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Seasonal diversity and abundance of zooplankton community index in river Okpokwu, Benue state, Nigeria

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Abstract
The study was done to investigate the seasonal diversity and abundance of zooplankton community index of River Okpokwu. In dry season, a total number of 1219 zooplankton whereas in rainy season, a total number of 611 zooplankton belonging to four classes; viz Copepoda, Monogononta, Branchiopoda and Class Insecta was encountered during the study period. Three species of Class Copepoda (*Mesocyclops sp, Diaptomus sp* and *Bryocamptus minute*), four species of Class Monogononta (*Trichocerca sp, Branchionus falcatus, Branchionus angularis* and *Polyarthra* sp), three species of Class Branchiopoda (*Chydorus* sp, *Bosmina* sp and *Diaphnia puplex*) and four species of Class Insecta (*Chironomid sp, Gerris remigis, Gyrinus* sp and *Corixid* sp) were encountered. In terms of zooplankton diversity index, Shannon Weinner diversity index (4.57, 4.51 and 4.56) were recorded for stations A, B and C, respectively in dry season but 4.47, 4.45 and 4.49 in stations A, B and C were recorded in rainy season while Margalef Index (4.43, 4.21 and 4.41) were recorded in stations A, B and C in the dry season, and 4.22, 3.99 and 4.27 were recorded in rainy season for stations A, B and C, respectively. Correlation occurred between physicochemical parameter and the zooplankton. In conclusion, River Okpokwu is highly rich in taxa and dominance of zooplankton in dry season. Among the zooplankton, Rotifers of genus *Brachionus* were most abundant. Therefore, River Okpokwu is a rich ecological ecosystem with high plankton diversity that can sustain fishery development.

Keywords: Seasonal diversity, community index, Okpokwu, Nigeria

Introduction

Microscopic plants and animals are collectively called plankton. Phytoplankton are drifted by water current and are not visible to the naked eyes, but can be observed under a microscope. As these plant microscopic organisms multiply, they are eaten directly by some fish or mostly by other microscopic aquatic animals called zooplankton. Plankton also serves as food for larger aquatic organisms like insects, worms and molluscs which are in turn eaten by fish. Zooplankton influence abundance and succession of phytoplankton through selective grazing activities and role in nutrient recycling, and form an important source of food for carnivorous fish as well as affect water quality (Mavuti, 1990) [13]. Changes in species composition, increases in phytoplankton abundance, increase in zooplankton biomass and significant changes in zooplankton community structures are some of the responses to biotic factors in water bodies.

Zooplankton is found in all freshwater habitats of the world, including industrial and municipal wastewaters (Mukhopadhyay *et al*., 2007) [15], and they play a very important role in the food chain as primary consumers and also serving as food for the higher trophic levels. Water quality generally refers to the parameters of water which are to be present at optimum levels for suitable growth of plants and animals (Kumar *et al*., 2011) [10]. A good water condition is a necessity for the survival and growth of fish since the entire life process of the fish wholly depends on the quality of its environment. The species assemblages of the zooplankton are indications of environmental quality and ecological changes as they respond to disturbances such as nutrient load, sediment input, contaminant densities and acidification (Jude *et al*., 2005) [9]. Zooplankton indicate the effects of low levels of chemical pollution in water and are good indicators of pollution in the biological monitoring (Rutherford *et al*., 1999; Soberon, *et al*., 2000; MBO, 2007) [18, 20, 14]. Zooplankton are not only useful as bio-indicators to help detect pollution load, but they are also helpful in ameliorating polluted waters (Mukhopadhyay *et al*., 2007) [15].

Relative species abundance describes how common or rare a species is relative to other species in a given community and usually described for single trophic level (Lawson and Olusanya, 2010) [11]. Species richness and related abundance are key element of biodiversity. Lawson and Olusanya (2010) [11] reported that, species richness relates to the number of different species in a given area and it is the fundamental unit used to access homogeneity of an environment. They are commonly used in conservation studies to determine the sensitivity of ecosystem and their species.

River Okpokwu is the second largest river in Benue South (Zone C), and serves many purposes including irrigation farming, fishing, animals and public water source. The population of the people practice small cottage industries like burnt bricks at the river bank, over 70% of the population of the people practice open defecation and dumping of wastes along the water course, practices which may have far reaching effects on the quality of the water. Also, there is dearth of information on the water quality and biodiversity of plankton (zooplankton) species of River Okpokwu. Against this backdrop, this study is designed to investigate zooplankton abundance and its correlation with the physico-chemical parameters of the river.

