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Influence of Water Quality on the Abundance of Freshwater Mollusc in Biase, Cross River State, South-Eastern Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author JAP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors UAU and ARO managed the analyses of the study. Author UIP managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study on the distribution, diversity and abundance of freshwater mollusc in Biase Local Government Area was carried-out over a period of 3 months; July – September 2017. Mollusc were collected using a mesh scoop method, then put in a well labelled plastic container and preserved appropriately, before they were sorted and identified to species level in the laboratory using the freshwater mollusc identification guide. A total of 652 individuals of freshwater mollusc belonging to Ampullariidae, Thiaridae and Margaritiferidae families were observed through-out the study. Four species of fresh water mollusc were observed namely; *Lanistes ovum*, *Lanistes libycus*, *Melanoides tuberculata* and *Margaritifera margaritifera*. Ampullariidae family was the most abundant (475 individuals), while the Thiaridae family was the least abundant (27 individuals).

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Lanistes libycus was the most abundant species (290 individuals). The abundance of fresh water mollusc varied across sampling stations. The Shannon Weinner, equitability and Margalef index were generally lower than 1 and varied across all the sampling stations. The pH, temperature and dissolved oxygen varied insignificantly across the 4 sampling stations at p>0.05. There is a need for Government to enforce policies and laws against careless discharge of energies and waste into the study area and over-exploitation of these resources, so as to restore the ecosystem back to its normal quality, as well as prevent possible extinction of these resources. More of similar research should also be carried out regularly, so as to monitor any possible improvement in terms of species abundance and water quality.

Keywords: Water quality; abundance; freshwater; mollusc and biase.

1. INTRODUCTION

Molluscs are soft-bodied invertebrates that show a wide diversity of form on a basic body plan. They are coelomate with a head, ventral muscular foot, dorsal visceral hump mass and mattle over the visceral hump which often secrets calcareous shell [1]. Molluscs have been and still are an important food source for anatomically modern humans. However, there is a risk of food poisoning from toxins which can accumulate in certain molluscs under specific conditions. About 80% of all known molluscs species are gastropods (snails and slugs), 14% Bivalvia and other 5 classes less than 2% [2]. In healthy functional river systems, freshwater mollusc alone number in millions (in terms of numbers of individuals) and serve as an important food source for other animals [3].

Molluscs are second only to arthropods in numbers of living animal species. Freshwater provides a thread of life and resources across the planet. It has been described as the spark of life that has allowed evolution and speciation to flourish over millennial, through geographically isolated and protected freshwater ecosystems [4]. However, there is a more urgent concern to develop baseline information about the current patterns of diversity and distribution of freshwater snails. This information forms the basis on which to assess how freshwater ecosystems are being directly changed over time by human activities, for example by habitat modification, impacts of pesticides on species physiology and community structures [5,6,7].

Despite the fact that freshwater snails play an important role in freshwater ecosystem some are an intermediate host of diseases to humans and animals [8]. Many freshwater mollusc is sensitive to water quality or flow and is therefore good bio-indicators of the environmental conditions of aquatic system [9]. Mollusc habitat include all types of freshwater bodies, ranging from small temporary ponds, streams to large lakes and rivers. Within each habitat, mollusc distribution may not be the same and detection requires examination of different sites, moreover, snail densities vary significantly with the seasons [5].

Freshwater mollusc contributes to nutrient exchange and help maintain good water quality by controlling algal blooms and cleaning substrates for other benthic invertebrates [10]. Ecological investigation of freshwater mollusc have shown that the population dynamics and ecology of these animals depend on various factors such as the physical geography of a given area, land contours, soil composition, type of bottom, soil sediment, climate change, anthropogenic activities and physico-chemical parameters such as temperature, PH and dissolved oxygen [11]. They react strongly to environmental changes, this makes them suitable for studies on their relationship with the environment [12]. The study was aimed at investigating the diversity and distribution of freshwater molluscs in Abini and Biakpan communities of Biase, South-east Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Biakpan and Abini villages of Biase local government area. Biakpan and Abini villages in Biase local government area are located in the Southern senatorial district of Cross River State, Nigeria. Its geographical coordinate are 5^{o} 35’ North, 7^{o} 56’ East and its headquarters is Akpet Central (Fig. 1). Biase local government area has high mangrove system and has a very large attachment area of swamp ecology. They also have Red mangrove (Rhizophora) and white mangrove (Avicenia).

