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Research Article

Abundance, Distribution and Diversity of Freshwater Gastropods in Three Local Government Areas of Plateau State, Nigeria

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ABSTRACT

Freshwater snail species are well known to play significant role in the transmission of parasites of public health importance. This study was aimed at investigating the abundance, distribution, diversity of freshwater snails in relation to physico-chemical parameters in three Local Government Areas in Plateau State. Snails were collected using scoop net and hand-picking methods. Water samples were collected and analyzed using standard procedures. Data were analyzed using a Generalized Linear Model using the transformed log-transformed abundance of species as dependent variable and location, season, species and physicochemical water parameters as independent variables using R statistical package. Analysis of Covariance (ANCOVA) was used to test for differences in abundance, between species and season and level of significance determined at $P<0.05$. A total of 5,288 freshwater snails were collected comprising of six genera and five families. More snails were collected during the dry season ($F=5.4049$, $P<0.05$). Relative abundance in Jos-North, Pankshin and Shendam were 54.82%, 27.05% and 18.10% respectively. Species population abundance observed across locations were 2,831(53.54%) for *Physa sp., Biomphalaria sp.* 830(15.69%), *Lanistes sp.,* 595(11.25%), *Melanoides sp.,* 537(10.16%), *Lymnaea sp.,* 410(7.87%) and *Bulinus sp.,* 79(1.49%). Temperature ($P = 0.001$) and alkalinity ($P = 0.000$) both played significant roles in the abundance and distribution of freshwater snails species. The presence of freshwater snails in the study areas poses a significant threat to public health, particularly with the discovery of two new snail species.

Keywords: Abundance; Distribution; Diversity; Freshwater snail; Water parameters

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INTRODUCTION

Gastropods are invertebrates with soft unsegmented bodies. They belong to the phylum Mollusca (Ab Hamid et al, 2023) with over 100,000 extant species and thousands of fossil species (WHO, 2015). As regards species richness, they rank second to the phylum arthropoda (Johnny et al, 2023). Gastropods are found almost in every habitats ranging from terrestrial, coastal freshwater to marine (Snail World, 2014). Freshwater snails are found all over the world colonizing several freshwater habitats from pools to lakes, and from seas and spring to rivers and streams (Johnson et al, 2023). Freshwater snails play significant role in freshwater ecology as well as contribute immensely to ecological functions by feeding on detritus and algae, serving as bio-indicators of aquatic ecosystem health and influencing the quality of water (Tukur et al, 2024). Despite their significance, freshwater snails are also known to play vital role in public and veterinary health (Lu et al, 2018; Barton et al, 2022). A number of freshwater snails are vectors of human and livestock diseases where they serve as intermediate hosts to several infections such as fascioliasis, fasciolopsiasis, angiostrongyliasis, clonorchiasis, paragonimiasis and schistosomiasis (Colley et al, 2014; McManus et al, 2018). Snail abundance, distribution and diversity in an

ecosystem is an interplay between biotic and abiotic factors which produces collective effects. Such factors may include alkalinity, topography, sunlight, turbidity, water chemical analysis, temperature, free carbon-dioxide, dissolved oxygen rainfall, predators amongst others (Njoku-Tony, 2011; Ayanda, 2009). These factors determine the suitability of a site to snail population (Banyigyi et al, 2022). This study was conducted to investigate the population dynamics of freshwater snails with emphasis on the abundance, distribution and diversity of freshwater snails in relation to physico-chemical factors in three Local Government Areas of Plateau State, Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out in three LGAs of Plateau State, Nigeria. The three LGAs include Jos-North. Pankshin and Shendam. Jos is the capital city of Plateau State and located at the northern part of the state. Jos-North LGA covers an area of about 291km^2. Over the years, temperature varies between 12°C to 33°C and from November to late January, night temperature may drop to as low as 7°C.

Pankshin LGA is located in the central part of Plateau State and covers an area of about 1524km^2. Pankshin is known for its cool temperature. The temperature vary between 12°C and 32°C. Average annual temperature is about 22°C and the annual rainfall is 1,150mm.

Shendam is located in the Southern part of Plateau State and bordered to the south by Ibi in Taraba State, Qua'an Pan to the East, Pankshin to the North and to the West by Mikan. Shendam is the second most populous town in Plateau State and occupies an area of 2,477km^2. Average temperature over the years ranges fron 18°C to 38°C and rarely below 16°C or above 40°C.

Collection and Identification of Snails

Snail collection was carried out in the morning between 7am and 11 am for about 45 minutes along the shorelines of selected water bodies. Snails were collected using scoop net and by manual search (hand picking) as described by Olofintoye and Odaibo (1999). Snail identification was carried out as described by Brown and Kristensen, (1993) and Usman et al., (2019). Snail identification was achieved by placing the snail shell with the apex pointing upward and checking for aperture opening and direction, Number of whorls, shell shape, apex type (pointed or blunt) were among other shell characters that were considered.

