*African Scientist Vol. 23, No. 1 March 31, 2022*
Printed in Nigeria

1595-6881/2021 $10.00 + 0.00

http://www.niseb.org/afs

AFS2022005/23105

# Zooplankton Community of the Cross River Estuary in Association with Some Physical Environmental Factors

Obialor, Philomena Nkolika and Antai, Ekpo Eyo

Department of Biological Oceanography, Faculty of Oceanography, University of Calabar, Calabar, Nigeria.

*Corresponding author; Email: obialorphilomena@gmail.com Tel: +234 (0) 803 338 9385

(Received February 19, 2022; Accepted in revised form February 24, 2022)

**ABSTRACT:** The zooplankton community in association with some physical environmental factors was studied for six (6) months. A total of 5,303 individuals made up 17 species belonging to 3 families was recorded. Rotifers had the highest species composition of 41.06%, followed by Copepods and Ciliates with 29.41% and 23.53% respectively. There was no significant relationship in zooplankton composition across the stations and between seasons ($P<0.05$). Significant positive relationship occurred between the zooplankton abundance and temperature ($r = 0.619$), DO ($r = 0.572$), salinity ($r = 0.481$), Silicate ($r = 0.462$) and ammonium ($r = 0.475$). For a proper management of our water bodies, further studies on the relationships between the zooplankton community and the environmental factors should be promoted.

**Keywords**: Environmental Factors, Zooplankton, Relationships, Cross River estuary, Water quality

## Introduction

Zooplankton are categorized by size and developmental stages of which some change into fishes, worms, crustaceans and insects. Pteropods, chaetognaths, larvaceans, siphonophores and copepods remain plankton throughout their life cycle, copepods feed on phytoplankton as well as other zooplankton smaller in size (MarineBio Conservation Society, 2017). Zooplankton composition, distribution and abundance are affected by the interactions between several biological and environmental factors (Julies and kaholongo, 2013, Ahmed *et al.,* 2011, MarineBio Conservation Society, 2017). Larger zooplankton species occupy the cooler regions of the aquatic ecosystem (Sanae *et al.,* 2015) as their metabolic rates are controlled by temperature (Heinle, 1969). Nutrients like nitrogen and phosphorus affects algae, protozoa and bacteria which serve as prey of zooplankton, indirectly affecting zooplankton themselves (MarineBio Conservation Society, 2017).

Changes in physicochemical properties resulting from deterioration of water quality brings about changes in species composition and diversity of the zooplankton community (Essien-Ibok and Ekpo, 2015). Water salinity due to natural and anthropogenic processes decreases species diversity and abundance (Dai *et al.,* 2014). The zooplankton community serve as bio indicators of eutrophication as they respond faster to environmental changes (Akpan, 2015). Zooplankton abundance and species diversity can determine the health of an ecosystem. Eutrophication is indirectly caused by anthropogenic inputs as well as industrialization from where chemicals enter the aquatic ecosystem (Azma and Anis, 2016). Due to these various sources (Dai *et al.,* 2014) including natural inputs, urbanized estuaries are open to pollution (Akpan 2015).

The present study was ardent on identifying the zooplankton species in the Cross River system in order to evaluate the relationships between zooplankton abundance and some physical environmental factors.

## Materials and methods

The Cross River Estuary is eutrophic in nature and is characterized by extensive mangrove islands. It is located between latitude 4°30´N and 5°15´N and longitude 8°00´E and 8°30´E, with the Calabar River, the Great Kwa River and the Akpa Yafe as its major tributaries (Akpan, 2015) (Fig. 1). Mangrove systems are particularly rich in bacteria due to the high content of organic substrate of the area (Akpan, 2006) and serve as breeding nursery grounds for important fish and shellfish species (Holzlöhner *et al*., 2003). Nutrient cycles and food web of the mangrove communities are strongly influenced by the adjoining water bodies (Antai *et al*., 2012). The important ecological roles played by estuaries are due to the high productivity associated with their nutrient rich waters (Akpan, 2015).