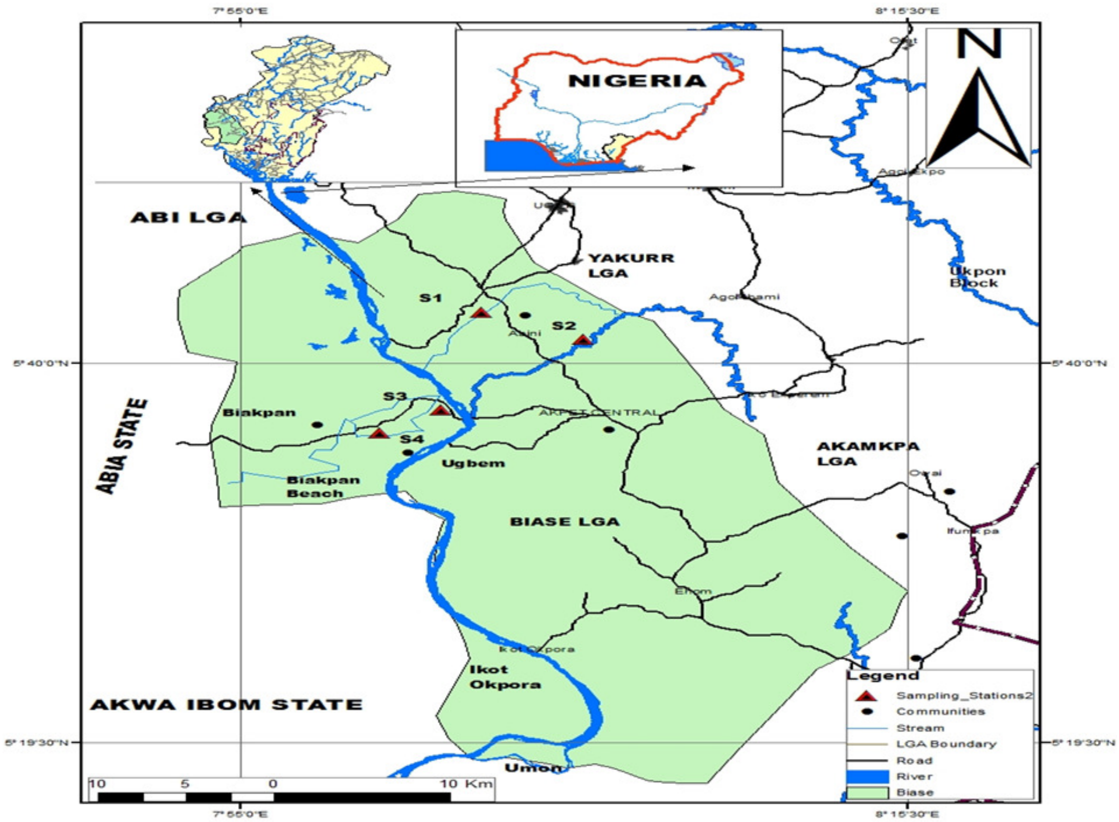

Fig. 1. Map of Cross River State showing the study area
Source: Adapted from Nigeria shapefile, 2006 and google earth pro, 2015

Rainfall of about 350 mm occurs along the coastal area, 120 mm to 200 mm rainfall annually, with maximum precipitation occurring from July-September. Ambient temperature changes throughout the year (22.4-33.2^{o}C) and relative humidity is high (60-93%) [13]. The common activities of the people are farming, fishing and cutting of firewood [13].

2.2 Collection of Mollusc Samples

Sampling was carried out in 4 different water bodies; 2 from Biakpan (Ubura River and Abibia stream) and 2 from Abini (Uzin Uwabutu stream and Edunak stream) areas of Biase. Mollusc samples were collected from each of the site once every month for 3 months; July – September, 2017 with the help of the fishermen using a scoop net with long handle. Samples were collected within a 5m^2 area and 10 meters along the water body per station for 30 minutes. The ones on the macrophyte was handpicked with hand gloves [14]. All snails collected were put in a well labelled container with perforated lids and taken to the laboratory for identification based on shell morphology using [15] identification guide.

2.3 Physico-chemical Parameters of Water

2.3.1 Surface water temperature

At each sampling station, surface water temperature was measurred in-situ using a mercury-in-glass thermometer. The probe was inserted at a depth of about 2 cm from surface for 3 minutes and the reading taken in degrees Celsius (℃).

2.3.2 pH

The pH was measured in-situ using an electronic pocket pH meter, Metrohm Herisau E 520 model. The glass probe of the meter was dipped into the water at about 2 cm depth and the pH read accordingly.