Shannon – Weiner Biodiversity Indices Measurement

The Shannon-Weiner diversity index was used to assess the biodiversity of fresh water snails. This was calculated using the formula

$$H = -\Sigma[(pi) \times \ln(pi)] \quad \text{(Ejtehad, et al., 2009)}$$

$$J = \frac{H'}{H'_{max}} = -\sum_{I=1}^{S} \frac{Pi\ lnPi}{lnS} \quad \text{(Martin \& Paddy, 1992)}$$

Water Sample Collection and Measurement of Physico-chemical Water Quality Parameters

Water samples were collected in stopper bottles using standard procedures. Physico-chemical water quality parameters that were studied included Temperature (°C), Total Hardness as $CaCO_3$ (mg/L), Dissolved Oxygen (mg/L), Free Carbon-dioxide (mg/L), Biological Oxygen Demand (BOD) (mg/L), pH, Alkalinity (mg/L), Total Dissolved Solids (mg/L) and Electrical Conductivity (µs). Temperature, pH, Total Dissolved Solid and Electrical Conductivity were measured in the field using a 6 in 1 RoHS Digital Water Analytical Instrument model pH-217 while other parameters were measured as describe by APHA (2017).

Data Analysis

Statistical analysis was carried out using R, version 4.4.2. Data were analyzed using General Linear Model (GLM), using the log-transformed abundance of species as response (dependent) variable and location, season, species and physico-chemical water parameters as explanatory (independent) variables. Analysis of Covariance (ANCOVA), which is a combination of ANOVA and regression, was used to test difference in abundance across study locations, between species and season while including water physico-chemical parameters as covariates. Level of significance was determined at $P<0.05$.

RESULTS

Malacological Studies

Collection and Identification of Freshwater Snails

A total of 5,288 freshwater snails were collected belonging to five families; Ampullariidae, Lymnaeidae, Physidae, Planorbidae and Thiaridae (Figure 1). Six genera of freshwater snails were identified across all study sites and these include *Biomphalaria pfeifferi*, *Bulinus globosus*, *Lymnaea natalensis*, *Melanoides tuberculata*, *Physa sp* and *Lanistes ovum* (Figure 1).

Distribution, Abundance and Diversity of Freshwater Snails

Spatial distribution of freshwater snails collected indicated that Jos-North had a higher relative abundance of 54.82% (n = 2899) of the total number of collected snails. This was followed by Pankshin and Shendam with (n = 1432) 27.08% and (n = 957) 18.10% respectively (Table 1). The percentage abundance of each snail species were, *Biomphalaria pfeifferi* (n = 830) 15.69%, *Lymnea natalensis* (n = 416) 7. 87%, *Melanoides*

tuberculata (n = 537) 10.16%, *Bulinus globosus* (n = 79) 1.49%, *Physa sp.* (n = 2831) 53.54% and *Lanistes ovum* (n = 595) 11.25%. Statistically there was a significant difference ($p < 0.05$) in the number of snail collected across locations. In terms of species richness, six (6) species were recorded across study areas. Four species; *Biomphalaria pfeifferi,* (22), *Lymnaea natalensis* (40), *Bulinus globosus* (8) and *Physa* sp. (2829) were collected from Jos-North LGA. Also four species; *Biomphalaria pfeifferi* (606), *Lymnaea natalensis* (330), *Melanoides tuberculata* (431) and *Bulinus globosus* (65) were collected from Pankshin LGA while six ; *Biomphalaria pfeifferi* (202), *Lymnaea natalensis* (46), *Melanoides tuberculata* (106), *Bulinus globosus* (6), *Physa sp.* (2) and *Lanistes ovum* (595) were collected from Shendam LGA (Table 1).

The most abundant family of freshwater snail species across all locations was the Physidae (n = 2831) which accounted for 54% of the total number of snails species collected. This was followed by Planorbidae (n = 909), Ampullariidae (n = 595), Thiaridae (n = 537) and Lymnaeidae (n = 416), accounting for 17, 11, 10 and 8% of the total number of freshwater snail species collected respectively. Table 2 shows the abundance, Shannon-Weiner diversity index, evenness and richness of snail species in the study areas. The results showed that Pankshin had the highest diversity and evenness indices of 1.204 and 0.868 respectively compared to other study areas. Shendam showed a diversity index of 1.058 and evenness indices of 0.591 while Jos-North recorded the lowest diversity and evenness indices of 0.136 and 0.098 respectively.

Table 3 indicated the abundance of freshwater snail species according to season. A total of 3,786 and 1,502 freshwater snails were collected during the dry and wet season, respectively. More freshwater snail species were collected during the dry season except for *M. tuberculata*. *Physa acuta* had the highest percentage abundance of 69.84% while *B. globosus* had the lowest (1.43%) during the dry season. During the wet season, *M. tuberculata* had the highest (25.97%) and closely followed by *B. pfeifferi* (25.30%), while *B. globosus* had the lowest (1.66%) abundance. Statistically there was no significant difference ($p > 0.05$) in the number of snails collected in relation to season.