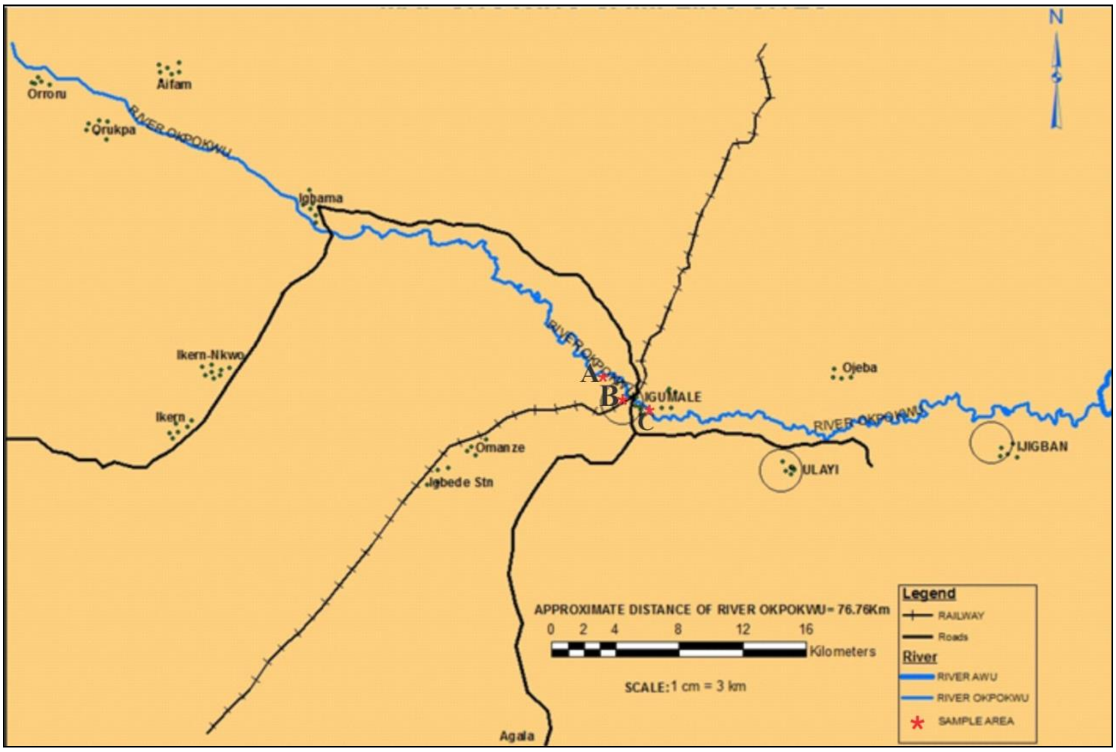
Materials and Methods

Description of study area

River Okpokwu transverses Ogbadibo, Ohimini, Okpokwu, Ado Local Government Areas of Benue State to Cross River State. There is a coal deposit in Owukpa, Ogbadibo Local Government Area which is upstream of River Okpokwu in Igumale, Ado Local Government Area of Benue State where the sampling sites are located. The river is used for irrigation, recreation, sewage disposal, fishing etc.

The study area is the only portion of the river where there are true riparian communities, with settlements on both banks of the river. The area is located between latitude 6° 48' 0" N and longitude 7° 58' 0" E. It contains mineral and natural resources in commercial quantities such as limestone, kaolin, petroleum and coal. The river covers about 76.76km. The climate is characterized by two distinct seasons, the dry season (November – April) and Wet season (May – October).

The three sampling stations (figure 1) were located at Igumale (Station A, known as Madam Ori side which is upstream of Igumale community, Station B, known as Ogbee side, midpoint with heavy human settlement and station C known as Igede side, downstream), all in Ado Local Government Area of Benue State covering a distance of about 1km (About 500m apart). These stations were selected considering the activities of the settlers such as agriculture at station A, cottage industries (Like block moulding and bunt bricks production) and domestic activities such as laundering at station B and laundering and agricultural activities at station C.



Source: Benue State Ministry of Land and Survey (2016).

