonny estuary (Chindah and Keremah, 2001).

Phytoplankton and physical characteristics in the lower Sombreiro River will provide information on the productivity and ecological potential for its optimum exploitation and exploration. It will also provide a scientific basis for decision-making and comparative studies.

MATERIALS AND METHODS

Study area: The study was carried out in the lower Sombreiro river. The river provides nursery and breeding grounds for a large variety of fish species (Ezekiel *et al*., 2002). The Niger delta basin covers all the land between latitude 4°14 and 5°35'N and longitude 5°26 and 7°37'E with a total area of 20,000 km^2. It extends along the coast from the river's basin in the West of Bonny River. The area is characterized by extensive inter-connection of creeks. It is the most important drainage feature of the Niger-Basin rivers system and covers about 2% of the surface area of Nigeria (Powell *et al*., 1985). The annual rainfall of the Niger Delta is between 2000-3000 mm per year (Powell, 1987).

The Sombreiro River is located between latitude 6°30 and 7°0'E and longitude 4°12 and 6°17'N. The river is a distributary of the River Niger, which rises from the northern parts of Ogba/Egbema/Ndoni Local Government Area of Rivers State. It is one of the series of the Niger Delta Rivers that drain into the Atlantic Ocean. It flows southwards from its source to the Atlantic Ocean and is connected to other rivers via creeks in the coastal areas of the Niger Delta (Ezekiel, 1986). The river is relatively narrow and deep and as it flows southwards, it widens. The river is lotic throughout the year, with its peak in the dry season. The river is within the tropical rainforest, though the mouth is within the brackish mangrove zone. Some characteristics of the sample stations along the Sombreiro River are as follows.

Sample station 1 (Degema): This is the largest of all the stations. The vegation (mangrove plants) fringing the river consists *Rhizophora*, *Avicennia* and *Nypha fruticans* (Nypa palm) arising from a characteristic muddy substrate that gives a foul smell. The water is turbid in the rainy months. The site is a brackish and tidal environment.

Sample station 2 (Ogbele): Vegetation is mainly riverine forest, consisting mainly of *Raphia*, *Pandanus sanderiana*, *Calamas* sp. (swamp cane), *Khaya* sp. (mahogany), *Vapaca* sp., Ficus vogeliana and *Triculia africana.* Aquatic macrophytes include *Nymphaea* sp., Eichhornia crassipes, *Sagittaria* sp., Pistia stratiotes. The station was flooded in the rainy period when the velocity is slow. The site has little influence from the immediate tidal mangrove zone. The bottom consists mainly of sand and some gravel.

Sample station 3 (Ihuaba): The common vegetation present was a mixture of riverine and terrestrial vegetation. Some common plants noticed included *Raphia* and *Elaeis guineensis* (palm trees). The aquatic macrophytes include *Typha lotifolia* (cat tail), *Eichhornia crassipes, Nymphaea* sp., *Utricularia* sp. and *Potamogeton* sp. (pond weed). The site was flooded in the wet season, which receded within November and February. The river bottom consisted of sand and gravel.

Sample station 4 (Odhieke): The vegetation consisted of terrestrial vegetation and riverine vegetation extending into large areas of swamps. Some include *Raphia, Pandanus sanderiana, Elaeis guineensis* (palm trees). Aquatic macrophytes include *Ipomea aquatica, Lemna* sp. (duck weed), *Utricularia* sp., *Nymphaea* sp. and *Pistia stratiotes* (water lettuce). The water was generally clear and water velocity increased as flood recedes. River bottom had mainly sand and gravel.

Common fishing gears used in the Sombreiro fisheries included seine nets, drift nets, cast nets, lift nets, long lines, fish fences, funnel traps, trigger traps, grass mats, hooks and lines.

Zooplankton sampling: Zooplankton was collected in the open water by filtration technique. About 25 μm mesh size plankton net was towed from a dugout boat at about 5-10 m s^{-1} for about a minute. The net content was washed out into a wide mouth plastic container and preserved with 10% formalin solution after proper labeling. This was stored in a cool box and taken to the laboratory (APHA, 1989).

In the laboratory, the samples were allowed to stand for at least 24 h for the zooplankton to settle before the supernatant was pipette off to concentrate the samples. The concentrated sample was agitated to homogenize before pipetting 1 mL sub sample with sample pipette (ibid). The content was placed in a Sedge wick-Rafter plankton-counting chamber and examined with Leltz-Wetzlar binocular microscope at a magnification of 200 X (APHA, 1989). The plankton was identified and total number per species recorded using keys and checklists of Hutchinson (1967), Pimentel (1967), Needham and Needham (1962), Prescott (1982) and Jeje and Fernando (1985). Enumeration of plankton was done on natural unit count and reported as units or organisms per milliliter (mL) (APHA, 1989).

