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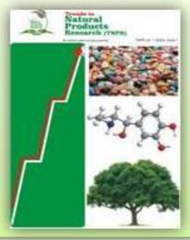

Thermal Effects on Zooplankton Diversity and Distribution of River Rima, Sokoto Nigeria

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Keywords: Dynamics, Physicochemical, Rima, Zooplankton

Abstract: Temperature is one of those physicochemical parameters that affect zooplankton dynamics, including their distribution and abundance. Changes in temperature in aquatic ecosystems usually affect the metabolic reactions in their body. Though, their distributions signify status of such water body. This study was carried out to evaluate the effects of temperature on zooplankton distribution of River Rima. Zooplankton samples were collected from three sampling points designed for the study. Samples of both zooplankton and water were collected in the morning and afternoon. Standard methods were used during the sample collection. Zooplankton samples were identified using standard identification keys and water physicochemical parameters were measured *insitu* and others in the laboratory. Results revealed that four groups of zooplankton were available in River Rima, represented by 25 species. The two dominant groups were; Cladocera (72 %) and Crustacera (16 %). Results also indicated a low distribution of zooplankton at temperature =31.6 ^{0}C and the least temperature recorded was of 29.8 ^{0}C, which has more distribution of these zooplanktons. Therefore, to study these zooplankton species, a low daytime temperature should be targeted.

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DOI: 10.48245/tnpr-2734391.2021.2.210
Page No.: 90-97
Volume: 2, Issue 2, 2021
Trends in Natural Products Research
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INTRODUCTION

Zooplanktons are microscopic organisms that are suspended in water; they include many kinds of protozoans, micro-crustaceans and other micro invertebrates that are planktonic in water bodies (Omudu and Odeh, 2006). They may serve as indicator of water quality. Zooplanktons are heterotrophic planktonic animals floating in water which constitute an important food source for many species of aquatic organisms (Guy, 1992). Cyclopoida, Ostracoda, and Cladocera are very important in the food chain of freshwater fish (Egborge, 1981). Their characteristics, coupled with high sensitivity to changes in environmental factors have drawn the attention of several hydrobiologists worldwide, who had investigated their occurrence composition, distribution and their significant roles in the study of aquatic pollution (Egborge, 1981). Zooplankton studies are of necessity in fisheries, aquaculture and paleolimnological research as they have been known to leave an impression record of geological past (Stout, 1974; Aoyagui and Bonecker, 2004). They are globally recognized as pollution indicator organisms in the aquatic environment (Rutherford *et al*., 1999; Yakubu *et al*., 2000; Abowei and Sikoki, 2005).

Most species in the zooplanktons community fall into three major groups; *Crustacea*, *Rotifers*, and *Protozoans*. *Crustaceans* are generally the most abundant, especially those in the order *Cladocera* (water fleas), and the class *copepoda* (the *copepods*), particularly the orders *Calanoida* and *Cyclopoida*. *Cladocerans* are typically most abundant in freshwater, with common genera including *Daphnia* and *Bosmina* (Omudu and Odeh, 2006). Commonly observed genera of marine calanoid include *Calanus*, *Pseudocalanus*, and *Diaptomus,* while abundant cyclopoid copepods include *Cyclops* and *Mesocyclops* (Carter *et al.,* 1986). Other crustaceans among zooplankton include species of *opossum shrimps* (order Mysidacea), amphipods (order Amphipoda), and fairly shrimp (order Anostraca). Rotifers (phylum Rotifera) are also among the protozoans belonging to Kingdom Protista (Fredrich *et al*. 1996).

Thermal is the transfer of heat from one stage to another. Thermal energy is the energy that comes from heat. This heat is generated by the movement of organic particles within the water bodies. Thermal effects have serious threats on the life of living organisms in water (Anon, 2017).

Temperature can also have a greater influence on the migration and movement of zooplankton. Consequently, temperature affects the overall development of zooplankton (Alain, 2009).

Light and temperature, of course affects zooplankton productivity, which in turn, exert its effects on the development of zooplankton population (Green, 1994).

Generally, there is a wide range of temperature within which zooplankton survives. The effects are of vital to be accelerated by warm temperature and decelerated by cold ones. Though sudden changes or temperature extremes are lethal, elevated sub lethal temperature may include hibernation. Temperature can also determine the success of species of zooplankton as well as its distribution within water body (Alain, 2009).