2.3.3 Dissolved oxygen (DO)

Dissolved oxygen was measured in-situ using a Dissolved Oxygen meter. The probe of the meter was inserted at about 2 cm from the surface of the water for about 3 minutes and the dissolved oxygen read accordingly to the nearest milligram per litre (mg/L).

2.3.4 Determination of numerical abundance

Mollusc species were identified, sorted and counted individually. The sum of each species from each sampling station over the 3 sampling months were added together in order to determine the total abundance of each species for each station.

2.3.5 Determination of relative abundance (%)

The Relative abundance (%) of freshwater mollusc species from Biase was calculated as follows:

% RA = n (100)/N

Where; n = the total number of individuals for each freshwater mollusc species.
N = the total number of individuals in the entire freshwater mollusc.

2.3.6 Ecological diversity indices

Margalef's index (d): is a measure of species richness [16] and expressed as:

$$d = \frac{S-1}{In\ (N)}$$

Where:

S = number of species in samples.
N = total number of individuals in the sample
In is the natural logarithm

Shannon and Weiner's index (H): is a measure of species abundance and evenness. It was calculated according to [17] as follows:

$$H = \sum \frac{Ni}{N} \log_2 \frac{Ni}{N}$$

Where;

N = total number of individual in the sample
Ni = total number of individuals of species in the sample

2.4 Statistical Analysis

Data obtained was subjected to descriptive statistics for mean, standard deviation and range values of water physico-chemical parameters. Analysis of variance (ANOVA) was used to test for the significance of difference in the physico-chemical parameters of water between the 4 sampling stations using predictive Analytics Software (PASW version 20). All analysis were carried-out at 0.05 level of significance and at their relevant degree of freedom. Also, co-relation analysis was carried out so as to evaluate the relationship between water quality and freshwater mollusc abundance. All graphs and charts were plotted with Microsoft Excel (version 2013).

3. RESULTS

3.1 Abundance and Distribution of Fresh Water Mollusc

The summary of the composition and distribution of fresh water mollusc families and species from Biase Local Government Area is shown in Table 1. A total of 652 individuals of fresh water mollusc belonging to Ampullariidae, Thiaridae and Margaritiferidae families were observed through-out the study in Biase Local Government Area.

Through-out the study, 4 species of fresh water mollusc were observed namely; *Lanistes ovum*, *Lanistes libycus, Malanoides tuberculata* and *Maragaritifera margaritifera*, Family Ampullariidae was represented by *Lanistes ovum and Lanistes libycus*, Thiaridae family was represented by *Malanoides tuberculata,* while family Margaritiferidae was represented by *Maragaritifera margaritifera*. Two classes of fresh water mollusc were observed through-out the study namely: Gastropoda and Bivalvia. Gastropoda was represented by *Lanistes ovum*, *Lanistes libycus* and *Malanoides tuberculata*, while Bivalvia was represented by *Maragaritifera margaritifera* (Table 1).

In terms of abundance and distribution, Ampullariidae family was the most abundant, having a total numerical abundance and relative abundance of 475 and 73.0% individuals

Table 1. Distribution and composition of fresh water Mollusc in Biase Local Government Area

S/N	Fresh water Mollusc	S1	%Ro	S2	%Ro	S3	%Ro	S4	%Ro	Total	%Ro
	Gastropoda										
	Ampullariidae										
1.	*Lanistes ovum*	91	33.45	14	8.28	25	21.36	55	58.51	185	28.37
2.	*Lanistes libycus*	27	9.92	148	87.57	90	76.92	25	26.59	290	44.47
		118	**43.37**	**162**	**95.80**	**115**	**98.28**	**80**	**85.10**	**475**	**73.00**
	Thiaridae										
3.	*Melanoides tuberculata*	9	3.30	2	1.18	2	1.70	14	14.89	27	4.00
		9	**3.30**	**2**	**1.18**	**2**	**1.70**	**14**	**14.89**	**27**	**4.14**
	Bivalvia										
	Margaritiferidae										
4.	*Margaritifera margaritifera*	145	53.30	5	2.95	-	-	-	-	150	23.00
		145	**53.30**	**5**	**2.95**	**-**	**-**	**-**	**-**	**-**	**-**
	Number of species	**4**		**4**		**3**		**3**			
	Total number of Individuals	**272**	**99.9**	**169**	**99.9**	**117**	**99.9**	**94**	**99.9**	**652**	**99.9**
	Shannon Weinner Index	**1.044**		**0.479**		**0.601**		**0.949**			
	Margalef Index	**0.535**		**0.584**		**0.420**		**0.440**			