Physico-chemical characteristics: Four sampling stations were selected along the shore of the river from Odhieke to Degema. Monthly rainfall values were obtained from the Meteorological Department of the Federal Ministry of Environment, Port Harcourt. Some monthly insitu measurements of parameters were made. Surface water temperature was measured 2 min after dipping an ordinary mercury-in-glass thermometer to a depth of about 5.0 cm below water surface. Depth measurements were done using a graduated line. Each month, average depth of pre-determined points were recorded as the water level. Water velocity/flow rate was measured with a floating object. The time taken for the floating object to move past 2 fixed points was recorded. The water velocity was calculated and expressed as the time taken (in sec) to flow through 1 m (m s^{-1}) (Welcomme, 1985).

The salinity, pH, conductivity and turbidity were measured using a portable Horiba meter (model U10). Dissolved oxygen was measured using the Winkler method (Stirling, 1999). Total Dissolved Solids (TDS) were determined by filtering a well-mixed water sample through a fibre filter paper into a weighted dish. The filtrate (in the dish) was evaporated to dryness to a constant weight. TDS was calculated with the following formula (APHA, 1989):

$$\text{Total dissolved solids (mg L}^{-1}) = \frac{(A-B)\times 1000}{\text{Sample vol (mL)}} \quad (1)$$

where:
A = Weight of dried residue + dish (mg).
B = Weight of dish (mg).

Statistical analysis: The SAS (2003) was used to analyze the data obtained. Analysis of Variance (ANOVA) was carried out on plankton collected from the different stations and seasons. The Duncan's Multiple Range Test was used to determine significance in mean catches and estimates. Correlation analysis of the water parameters was done. The same analysis was done for plankton. This was to verify the factors that relate significantly to one another that could influence the abundance of plankton. The number of zooplankton collected were categorized into 2 groups: Those collected in November, December, January and February were designated as dry season samples, while others, as wet season samples.

Monthly ecological diversity of samples were calculated by the following diversity indices:

Shannon-Wiener Diversity index (H), which Ogbeibu (2005) presented as:

$$H = \sum_{i=1} p_i \ln p_i \quad (2)$$

where:
S = The number of species in the sample.
P_i = The proportion of individuals found in the ith species.

The Shannon-Wiener diversity index measures the importance of each species in the community (Van den Broek, 1979).

Evenness or Equitability (J) index (E), which Ogbeibu (2005) presented as:

$$E = \frac{H}{H_{max}} \quad (3)$$

The ratio of the observed diversity (H) to the maximum diversity (H_{max}) was taken as a measure of the Evenness (ibid). According to Krebs (1989), it measured the distribution of individuals.

Margalef's species richness index (d), was presented by Ogbeibu (2005) as:

$$d = \frac{S-1}{\ln N} \quad (4)$$

where:
S = Number of species in the sample.
ln = Natural or Naperian logarithm.
N = Total number of individuals in the sample.

Simpson's Dominance index (c),

$$c = \sum_{i=1}^{s} P_i^2 \quad (5)$$

where:

S = Number of species in the sample.

p_i = The proportional abundance of the ith species.

$$\text{i.e., } p_i = \frac{n_i}{N}$$

where:

n_i = Number of individuals in the ith species.

N = Total number of individuals for all species (ibid).

RESULTS AND DISCUSSION

From the lower Sombreiro River, 17 species from 6 taxonomic groups were recorded during the study period (Table 1). The species with the highest number 248 was *Paracyclops fimbriatus*, with 12.1%, while *Mysis* sp. had the lowest number 25, with 1.2%.

The monthly number of zooplankton in the Lower Sombreiro River is shown in (Table 2). The highest record 262 with 12.7% was observed in May and September and lowest 59 with 2.9%. *Mysis* sp. was not recorded between April and September. *Halteria* sp. was not recorded in July. Other species were observed in all the months.

The family Copepoda had the highest (45.5%), Cladocera, 23.4%, Euphausiacea, 10.3%, Protozoa, 11.9%, Rotifera, 7.8% and Decapod Crustacean, 1.2% (the least). More zooplankton was recorded in the wet season 1267, with 61.6%, than the dry season 790, with 38.4% (Table 3). All species were observed in both seasons. In the wet season, *Meganicliphanes norvegica* had the highest record 159, while *Paracyclops fimbriatus* was the highest in number 95 for the dry season. *Mysis* sp. was the least recorded for both seasons, as 9 individuals were recorded for the wet season and 16 for the dry season.

