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Spatial Distribution and Abundance of Freshwater Snails in Relation to Physico-chemical Parameters at Lake Njoboliyo, Adamawa State, Nigeria

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Abstract

A study on the spatial distribution and abundance of snail intermediate host in relation to some physico-chemical parameters at Lake Njoboliyo, Adamawa state, Nigeria was carried out. Snail and water samples were collected on a monthly basis from three distinct sites (A, B, and C) between November, 2023 and March, 2024 using a scoop net and handpicking technique. Snails were identified to species level on the basis of their morphological characteristics, using standard keys. Physicochemical parameters of the water body, including temperature, pH, dissolved oxygen, biological oxygen demand, total dissolved solid, electrical conductivity, transparency and water depth were measured following standard procedures. A total of 1,602 freshwater snails were collected, comprising five (5) families and eight (8) different species, including *Melanoides tuberculata* 490(30.6%), *Bellamya unicolor* 387(24.2%), *Pila ovata* 328(20.5%), *Lanistes ovum* 288(17.9%), *Lymnaea natalensis* 74(4.6%), *Bulinus globosus* 19(1.2%), *Cleopatra bulimoides* 10(0.6%) and *Bulinus truncatus* 6(0.4%). All snail species were encountered in the three sites of the lake. However, site C recorded the highest snail population, with a total count of 586. *Melanoides tuberculata* was the most abundant snail species in the study area, comprising approximately 30.6% of the total snail population surveyed, while *Bulinus truncatus* was the least, constituting about 0.4%. The highest prevalence of snails was observed in the month of January 398(24.85%), while March recorded the least 273(17.04%). There was a significant difference ($P<0.05$) in the distribution of snails across the sampling months. Transparency was the only significant water parameter influencing the abundance of snail species in the lake. Hence, public awareness on the role of snails in transmitting diseases for efficient control program is highly recommended

Introduction

Schistosomiasis is second only to malaria as a parasitic disease with greater economic impact in tropical countries and classified as a neglected tropical disease (NTD) (CDC, 2013). Three species are pathogenic to man. *Schistosoma haematobium, S. mansoni* and *S. japonicum* account for 95% of all human cases of schistosomiasis found in the world (Mutapi *et al*., 2006). In Nigeria, three species are pathogenic to man, these are; *S. haematobium, S. mansoni* and *S. intercalatum* (Singh *et al*., 2016). In Africa, snails of the genus *Biomphalaria* serve as intermediate hosts of *S. mansoni*, *Bulinus* serve as the intermediate hosts of *S. haematobium* and *S. intercalatum* while *Lymnaea* are of importance in the transmission of liver flukes (*Fasciola* spp) (Urude *et al*., 2021).

Human and other animals get infected via cercarial skin penetration when they come in contact with water infested with cercaria larva of schistosomes shed by freshwater snails of the *Bulinus, Biomphalaria*, and *Oncomelania* species (Tierney *et al*., 2005). Infection also occurs when people suffering from schistosomiasis contaminate freshwater sources with faeces or urine containing parasite eggs, which hatch in water, animals acquire these infections through repeated grazing on contaminated vegetation (Usman *et al*., 2017). Schistosomiasis caused by *S. haematobium* is characterized by bloody urine, lesions and calcification of bladder, kidney failure and bladder cancer in children, while *S. mansoni* infection is characterized by bleeding from gastroesophageal region, hepatosplenomegaly, persistent bloody diarrhoea, pain, growth retardation, delayed sexual maturity and chronic dermatitis (Norberg, 2004).

Several studies in Nigeria have indicated an increased prevalence of schistosomiasis associated with dam construction and irrigation works. These include but are not limited to that of Adamu *et al*. (2004), at Piro village near, Gubi Dam, Bauchi, Akinwale *et al*.(2009), in a neglected Community, South Western Nigeria, Okpala *et al*. (2010), in Jos Plateau State, Nigeria and Chessed *et al*. (2017), in Communities around Kiri Lake, Shelleng Local Government Area, Adamawa State, Nigeria.

Freshwater snails belong to the class Gastropoda (Strong *et al*. 2007), subclasses: Prosobranchia (with gills in front of the heart), Opisthobranchia (with gills to the right and behind the heart), and Pulmonata (with a lung instead of gills). Apart from being an important component of food chain and food web of most freshwater ecosystems, freshwater snails are equally important to mankind because they serve as intermediate hosts to various parasites of public health importance. Some of them are known to be vectors of diseases of humans and livestock, they also serve as the intermediate hosts for several infections such as angiostrongyliasis, clonorchiasis, fascioliasis, fasciolopsiasis, opisthorchiasis, paragonimiasis and the most common, schistosomiasis (bilharziasis) that is caused by a blood fluke parasite of the genus *Schistosoma* (Dida *et al*., 2014).