Fig 1: Map of River Okpokwu showing the sampling sites

Plankton sampling of river Okpokwu

Samplings were undertaken fortnightly in the mornings from May, 2015 to April, 2017 by pour through method. Twenty litres of the water sample were collected just beneath the surface and poured through 55µm mesh size plankton net. These were repeated 5 time to add up to 100 litres. The plankton were immediately fixed with 5% formalin solution in 50 ml sampling bottle and transported to the laboratory for analysis and identification. The samples were concentrated to 10mls to enable analysis. One ml of the preserved sample was taken using a pipette. This was placed into Sedgwickrafter counting chamber and viewed under different magnifications (x100 and x400) using a light binocular microscope (Nikon 400 binocular microscope). These were done in triplicates. The plankton were identified and sorted into different taxonomical groups with the aid of appropriate identification schemes (Mann 2000, Prasad 2000, Castro and Huber 2005) [12, 17, 4].

Statistical analyses

All data on the physicochemical parameters and biological studies were analyzed using analysis of variance (ANOVA). Correlation among parameters was done to determine relationship between variables (Gomez and Gomez, 1984) [6]. The effect of significance in ANOVA was tested using Fisher protected LSD to distinguish difference between means. The estimation of species abundance and diversity of zooplankton among the stations were done using species Shannon Weiner index and Marglef's index.

Results

Results of the percentage zooplankton abundance in dry season at the three stations are presented in Table 1 while Table 2 presents the results of percentage zooplankton abundance in rainy season at the three stations. In dry season, a total number of 1219 zooplankton belonging to four classes; viz Copepoda, Monogononta, Branchiopoda and Class Insecta were encountered during the study period. Three species of Class Copepoda (*Mesocyclops sp, Diaptomus sp* and *Bryocamptus minute*) were encountered four species of Class Monogononta (*Trichocerca sp, Branchionus falcatus, Branchionus angularis* and *Polyarthra sp*) were encountered, also encountered were three species of Class Branchiopoda (*Chydorus sp, Bosmina sp* and *Diaphnia puplex*) while four species of Class Insecta (*Chironomid sp, Gerris remigis, Gyrinus sp* and *Corixid sp*) were encountered.

Of the 565 zooplankton from station A, Class Copepoda accounted for 39, out of which *Mesocyclops sp* and *B. minutes* were the most abundant (35.90% each) and *Diaptomus sp* the least abundant (28.21%). Class Monogononta accounted for 229, out of which *Branchionus falcatus* was most abundant (35.81%) and *Trichocerca sp* was least abundant (19.65%). Class Branchiopoda accounted for 119 number of zooplankton of which *Diaphnia puplex* was most abundant (41.18%) while *Bosmina sp* was least abundant (21.01%). whereas, Class Insecta accounted for 178 of which *Corixid sp*was most abundant (28.65%) and *Gerris remiges* least abundant (20.22%);

Out of the 250 zooplankton encountered at station B, Class Copepoda accounted for 35, out of which *Diaptomus sp* was the most abundant (42.86%) and *Mesocyclops sp* the least abundant (25.71%). Class Monogononta accounted for 91, out of which *Branchionus falcatus* was most abundant (36.26%) and *Trichocerca sp* was least abundant (15.38%). Class Branchiopoda accounted for 56 number of zooplankton of which *Diaphnia puplex* was most abundant (55.36%) while *Bosmina sp* was least abundant (7.14%) whereas, Class Insecta accounted for 68 of which *Chironomid sp* was most abundant (35.29%) and *Corixid sp* least abundant (11.77%);

At station C, Class Copepoda accounted for 61 out of the 351 zooplankton encountered; of which *Diaptomus sp* was the most abundant (40.98%) and *Mesocyclops sp* the least abundant (24.59%). Class Monogononta accounted for 125, out of which *Branchionus falcatus* was most abundant (36.80%) and *Branchionus angularis* was least abundant (16.00%). Class Branchiopoda accounted for 62 number of zooplankton of which *Diaphnia puplex* was most abundant (46.77%) and *Bosmina sp* was least abundant (24.19%), while Class Insecta accounted for 103 of which *Chironomid sp* was most abundant (28.16%) and *Gerris remigis* and *Gyrinus sp* were least abundant (23.30% each). Generally, Class Monogononta was the most abundant (38.16%) in dry season while Class Copepoda was least abundant (11.58%).