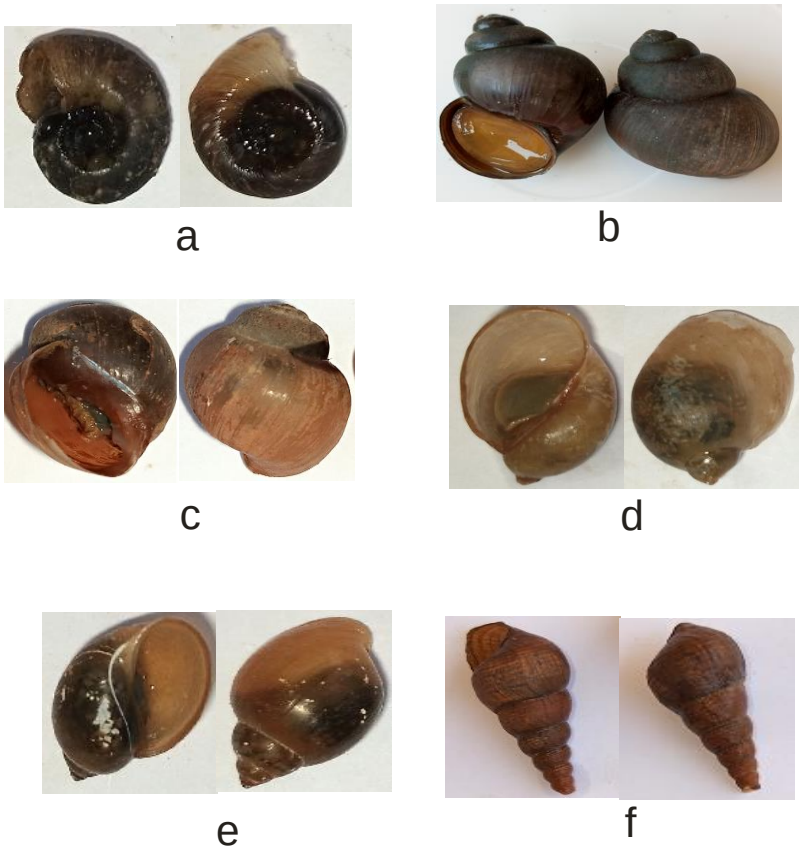

Figure 1. Identified Snail Species a. *Biomphalaria pfeifferi* (apertural and Dorsal views), b. *Lanistes ovum* (apertural and Abarpertural views), c. *Bulinus globosus* (apertural and Abarpertural views), d. *Lymnaea natalensis* (apertural and Abarpertural views), e. *Physa sp.* (apertural and Abarpertural views), and f. *Melanoides tuberculata* (apertural and Abarpertural views)

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Table 1. Relative Abundance and Distribution of Snail Species in Relation to Location

Species/Location	*B. pfeifferi*	*L. natalensis*	*M. tuberculata*	*B. globosus*	*P. acuta*	*L. ovum*	Total (%)
Jos- North	22	40	0	8	2829	0	2899 (54.82)
Pankshin	606	330	431	65	0	0	1432 (27.08)
Shendam	202	46	106	6	2	595	957 (18.10)
Total	830 (15.69)	416 (7.87)	537 (10.16)	79 (1.49)	2831 (53.54)	595 (11.25)	5288 (100)

[F (2,132) = 4.9913, P = 0.008135]

Table 2. Shannon -Weiner Diversity Index, Evenness and Richness of Freshwater Snail Species Abundance across Locations

Species	JOS- NORTH					PANKSHIN					SHENDAM				
	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Total	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Total	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Total
B. pfeifferi	2	20	0	0	22	285	52	143	126	606	8	83	111	0	202
L. natalensis	7	3	30	0	40	114	81	113	22	330	1	11	34	0	46
M. tuberculata	0	0	0	0	0	47	6	11	367	431	80	14	12	0	106
B. globosus	3	4	1	0	8	23	18	13	11	65	2	4	0	0	6
P.acuta	978	1664	187	0	2829	0	0	0	0	0	0	2	0	0	2
L. ovum	0	0	0	0	0	0	0	0	0	0	40	234	321	0	595
Shannon - Weiner Index (H)	0.136					1.203					1.058				
Evenness (J)	0.098					0.868					0.591				
Species Richness	4					4					6				

Table 3. Seasonal Abundance of Freshwater Snail Species

Species/Season	Dry Season	Relative Percentage (%)	Wet Season	Relative Percentage (%)
B. pfeifferi	450	11.88	380	25.30
L. natalensis	217	5.73	199	13.25
M. tuberculata	147	3.88	390	25.97
B. globosus	54	1.43	25	1.66
P. acuta	2644	69.84	187	12.45
L. ovum	274	7.24	321	21.37
Total	3786	71.60	1502	28.40

[F (15, 132) = 0.9671, p = 0.493299

Physicochemical Water Parameters

Physicochemical parameters of the study areas varied with slight differences. Table 4-6 shows seasonal variations of physicochemical water quality parameters within the study areas. The water temperature for the period of this study ranged between 15.43°C – 31.90°C across the study areas. The highest water temperature of 31.90°C was recorded in Shendam (Table 6) and the lowest temperature of 15.43°C in Pankshin (Table 5). Water temperature in Pankshin generally was relatively lower when compared with those from Jos-North and Shendam. Alkalinity ranged between 31.17 – 254.17 mg/L across study areas. The highest alkalinity recorded were 47.67mg/L (July - September), 31.17mg/L (October – December), and 41.00mg/L (July – September) in Jos – North, Pankshin and Shendam respectively (Tables 4,5 and 6). pH ranged between 5.47 – 9.78 across all areas. The highest pH of 9.78 and a mean value of 8.08 ± 1.42 (Table 6) was recorded in Shendam while the lowest pH of 5.47 and a mean value of 6.44± 0.68 (Table 5) was recorded in Pankshin. pH was significantly different (p=0.005) across all locations. Highest water hardness recorded was 66.17mg/L and the lowest 9.75mg/L. In Jos-North, water hardness was relatively higher than those of Pankshin and Shendam. 66.17 and 27.25mg/L were the highest and lowest water hardness respectively recorded in Jos-North with a mean value of 47.13 ± 16.09mg/L (Table 4). Total Dissolved Solids (TDS) ranged between 30 – 459mg/L across all study areas. The highest value of 459 ppm was recorded in Jos-North with a mean value of 284 ± 118.89 mg/L (Table 4) while the lowest 30 ppm was from Pankshin and Shendam (Tables 5 & 6 respectively). Jos-North had the highest values (16.85mg/L with a mean value of 13.94mg/L) in terms of free Carbon dioxide (Table 4). The lowest value of 0.00mg/L was recorded in Shendam (Table 6) with a mean value of 6.80 ± 5.29mg/L. Biological Oxygen Demand (BOD) ranged between 0.62-5.70mg/L. Jos-North recorded the highest BOD of 5.70mg/L (Table 4) while the lowest BOD of 0.62mg/L was recorded in Pankshin LGA (Table 5). The amount of dissolved oxygen (DO) available in water ranged between 3.15-13.00mg/L. Shendam recorded the highest (13.00mg/L) table 6) while Pankshin recorded the lowest (3.15mg/L (Table 5). Electrical conductivity (EC) was higher in the flowing freshwater body compared to the stagnant ones. Pankshin and Shendam recorded the lowest (0.04µs) EC (Tables 5 & 6 respectively) while the highest EC (0.66µs) was recorded in Jos-North LGA. Interactions between species abundance and physico-chemical parameters indicated that temperature (p=0.001) and alkalinity (p=0.000) both played significantly roles in freshwater snail species abundance. The effect of temperature and alkalinity on species abundance is represented in figures 2 and 3 respectively.

