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Research Article
Zooplankton Assemblages of a Tropical Coastal Creek, South-Eastern Nigeria

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Abstract

Background and Objective: The study of zooplankton composition, abundance and seasonal variations is helpful in planning and successful fishery management, therefore this study attempts to shed light on the current state of the zooplankton community of this creek given its present poor state of knowledge. **Materials and Methods:** The zooplankton assemblage structure and distribution in Stubbs Creek, Akwa-Ibom state, Nigeria was studied (September, 2011-August, 2013). Three sampling stations were chosen. Samples were obtained by filtering 100 L of water through standard plankton net with a base collector of 500 mL. The samples were preserved in 5% formalin. Identification and counting of zooplankton was done using Zeis inverted microscope and identification keys. **Results:** A total of 9 species belonging to 6 taxonomic groups were recorded. The class Maxillopoda was the most abundant in number and species. Maxillopoda made up 50% of the total zooplankton identified, followed by Appendicularia with 22%. Other classes consisted of <10% each of the total zooplankton. Only Maxillopoda had 4 species, the other classes had 1 species each. The low zooplankton diversity observed in this study is common in tropical waters. Calanoida copepod was the most dominant (27.27%) zooplankton taxa, followed by *Oikopleura* (22.73%). The dominance of copepods in this creek makes it a good breeding ground for most fish fauna. Although there were differences in the abundance of the zooplankton taxa with seasons, they were not statistically different ($p>0.05$). The highest number of zooplankton taxa (6) was observed in station 1 while the highest number of zooplankton individuals (180) was observed in station 2. Stations 3 recorded the lowest zooplankton taxa of 4. The dominance of copepods may have accounted for the low Margalef species diversity ($\leq$1.012) and low Shannon-wiener index ($\leq$1.748) recorded during the study. **Conclusion:** It is agreed by pollution biologist that species diversity declines as pollution effects are more severe. Stubbs creek is environmentally stressed and this requires urgent monitoring of the activities on this creek to maintain a sustainable, productive and healthy ecosystem.

Key words: Zooplankton, stubbs creek, pollution, rotifera, copepoda

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Many rivers in urban and semi urban areas of Nigeria have been used for disposals of both solid wastes and wastewaters, usually untreated and are thus adversely polluted[1]. This high pollution status threatens and, in many cases, has already altered the ecological balance of most rivers in Nigeria[2]. Aquatic communities and populations can be considered biological indicators of the contamination level of an environment, where the presence or the absence of species can be an indication of the disturbance of ecosystems[3].

Zooplankton are heterotrophic planktonic animals floating in the water, which constitute an important food source for many species of aquatic organism[4]. Zooplankton is an important link in the energy transfer of organic matter produced by photosynthesis to other trophic levels as well as including indicator species and providing subsidies for present and past ecological processes[5]. Zooplankton as a biotic component of the aquatic ecosystems plays a key role in cycling of organic materials, helping in regulating algal and microbial productivity through grazing as suspension feeders and predators in the transfer of primary productivity to fish and other consumers[6]. Due to their large density, shorter life span, drifting nature, high group or species diversity and different tolerance to stress, zooplankton are being used as indicator organisms for the physical, chemical and biological processes in the aquatic ecosystem. They are globally recognized as pollution indicator organisms in the aquatic environment[7]. Zooplankton studies are of necessity in fisheries, aquaculture and paleolimnological research as they have been known to leave an impression record of geological past[8].

According to Kiran *et al.*[9] the study of zooplankton composition, abundance and seasonal variations is helpful in planning and successful fishery management, therefore this study attempts to shed light on the current state of the zooplankton community of this creek given its present poor state of knowledge. Poor attention has been given to zooplankton studies in smaller creeks scattered across the Niger Delta and which contribute significant proportions to the region's aquatic biodiversity. The aim of the study is to determine the diversity of the zooplankton groups, their abundance and seasonal variations in Stubbs creek, Akwa-Ibom state.