Whereas in rainy season, a total number of 581 zooplankton was encountered during the study belonging to four classes which include Copepoda, Monogononta, Branchiopoda and Class Insecta. Three species of Class Copepoda were encountered viz: *Mesocyclops sp, Diaptomus sp* and *Bryocamptus minutes*. The four species of Class Monogononta encountered are *Trichocerca sp, Branchionus falcatus, Branchionus angularis* and *Polyarthra sp*. Three species of Class Branchiopoda encountered are *Chydorus sp, Bosmina sp* and *Diaphnia puplex* while four species of Class Insecta encountered are *Chironomid sp, Gerris remigis, Gyrinus sp* and *Corixid sp.*

At station A, Class Copepoda accounted for 35 out of the 189 zooplankton encountered. *Diaptomus sp* was the most abundant (37.14%) and *Mesocyclops sp* and *B. minutes* were the least abundant (31.43% each). Class Monogononta accounted for 69, while *Branchionus falcatus* was most abundant (34.78%), *Trichocerca sp* was least abundant (18.84%). Class Branchiopoda accounted for 35 number of zooplankton of which *Chydorus sp* was most abundant (45.71%) while *Bosmina sp* was least abundant (17.14%); whereas, Class Insecta accounted for 50 of which *Corixid sp* was most abundant (30.00%) while *Gerris remigis* was least abundant (16.00%).

At station B, Class Copepoda accounted for 29 out of the 167 zooplankton encountered. While *Mesocyclops sp* was the most abundant (41.38%), *Diaptomus sp* was the least abundant (20.69%). Class Monogononta accounted for 66, out of which *Branchionus falcatus* was most abundant (34.85%) and *Trichocerca sp* was least abundant (18.18%). Class Branchiopoda accounted for 28 number of zooplankton of which *Chydorus sp* was most abundant (42.86%) and *Diaphnia puplex* was least abundant (25.00%) whereas, Class Insecta accounted for 44 of which *Corixid sp* was most abundant (38.64%) and *Gyrinus sp* least abundant (13.64%);

At station C, Class Copepoda accounted for 37 out of the 225 zooplankton encountered; of which *Mesocyclops sp* and *B. minutes* were the most abundant (35.14% each) and *Diaptomus sp* the least abundant (29.73%). Class Monogononta accounted for 89, out of which *Trichocerca sp* was most abundant (30.34%) and *Branchionus angularis* was least abundant (22.47%). Class Branchiopoda accounted for 44 number of zooplankton of which *Chydorus sp* was most abundant (38.64%) and *Diaphnia puplex* was least abundant (27.27%), while, Class Insecta accounted for 55 of which *Corixid sp* was most abundant (30.91%) while *Chironomid sp and Gerris remigis* least abundant (20.00% each). Generally, while Class Monogononta was most abundant (38.55%), Class Copepoda was least abundant (17.38%).

In terms of zooplankton diversity index, Shannon Weinner diversity index (4.57, 4.51 and 4.56) were recorded for stations A, B and C, respectively in dry season but 4.47, 4.45 and 4.49 in stations A, B and C were recorded in rainy season while Margalef Index (4.43, 4.21 and 4.41) were recorded in stations A, B and C in the dry season, 4.22, 3.99 and 4.27 were recorded in rainy season for stations A, B and C, respectively (Tables 1 and 2).

Results of correlation matrices for zooplankton species with physic-chemical parameters during the study period in dry season are presented in Table 3 while results of the correlation matrices for zooplankton species with physic-chemical parameters during the study period in rainy season are presented in Table 4.

Table 1: Percentage zooplankton abundance in river Okpokwu during dry season

Zooplankton	Station A		Station B		Station C	
	No.	%	No.	%	No.	%
Copepoda						
Mesocyclops sp	14	35.90	9	25.71	15	24.59
Diaptomus sp	11	28.21	15	42.86	25	40.98
B. minutes	14	35.90	11	31.43	21	34.43
Monogononta						
Trichocerca sp	45	19.65	14	15.38	33	26.40
Branchionus falcatus	82	35.81	33	36.26	46	36.80
Branchionus angularis	46	20.09	16	17.58	20	16.00
Polyarthra sp	56	24.45	28	30.77	26	20.80
Branchiopoda						
Chydorus sp	45	37.82	21	37.5	18	29.03
Bosmina sp	25	21.01	4	7.14	15	24.19
Diaphnia puplex	49	41.18	31	55.36	29	46.77
Insecta						
Chironomid sp	44	20.85	24	32.43	29	24.79
Gerris remigis	36	17.06	20	27.03	24	20.51
Gyrinus sp	51	24.17	16	21.62	24	20.51
Corixid sp	47	22.27	8	10.81	26	22.22
Total Abundance	565		250		351	
Shannon weinner index	4.57		4.51		4.56	
Margalef index	4.43		4.21		4.41	