As temperature increases, the abundance of *M. tuberculata* and *L. ovum* also increases. However, with increase in temperature the abundance of *L. natalensis, P. acuta. B. pfeifferi and B. globosus* decrease (Figure 2). Additionally, as alkalinity increases (Figure 3), the abundance of *P. acuta* and *L. ovum* increases whereas the abundance of *M. tuberculata, B. pfeifferi, B. globosus* and *L. natalensis* all decreases.

Table 4. Seasonal Variation of Physicochemical Water Quality Parameters in Jos-North LGA

WATER PARAMETERS	OCT. – DEC. Early Dry Season	JAN. – MAR. Late Dry Season	APR. – JUN. Early Wet Season	JUL. – SEPT. Late Wet Season	MEAN VALUE ±SD
Temperature (OC)	20.66	19.07	23.53	23.27	21.63 ± 2.14
pH	7.41	7.06	7.65	6.16	7.07 ± 0.66
Alkalinity (mg/L)	101.00	214.67	254.17	60.67	157.62 ± 91.62
Free Carbon Dioxide (mg/L)	13.17	16.85	16.85	8.90	13.94 ± 3.78
Dissolved Oxygen (mg/L)	3.95	6.63	6.63	6.20	5.85 ± 1.28
Biological Oxygen Demand (mg/L)	3.48	2.92	2.17	5.70	3.57 ± 1.52
Water Hardness (mg/L)	50.58	66.17	44.50	27.25	47.13 ± 16.09
Electrical Conductivity (µs)	0.28	0.51	0.66	0.33	0.45 ± 0.17
Total Dissolved Solid (mg/L)	208	261	459	210	284.50 ± 118.89

Table 5. Seasonal Variation of Physicochemical Water Quality Parameters in Pankshin LGA

WATER PARAMETERS	OCT. – DEC. Early Dry Season	JAN. – MAR. Late Dry Season	APR. – JUN. Early Wet Season	JUL. – SEPT. Late Wet Season	MEAN VALUE ±SD
Temperature (^{O}C)	28.90	31.90	31.30	27.90	30.00 ± 1.91
pH	6.88	9.78	8.72	6.94	8.08±1.42
Alkalinity (mg/L)	41.50	120.00	116.00	41.00	79.65±44.34
Free Carbon Dioxide (mg/L)	12.50	0.00	9.00	6.00	6.88±5.29
Dissolved Oxygen (mg/L)	3.75	13.00	9.65	8.30	8.68± 3.83
Biological Oxygen Demand (mg/L)	1.20	1.45	4.35	2.30	2.33± 1.43
Water Hardness (mg/L)	31.00	46.75	49.35	9.75	34.19± 18.19
Electrical Conductivity (µs)	0.11	0.32	0.36	0.04	0.21± 0.16
Total Dissolved Solid (mg/L)	70.00	224.00	250.00	30.00	143.50±109.07

Table 6. Seasonal Variation of Physicochemical Water Quality Parameters in Shendam LGA

WATER PARAMETERS	OCT.– DEC. Early Dry Season	JAN.– MAR. Late Dry Season	APR – JUN. Early Wet Season	JUL.– SEPT. Late Wet Season	MEAN VALUE ±SD
Temperature (^{O}C)	17.87	21.53	15.43	25.73	20.14±4.49
pH	6.79	7.01	5.47	6.47	6.44±0.68
Alkalinity (mg/L)	31.17	41.17	47.67	40.17	40.00±8.31
Free Carbon Dioxide (mg/L)	5.33	12.17	9.02	7.33	8.46±2.89
Dissolved Oxygen (mg/L)	6.45	3.98	3.51	5.63	4.89±1.38
Biological Oxygen Demand (mg/L)	0.65	0.96	0.62	3.75	1.49±1.51
Water Hardness (mg/L)	25.17	27.67	11.67	10.00	18.63±9.08
Electrical Conductivity (µs)	0.06	0.29	0.07	0.04	0.12±0.11
Total Dissolved Solid (mg/L)	44	205	41	30	80.00±83.55