According to Akpan *et al*. (2003), the Calabar city and the current developments associated with the Export Processing Zone (EPZ) of Nigeria presents a potential source of pollution as discharge of lubricating oils and other hydrocarbon into the river will increase.

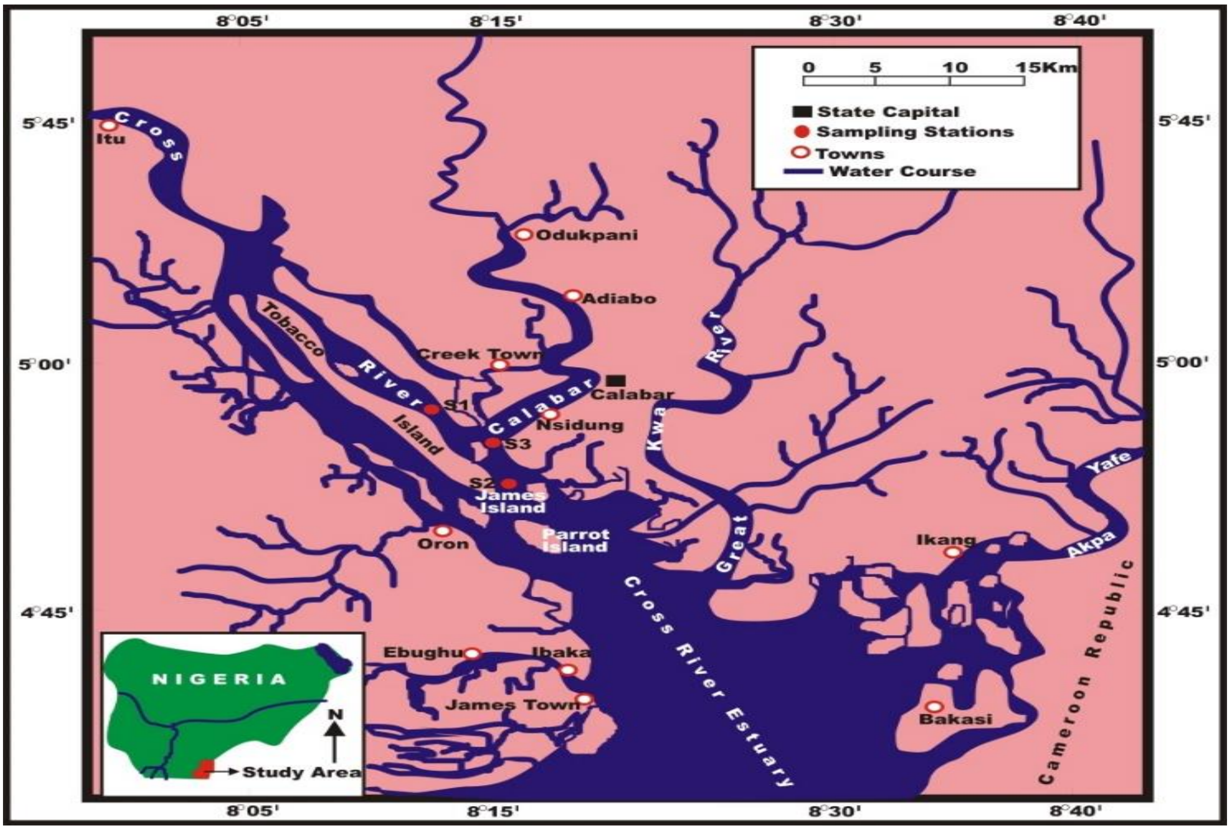


**Figure 1**: Map of Cross River estuary showing the sampling stations

Water samples for the analysis of physicochemical parameters were collected into one litre (1 L) sterile sampling bottles. For zooplankton samples, 20 L of water was filtered through a 55 µm plankton net, transferred into a 20 mL sterile container and fixed with 4% formalin. The samples were transported to the laboratory in an ice-cold chest for analysis.