In the dry season, *Mesocyclops sp* exhibited a high degree of positive correlation with dissolved oxygen (DO), and a degree of positive correlation with biological oxygen demand (BOD), carbon dioxide (CO_2) and transparency but showed degree of negative correlation with total dissolved solid (TDS), alkalinity, nitrate and phosphate. *Diaptomus sp* exhibited degree of positive correlation with DO, BOD, CO_2, water temperature, transparency, pH and chloride but showed degree of negative correlation with TDS, alkalinity and phosphate.

Table 2: Percentage Abundance of Zooplankton in River Okpokwu during Rainy Season.

	Station A		Station B		Station C	
Zooplankton	No.	%	No.	%	No.	%
Copepoda						
Mesocyclops sp	11	31.43	12	41.38	13	35.14
Diaptomus sp	13	37.14	6	20.69	11	29.73
B. minutes	11	31.43	11	37.93	13	35.14
Monogononta						
Trichocerca sp	13	18.84	12	18.18	27	30.34
Branchionus falcatus	24	34.78	23	34.85	21	23.60
Branchionus angularis	15	21.74	16	24.24	20	22.47
Polyarthra sp	17	24.64	15	22.73	21	23.60
Branchiopoda						
Chydorus sp	16	45.71	12	42.86	17	38.64
Bosmina sp	**6**	17.14	9	32.14	15	34.09
Diaphnia puplex	13	37.14	7	25.00	12	27.27
Insecta						
Chironomid sp	13	21.67	12	23.53	11	16.18
Gerris remigis	**8**	13.33	9	17.65	11	16.18
Gyrinus sp	14	23.33	6	11.76	16	23.53
Corixid sp	15	25.00	17	33.33	17	25.00
Total Abundance	189		167		225	
Shnnon weinner index	4.47		4.45		4.49	
Margalef index	4.22		3.99		4.27	

B. minutes exhibited degree of positive correlation with DO, BOD, CO_2, transparency and pH but showed some degree of negative correlation with TDS, alkalinity, hardness, nitrate and phosphate. *Trichocerca sp* exhibited degree of positive correlation with CO_2, pH and chloride but showed degree of negative correlation with TDS, alkalinity, hardness and phosphate. *Branchionus falcatus* exhibited degree of positive correlation with DO, BOD, CO_2, transparency and pH but showed degree of negative correlation with air temperature, water temperature, TDS, alkalinity, hardness, chloride and phosphate. *Branchionus angularis* exhibited degree of positive correlation with DO, BOD, CO_2, air temperature, pH, alkalinity and chloride but showed degree of negative correlation with transparency, nitrate and phosphate. *Polyarthra sp* exhibited degree of positive correlation with DO, BOD, CO_2, transparency and pH but showed degree of negative correlation with air temperature, TDS, alkalinity, hardness, nitrate and phosphate. *Chydorus sp* exhibited degree of positive correlation with DO, BOD, CO_2, transparency and chloride but showed degree of negative correlation with air temperature, water temperature, TDS, alkalinity, hardness, nitrate and phosphate. *Bosmina sp* exhibited degree of positive correlation with DO, BOD, CO_2, air temperature, water temperature, pH and nitrate but showed degree of negative correlation with TDS, transparency, alkalinity, hardness and chloride. *Diaphnia puplex* exhibited degree of positive correlation with CO_2, transparency and pH but showed high degree of negative correlation with air temperature, TDS, alkalinity, hardness, nitrate and phosphate. *Chironomid sp* exhibited degree of positive correlation with DO, BOD, CO_2, water temperature, pH and chloride but showed degree of negative correlation with TDS, alkalinity, hardness, and nitrate; *Gerris remigis* exhibited degree of positive correlation with DO, BOD, CO_2, air temperature, water temperature, pH, alkalinity and hardness but showed degree of negative correlation with transparency, nitrate and phosphate. *Gyrinus sp* exhibited degree of positive correlation with DO, CO_2, transparency, pH and chloride but showed high degree of negative correlation with water temperature, and degree of negative correlation with air temperature, TDS, hardness, nitrate and phosphate while *Corixid sp* exhibited degree of positive correlation with $CO_{2,}$ air temperature, water temperature, pH and alkalinity but showed degree of negative correlation with transparency, hardness and chloride.