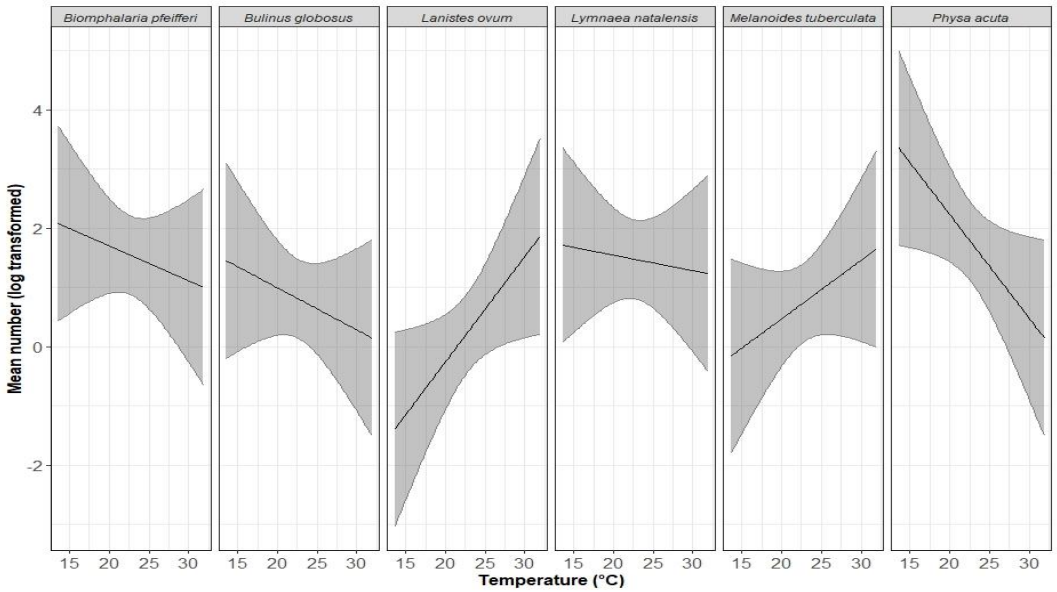

Figure 2. Interaction between snail species and temperature

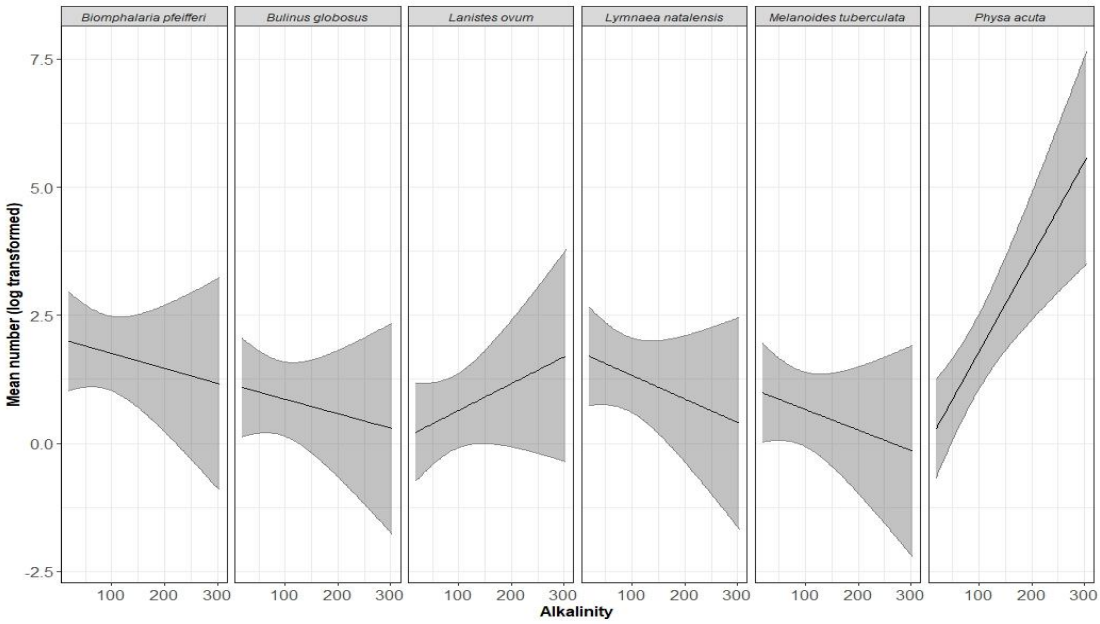

Figure 3. Interaction between snail abundance and alkalinity

DISCUSSION

The result obtained from this study indicated relatively high abundance and diversity of freshwater snails of public importance across the study areas. All six (6) freshwater snail species encountered at all the study areas are of medical importance, which are intermediate hosts of veterinary and human diseases. From this study *Bulinus globosus* was the least abundant. This finding corroborated the findings of Oloyede et al. (2016) who reported 18 and 0.18% as the total number and relative abundance respectively of *B. globosus* in Eleyele dam in Ibadan, South Western Nigeria. This may be due to the confinement of *B. globosus* to small patches, ditches and tributaries of streams, rivers and ponds (Owojori, et al., 2006). The occurrence of *B. pfeifferi* in dams in Pankshin and Shendammay be an indication of the good physico-chemical content of the water bodies, coupled with the relatively low water temperature throughout most parts of the year. All the freshwater snail species encountered during this study have been reported in different parts of Nigeria (Salawu & Odaibo, 2014; Omonijo et al., 2016; Awosolu, 2016). This further established the fact that these freshwater snail species are part of the most common freshwater snail fauna in Nigeria. The presence of freshwater snails in both the