Physicochemical parameters were analysed *in situ* (temperature °C) and *ex situ* (pH, DO (mg/L), salinity (ppm), nitrate (mg/L) and phosphate (mg/L)) during each sampling occasion.

Temperature was measured using a mercury-in-glass thermometer. pH was measured using a pH meter (Model PHS-3C). Dissolved oxygen (DO) was determined with the aid of a DO meter (Model JPB-607). For salinity, conductivity was measured using the conductivity meter (Model DDS-307) and the values were then converted to salinity using the formular:

$$Salinity = 0.65 \times Conductivity/1000$$

The Cadmium Reduction method was used to determine Nitrate concentration which was measured with a spectrophotometer at 540 nm.

The Molybdenum Blue method was used to measure for silicate and phosphate, the absorbance of the resultant colour was read with a spectrophotometer at 810 nm and 885 nm respectively. For Ammonium, the Direct Nesslerization method was and the extinction was measured spectrophotometrically at 425 nm.

A homogenate of the sample fixed with 4 % formalin was put in a 1 mL plankton counting chamber and allowed to settle after covering it with a glass slide. Examination and photomicrographs were done at different magnifications of 80, 100 and 200X using the X10 magnification lens. Identification was done using different taxonomic keys (Newell and Newell, 1959), Maochlan (1983) and Ward and Whipple (1959)).
Statistical analysis was done using Excel (2016). Significant relationships between seasons and stations were determined by ANOVA. Descriptive statistics provided the means and standard deviations of the physicochemical parameters while the significant correlations between zooplankton species and physicochemical parameters were determined by the correlation coefficients (r) using regression analysis.

## Results

A total of 5,303 individuals made up by 17 species of zooplankton belonging to 3 families was identified during this study and arranged in their order of species abundance (Table 1). The families were Rotifera represented by 8 species, Copepoda represented by 5 species and Cilliophora represented by 4 species. Copepods were the most abundant with 4,353 individuals constituting 82.09% of the total zooplankton population followed by Rotifers which was represented by 531 individuals with relative abundance of 10.01%. Cilliates were the least represented group with 419 individuals constituting only 7.90% of the total population. In terms of species composition, Rotifers were the highest having a species composition of 47.06%. Copepods had a species composition of 29.41% and was followed by ciliates with 23.53% species composition (Fig. 2). Temporal distribution of zooplankton in the study area shows that the highest abundance of zooplankton was recorded in the month of May with 2853 individuals, followed by June (1021), January (483), March (383), February (358) and April (206) being the least recorded abundance (Fig. 3).
The most dominant zooplankton species was *Copepod nauplii* (4262 individuals), followed by *Keratella tropica* (438 individuals) and *Tintinopsis sp.* (403 individuals). The least dominant species were *Vorticella sp.*, *Arcella discoides*, *Polyarthra encryptera* and *Bryocamptus birstenii* with 3 individuals each. They were followed by *Notholca acuminate* (2 individuals) then *Ectocyclops sp.* and *Thermcyclops sp.* each represented by a lone individual. Station 1 recorded the highest number of species with Rotifers topping the list.
The mean values for physicochemical parameters were recorded as follows, temperature ranged from 29 °C in June to 30.67 °C in March. pH was between 5.83 in January and 7.29 in April, DO ranged between 3.70 mg/l in May and 7.43 mg/l in January, Salinity ranged from 0.05ppm in June to 11.35 ppm in February. Nitrate was between 0.06 mg/l in May and 0.72 mg/l in June, Silicate was within the range of 1.41 mg/l in June and 4.85 mg/l in January. Mean concentrations for Ammonium was from 0.21 mg/l in May to 5.58 mg/l in March while Phosphates ranged between 0.01 mg/l in March and 2.02 mg/l in January (Table 3, Fig. 4).