Where: S1 = Ubura River; S2 = Abibia Stream; S3 = Uzin Uwabutu Stream; S4 = Edunak Stream
%Ro = Relative Abundance

respectively, followed by Margaritiferidae with 150 individuals and 23.0% in relative abundance, while the Thiaridae family had as little as 27 individual and 4.0% abundance (Fig. 2). The most abundant fresh water mollusc species in Biase Local Government Area according to the study was *Lanistes libycus*, having a numerical abundance of 290 (44.47% abundance), followed by *Lanistes ovum* with a numerical abundance of 185 (28.37% abundance). The least abundant species of fresh water mollusc through-out the study was *Melanoides tuberculata*, having a numerical and relative abundance of 27 and 4.00% respectively (Fig. 3). In terms of distribution of fresh water mollusc classes, Gastropoda was the most dominant, with a numerical abundance of 502 individuals (77% abundance), while Gastropoda had just 150 individuals (23% abundance) (Fig. 4).

The distribution of fresh water mollusc across sampling stations showed that Ubura River (Station 1) had the highest number of fresh water mollusc with 272 individuals, followed by Abibia stream (station 2) with 169 individuals, then Uzin Uwabutu stream (station 3) with 117 individuals and finally Edunak stream (station 4) with 94 fresh water snail individuals in that order, making up a total of 652 individuals of fresh water mollusc (Table 1).

The Shannon weinner diversity indices of fresh water mollusc from Biase Local Government Area were 1.044, 0.479, 0.601 and 0.949 for Ubura River, Abibia Stream, Uzin Uwabutu Stream and Edunak stream respectively. The Margalef diversity indices were 0.535, 0.584, 0.420 and 0.440 for Ubura River, Abibia Stream, Uzin Uwabutu Stream and Edunak stream respectively (Table 1).

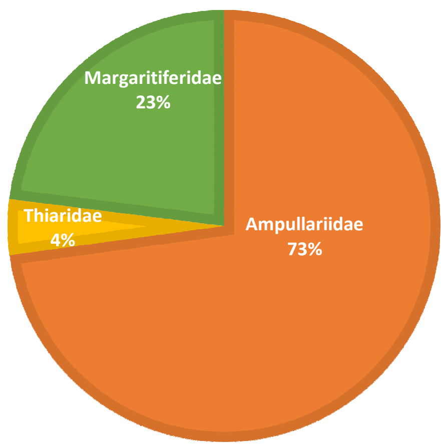

Fig. 2. The relative abundance of the fresh water mollusc family from Biase Local Government Area

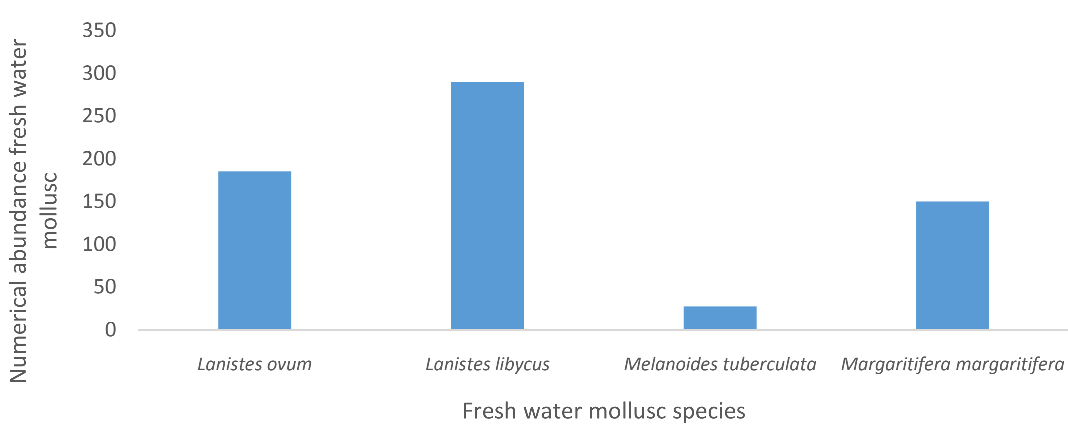

Fig. 3. Numerical abundance of fresh water mollusc in Biase Local Government Area

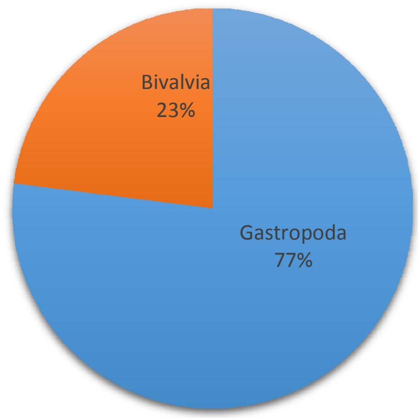

Fig. 4. The relative abundance of fresh water mollusc classes from Biase Local Government Area