Whereas, In the rainy season, *Mesocyclops sp* exhibited degree of positive correlation with DO, BOD, $CO_{2,}$ alkalinity and chloride but showed degree of negative correlation with TDS, pH, hardness, nitrate and phosphate; *Diaptomus sp* exhibited degree of positive correlation with DO and chloride but showed degree of negative correlation with $CO_{2,}$ air temperature, hardness, nitrate and phosphate. *Bryocamptus minutes* exhibited degree of positive correlation with DO, BOD and chloride but showed degree of negative correlation with TDS, pH, nitrate and phosphate; *Trichocerca sp* exhibited degree of positive correlation with $CO_{2,}$ water temperature, transparency and chloride but showed degree of negative correlation with TDS, pH, hardness nitrate and phosphate. *Branchionus falcatus* exhibited degree of positive correlation with BOD, $CO_{2,}$ TDS, hardness and chloride but showed degree of negative correlation with DO, air temperature, water temperature, nitrate and phosphate. *Branchionus angularis* exhibited degree of positive correlation with BOD, $CO_{2,}$ air temperature, water temperature, transparency, and chloride but showed degree of negative correlation with pH, nitrate and phosphate. *Polyarthra sp* exhibited degree of positive correlation with DO, BOD, water temperature, transparency and chloride but showed degree of negative correlation with TDS, hardness, nitrate and phosphate; *Chydorus sp* exhibited degree of positive correlation with BOD, transparency, pH and chloride but showed degree of negative correlation with DO, nitrate and phosphate; *Bosmina sp* exhibited degree of positive correlation with transparency but showed degree of negative correlation with DO, air temperature, TDS, pH, alkalinity, hardness, chloride, nitrate and phosphate. *Diaphnia puplex* exhibited degree of positive correlation with DO, BOD and chloride but showed degree of negative correlation with air temperature, water temperature, TDS, hardness, nitrate and phosphate; *Chironomid sp* exhibited degree of positive correlation with BOD and CO_2 but showed degree of negative correlation with DO, air temperature, water temperature, transparency, alkalinity, hardness, chloride, nitrate and phosphate. *Gerris remigis* exhibited degree of positive correlation with DO, BOD, CO_2, air temperature, water temperature, transparency, alkalinity and chloride but showed degree of negative correlation with TDS, pH, nitrate and phosphate. *Gyrinus sp* exhibited degree of positive correlation with CO_2, but showed degree of negative correlation with DO, air temperature, water temperature, TDS, transparency, pH, alkalinity, hardness, chloride, nitrate and phosphate while *Corixid sp* exhibited degree of positive correlation with BOD, $CO_{2,}$ and chloride but showed degree of negative correlation with air temperature, water temperature, alkalinity, hardness, nitrate and phosphate.

Table 3: Correlation matrices (r) for different zooplankton species with physico-chemical parameters of river okpowu in dry season