MATERIALS AND METHOD

Study area: Stubbs creek is located within latitude 4.57° and longitude 7.98°. It is a tidal creek. The mangrove of this creek has been overtaken by Nipa palm. Human activities going on within and around this creek include farming, fishing, washing, disposal of excreta, bathing, swimming and timber transportation. Three sampling stations were chosen (Fig. 1). The map (Fig. 1) was produced using ArcGIS 10.3. Stations 1 and 2 were at areas of increased human activities, unlike station 3 which was a relatively calm spot:

- **Station 1:** Located at the point where Stubbs creek empties into Qua-Iboe River (4° 33' 47" N and 7° 59' 7" E). The vegetation along the creek is mainly Nipa palm
- **Station 2:** Located along Stubbs creek (4° 34' 25" N and 7° 59' 17" E). From this point, farming lands with human settlements could be observed
- **Station 3:** Located along Stubbs creek (4° 33' 22" N and 7° 59' 9" E). Although close to a bridge, the station was observed to be serene

Sample collection: Monthly sampling at the 3 stations for 24 months (September, 2011-August, 2013) was carried-out. Samples were obtained by filtering 100 L of water through standard plankton net with a base collector of 500 mL. The samples were preserved in 5% formalin. Identification and counting of zooplankton was done using Zeis inverted microscope and identification keys including[10-12]. Number of cells of plankter was calculated according to Onuoha[13]. Rainfall data was collected from the meteorological unit, Department of Geography, University of Uyo, Nigeria.

Statistical analysis: The means, ranges, percentages and one-way analysis of variance (ANOVA) at probability level of $p<0.05$ of the data generated were determined using SPSS (v. 19 by IBM Corporation, New York, USA) package. Microsoft Excel 2010 (Microsoft Corporation, Washington, USA) was used for graphical illustrations. The community structure (Margalef species diversity, Shannon-wiener index and species evenness) was analyzed using PAST software (v 2.12 by Hammer, Oslo, Norway).

RESULTS

The zooplankton community observed in Stubbs creek during this study is presented in Table 1, 2 and 3. Table 1 shows the number and percentage composition of zooplankton class found in Stubbs creek. Table 2 shows the spatial variation of zooplankton taxa encountered along the creek while Table 3 shows the monthly variation of zooplankton taxa found in the creek.