In a natural condition, freshwater snails are usually exposed to a range of varying environmental factors. These factors which are biotic (availability of food, competition and predator-prey interactions) and abiotic (temperature, dissolved oxygen, conductivity, alkalinity, water depth, pH etc.) affect the distribution and habitat preference of these snails (Barkia *et al*., 2015; Yigezu *et al*., 2018). Mustapha and Omostosho (2005), reported that physicochemical parameters of water play a significant role in the composition, distribution and abundance of aquatic organisms. This was further substantiated by Abdulkadir *et al*. (2017), who reported that some physico-chemical parameters such as high DO, BOD and pH were found to influence freshwater snail distribution in Gimbawa Dam, Kaduna State, Nigeria. Hence, it is against this backdrop that this study intends to find out the distribution and abundance of snail intermediate host in relation to physico-chemical parameters at Lake Njoboliyo,

Adamawa State Nigeria for designing a suitable programme for effective freshwater snail control.

Materials and Methods

Description of Study Area

Njoboliyo Lake (Figure 1) lies within Latitude 9.12 - 16.51°N and Longitude 12.28 - 12.43°E on the Eastern part of Yola South L. G. A. The major ethnic groups of this area are Bwatiye, Fulbe, Mbula and few migrant fishers that comprises of Hausa and Jukun/Agatu. Some of those migrant fishers have over the years become indigene to those areas (Ladu and Neiland, 1997). Lake Njoboliyo is a wet flooded plain found adjacent River Benue having its course from River Nafari and Chigari as inlets and empties into the River Benue. The lake is perennial. The characteristic formation of the lake is due to the fact that as river Benue, Chigari and Nafari take their courses from the Mandara highlands on entering Nigeria they meet a flat plain basin, which at peak rainfall from July to September they meanders along their ways with continues deposition of alluvium and sands, leading to formation of many oxbow lakes within the Benue river basin (Amos and Linus, 2017).

Snails and Water Sample Collection

The scoop net and hand picking techniques were employed. Three different sampling point A, B and C of the lake were extensively searched for snails between 7:00 AM and 12:00 PM using a long handled scoop net of 2 cm mesh size and complimented by hand picking of snails from vegetation around the sampling points while wearing hand gloves. This was done on a monthly basis between November, 2023 and March, 2024, where snails collected from each point were kept in a separate plastic buckets half filled with water from the same habitat and labeled. They were transported to the Biology Laboratory, Department of Zoology, Modibbo Adama University, Yola for sorting and identification. Water samples were equally collected immediately after the snail collection using plastic containers (2L) dipped 6 cm - 10 cm below the surface of the water body and were conveyed to the same laboratory in an ice box for physico-chemical analysis.

Identification of Snails

The snails were identified based on the morphological features of their shell, shell colour, position of aperture, number of whorls with reference to standard keys of Brown (1994). The identified snails were captured using an Android phone's camera, after which they were counted and recorded.

Physicochemical Analysis of Water

Eight physicochemical parameters including Temperature, pH, Dissolved oxygen (DO), biological oxygen demand (BOD), conductivity, Total dissolved solid (TDS), water depth and Transparency of the water body were measured fortnightly using standard methods. Water temperature, dissolve oxygen, pH, water depth and Transparency were measured *in-situ*, while biological oxygen demand, total dissolved solid and conductivity were measured in the laboratory. Temperature was determined using mercury-in-glass thermometer, pH was determined using a portable hand held pH meter (Hanna instruments, HI98311.°C), dissolved oxygen using DO meter (model-40), water depth using a meter rule calibrated in centimeter (cm), Transparency was measured using Secchi disc, conductivity was determined using a conductivity meter (OAKTON®, Model WD35607-10, Singapore), while BOD and TDS were measured using Titrimetric method following analytical methods by American Public Health Association (APHA)(2005).

Statistical Analysis

The data collected were subjected to statistical analysis using Statistical Programme for Social Sciences (SPSS) software, Version 26.0. Chi-square was used to test for the significance in snails and values at $p<0.05$ were considered

significant. Correlation analysis was used to test for the relationship between each of the physicochemical parameters on the abundance of freshwater snails.