3.2 Physico-chemical Parameters of Water

The summary of the physico-chemical parameters of water from Biase Local Government area is shown in Table 2. At Ubura River (station 1), the pH of the water ranged from 5.44 – 6.39, with a mean and standard deviation of 5.793 ± 0.519, while temperature ranged from 28.70 – 29.50℃, with a mean and standard deviation of 29.166 ± 0.416℃. The dissolved oxygen (DO) of water ranged from 3.60 – 5.00 mg/L, with a mean and standard deviation of 4.100 ± 0.781 mg/L (Table 2).

At Abibia stream (station 2), the pH of the water ranged from 5.11 – 6.45, with a mean and standard deviation of 5.643 ± 0.710, while temperature ranged from 29.00 – 30.20℃, with a mean and standard deviation of 29.500 ± 0.624℃. The dissolved oxygen (DO) of water ranged from 3.90 – 4.00 mg/L, with a mean and standard deviation of 3.966 ± 0.057 mg/L (Table 2).

At Uzin uwabutu stream (station 3), the pH of the water ranged from 5.10 – 6.44, with a mean and standard deviation of 5.836 ± 0.679, while temperature ranged from 28.80 – 29.90℃, with a mean and standard deviation of 29.300 ± 0.556℃. The dissolved oxygen (DO) of water ranged from 3.70 – 5.20 mg/L, with a mean and standard deviation of 4.600 ± 0.793 mg/L (Table 2).

At Edunak stream (station 4), the pH of the water ranged from 5.06 – 6.08, with a mean and standard deviation of 5.730 ± 0.580, while temperature ranged from 29.01 – 29.70℃, with a mean and standard deviation of 29.403 ± 0.355℃. The dissolved oxygen (DO) of water ranged from 4.50 – 5.00 mg/L, with a mean and standard deviation of 4.766 ± 0.251 mg/L (Table 2).

The distribution of the water physico-chemical parameters in Biase Local Government Area is shown in Table 2. The physico-chemical parameters of the water varied across the different sampling stations. From the statistical point of view, the pH, temperature and dissolved oxygen varied insignificantly across the four sampling stations at $p>0.05$. Through-out the study, the pH ranged from 5.06 – 6.45, with a mean and standard deviation of 5.750 ± 0.540, while temperature ranged from 28.70 – 30.20℃, with a mean and standard deviation of 29.342 ± 0.445℃. The dissolved oxygen (DO) of water ranged from 3.60 – 5.20 mg/L, with a mean and standard deviation of 4.358 ± 0.599 mg/L (Table 2). The pH and dissolved oxygen values were all above the WHO permissible limit, but water temperature was within the acceptable range (Table 2).

3.3 Relationship between Fresh Water Mollusc Species and Physico-Chemical Parameters

The summary of the relationship strength between the abundance of fresh water mollusc species and physico-chemical parameters of water is shown in Table 3. *Lanistes ovum* had a weak positive relationship with pH, having a r-value of 0.41. *Lanistes ovum* had a negative strong relationship with temperature, having a r-value of -0.78, but had no relationship with dissolved oxygen (Table 3).

Table 2. Mean, Standard deviation, Ranges of the Physico-chemical Parameters of Water from Biase Local Government Area

Physico-chemical Parameters	Ubura River	Abibia Stream	Uzin Uwabutu Stream	Edunak Stream	Mean	WHO Limit
pH	5.793 ± 0.519[a] (5.44 – 6.39)	5.643 ± 0.710[a] (5.11 – 6.45)	5.836 ± 0.679[a] (5.10 – 6.44)	5.730 ± 0.580[a] (5.06 – 6.08)	5.750 ± 0.540 (5.06 – 6.45)	6.0–8.5
Temperature (°C)	29.166 ± 0.416[a] (28.70 – 29.50)	29.500 ± 0.624[a] (29.00 – 30.20)	29.300 ± 0.566[a] (28.80 – 29.90)	29.403 ± 0.355[a] (29.01 – 29.70)	29.342 ± 0.445 (28.70 – 30.20)	<40
Dissolved oxygen (mg/l)	4.100 ± 0.781[a] (3.60 – 5.00)	3.966 ± 0.057[a] (3.90 – 4.00)	4.600 ± 0.793[a] (3.70 – 5.20)	4.766 ± 0.251[a] (4.50 – 5.00)	4.358 ± 0.599 (3.60 – 5.20)	>6