The number of zooplankton recorded in various sample stations is shown in (Table 4). Station 1 had the highest record (631), with 30.7%, while station 4 had the lowest (376), with 18.3%.

The analysis of variance for the seasons and stations for number of zooplankton recorded showed that there was significant difference (F = 14.10, d.f = 604, p = 0.05) between the stations. There was, however, no significant difference between seasons and also none for the combined effects of seasons/stations. Using the Duncan's multiple range test, a further analysis showed the significant differences between means for the stations.The distribution showed that station 1 differed significantly from the rest. Station 3 also differed significantly from others. Stations 2 and 4 did not differ significantly.

The zooplankton diversity index was measured by the Shannon-Wiener information function (H). The highest value was in January (1.085) and the least (0.875) in September.There was variability between the months. For the Equitability (Evenness) index (E), October had the highest value (0.994) and ebruary,the lowest (0.882). The variations were minor through out the study period. The Margalef's species richness index (d) showed appreciable fluctuations. The lowest value (2.595) was observed in April.

Table 1: Zooplankton species and their composition in the lower Sombreiro River (August 2005-July 2006)

Taxa	No. of specimen (org mL^{-1})	Percentage number
Cladocera		*(23.4)
Alonella costata	104	5.1
Bosmina fatalis	99	4.8
Daphnia carinata	94	4.6
Daphnia longippina	90	4.3
Moina cacrocopa	94	4.6
Copepoda		*(45.5)
Acanthocyclops carinetus	183	8.9
Acanthocyclops viridis	113	5.5
Cyclops stenuis	218	10.6
Paracyclops afinis	172	8.4
Paracyclops fimbriatus	248	12.1
Decapod crustacean		*(1.2)
Mysis sp.	25	1.2
Euphausiacea		*(10.3)
Meganicliphanes norvegica	211	10.3
Protozoa		*(11.9)
Halteria sp.	68	3.3
Spirostomum sp.	79	3.8
Tintinopsis senensis	99	4.8
Rotifera		*(7.8)
Brachionus calyciflorus	95	4.6
Brachionus falcatus	65	3.2
Total	2057	100.0

*Group (taxanomic) percentage

Table 2: Monthly number of zooplankton from the lower Sombreiro River (August 2005-July 2006)

Months	Number of specimen (org mL^{-1})	Percentage number
August	135	6.6
September	59	2.9
October	128	6.2
November	144	7.0
December	189	9.2
January	234	11.4
February	223	10.8
March	247	12.0
April	125	6.1
May	262	12.7
June	193	9.4
July	118	5.7
Total	2057	100.0

Table 3: Seasonal number of zooplankton from the lower Sombreiro River (August 2005-July 2006)

Season	Number of specimen (org mL^{-1})	Percentage number
Wet season	1267^a	61.6
Dry season	790^b	38.4
Total	2057	100.0

Note: Wet season: March-October; Dry season: November-February

The highest value (4.212) was recorded in October. There was hardly any sharp variation from one month to the next. The Simpson's dominance index (C) showed that January had the highest value (0.183). August had the lowest (0.089). The trend was relatively smooth.

Table 5 shows the relationship between the percentage collection in zooplankton (in numbers) and physico-chemical parameters for the study period. Basically, the catch increased with higher conductivity, lower dissolved oxygen, relatively faster flow rates and more rainfall. The abundance seemed to decline with lower conductivity, higher turbidity, higher dissolved oxygen and slower flow rates.

Table 6 shows the correlation coefficients of zooplankton abundance and physico-chemical characteristics studied. The correlation between zooplankton collected and turbidity was negative.

The zooplankton species recorded in this study, compared favorably with Kosa (2007), that recorded 13 species from 5 groups. Nilssen (1984) reported that zooplankton communities are usually simplified, with low densities in tropical waters. Information on zooplankton in rivers, particularly in the tropics is rather sparse, but existing studies indicate that factors influencing zooplankton and phytoplankton densities are similar (Welcomme, 1985). According to Charaborty *et al.* (1956) and Ayyapan (1977), the abundance of phytoplankton itself is possibly one of the major determining features, as high phytoplankton abundance is followed by a similar trend in zooplankton.

Welcomme (1985) and Wetzel (1983) also attributed zooplankton abundance to differences in flow, turbidity, dissolved oxygen concentration and conductivity. The earlier reported a negative relationship between current velocity and zooplankton densities. However, this was not the trend in this study, though a drop in percentage collection was noticed in February, when the current velocity was highest. According to Carney (1990) and Kosa (2007), most zooplankton migrates upward from deeper strata as darkness approaches and return to the deeper areas at dawn. At the time of sampling (during the day) zooplankters could be concentrated in the deeper areas.