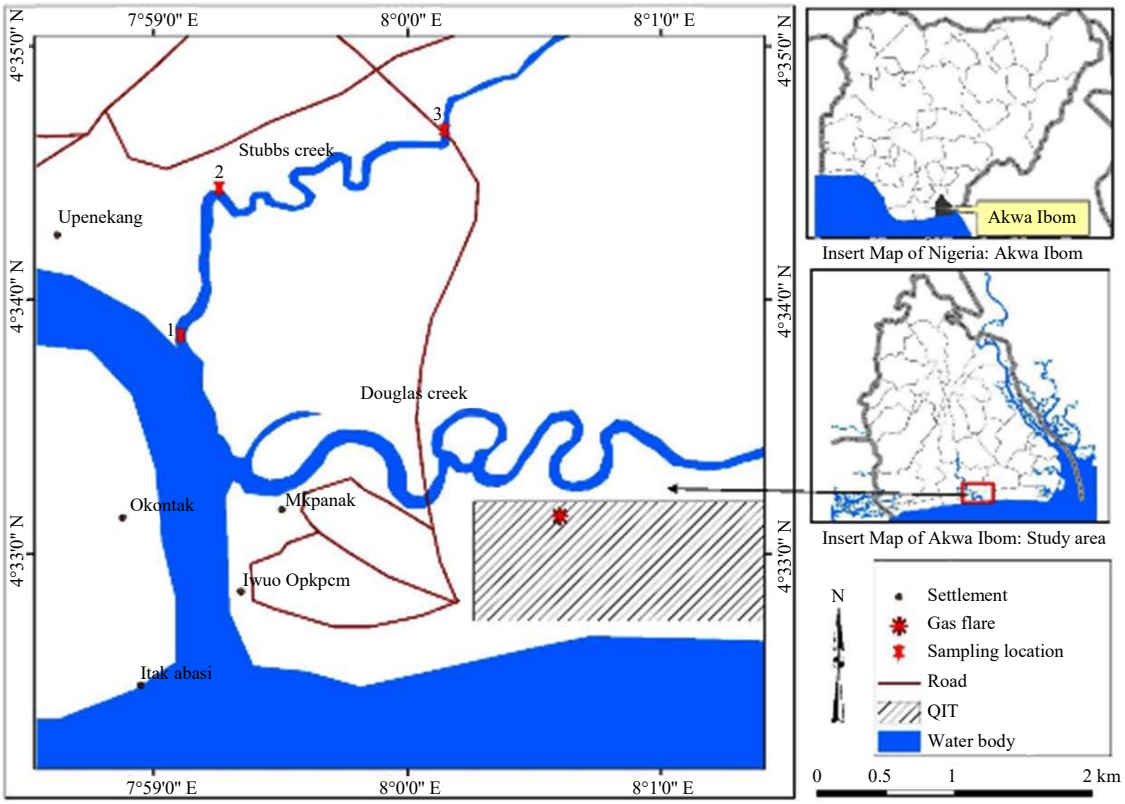

Fig. 1: Map showing sampling stations (1-3)

Source: Arc GIS 10.3

Table 1: Number and percentage composition of zooplankton class recorded at Stubbs creek

Taxa	Total number of Individuals	Relative abundance (%)	Number of taxa	Taxa composition (%)
Monogononta	20	4.55	1	11.11
Maxillopoda	220	50.00	4	44.44
Hydrozoa	40	9.09	1	11.11
Malacostraca	20	4.55	1	11.11
Appendicularia	100	22.73	1	11.11
Spirotrichea	40	9.09	1	11.11

Table 2: Spatial variation of zooplankton taxa (No. mL^{-1}) encountered along Stubbs creek

Taxa	Station 1	Station 2	Station 3
Monogononta			
Branchionus plicatilis	20	0	0
Maxillopoda			
Calanoida copepod	0	60	60
Zoea	20	20	0
Copepod nauplius	20	0	20
Barnacle nauplius	20	0	0
Hydrozoa			
Actinula larvae	20	0	20
Malacostraca			
Crustacean nauplius larvae	0	20	0
Appendicularia			
Oikopleura	40	40	20
Spirotrichea			
Tintinnidae	0	40	0

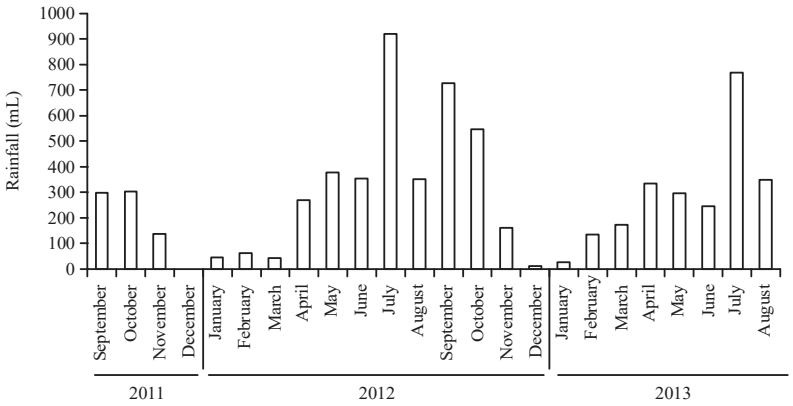

Fig. 2: Rainfall data during the period of study

Source: Meteorological unit, Department of Geography, University of Uyo, Nigeria

Table 3: Monthly variation of zooplankton class encountered along Stubbs creek

Seasons	Monogononta	Maxillopoda	Hydrozoa	Malacostraca	Appendicularia	Spirotrichea
2011						
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
2012						
January	0	0	0	0	0	0
February	0	20	20	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	20	0	20	0	0
August	0	20	0	0	0	0
September	0	0	0	0	0	0
October	0	0	20	20	40	0
November	0	40	0	0	0	0
December	0	20	0	0	0	0
2013						
January	0	20	0	0	0	0
February	20	20	0	0	20	0
March	0	0	0	20	0	0
April	0	0	0	0	0	0
May	0	20	0	0	0	20
June	0	0	0	0	20	0
July	0	0	0	0	40	0
August	0	0	0	0	0	0