Values are in Mean ± Standard deviation
Ranges are in Parenthesis ( )
Difference significant at p<0.05
Values with different superscript are significantly different

Table 3. Relationship between fresh water mollusc species and physico-chemical parameters of water

Physico-chemical Parameters of water	***L. ovum*** **against Physico-chemical Parameters (r-value)**	***L. libycus*** **against Physico-chemical Parameters (r-value)**	***M. tuberculata*** **against Physico-chemical Parameters (r-value)**	***M. margaritifera*** **against Physico-chemical Parameters (r-value)**
Ph	0.14	- 0.54	0.07	0.33
DO	- 0.01	- 0.48	0.46	-0.47
Temperature	- 0.78	0.65	- 0.21	-0.81

Co-relation rating:
0.75 – 0.99 (Strong relationship)
0.50 – 0.74 (Slightly strong relationship)
0.1 – 0.49 (Weak relationship)
0.01 – 0.09 (No relationship)

Lanistes libycus had a negative slightly strong relationship with pH (r = -0.54), but had a positive slightly strong relationship with temperature (r = 0.65). *Malenoides tuberculata* had a weak relationship with dissolved oxygen (DO) (r = 0.46), but had no relationship with pH (r = 0.07). *Margaritifera margaritifera* had a weak relationship with pH (r = 0.33) and DO (r = -0.47), but had a negative strong relationship with temperature (r = -0.81) (Table 3).

4. DISCUSSION

Freshwater mollusc are an integral part of the complex web of life that supports biodiversity [18]. They play a vital part in cycling of nutrients, functioning of decomposers. They form very important ecological communities and are both economically and medically beneficial [19]. Native freshwater mollusc provide important ecosystem services and are powerful management tool for maintaining and reclaiming water quality [19]. They form a vital link in food chain and also improve water quality by straining out suspended particles and pollutants.

In the present study, a total number of 652 fresh water mollusc individuals were collected throughout the study, which was by far lower than that reported by [20], who reported a total of 2230 fresh water snails while they were studying the distribution and abundance of freshwater snails in Eleyele Dam, Ibadan, South-east Nigeria. The difference in the numerical abundance of fresh water mollusc in the two compared studies could be due to the difference in study period, study duration, study area, study area quality and food availability. The low numerical abundance of freshwater mollusc could be an indication of over-exploitation of these resources by man. The 5 species of gastropod reported by [21], the 31 species of freshwater mollusc reported by [22], the 15 species of freshwater mollusc reported by [23] and the 7 species of fresh water gastropods reported by [24] were all higher than the 4 freshwater mollusc species and 3 gastropod species observed in the present study. Also, the freshwater species of mollusc (*Lanistes ovum, Lanistes libycus, Melanoides tuberculata* and *Margaritifera margaritifera*) observed in the present study were totally absent from the freshwater snails species reported by [25,23]. The differences in the number of species observed and species composition in the compared studies with that of the present study could be due to differences in the distribution of organic matter, sub stratum texture and current velocity [26], food supply [27] and geographical area. The number of species of freshwater mollusc observed was very low (4 species), and this could be due to study techniques, number of study sites or possibly geographical locations of the study sites [28]. The most abundant species of freshwater mollusc was *Lanistes libycus* (290) followed by *Lanistes ovum* (185), then *Margaritifera margaritifera* (150), while *Melanoides tuberculata* occurred least (27), indicating that the Lanistes species are more suited to the ecosystem of the study area.

The distribution of freshwater mollusc in the present study varied across the sampling stations, with some stations having higher abundance of freshwater mollusc, similar findings was reported by [20]. The spatial distribution in freshwater communities could be due to topographical differences, terrestrial vegetation and land use [29]. The Ubura River (station 1) had the highest numerical abundance of freshwater mollusc (272 individuals), while Edunak stream (station 4) had the least numerical abundance (94 individuals) and the differences in numerical abundance could be due to the difference in the distribution of organic matter, sub stratum texture, current velocity [26, 27] and conditions of sampling stations.

The present study revealed low Shannon Weinner and Margalef index across all the sampling stations and this could be attributed either to the study techniques or possibly geographical locations of the study sites [28]. The Shannon Weinner and Margalef index in the present study were all lower than one (1) except for Shannon weinner index in Ubura River, and according to water quality index, diversity indices lower than 1 could be an indication of pollution of the study area or over-exploitation of the fresh water mollusc by man as shown by the unhealthy water quality of the study area. The diversity indices of freshwater mollusc varied across sampling stations and this could be as a result of the differences in topography, terrestrial vegetation and land use [29].