	DO	BOD	CO_2	Air temp.	Water temp.	TDS	Transparency	pH	Alkalinity	Hardness	Chloride	Nitrate	Phosphate
Mesocyclops sp	0.54	0.12	0.27*	0.09	0.02	-0.14	0.12	-0.01	-0.14	-0.07	0.07	-0.18	-0.10
Diaptomus sp	0.09	0.17	0.30*	0.09	0.12	-0.02	0.12	0.25*	-0.01	-0.08	0.15	0.05	-0.02
B. minutes	0.10	0.21	0.14	0.01	0.04	-0.07	0.10	0.16	-0.02	-0.10	0.08	-0.05	-0.03
Trichocerca sp	0.07	0.08	0.28*	0.06	0.08	-0.04	0.08	0.20	-0.02	-0.09	0.10	0.05	-0.02
Branchionus falcatus	0.24*	0.13	0.30*	-0.09	-0.01	-0.17	0.24*	0.20	-0.17	-0.20	-0.04	-0.08	-0.15
Branchionus angularis	0.14	0.07	0.28*	0.10	0.01	0.03	-0.02	0.22	0.12	0.05	0.27*	-0.05	-0.04
Polyarthra sp	0.20	0.10	0.22	-0.06	0.01	-0.13	0.18	0.14	-0.06	-0.07	0.09	-0.19	-0.14
Chydorus sp	0.13	0.23	0.29*	-0.15	-0.01	-0.18	0.32**	0.03	-0.13	-0.17	0.28*	-0.20	-0.20
Bosmina sp	0.24*	0.11	0.29*	0.13	0.11	-0.08	-0.02	0.14	-0.05	-0.10	-0.08	0.10	0.04
Diaphnia puplex	0.09	0.09	0.27*	-0.07	0.01	-0.08	0.18	0.10	-0.02	-0.03	0.07	-0.19	-0.15
Chironomid sp	0.16	0.20	0.25*	0.06	0.12	-0.06	0.08	0.22	-0.10	-0.05	0.20	-0.08	0.03
Gerris remigis	0.22	0.13	0.28*	0.10	0.18	0.07	-0.07	0.36**	0.12	0.13	0.01	-0.07	-0.01
Gyrinus sp	0.16	0.07	0.32**	-0.15	-0.44	-0.14	0.16	0.18	-0.07	-0.10	0.13	-0.20	-0.21
Corixid sp	0.03	-0.06	0.26*	0.16	0.21	0.02	-0.06	0.10	0.11	-0.01	-0.08	0.09	0.06

***Correlation is significant at the 0.05 level (2-tailed).

Table 4: Correlation matrices (r) for different zooplankton species with physico-chemical parameters of river okpowu in rainy season

	DO	BOD	CO_2	Air temp.	Water temp.	TDS	Transparency	pH	Alkalinity	Hardness	Chloride	Nitrate	Phosphate
Mesocyclops sp	0.11	0.26*	0.19	0.02	0.03	-0.08	0.05	-0.18	0.10	-0.02	0.11	-0.07	-0.27*
Diaptomus sp	0.17	0.05	-0.01	-0.05	0.04	0.03	0.02	0.00	0.08	-0.02	0.12	-0.05	-0.01
B. minutes	0.16	0.23	0.07	0.02	0.08	-0.07	0.08	-0.07	0.07	0.01	0.26*	-0.01	-0.16
Trichocerca sp	0.01	0.04	0.10	0.08	0.13	-0.07	0.23	-0.09	0.01	-0.03	0.09	-0.22	-0.12
Branchionus falcatus	-0.04	0.23	0.13	-0.03	-0.02	0.12	0.01	0.01	0.02	0.12	0.16	-0.05	-0.19
Branchionus angularis	0.07	0.23	0.12	0.12	0.12	0.00	0.16	-0.18	0.07	0.04	0.11	-0.07	-0.02
Polyarthra sp	0.10	0.10	0.05	0.03	0.10	-0.04	0.11	0.01	0.05	-0.03	0.22	-0.08	-0.13

Chydorus sp	-0.03	0.15	0.03	0.02	0.04	0.04	0.09	0.13	-0.01	0.05	0.13	-0.08	-0.13
Bosmina sp	-0.03	0.02	0.20	-0.09	0.01	-0.15	0.06	-0.12	-0.10	-0.10	-0.05	-0.20	-0.13
Diaphnia puplex	0.13	0.17	0.02	-0.06	-0.00	-0.02	0.03	0.04	0.06	-0.03	0.10	-0.10	-0.09
Chironomid sp	-0.08	0.11	0.25*	-0.23*	-0.20	0.06	-0.16	0.01	-0.13	-0.02	-0.05	-0.09	-0.18
Gerris remigis	0.09	0.25*	0.12	0.10	0.12	-0.06	0.09	-0.07	0.15	0.03	0.19	-0.09	-0.19
Gyrinus sp	-0.03	0.06	0.17	-0.27*	-0.19	-0.08	-0.08	-0.01	-0.06	-0.10	-0.04	-0.28*	-0.16
Corixid sp	0.04	0.23	0.10	-0.04	-0.01	0.00	0.01	-0.04	-0.02	-0.02	0.20	-0.06	-0.15