Temperature affects enzyme's function, which affect how living things carryout everyday metabolic processes, such as synthesis of protein and other chemical reactions. At low temperature, enzyme's function is lower, but it is still working, but at higher temperature, the enzymes bonds are destroyed and the enzymes are denatured, so it cannot carry out its function of catalysing reaction anymore (Michael, 1999).

All metabolic rates of zooplanktons are dependent on temperature. Temperature affects both the physiology and ecology of zooplanktons. The physiological effects include mortality at high or low temperature, which is the most drastic physiological effect. Temperature facilitates enzymatic reaction which causes cell respiration, which produces ATP.

MATERIALS AND METHODS

Study Area

River Rima is located in the North- western region of Sokoto State Nigeria, the area is located between Longitude 4°E and 6° 54'E and Latitude 12° 0' and 13° 54'N (Mamman, 2000*)*. Rainy season is usually between May/June to early October/November (Umar and Ipinjolu, 2001). River Rima is the most important perennial river network in Sokoto (Figure 1). It's one of the major tributaries of River Bunsuru and Gangare. The river takes it course from Katsina State flows through Zamfara State and in Sokoto State joins River Sokoto before flowing to River Niger in Kebbi State (Ita, 1993).

Figure 1. Map of River Rima (Kwalkwalawa) source: Google earth map

Sample Collection

Water samples was collected in one litre capacity plastic bottles between 7:00am to 9:00 am, from all the sampling locations for the period of 3 Months (April to July 2017), The three different stations on the river namely: site A, B and C. Each sample collected was analysed for physicochemical variables. Temperature, depth and transparency were determined *in situ.*
The zooplanktons were collected from the three different stations with standard plankton net (25µm mesh size) which was transferred to 1 litre capacity plastic bottles with 10% formalin for preservation before transporting it to parasitology laboratory for zooplankton identification.

Determination of physicochemical variables

Transparency of water samples was determined using Secchi disc of 25cm by disappearance and reappearance method. The transparency was computed according to UNEP (2004). Temperature was determined with a mercury thermometer, and depth was measured accordingly (Panday *et al*., 2005). The pH was determined using JENWAY pH meter 3015 model at 25^0C. Flame photometer was used to determine sodium and potassium (UNEP, 2004). Ethylene diamine tetra-acetate acid (EDTA) method will be used to determine calcium and magnesium (UNEP, 2004). Other physicochemical variables such as biological oxygen demand (BOD), phosphorus, calcium, nitrogen and total dissolved oxygen were measured according to United Nations Environment Programme (2004).

Identification of zooplankton

The zooplanktons were identified to species level and each was compared with zooplankton identification chart. One ml of the sample taken on the slide with a dropper and observed under the microscope. Identification chart of freshwater zooplankton (Altaff *et al*., 2004). The following are the specific volumes for identification of different groups of zooplankton Rotifers (Dhanapathi, 2003). Copepods (Reddy and Dussart, 1994), the species name was counted and recorded. The data were subjected to analysis of variance (ANOVA).

Determination of Physical Parameters

Transparency

A Secchi disc of 25cm diameter was used to determine the transparency, by lowering it into the water until it disappears from view, the measurement of which was recorded as P_1. The Secchi disc was pulled out and the depth of reappearance was measured and recorded as P_2. The transparency was computed using the following formula:
Transparency= $P_1+P_{2/2}$ which was recorded in centimetre (UNEP, 2004)

Temperature

Water temperature was determined with a mercury thermometer, calibrated to the nearest 1 ºC. The temperature was taken by lowering the thermometer into the surface water for two minutes to allow equilibrium before recording. After which the reading was taken and recorded in degree Celsius (Panday *et al*., 2005).

Depth

Depth of each station was determined with mushroom string or Secchi disc. In this method, the depth of each station was measured by dipping the spring until it settles down. The measurement was taken using a measuring tape or ruler and recorded in metres (Panday *et al*., 2005).

Determination of water chemical parameters

Water chemical parameters such as biological oxygen demand (BOD), Dissolved oxygen (DO), Electrical conductivity (EC), pH, Nitrate (NO_3^-)**,** Phosphates (PO_4^{-3}), Magnesium and sodium were determined using standard methods and procedure.

Statistical analysis

Prevalence (%), mean intensity and mean abundance were calculated according to Magami *et al.* (2014) and (Yakubu and Shelika, 2005). Analysis of Variance (ANOVA) at 95% significance level was used to compared the mean intensity and mean abundance of different groups of zooplankton species. The data obtained from three field and laboratory were statistically analysed using Mintab statistical packaged. Two-way Analysis of Variance (ANOVA) was conducted at 5 % probability.