**Table 1:** Spatial distribution of zooplankton species within the three sampled stations

| S/N | Family | Stations 1 | 2 | 3 | Total |
|---|---|---|---|---|---|
| | **ROTIFERA** | | | | |
| 1 | *Branchionus calyciflorus* | 1 | 0 | 48 | 49 |
| 2 | *Filinia opolemais* | 56 | 0 | 0 | 56 |
| 3 | *Hexarthra sp.* | 48 | 1 | 0 | 49 |
| 4 | *Keratella tropica* | 138 | 146 | 54 | 338 |
| 5 | *Lecane luna* | 0 | 0 | 29 | 29 |
| 6 | *Lepadella apsida* | 4 | 1 | 0 | 5 |
| 7 | *Notholca acuminate* | 2 | 0 | 0 | 2 |
| 8 | *Polyarthra encryptera* | 0 | 0 | 3 | 3 |
| | **COPEPODA** | | | | |
| 9 | *Bryocamptus birstenii* | 3 | 0 | 0 | 3 |
| 10 | *Copepod nauplii* | 927 | 758 | 2577 | 4262 |
| 11 | *Cyclops sp.* | 14 | 0 | 72 | 86 |
| 12 | *Ectocyclops sp.* | 0 | 1 | 0 | 1 |
| 13 | *Thermycyclops sp.* | 0 | 0 | 1 | 1 |
| | **CILLIOPHORA** | | | | |
| 14 | *Arcella discoides* | 2 | 0 | 1 | 3 |
| 15 | *Flavella Ehrenbergii* | 8 | 2 | 0 | 10 |
| 16 | *Tintinopsis sp.* | 341 | 60 | 2 | 403 |
| 17 | *Vorticella sp.* | 2 | 1 | 0 | 3 |
| | **Total** | 1546 | 970 | 2787 | 5303 |
| | **No. of species** | 13 | 8 | 9 | |
| | **Margalef's index (d)** | 1.6341 | 1.0178 | 1.0085 | |
| | **Simpson's index of diversity (D)** | 0.5818 | 0.3632 | 0.1436 | |