dry and wet seasons is an indication of continuous activities in some of the study sites throughout the year thus the presence of definitive host in some of these study sites may have influenced the occurrence of the freshwater snails. Overall, more snails were collected during the months of October and March when there was less rainfall on average in the study areas. This observation was also reported by Ikpeze & Obikwelu (2016), Abdulkadir et al. (2017) who both reported more snail abundance during the dry season compared to the wet season in Agulu lake shorelines in Anambra State and the Gimbawa dam in Kaduna State, respectively in Nigeria. Salawu & Odaibo (2014) also reported similar findings in Yewa-North in Ogun State, South western Nigeria. Our findings agrees with their findings when they reported that, highest snail abundance was recorded during the early wet season compared to the late wet season. Ngele et al., (2012) and Usman, et al. (2019) also made similar observations independently in their studies carried out in Abia and Katsina states respectively. This they attributed to the fact that such period marks the beginning and peak of dry season when snails are capable of repopulating their natural habitats after a heavy period of rainfall. However, the findings of this study as regards seasonal freshwater snail abundance contradicts the findings of Oloyede et. al. (2016) where they reported a higher freshwater snail abundance during the late wet season when compared to early wet season at the Eleyele dam in Ibadan South West Nigeria. This contrast may be attributed to the type of water body sampled (lotic or lentic), the nature of the type of water and the point of sampling if the water body types are the same. The amount of snails collected in the fourth quarter also suggests that heavy rainfall had negative effect on the survival of the snails (Taofiq et al., 2017). The reduction of snail population at the end of the wet season agrees with the report of Ejehu et al, (2017) who linked it to the flushing away of snails from their habitat by increased water flow. It has been reported (Danladi, et al., 2019; Olkeba, et al., 2020) that predation and competition are important variables that play significant roles in the determination of occurrence, abundance and distribution of freshwater snail species. Large freshwater snail species such as *Melanoides tuberculata* and *Lanistes ovum* with thick strong shell have been suggested to have an advantage over small thin shelled snail species such as *Bulinus, Biomphalaria, Lymnaea* and *Physa* species. Danladi, et al (2019) also reported snail population abundance can be affected indirectly especially in snails with operculum and thick shell as this can serve as a protective cover against shell-invading predators. Therefore, it may not be wrong to predict that the importance of predation in habitat preference of snail species will increase in a direct proportion with water body size and permanence (Danladi, et al., 2019). It is therefore, likely that this factor might have played an important role in snail occurrence, abundance and distribution in freshwater bodies sampled, and also affected their distributions along the main water body and along the shorelines.

Molluscs are well represented in aquatic freshwaters. They are a group of most diverse and dominant benthic fauna in water bodies (Garg, et al., 2009). They perform a key role in the functioning of aquatic ecosystems and their population may be affected either positively or negatively by the biotic and abiotic factors that operate within such an aquatic environment. Different freshwater snails are known to have preference for different environmental conditions. Malaan et al. (2017) reported that distribution and abundance of snails varies, depending on the effect of their interacting physico-chemical parameters. Conditions such as water depth, dissolved oxygen, abundant microflora, water bedding (substrate), temperature, pH, alkalinity and many other abiotic factors and natural behavioural mode of adaptations may explain why the snail species showed marked differences in each sampled area. Hamli et al., (2020) reported that abiotic factors such as conductivity, water temperature, pH, turbidity, dissolved oxygen all play important roles in the richness and composition of freshwater gastropod species, shell formation growth and survival.

In this study, seasonal variations of physico-chemical parameters in terms of their influence on the change in species abundance rather than complete species replacement in the aquatic systems sampled was noticed. Under natural conditions, snails are exposed to several environmental factors which produces a collective effect on the snails. Irrespective of the sampling month/period, variation of snails may exist (Usman, et al., 2019). Environmental parameters can have a significant effect on the density and population dynamics of freshwater snails (Izah & Angaye, 2016) and the resulting variations in the number of snails collected seasonally during this study can be attributed to changes in climatic and other environmental factors. It was also observed that seasonal changes and fluctuation of rainfall has affected the number of snail species in some areas especially in lotic waters. Most snails cannot thrive in the absence of water and too much water reduces snail population (Simoonga et al., 2009).

The highest percentage of total snail species abundance was recorded at an average temperature of 31.60^{O}C in Shendam Local Government Area. This showed that increase in temperature within the observed range favours the growth of molluscs. Garg, et al., (2009); Ikpeze & Obikwelu, (2016) recorded a positive correlation between mollusk population and

temperature. A wide range of temperature (15.43 – 31.90^{O}C) was observed during this study. This is in coincidence with El-Khayat et al., (2009), who revealed that snails can tolerate a wide range (19-34^{O}C) of temperature. Mahmoud, (1994) reported that snails can tolerate low temperatures than high temperatures which can lethally affect them. This is an indication that snail species are highly sensitive to an elevation in temperature that may cause thermal stress and also reduce the dissolved oxygen content of water body (Hofkin et al., 1991). In this study however, a significant positive link was found between snail species abundance and water temperature. As the water temperature increases, the abundance of snail species specifically *M. tuberculata* and *L. ovum* also increases. This was not the same for *L. natalensis, P. acuta, B. pfeifferi* and *B. globosus* where with increase in water temperature, the abundance of snail species significantly declined. Not all snail species are capable of developing sustainable population at a wider tolerance range of environmental parameters (Hamli et al., (2020). This indicated that *M. tubercualta* and *L. ovum* have developed a unique life history strategy which enables both species to develop population at any watercourse around the globe (Hamli, et al., 2020) under increasing temperature and this may be due to their thick shell. Nonetheless, other gastropod species can only be found under a specific condition that is mostly pristine. A significant link was also found between snail species abundance and alkalinity. As alkalinity increases, the abundance of *Physa sp* and *M. tuberculata* increases while the abundance of *B. pfeifferi, L. natalensis, B. globosus* and *L. ovum* all decreased.