The level of physico-chemical parameters in water is an indication of water quality. The present study revealed the variation in physico-chemical parameters of water across the different sampling stations. This could be due to the variation in the level of human activities across the sampling stations. The pH and dissolved oxygen were all above the WHO acceptable limit, but the temperature level was within the WHO limit. This denotes that the study area is contaminated due to human activities and as such not safe for drinking. As a result, there is need to improve the water quality by controlling the level of human activities over time, while continuously monitoring the study area. The mean pH value in water for the present study is lower, but the dissolved oxygen and temperature were higher than that reported by [30,31]. These discrepancies in the physico-chemical parameters in water for the different compared studies could be due to the differences in study area, geographical area, level of human activities and intensity of heavy metal contamination.

Generally, the relationships between the numerical abundance of fresh water mollusc and physico-chemical parameters of water were not really very strong. *Lanistes ovum* had a negative strong relationship with temperature, denoting that an increase in the temperature will lead to a decrease in the numerical abundance of *Lanistes ovum*. Also, the no relationship with dissolved oxygen indicates that dissolved oxygen had no influence on the abundance of *Lanistes ovum*. *Lanistes libycus* had a negative slightly strong relationship with pH, indicating that the increase in the pH will lead to a slight decrease in abundance of *Lanistes libycus*, also its positive slightly strong relationship with temperature indicates that an increase in the temperature leads to a slight increase in the abundance of *Lanistes libycus*. *Malenoides tuberculata* had a weak relationship with dissolved oxygen (DO), but had no relationship with pH; denoting that the dissolved oxygen and pH had no real influence on the abundance of *Malenoides tuberculata*. *Margaritifera margaritifera* had a weak relationship with pH and DO, indicating that pH and DO had no significant effect on the abundance of *Margaritifera margaritifera*, but its negative strong relationship with temperature denotes that the increase in the temperature will lead to the decrease in the abundance of *Margaritifera margaritifera*. Generally, the abundance of *Margaritifera margaritifera* and *Lanistes ovum* were adversely influenced by temperature increase.

5. CONCLUSION

In conclusion, the freshwater mollusc distribution varied across sampling stations and had low individuals and species abundance. The Shannon Weinner, equitability and Margalef index were generally lower than 1 and varied across all the sampling stations, indicating a possible pollution of the study area. The physico-chemical parameters of water varied across the different sampling stations. The water from the study area is unhealthy and unsafe for drinking. The abundance of *Margaritifera margaritifera* and *Lanistes ovum* were adversely influenced by temperature increase. There is need to improve the water quality by controlling the level of human activities over time, while continuously monitoring the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Barney WR. Submerged macrophytes mitigate direct and indirect Insecticide effects in Freshwater Communities. Plos One. 2000;10(5):11–19.
2. Ponder WF, Lindberg DR, Revenge RT. Phylogeny and Evolution of the Mollusca, Berkeley: University of California Press. 2008;481.
3. Chyleh G, Dodel M, Delay B, Khallanyone K, Jarne P. Spatio-temporal distribution migration and environmental factors in an irrigation area from Morocco. Hydrobiology. 2006;1(1):129–142.
4. MCAllister SB. Introduction: Non-Native species in the world in: piniental D. (Ed. Biological Invasions: Economic and Environmental coasts of Alienplants. CRC. Press board Ratio. 1997;3–10.
5. Revenge AP, Robert T, Junior S. The ecology of freshwater mollusc. Cambridge University Press, USA. 2005;80.
6. Dudgeon D and Muyideen B. Ecological strategies of Hong Kong Thiaridae (Gastro: prosobranchia) Malacol Rev. 2006;22:39–53.
7. Hayes MA, Obuid-Allah AH, Mahmoud AA and Fangary HM. Population dynamics of freshwater snails (Mollusca Gastropoda) at Gena Government upper Egypt. Egypt Academic Journal of Biology Sci. 2010; (1):11–22.
8. Senghor BO, Diaw S, Doucoure S, Seye M, Talla A, Diallo C, Ba T, Sokhna C. Study of the snail intermediate host of urogenital schistosomiasis in Niakhar

region of Fatrick, West Central Senegal. Parasites and Vectors. 2015;8(1):1–8.

9. Daniels IC. First record of a wild population of the tropical snail *Melanoides tuberculata* in New Zealand natural water. Marine Freshwater Res. 2001;36:825–829.