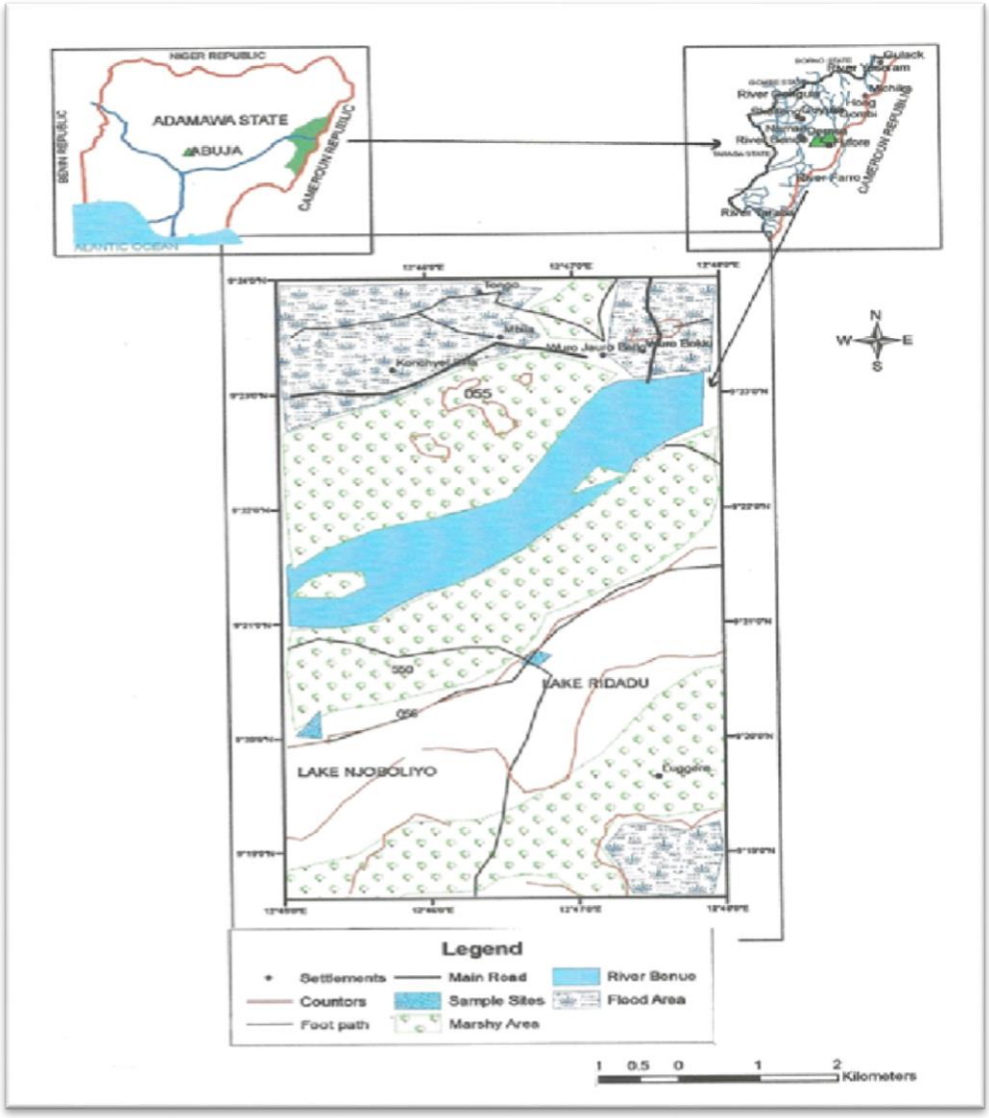

Figure 1: Map of Adamawa State, showing Lake Njoboliyo (Amos and Linus, 2017).

Result and Discussion

A total of 1,602 freshwater snails were encountered in the study area. The snails comprised of five (5) families and eight (8) different species, including *Melanoides tuberculata* 490(30.6%), *Bellamya unicolor* 387(24.2%), *Pila ovata* 328(20.5%), *Lanistes ovum* 288(17.9%), *Lymnaea natalensis* 74(4.6%), *Bulinus globosus* 19(1.2%), *Cleopatra bulimoides* 10(0.6%) and *Bulinus truncatus* 6(0.4%) (Plates 1- 8). However, the spatial distribution of snails in the study area shows that *Melanoides tuberculata* was the most abundant snail species (30.6%) while *Bulinus truncatus* was observed to be the least 6(0.4%) (Table 1). Considering collection sites, site C (586, 36.6%) was the most populated, followed by site A (510, 31.8%) and site B (506, 31.6%) had the least number of snails collected (Table 1). All snail

species were encountered in all the sampling points (Table 1).

Table 2 depicts the monthly distribution of different snail species at Lake Njoboliyo with the month of January having the highest abundance 398(24.85%), followed by December 336(20.97%), November 304(18.98%), February 291(18.16%), while March recorded the least 273(17.04%). *Lymnaea natalensis* occurred in two months, *Bulinus globosus* and *B. truncatus* occurred in three months, *Cleopatra bulimoides* occurred in four months while *Melanoides tuberculata*, *Bellamya unicolor*, *Pila ovata* and *Lanistes ovum* occurred in all the months of the study. However, there is a significant difference in the monthly distribution of snails across the sampling months ($P<0.05$).