The class Maxillopoda was the most abundant in number and species. Maxillopoda made up 50% of the total zooplankton identified, followed by Appendicularia with 22%. Other classes consisted of less than 10% each of the total zooplankton. Only Maxillopoda had 4 species, the other classes had one species each. Calanoida copepod was the most dominant (27.27%) zooplankton taxa, followed by *Oikopleura* (22.73%). The least abundant zooplankton taxa were *Branchionus plicatilis*, *Barnacle nauplius* and Crustacean nauplius larvae each making up 4.55% of the total zooplankton composition. Maxillopoda was relatively most abundant in all the stations. None of the zooplankton taxa was observed in all the stations except *Oikopleura*. *Branchionus plicatilis, Barnacle nauplius* and Crustacean nauplius larvae had very low frequencies, only appearing in one station each. The presence of low zooplankton diversity reflects the health of the ecosystem.

Figure 2 shows a graphical presentation of rainfall for the period of study and Fig. 3 is a graphical presentation of the seasonal variations of the zooplankton class in Stubbs creek

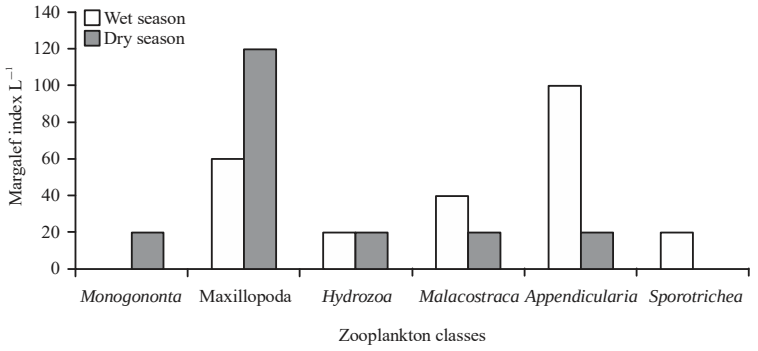

Fig. 3: Class seasonal variation of zooplankton in Stubbs creek

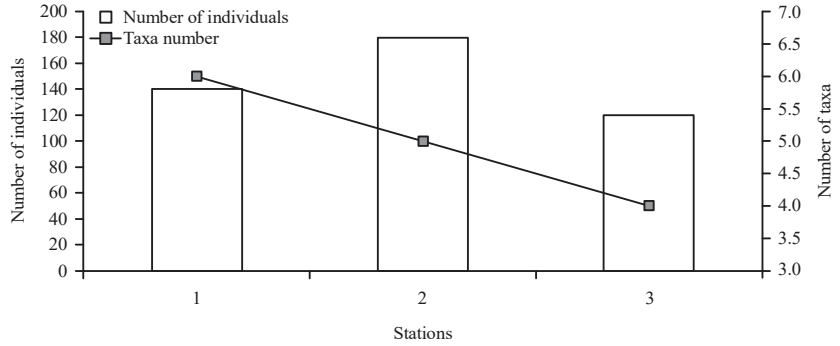

Fig. 4: Relationship between number of individuals and number of taxa of zooplankton in Stubbs creek