10. Dillon RTJ. The ecology of freshwater mollusk Cambridge: Cambridge University Press, 58.

11. Yousiff F, Kamel G, El-Emam M, Mohammed S. Ecology of Biomphalaria Alexandia and snail vector of Schistosoma mansoni in Egypt. Lournal of Egyptian Society of Parasitology. 1998;22(1):29–42.

12. Oktener AEV. Hydrobiological studies of water bodies in the Okomu forest Reserve (sanctuary) in Southern Nigeria. Physica and chemical hydrology. Tropical Fresh Water Biology. 2004;4:83–100.

13. Adie H, Oyo-Ita A, Okon O, Arong GA, Altinus, A, Braide, EI, Nebe, O, Emanshe, UE and Out, AA. Education of intensity of Urinary scistosomiasis in Biase and Yakurr Local Government Area of Cross River State Nigeria after two years of integrated control measures. Research Journal of Parasitology. 2015;2:24–30.

14. Ofoezie JE. Water contact patterns and behavioural knowledge of Schistosomiasis in south west Nigeria. Journal of biosocial science. 1998;30:245–259.

15. Brown DS. Freshwater mollusc of Africa and their medical importance. Second edition. Taylor and Francis CRC Press. London, U.K. 1994;45.

16. Margalef, DI. Diversidad de species en las comunidales naturals. Publication institute biological application (Barcelona). 1949;9: 5-27.

17. Shannon CE, Weiner W. The Mathematical Theory of Communication. University of Illinois Press-Urbana. 1949; 125.

18. Burch B. Freshwater Sphaeriacean Clams (Mollusca: Pelecypoda) of North America. USA EPA Identification Manual. 1972;3: 31.

19. Kreeger D, Gatenby C and Raksany D. Beyond biodiversity: The conservation and propagation of native mussel biomass for ecosystem services. Abstract from paper presented at the second annual meeting of the Pacific Northwest Native Freshwater Mussel workshop group. April, 20, Vancouver, Washington. 2004;58.

20. Oleyede OO, Otarigho B and Morenikei O. Diversity, distribution and abundance of freshwater snails in Eleyele Dam, Ibadan, South-west Nigeria. Zoology and Ecology. 2016;27(1):46–52.

21. Ugwumba AA, Edward B. Macro-invertebrates fauna of a tropical southern reservoir, Ekiti State. Continental Journal of Biological Science. 2011;4(1): 30–40.

22. Agnieszka MK. The occurrence and distribution of freshwater snails in a heavily industrialized region of Poland (Upper Silesia). Limnologica ecology and management of Inland waters. 2008; 38(1):43–55.

23. Tomas C. Diversity patterns and freshwater mollusk similarities in small water reservoirs. Malacologica Bohemosslovaca. 2011;10:5–9.

24. Gloria I, Galan MM, Ediza MS, Servasques A, Heldi CP. (Diversity of Gastropod in selected Rivers and lakes in Bukidnon. International Journal of Environmental Science and Development. 2015;6:8.

25. Okon OE, Ndome CB, Ikfungei R. The distribution and abundance of fresh water snails in Adim community, Biase, Nigeria. Bioscience Reseaerch Communications. 1999;12(3):281–286.

26. Okorafor KA, Andem AB, Okete JA, Ettah AE. The composition and abundance of macroinvertebrates in the shores of the Great Kwa River, Cross River State, Southeast Nigeria. European Journal of Zoological Research. 2012;2:31–36.

27. Katrin L. Abundance and diversity of Mollusca in the Beagle channel. Scientia Marina. 1999;63(1):391–397.

28. Ziaullah S, Itrat Z, Muhammand AG. Species diversity, distribution and seasonal abundance in mangrove associated molluscs along the Karachi coast. Pakistan J. Bio-resource Mange. 2015;2(3):9–22.

29. Ralf C. Freshwater Snails communities and lake classification, an example from the Aland Island. Southwestern Findland Limnologica. 2001;31:129–139.

30. Andem AB, Udofia U, Okorafor KA, Okete JA, Ugwumba AA. A Study on Some

Physical and Chemical Characteristics of Ona River, Apata, Ibadan South-west, Oyo State, Nigeria. European Journal of Zoological Research. 2012;1(2):37-46.

31. Andem BA, Okoroafor KA, Eyo VO, Ekpo PB. Ecological Impact Assessment and Limnological Characterization in the intertidal region of Calabar River using benthic macro invertebrates as bioindicator. International Journal of Fisheries and Aquatic Studies. 2013;1(2): 8–14.

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