Table 4: Number of zooplankton from various sample stations in the lower Sombreiro River (August 2005-July 2006)

Stations	No of specimen (org mL^{-1})	Percentage number
1	631[a]	30.7
2	487[c]	23.7
3	563[b]	27.4
4	376[c]	18.3
Total	2057	100.0

All the species were observed in all the stations, with the exception of *Mysis* sp. that was absent in station 4

Table 5: Monthly percentage collection of zooplankton and physico-chemical characteristics in the Lower Sombreiro River (August 2005-July 2006)

Collection (monthly) (%)	Water Temp (°C)	pH	Conductivity (µs cm^{-1})	Turbidity (Ntu)	Salinity (%)	Dissolved oxygen (mg L^{-1})	TDS (m)	Depth (mg L^{-1})	Flow rate (m s^{-1})	Rainfall (mm)
(Aug) 6.6	26.5	6.9	3821.0	3.0	3.1	7.85	527.9	7.62	0.11	228.4
(Sep) 2.9	26.5	6.8	3755.6	2.8	2.7	7.45	590.8	7.30	0.14	285.2
(Oct) 6.2	26.5	6.8	4051.1	2.2	3.1	7.25	544.5	6.75	0.16	195.2
(Nov) 7.0	27.0	6.6	4377.6	2.7	3.2	7.24	654.9	5.73	0.20	28.7
(Dec) 9.2	27.0	6.3	4539.6	2.2	3.4	7.60	841.7	5.00	0.23	38.4
(Jan) 11.4	27.5	6.3	4821.6	1.3	3.5	6.80	874.5	4.40	0.32	39.6
(Feb) 10.8	28.0	6.0	4476.4	0.9	3.3	6.60	859.5	4.40	0.33	103.7
(Mar) 12.0	27.0	5.9	5091.2	0.8	3.4	6.50	791.1	6.33	0.27	95.6
(Apr) 6.1	27.5	6.1	5364.2	0.8	3.1	6.71	757.6	7.25	0.31	59.8
(May) 12.7	27.0	6.8	5196.8	1.6	3.0	6.50	592.9	7.50	0.21	397.4
(Jun) 9.4	28.0	6.7	4748.3	1.8	2.6	7.10	556.9	8.03	0.14	344.7
(Jul) 5.7	27.5	6.6	3939.9	1.9	2.6	7.40	487.5	8.03	0.09	392.6

The temperature did not show much difference between the 2 extreme percentage collections

Table 6: Correlation coefficients of zooplankton and water parameters measured in the Lower Sombreiro River (August 2005-July 2006)

Correlation	Zooplan-kton	Temp (°C)	pH	Cond. (µscm^{-1})	Turb (Ntu)	Sal. (%)	DO (mg L^{-1})	TDS (mg L^{-1})	Depth (m)	Flow rate (m s^{-1})	Rainfall (mm)
Zooplankton	1.0000										
Temp	0.0909	1.0000									
PH	-0.1616	0.2934*	1.0000								
Conductivity	0.0705	0.4611*	0.4902*	1.0000							
Turbidity	-0.1984	-0.1209	0.2259*	0.0604	1.0000						
Salinity	0.0654	0.4182*	0.4932*	0.9892*	0.0775	1.0000					
Dissolved oxygen	-0.1516	0.1585	0.4248*	0.4463*	0.4544*	0.4530*	1.0000				
TDS	0.0719	0.4568*	0.4605*	0.9792*	0.0192	0.9831*	0.4114*	1.0000			
Dept	-0.1100	0.3789	0.6855*	0.7572*	0.2994*	0.7482*	0.5348*	0.6820*	1.0000		
Flow rate	0.1718	0.2982*	0.6536*	0.6047*	0.4197	0.6105*	0.5669	0.5321*	0.9043*	1.0000	
Rainfall	-0.1656	0.0055	0.2993*	-0.0225	0.1415	-0.0554	-0.0252	-0.0890	0.4210*	0.4625	1.0000

Significant at $p<0.05$

The observed less zooplankton during the wet/flood season could be attributed to dilution effect. This view was supported by Welcomme (1985). There was also a positive correlation between zooplankton occurrence and conductivity in this study. Carney (1990) holds that some species, especially Cladocerans regenerate nitrogen and phosphorus in the soluble available forms. This enhances phytoplankton productivity (which zooplankton depend on) and speeds nutrient cycling.

The higher record of zooplankton for sample station 1 could probably due to the very high conductivity and total dissolved solids values. Also, there was comparatively higher discharge of organic wastes at this station. There was also an inverse relationship between the Shannon-Wiener index (H) and the Simpson's dominance index (c).

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