CONCLUSION

Freshwater snail intermediate host of trematodes are present in Plateau State and at all the locations that have been studied. These snail intermediate hosts are in abundance and well distributed. The prevailing physico-chemical parameters in the study are conducive for optimal growth and propagation of freshwater snails. The physico-chemical parameters measured are comparable with findings from similar studies in African and Nigerian water bodies and are within tolerable limits for freshwater snail intermediate host. Temperature and alkalinity are two physico-chemical parameters that influences the distribution and abundance of freshwater snail species in parts of Plateau State, Nigeria.

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REFERENCES

Ab Hamid, S. Haron, A. Nor, A. and Othman, S. (2023). Snails (Mollusca) diversity and its distribution in various types of microhabitats. Journal of Tropical Resources and Sustainable Science. 11(2):23-29. https://doi.org/10.47253/jtrss.vlli2.1237

Abdulkkadir, F. M., Maikaje, D.B. & Umar, Y. A. (2017). Ecology and distribution of freshwater snails in Gimbawa Dam, Kaduna State, Nigeria. *Nigerian Journal of Chemical Research,* 22(2), 98-106.

American Public Health Association (APHA) (2017). Standard Methods for the Examination of Water and Wastewater. 23Rd edition, (Eds.) Rice, E.W., Baired, R.B., Eaton, A and Clesceri, L.S. *American Public Health Association, American Water Works Association and Water Environment Federation*. Washington DC.New York, USA. 1496pp.

Awosolu, O.B. (2016). Epidemiology of urinary schistosomiasis and knowledge of health personnel in rural communities of south western Nigeria. *Nigeria Journal of Parasitology and Vector Biology,* 8(10),99-106.

Banyigyi, A.A., Isah, M.H. Ameh, S.M. and Ibrahim J.O.(2022). A ssurvey of freshwater snails in three rivers of keffi local government, nasarawa state, Nigeria. Savanna jpurnal of Basic and Applied Sciences 5(1):66-71

Barton, D.P., Zhu, X., Nuhoglu, a., Pearce, L., McLellan, M. and Shamsi, S. (2022). Parasites of selected freshwater snails in Eastern Murray Darling basin, Australia. International Journal of Environmental Research and Public Health 19:1-15.

Brown, D.S. & Kristensen, T.K. (1993). A field guide to African freshwater snails. 1. West African species. *Danish Bilharziasis Laboratory*, Chatollenlund, Denmark, pp55.

Colley, D.G. Bustinduy. A.L., Secor, W.E and King, C.H. (2014). Human schistosomiasis. Lancet 383(9936):2253-2264. https://doi.org/10.1016/S0140-6736(13)61949-2.

Danladi, S.I., Istifanus, W.I. & Samaila, A.B. (2019). The freshwater snail fauna of the dadinkowa man-made reservoir, Gombe State, Nigeria. *International Journal of Fauna and Biological Studies,* 6(5), 31-35.

Ejehu, Z. U., Ekwunifem, C. A., Anumba, J. U., Onyido, A.E. & Umeaneto, P. U. (2017). Snail fauna and investigation into the incidence of *Schistosoma* infection in Lake of oguta 1 region, Imo State, Nigeria. *Nigerian Journal of Parasitoligy*, 28(2), 173-178.

Ejtehad, H., Sepehri, A. & Akefi, H.R. (2009). The measuring way of biodiversity. Mashhad Ferdosi Publications University, pp. 229.

El-khayat, H.M., Mostafa, B.B.,Mahmoud, K.M.A., El-Said, K.M. & Ismail, N.M.M. (2009). The association