*****Correlation is significant at the 0.05 level (2-tailed).

Discussion

It was observed that zooplankton composition reported in this study is comparable to that reported in the studies of Arsène, *et al*. (2015) [3] who reported Structure and seasonal dynamics of zooplankton of River Ouémé, Benin. Seasonal variation in zooplankton concentration could largely be due to the rotifers which normally constitute major diet items of larger zooplankton during the dry season. Species of rotifers that are considered as good indicators of the trophic state of the river were identified in the zooplankton community. Among the zooplanktons, Rotifers are good indicators of water quality. Rotifers of genus *Brachionus, Keratella, Asplanchna Cyclops*, *Daphina*, *Ceriodaphnia* and *Filinia* are abundant in freshwaters; their occurance in eutrophic water is well documented. This finding is in agreement with the findings of Sudha, (2012) [21]. Zooplankton holds a central position in the food chain of most rivers, lakes, reservoirs and ponds and are highly sensitive to environmental variations which as a result bring changes in their abundance, species diversity or community composition, because most species have short generation time (Shah and Pandit, 2013) [19]. The dominant status of rotifer species in rivers comparative to the cladocerans, copepods, ostracods, and decapods is the characteristic of tropical rivers and this has been reported in the studies of Agouru and Audu (2012) [2].

The lower zooplankton abundance recorded during the wet season could be due to predation by juvenile fish which might have contributed to the decline in zooplankton. Lecanidae and Brachionidae are usually represented by the highest number of species and the frequently encountered genera include *Brachionus*, *Lecane* and *Keratella spp* (Sudha, 2012) [21]. The presence of pollution indicator species as *Brachionus* and *Keratella* along with clean water indicator species like *Mesocyclops* in large quantity and *nauplius sp* indicates a good water quality with presence of some organic pollution (Sudha, 2012) [21]. Peak in total zooplankton abundance was recorded during the dry season. This coincided with the period of abundance of phytoplankton which serves as primary producer. High abundance of copepods and cladocerans zooplankton community may be due to increase in cyclopoid copepodids and mesocyclops, as indicators of good water quality. Temperature and the availability of food are about the most important factors controlling the abundance of zooplankton in water. Higher temperature regimes during the dry season coupled with high level of food in the water as a result of high primary productivity (phytoplankton), can be responsible for the high populations of zooplankton. The zooplankton population dominated by ciliates during the dry season in the present study was regarded as a booster of all year round food for fish in the river. Similar findings were observed by Gabriel *et al*., (2013) [5].

Adeyemi (2012) [1] reported that the zooplanktons community was made up of Rotifera, Cladocera, Copepoda and Protozoa. Okayi *et al*. (2001) [16] also reported zooplankton community to consist of Copepoda, Cladocera and Rotifera in their study of seasonal pattern of zooplankton community in River Benue at Makurdi corridor. These findings are in contrast with the findings of this study. Shah and Pandit (2013) [19] also observed sudden increase in species diversity and density with the advent of warm season in March. There are also indications that zooplankton differ in their response to variations in season, water depth and type of bottom sediments of the water body. This may be the reason for the seasonal variation and abundance of the different species of zooplankton.

The abundance of zooplankton varies according to limnological features and trophic state (Jeppensen *et al*., 2002; Imoobe and Adeyinka, 2010) [8, 7]. The correlation matrices (r) for different zooplankton Species with Physiochemical parameters for all Stations reported in this study is in agreement with that reported by Sudha, (2012) [21] in Bisalpur Reservoir. Shannon Weiner diversity index as adopted by Tanimu *et al*., (2012) [22] revealed that species diversity and pollution status of aquatic system are classified as follows; >3 clean water, 1-3 moderately polluted and <1 heavily polluted. Based on this classification, the water of River Okpokwu is clean for zooplankton. Shannon-Weaver diversity index did not vary significantly between seasons which are characteristics of stable physico-chemical conditions. This suggests that the river is not under pollution threat presently.

Conclusion

The population of zooplankton was generally high in the river during the study period. River Okpokwu is highly rich in taxa and dominance of zooplankton in dry season. Among the zooplankton, Rotifers of genus *Brachionus* were most abundant. River Okpokwu is a rich ecological ecosystem with high plankton diversity that can sustain fishery development. Also, the variation in the abundance and kind of zooplankton found in the different stations is an indication that there may be variations in the kind and levels of stresses in the different courses of the same water bodies and this could exert some impacts on the characteristics of the organisms that are found in the water.

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