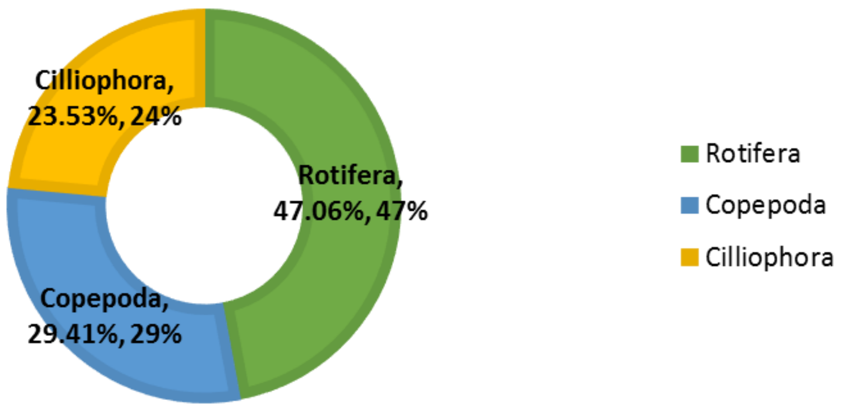


**Figure 2**: Species composition of zooplankton species identified

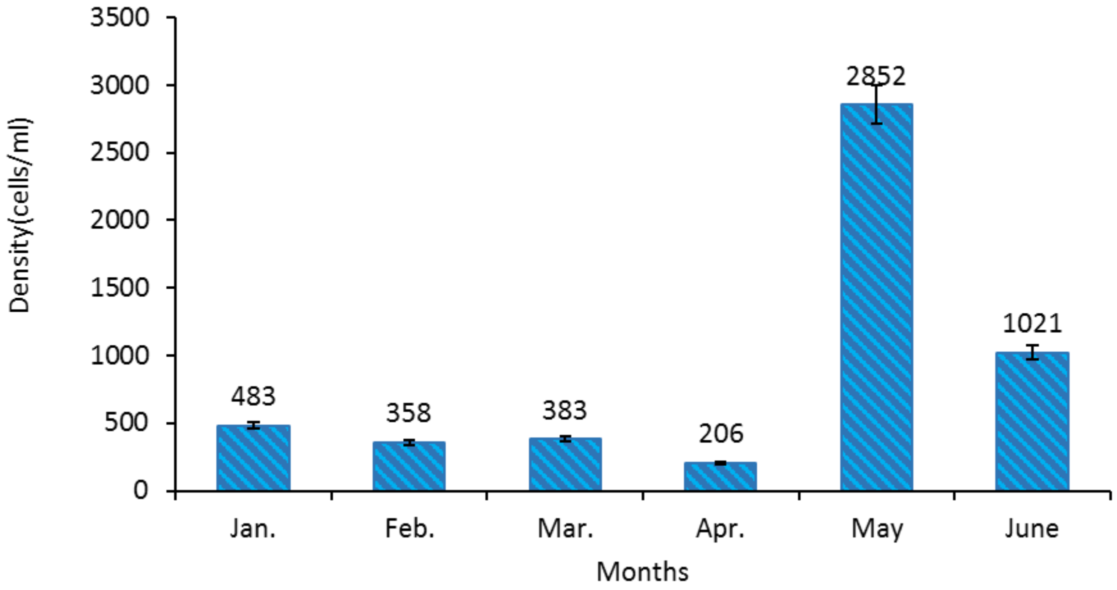


**Figure 3:** Temporal distribution of zooplankton in the study area

**Table 3:** Mean values of physicochemical parameters (January – June, 2017)

| Parameters | Months | | | | | |
|---|---|---|---|---|---|---|
| | **January** | **February** | **March** | **April** | **May** | **June** |
| Temperature (°C) | 30.33±0.59 | 31.17±1.04 | 30.67±0.58 | 30.00±1.00 | 29.33±0.58 | 29.00±0.00 |
| pH | 5.83±0.16 | 6.64±0.02 | 7.16±0.14 | 7.29±0.38 | 6.28±0.13 | 6.17±0.25 |
| DO (mg/l) | 7.43±0.80 | 5.13±0.85 | 5.33±0.85 | 4.67±0.31 | 3.70±0.56 | 5.13±0.35 |
| Salinity (ppm) | 3.19±0.70 | 11.35±0.46 | 7.75±0.38 | 3.87±0.45 | 1.89±1.58 | 0.05±0.01 |
| Nitrate (mg/l) | 0.14±0.04 | 0.11±0.11 | 0.44±0.33 | 0.37±0.02 | 0.06±0.08 | 0.72±0.07 |
| Silicate (mg/l) | 4.85±0.34 | 4.28±0.26 | 3.25±0.52 | 2.69±0.19 | 2.28±0.15 | 1.41±0.19 |
| Ammonium(mg/l) | 0.42±0.11 | 3.23±0.35 | 5.58±0.28 | 1.32±0.25 | 0.21±0.16 | 0.48±0.06 |
| Phosphate (mg/l) | 2.02±0.01 | 1.04±0.01 | 0.01±0.01 | 0.02±0.01 | 0.19±0.27 | 0.04±0.01 |