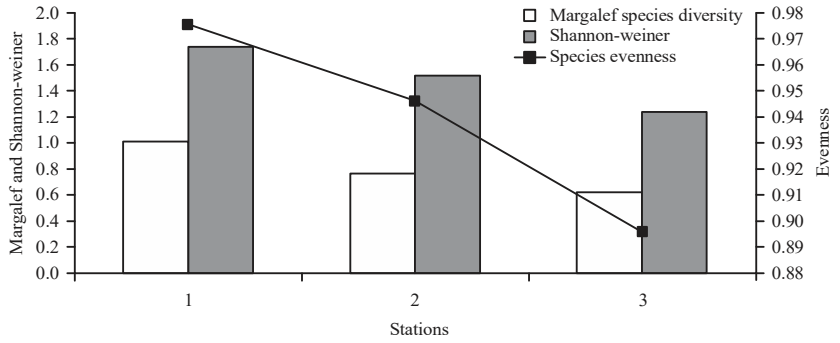

Fig. 5: Relationships between the diversity indices of macro-invertebrates in Stubbs creek

during the study. Figure 4 gives a graphical presentation of the relationship between number of individuals and number of taxa of zooplankton in Stubbs creek for the study period. The rainfall data obtained from the Meteorological unit, Department of Geography, University of Uyo, Nigeria, showed a 7 months' wet season period, which stretched from April-October and a dry season extending from November-March. Malacostraca, Spirotrichea and Appendicularia were more frequent in the wet season than dry season while Monogononta, Hydrozoa and Maxillopoda were more frequent in the dry season than wet season. Monogononta was only encountered in the dry season while Spirotrichea was only encountered in the wet season. Although there were differences in the abundance of the zooplankton taxa with seasons, they were not statistically different ($p>0.05$). The highest number of zooplankton taxa (6) was observed in station 1 while the highest number of zooplankton individuals (180) was observed in station 2. Stations 3 recorded the lowest zooplankton taxa of 4. Figure 5 shows the relationships between the diversity indices of macro-invertebrates sampled from Stubbs creek.

DISCUSSION

Nine zooplankton taxa comprising of 6 classes were identified in this study. This result is similar to 10 species of zooplankton by Yakubu *et al.*[14] from Nun River but <24 species reported by Zabbey *et al.*[15] from Imo River and the 66 species reported by Ekwu and Sikoki[7] in the lower Cross River estuary all in the Niger Delta. The difference in the number of zooplankton species in this study and other studies may be attributed to the natural conditions of water bodies and time of sampling. FAO[16] had earlier reported that distributions of zooplankton vary from place to place and year to year due to the dynamic nature of aquatic systems. Carney[17] also reported that most zooplankton migrate upward from deeper strata as darkness approaches and return to the deeper areas at dawn. Furthermore, Welcomme[18] and Wetzel[19] attributed zooplankton abundance to differences in flow, turbidity, dissolved oxygen concentration and conductivity.

Zooplankton species type, number and distribution in any particular aquatic habitat usually create clues on the prevailing physical and chemical conditions of that habitat[20]. Therefore, the interaction between various environmental variables can either favour the growth or mortality of zooplankton, both spatially and seasonally[21]. As reported by Abowei and Sikoki[22], zooplankton have been underlined as bio-indicators of aquatic environmental perturbation which might be because of their easy identification during their period of high density and high sensitivity to aquatic environmental change compared to other aquatic fauna. Also, the diversity, abundance and seasonality of different zooplankton groups in aquatic ecosystem affect different biotic components therein, making them have significant potential in assessing aquatic ecosystem health. In terms of composition, Calanoida copepod was the most dominant zooplankton taxa, followed by *Oikopleura*. The least abundant zooplankton were *Branchionus plicatilis*, Barnacle nauplius and Crustacean nauplius. The creek can be a good breeding ground for most fish fauna because of the dominance of copepods as claimed by Olomukoro and Oronsaye[23]. The dominance of copepods in this study in terms of abundance indicates pollution according to Ruivo[24] and is similar to reports by Onyema *et al.*[25], Davies[26], Raji and Saidu[27] and Ikhuoriah *et al.*[28] but in contrast to Adeyemi[29] and Abdul *et al.*[30], who reported the dominance of rotifer. The high population densities of rotifers have been attributed to their parthenogenetic reproductive pattern and short developmental rates under favourable conditions[31]. *Branchionus plicatus* was the only rotifer observed in this study. It is common in tropical waters[32]. Dirican *et al.*[33] reported the prevalence of rotifer species including *Brachionus* and *Keratella* as indicators of eutrophic condition in aquatic systems. Similarly, Rao and Durve[34] and Padmanabha and Belagali[35] confirmed that the occurrence of species like *Filinia longiseta*, *Brachionus forficula* and *Brachionus angularis* and high level of some ostracods and cladoceras species such as *Bosmina*, *Moina* and *Macrothrix* indicate high level organic pollution as a result of high organic matter deposit.