RESULTS

Diversity and distribution of zooplankton

In the present study a total of 25 species of fresh water zooplankton were identified. The study revealed the presence of 18 species of cladocerans, 4 species of crustacean, 1 species of nematodes and 2 species. These results indicate that temperature recorded from morning, afternoon and evening sampling station C station has the highest mean temperature of 32.3 ^oC while station A has the lowest temperature recorded with 28.6 ^0C. Cladocera appears to have the highest abundance of zooplanktons species identified, the second largest group was crustacean, the third group is annelida and the fourth or lowest group is nematode.

In all the collections of the morning, afternoon and evening sampling twenty-five (25) species were identified which include *Hesperocorixacastanea, Synpetrumflaveolum, Dytiscuslatissimus, Anopheles gambiae, Sialislutaria, Dolpilodesdistinctus, Ischnuraheterostica,Hygrobatidae, Acroneuriainternata, Daphina magna, Baetisniger,Isopteratermopsida, Bosminialongirostris,Narpusconcolor, Sternoceraaequisignata,Pternonarcyidae, Acroneurialycorias,Limnorialignorum, Misophrioida, Palaemonhastatus, Secernentea, Hirudo medicinalis* and *lumbriculidae.*Cladocereans were the most abundant followed by crustaceans and then the lowest species were the annelids.

Table 1. Temperature (^0C) recorded in month of May- July, 2017.

Month	Station A	Mean	Station B	Mean	Station C	Mean
May	30,33,31	31.33	28, 35, 31	31.33	32, 33, 31	32.33
June	28, 30, 32	30	29, 32, 31	30.6	30, 33, 31	31.66
July	27, 29, 30	28.66	29, 30, 31	30	30, 31, 31	31

The temperature varied slightly from May 31.5^0C and June 30.8^0C with July recording the least temperature of 29.8^0C (Table 1). The results also showed temperature similarity in the month of May and June and a decrease in July. In terms of temperature variability in the morning, afternoon and evening samples, there was no significance difference between the sampling unit (A, B and C).

Table 2. Morphometric and physical variables of River Rima from May-July, 2017.

Variables	Station A	Station B	Station C
Latitude	13^{0}06'15N	13^{0}06'14N	13^{0}06'14"N
Longitude	5'12'26^{0}E	5'12'22"E	5'12'21"E
Depth	13.5	14	12
Temperature	32.33	31.6	31
Mean depth	4.3	3.9	3.4

The temperature of River Rima varied monthly as the weather changes according to season. The least temperature obtained was 31^0C in July, and the maximum recorded was 32.3^0C at Station C. The temperature revealed monthly fluctuations with rapid increase from Station A to B while decrease in temperature was observed in station C (Table 2). Depth of the river increases as water volume increases.

Table 3. Variation in the chemical parameters of water samples from the month of May – June in River Rima.

Parameters	May	June	July
pH	8.36$\pm$0.05	8.23$\pm$0.05	7.88$\pm$0.06
BOD (mg/l)	15.60$\pm$4.23	22.97$\pm$7.30	3.4$\pm$1.78
DO (mg/l)	15.60$\pm$4.23	11.14$\pm$9.73	16.23$\pm$2.94
Nitrate (mg/l)	1.07$\pm$0.12	1.4$\pm$0.35	1.47$\pm$0.76
Ammonia(mg/l)	0.73$\pm$0.12	1.07$\pm$0.23	1.07$\pm$0.23
Phosphate(mg/l)	0.26$\pm$ 0.12	0.34$\pm$0.07	0.43$\pm$0.27
Phosphorus(mg/l)	11.33$\pm$1.15	2.53$\pm$0.38	2.53$\pm$0.38
Potassium (mg/l)	1.13$\pm$0.12	0.87$\pm$0.12	0.3$\pm$0.1
Sodium (mg/l)	0.47$\pm$0.12	0.43$\pm$0.06	0.3$\pm$0

The range of pH was 7.88-8.234, July has 7.8 and the highest 8.3 which was obtain in May. BOD level increase in June and decrease drastically in July while DO experience slight variation in the month of May and July and decreases in June. Ammonia, phosphate and Ammonia concentration fluctuated (Table 3).

Table 4. Zooplankton species identified and their relative abundance in River Rima.