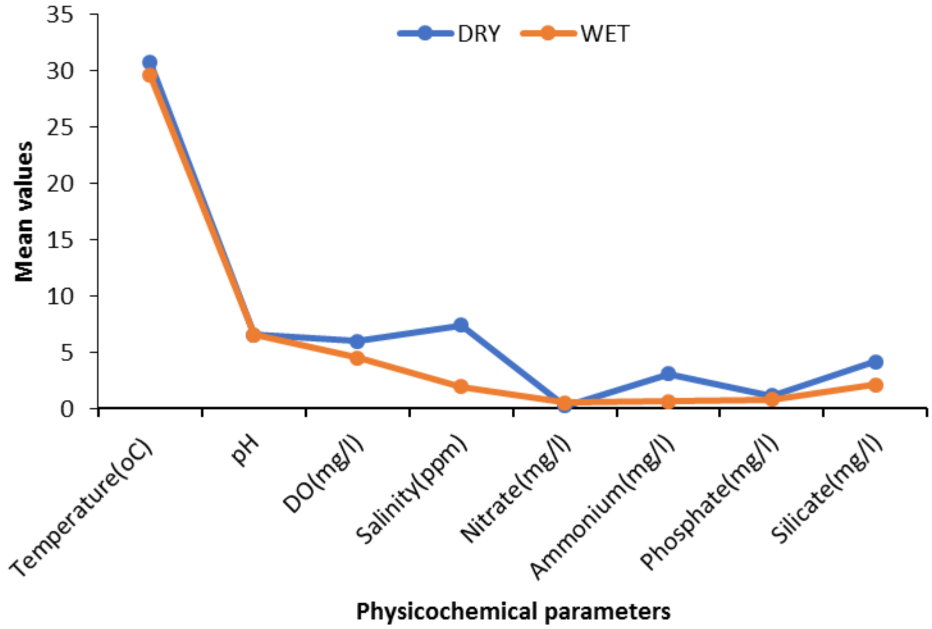


**Figure 4:** Mean values of physicochemical parameters during the two seasons

There was a positive correlation (P<0.05) between zooplankton abundance and temperature (r = 0.619), DO (r = 0.572), salinity (r = 0.481), Silicate (r = 0.462) and ammonium (r = 0.475).

## Discussion

From the results of this study, copepods were the most abundant family and this observation is similar to the reports of Eyo *et al.* (2013), Akpan (2015) and Ekwu and Sikoki (2005), followed by the Rotifera while the least was the Cilliophora and the most dominant zooplankton species (*Copepod nauplii*) belongs to this family. Copepod is an important group of zooplankton and are present in marine and freshwater bodies. Rotifers are known to prefer freshwater (Toruan, 2012), but most species such as *Branchionus* and *Keratella sp*. are salt tolerant species. There was a tremendous increase in zooplankton abundance during the rainy season (May). Increase in their numerical and species abundance during the rainy season might be due to dilution of the estuary by rainfall and the inflow of water from the connecting rivers.

Various physicochemical parameters of Nigerian waters have been studied by Akpan (1993) in Cross River Estuary and Akpan *et al.* (2003) in Calabar River. Zooplankton are highly responsive to nutrient levels, temperatures, pollution, food that are not nutritious, levels of light and increases in predation and nutrients like nitrogen and phosphorus affect algae, protozoa and bacteria which serve as prey to zooplankton, indirectly affecting zooplankton survival. Copepods are microzooplankton feeding on phytoplankton, detritus and occasionally on other zooplankton smaller in size, hence, their high abundance (MarineBio Society 2017). The present study recorded higher abundance of zooplankton individuals and species in the wet season than in the dry season. This observation is in contrast with the reports of Akpan (2015) and Ekwu and Sikoki (2005) where high abundance of zooplankton was recorded during the dry season. This might be due to high tide, increased rainfall and the sampling technic employed.

Zooplankton composition decreased with increased salinity during the sampled months and seasons which might have led to loss of sensitive species (Toruan, 2012). Therefore, the relationships between zooplankton community structure and environmental factors should be further studied to help understand the biodiversity of the Cross River system with proper management of our water bodies.

## Acknowledgements

The author acknowledges Prof. Paul Ajah of Fisheries and Aquaculture Department, Faculty of Oceanography, University of Calabar, Nigeria for zooplankton analysis and Mr. Ekene Iwuagwu of the Institute of Oceanography for the analysis of physicochemical parameters.