According to Ikomi and Anyanwu[36], the presence of a species will depend on its environmental tolerance but the resources available to it will determine its abundance. If competition or predation is reduced or the food supply or suitable habitat increased, the species will become more abundant. Margalef species diversity (d) ranged from 0.6266-1.012 across the stations with the highest at station 1 and lowest at station 3 while Shannon-Wiener index ranged from 1.242-1.748 with the highest at station 1 and lowest at station 3. Species Evenness (j) index was highest (0.9755) at station 1 and least in station 3 (0.8953). The higher diversity indices observed in station 1 compared to other stations showed the abundance of zooplankton in the region where Stubbs creek empties into Qua Iboe river. The diversity indices, including Shannon-Weiner Index (1.242-1.748) and Margalef species diversity (0.6266-1.012) reported in this study is lower than that reported by Varadharajan and Soundarapandian[37] (5.5201-5688, 5.176-5.567) for South East coast of India, Ikhuoriah *et al.*[28] (1.592-2.508, 1.496-3.196)for River Ossiomo, Nigeria and Abdul *et al.*[30] (2.954-3.108, 3.091-3.192) for a South-west estuary, Nigeria. However, Species Evenness Index (0.8953-0.9755) for the present study is higher than report of Ikhuoriah *et al.*[28] (0.5461-0.6916) and Abdul *et al.*[30] (0.731-0.829). According to Onyema *et al.*[25], the dominance of copepods may have accounted for the low Margalef species diversity ($\leq$1.012) and low Shannon-wiener index ($\leq$1.748) recorded during the study. Also the low species diversity values might be associated with environment under stress. It is agreed by pollution biologist that species diversity declines as pollution effects are more severe[26]. As suggested by Varadharajan and Soundarapandian[37], the diversity of zooplankton species in aquatic ecosystems is linked to its abundance.

CONCLUSION

A total of 9 species belonging to 6 taxonomic groups were recorded. The low zooplankton diversity observed in this study is common in tropical waters. The class Maxillopoda was

the most abundant in number and species. Maxillopoda made up 50% of the total zooplankton identified. Although there were differences in the abundance of the zooplankton class with seasons, they were not statistically different ($p>0.05$). Calanoida copepod was the most dominant (27.27%) zooplankton taxa. The dominance of copepods in this creek makes it a good breeding ground for most fish fauna and also may have accounted for the low Margalef species diversity ($\leq$1.012) and low Shannon-wiener index ($\leq$1.748) recorded during the study. It is agreed by pollution biologist that species diversity declines as pollution effects are more severe.

SIGNIFICANCE STATEMENT

The study shows variation in composition, abundance of the zooplankton encountered in Stubbs Creek, Nigeria. The study further confirmed that zooplankton organisms are unique indicators for pollution status and productivity of aquatic ecosystem. The occurrence of *Branchionus plicatilis* suggests the creek to be highly organically polluted as a result of high organic matter deposit. The prevalence of copepods from the present study places Stubbs creek as a favourable breeding ground for fish assemblages. Stubbs creek is environmentally stressed and this requires urgent monitoring of the activities on this creek to maintain a sustainable, productive and healthy ecosystem.

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