SPECIES	MAY Cells/l	JUNE Cells/l	JULY Cells/l	Abundance %
Cladocerans				
Hesperocorixa castanea	9	7	6	8.30
Sympetrum flaveolum	4	2	3	3.39
Dytiscus latissimus	7	2	1	3.77
Anopheles gambiae	40	6	3	18.49
Sialis lutaria	7			2.64
Dolopilodes distinctus	8	1		3.39
Ischnura heterosticta	2	1	3	2.26
Hygro batidae	1	2	1	1.51
Acroneuria internata	12	3		5.66
Daphina magna	4			1.51
Baetis niger	6	2	4	4.53
Isoptera termopsida	1	5	3	3.39
Notholea			1	0.38
Bosminia longirostris		2		0.75
Narpus concolor		2		0.75
Sternocera *aequisignata*	4		2	2.26
Pternonarcyidae			2	0.75
Acroneuria lycorias		2		0.75
Crustaceans				
Limnoria lignorum	11	1		4.15
Misophrioida	15	1		6.04
Hyperia macrocephala			2	0.75
Palaemon hastatus		2	3	1.88
Nematodes				
Secernentea	22	23	4	18.49
Annelida				
Hirudo medicinalis		2		0.75
Lumbriculidae		1		0.38
TOTAL	**153**	**78**	**34**	

May had the most abundant species of 153 (55.61%) followed by June which had 88 (32%) species and July had 34 species (12.36%) (Table 4)

Figure 2 ***Acroneuria internata***

Figure 3 ***Isoptera termopsidae***

Figure 4 ***Secernentea***

DISCUSSION

The present findings are similar to that of Magami, *et al.,* (2014) who obtained minimum of 6.4 and maximum of 8.1 while assessing physicochemical flux and phytoplankton diversity in shagari reservoirs. Hence, the recorded pH values are suitable for aquatic animals such as fish. The monthly variations of these elements were as results of significant seasonal and spatial variation in the weather and other human activities near the river such as irrigation, other farming activities.
The results of this study are similarity to that obtain by Hashemzadeh and Venkataramana -(2012) which reported rotifers. More so, the results contradict that of Yakubu (2005) and shows where they indicate that rotifers had the highest abundance of 47.5 % followed by the second largest group which was found to be crustaceans (32.6 %). The last group was found to be mollusk with (18.9 %).
However, there is a little difference between the result obtained during this research work and that of (Hashemzadeh and Venkataramana, 2012), this may be as a result of environmental factors, changes within the river like the temperature, turbidity, salinity and availability of food as well as time variation of the research work. Another important factor that may bring a little difference was the water movements (water currents). This is because some species of zooplanktons lack attachment devices while others such as the larvae form of certain insects e.g *Simulium spp* attachment device which they use in attaching themselves to certain substratum (Needham, 1985).
Turbidity caused by the effects of agriculture run-off or other forms of erosion can severely affects the zooplankton productivity. It can interfere with photosynthesis inhibiting algae food production and resulting in elimination of certain filer feeders, such as cladocera and copepods (Whitton, 1995). Zooplanktons are affected by a variety of factors; these factors may affect them either directly or indirectly. Phytoplankton may also affect the distribution of zooplankton in aquatic ecosystem. This may in turn affect the distribution of other organisms in the aquatic ecosystem, e.g., fish and other aquatic organisms, which are in turn consumed by human as important amino acid and protein. Therefore, industrial wastes and all other form of chemical are harmful to the life of zooplanktons and must be kept at minimum, this is because zooplankton are contributing from one trophic level to another (food chain), (Yakubu and Shelika,2005). Another important factor that may bring a little difference between the recent research and previous ones conducted by Yakubu and Shelika shows unequal distribution of food which may promote the chance of having more species from one time to another.

CONCLUSION

The knowledge of plankton species composition and distribution to time and space are of great value especially in running water system. The present study reveals some aspect of zooplanktonic dynamic to explain their relation with the physicochemical parameters of river water and industrial area of Rima. Fluctuation of abiotic factors i.e., concentration of dissolved oxygen, temperature, total alkalinity, total nitrogen, phosphate and pH can influence the growth of zooplankton. The study shows that zooplankton species survive in neutral condition.

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CITATION: Tambuwal AA, Umar AR, Tambuwal AA, Ahmad MB, Hassan, S, Usman A, Lubabatu, JM and Garba S. (2021). Thermal Effects on Zooplankton Diversity and Distribution of River Rima, Sokoto Nigeria. Trend Nat Prod Res 2(2). 90-97. DOI: 10.48245/tnpr-2734391.2021.2.210