## References

Ahmed U, Parveen S, Khan AA, Kabir HA, Mola HRA, Ganai AH: Zooplankton population in relation to physico-chemical factors of a sewage fed pond of Aligarh (UP), India. Biol Med 3(2): 336 – 341, 2011.

Akpan E R: Nutrient–phytoplankton relationship in the Cross River Estuary. J Chem Soc Niger 31(1&2): 102 - 108, 2006.

Akpan ER: Seasonality of Plankton in the Cross River estuary, South Eastern Nigeria. Afr J Environ Pollut Health 11: 57 – 71, 2015.

Akpan ER, Ekpo EH, Ekpe UJ: Seasonal variation in water quality of the Calabar River: Effects of tidal and coastal activities. Glob J Environ Sci 2(2): 106 – 110, 2003.

Antai EE, Ewa-Oboho I, Asitok AD: Rates of phytoplankton production, biomass and bacterial production in the Gulf of Guinea, Southeast Nigeria. J Appl Sci Environ Sanit 7(1): 65 – 74, 2012.

Azma HI, Anis AMA: Zooplankton composition and abundance as indicators of eutrophication in two small man-made lakes. Trop Life Sci Res 27(1): 31 – 38, 2016.

Dai L, Gong Y, Li X, Feng W, Yu Y: Influence of environmental factors on zooplankton assemblages in Boston Lake, a large oligosaline lake in arid northwestern China. Sci Asia 40: 1 - 10, 2014.

Ekwu AO, Sikoki FD: Phytoplankton diversity in the Cross River Estuary of Nigeria. J Appl Sci Environ Manage 10(1): 89 - 95, 2006.

Essien-Ibok MA, Ekpo IE: Assessing the impact of precipitation on zooplankton community structure of a tropical river, Niger Delta, Nigeria. Merit Res J 3(2): 31 – 38, 2015.

Eyo VO, Andem AB. Ekpo PB: Ecology and diversity of zooplankton in the Great Kwa River, Cross River State, Nigeria. Int J Sci Res 2(1): 67 - 71, 2013.

Heinle DR: Temperature and zooplankton: Chesapeake Science 10(3/4): 186 - 209, 1969. doi.org/10.2307/1350456.

Holzlöhner S, Nwosu FM, Akpan ER: Mangrove mapping in the Cross River Estuary, Nigeria. Afr J Environ Pollut Health 1(2): 67 - 79, 2003.

Julies EM, Kaholongo IK: Relationship between dissolved oxygen and the vertical and longitudinal distribution of zooplankton off the Namibian Coast. Int Sci Technol J Namib 1(1): 12, 2013.

Maochlan H: Illustrations of freshwater plankton (1983). Cited by Obialor, P.N., Mowang, D.A., Ekpo, E.A. and Ayim, M.E., Influence of high tide on zooplankton population, J Innovat Res Life Sci, 1(2): 33-39. 2019.

MarineBio Conservation Society: Zooplankton (2017). Cited by Obialor P.N. and Ayim, E. M. Glob Sci J, 9(7): 999-1011, 2021.

Newell GE, Newell RC: *A Practical Guide*. 5th Edition. Hutchinson Educational, London. 220p. 1977.

Sanae C, Sonia DB, Tomoko, Y, Yuka S, Kosei S, Hiroya S, Tadafumi I: Temperature and zooplankton size structure: Climate control and basin-scale comparison in the North Pacific. Ecol Evol 5(4): 968 - 978, 2015.

Toruan RL: Zooplankton community emerging from fresh and saline wetlands. Ecohydrobiol Hydrobiol 12(1): 53 - 63, 2012.

Ward HB, Whipple GC: Freshwater Biology. Ed. W.T. Edmondson. 2nd Ed. John Wiley & Sons Inc., New York. 1248p. 1959.