between freshwater snails, macrophytes and water quality in different water courses in Egypt. *New Egyptian Journal of Medicine*, 40, 381-392.
Garg, R.K., Rao, R.J. & Saksena, D. N. (2009). Correlation of molluscan diversity with physicochemical characteristics of water of Ramsagar reservoir. *India international Journal of Biodiversity of Conservation,* 1(6), 202-207.
Hamli, H., Syed Azmai, S.H., Abdul Hamed, S. & Abdulla-Al-Asif (2020). Diversity and habitat characterictics of local freshwater gastropoda (Caenogastropoda) from Sarawak, Malaysia. *Singapore Journal of Scientific Research,* 10(1), 23-27.
Hofkin, B.V., Mkoji, G.M., Koech, D.K. & Loker, E.S. (1991). Control of schistosome-transmitting snails in Kenya by the North American Crayfish *Procambarus clarkii. American Journal of Tropical Medicine and Hygiene,* 45, 339-344.
Ikpeze, O.O. & Obikwelu, M.E. (2016). Factors affecting seasonal abundance of gastropods of public health importance found at Agulu Lake shoreline in Nigeria. *International Journal of Pure and Applied Bioscience,* 4(2), 91-102.
Izah, S.C., & Angaye, T.C. (2016). Ecology of human schistosomiasis intermediate host and plant molluscicides used for control: a review. *Sky Journal of Biochemistry Research,* 5(6), 075-082.
Johnny, J. Patrick, H., Osborne, A., WIllams, S,M,T., Saidu J.B., bangure, C., Bakarr, I.A., Koroma, A.H. and Musa, J. (2023). Distribution of freshwater snails and their socio-cultural values in Kambui Hills Forest Reserve, Eastern Sierra Leone. Nigerian Jornal of Wildlife Management. 7(1):1-11.
Johnson, P.D., Bogan, A. Brown, K.M. and Burkhead, N.M. (2013). Conservation status of freshwater gastropods of Canada and the united Sates. American Fisheries Society 28(6):247-282. Doi: 10.1080/03632415.2013.785396.
Lu, X.T., Gu, Q.Y., Limpanont, Y., Song, L.G., Wu, Z.D., Okanural, K. & Lv, Z.Y. (2018). Snail-borne parasitic diseases: an update on global epidemiological distribution, transmission interruption and control methods. *Infectious Diseases of Poverty*, 7(1), 28.
Mahmoud, K.A. (1994). The feeding ecology of the snail intermediate host of schistosomiasis in Egypt. M.Sc. thesis, Faculty of Science, Cairo University.
Malann, Y.D., Udie, D.A. & Lumi, E.B. (2017). Ecology and distribution of gastropod snails of medical and veterinary importance in municipal area of council, FCT, Abuja Nigeria. *Nigerian Journal of Parasitology,* 38(1), 27-31.
Martin Kent & Paddy Coker (1992). Vegetation description and analysis: A practical approach. Ed. Paddy Coker. Publisher CRC Press, 363 pages.
McManus, D.P., Dunne, D.W., Sacko, M., Utsinger, J., Vnnervald, B.J. aand Zhou, X. (20180. Schistosomiasis. Journal of Cell and Animal Biology 3(4):58-61.
Ngele, K., Kalu, E., Ukwey, M. & Onyeukwu, C.A. (2012). A survey of freshwater snails; the intermediate host of schistosomiasis in Bende Local Government Area, Abia State, Nigeria. *International Journal of Science and Nature,* 3(4), 879-882.
Njoku-Tony, R.F. (2011). Effect of some physicochemical parameters on abundance of intermediate snails of animal trematodes in Imo State, Nigeria. *Researcher*, 3(4), 5-12.
Olkeba, B.K., Boets, P., Mereta, S. T., Yeshigeta, M., Akessa, G.M., Ambelu A. & Goethal, P.L.M. (2020). Environmental and biotic factors affecting freshwater snail intermediate hosts in the Ethiopian Rift Valley Region. *Parasites and Vectors*, 13(1), 292.
Olofintoye, L.K., & Odaibo, A.B., (1999). Pattern of distribution and seasonality in the population dynamics of freshwater snail in river odo-ona Ibadan, Nigeria. *Bioscience Biotechnology Research Communication*, 1, 173-179.
Oloyede, O.O., Otarigho, B. & Morenikeji, O. (2016). Diversity, distribution and abundance of freshwater snails in Eleyele dam, Ibadan, South-West Nigeria. *Zoology and Ecology,* 27(1), 35-43.
Omonijo, A. O., Asaolu, S.O. & Ofoezie, I.E. (2016). Ecology of schistosoma snail vectors in Ado-Ekiti Local Government Area, Ekiti State, Nigeria. *International Journal of pure and Applied Zoology,* 4(1), 77-84.
Owojori, O.J., Asaolu, S.O. & Ofoezie, I.E. (2006). Ecology of freshwater snails in Opa reservoir and research farm ponds at Obafemi Awolowo University Ile-Ife, Nigeria. *Journal of Applied Sciences*, 6(15), 3004-3015.
Salawu, O.T. & Odaibo, A.B., (2014). The bionomics and diversity of freshwater snail species in Yewa North, Ogun State, Southwestern Nigeria. *Helminthologia,* 51(4), 337-344.
Simoonga, C., Utzinger, J., Brooker, S., Vounatsou, P., Appleton, C.C., Stensgaard, A.S., Olsen, A. & Kristensen, T.K. (2009). Remote sensing, geographical information system and spatial analysis for schistosomiasis epidemiology and ecology in Africa. *Parasitology,* 136, 1683-1693.
Snail World (2014) where do snails live. http://www.snail-world.com/where-do-snails-live/.
Taofiq, S., Bunza, M.D. Majeed, Q., Abubakar, M.B. & Ladan, M.U. (2017). Studies on snail vectors of helminth disease agents along Rima Valley, Wamakko L.G.A., Sokoto State, Nigeria. *Tropical Medicine Journal,* 2(1), 1011-1015.
Tukur, S.A., Auta, T and Atalabi, T.E. (2024). Ecological observation of freshwater snails in the vivinity of an artificial lake. Science World Journal 19(1):132-137. https//dx.doi.org/10.4314/swj.v19i1.18

Usman, A.I., Adamu, T. & Abdulhamid, A. (2019). Studies on distribution and abundance of freshwater snail intermediate hosts of schistosomiasis along Kwanar Areh dam in Rimi L.G.A. of Katsina State. *Journal of Parasitology and Vector Biology,* 11(2), 26-35. https://doi.org/10.4897/JPVB2018.0345

WHO (2015). Freshwater snail. World Health organization. http://www.who.int/mediacentre/factsheets/fs368/en/