Table 1: Freshwater snail species encountered at Lake Njoboliyo, Adamawa State, Nigeria

Sub-class	Families	Species	Sampling points			Total (%)
			A	B	C	
Pulmonata	Planorbidae	*Bulinus globosus*	5 (26.3)	6 (31.6)	8 (42.1)	19 (1.2)
		Bulinus truncates	2 (33.3)	3 (50.0)	1 (16.7)	6 (0.4)
	Lymnaeidae	*Lymnaea natalensis*	35 (47.3)	22 (30.0)	17 (23)	74 (4.6)
Prosobranchia	Thiaridae	*Melanoides tuberculata*	156 (31.8)	121 (24.7)	213 (43.5)	490 (30.6)
		Cleopatra bulimoides	3 (10.0)	5 (50.0)	2 (20.0)	10 (0.6)
	Ampullariidae	*Lanistes ovum*	88 (30.6)	79 (27.4)	121 (42.0)	288 (17.9)
		Pila ovate	102 (31.1)	142 (43.3)	84 (25.6)	328 (20.5)
	Viviparidae	*Bellamya unicolor*	119 (30.7)	128 (33.1)	140 (36.2)	387 (24.2)
Total			**510(31.8)**	**506(31.6)**	**586(36.6)**	**1,602 (100)**

Table 2: Monthly Distribution and Abundance of freshwater snails at Lake Njoboliyo, Adamawa State, Nigeria

Months	Bg	Bt	Bu	Cb	Ln	Lo	Mt	Po	Total (%)
Nov, 2023	0(0)	0(0)	7(2.30)	0(0)	0(0)	36(11.84)	55(18.09)	206(67.76)	304(18.98)
Dec	0(0)	0(0)	16(4.76)	1(0.28)	0(0)	128(38.10)	120(35.71)	71(21.13)	336(20.97)
Jan, 2024	2(0.50)	1(0.25)	82(20.60)	1(0.25)	0(0)	110(27.64)	170(42.71)	32(8.04)	398(24.85)
Feb	7(2.41)	1(0.34)	155(53.26)	2(0.69)	22(7.56)	6(2.06)	87(29.90)	11(3.78)	291(18.16)
March	10(3.66)	4(1.47)	127(46.52)	6(2.20)	52(19.04)	8(2.93)	58(21.25)	8(2.93)	273(17.04)
Total	19(1.2)	6(0.4)	387(24.2)	10(0.6)	74(4.6)	288(17.9)	490(30.6)	328(20.5)	1,602(100)

BG= *Bulinus globosus*, Bt= *B. truncates*, Bu= *Bellamya unicolor*, Cb= *Cleopatra bulimoides*, Ln= *Lymnaea natalensis*, Lo= *Lanistes ovum*, Mt= *Melanoides tuberculata, and* Po= *Pila ovate*, X^2=1168.128, df = 28, $P<0.05$

The monthly mean variation of physico-chemical parameters for Lake Njoboliyo within the study period is shown in table 3. The water temperature ranged between 27.5 ± 0.5 °C to 23.5 ± 0.5 °C, with highest mean temperature of 27.5 ± 0.5 °C recorded in the month of November. The highest pH (7.07 ± 0.17) was in the month of January with a range value of 6.30 ± 0.21 to 7.07 ± 0.17.

Conductivity and total dissolved solid were highest in the month of November, with a mean value of 179.7 ± 4.7μS/cm and 126.4 ± 2.4 mg/L respectively. Similarly, BOD had the highest mean value of 4.00 ± 0.20 mg/L in the month of February, Water depth recorded 148.0 ± 2.0 cm as the highest mean value in the month of December, dissolved oxygen was highest (6.52 ± 0.50 mg/L) in March and Transparency had 33.5 ± 0.5 cm in January as the highest mean value.

The relationship between abundance of snail species and physico-chemical parameters revealed that, transparency is the only significant parameter (r = 0.994, P= 0.001) influencing the abundance of snails in Lake Njoboliyo, Adamawa State, Nigeria (Table 4). However, there was a very weak negative relationship between temperature (r = −0.037; P-value = 0.953) and Biological oxygen demand (r = −0.113, P = 0.856) on snail abundance. Conversely, a week and moderate positive correlation that is not statistically significant was exhibited between conductivity (r = 0.107, P = 0.864) and Water depth (r=0.692, P = 0.195) on the abundance of snails.

More so, Total dissolved solids (TDS) (r = 0.513, P = 0.376) and pH (r = 0.410, P = 0.493) showed a moderate positive correlation that is not statistically significant on snail abundance whereas dissolved oxygen (r = -0.352, P = 0.562) exhibited a moderate negative relationship on the abundance of snails in the lake, although not statistically significant (Table 4).

The study revealed a co-existence amongst eight different snail species in the study area namely, *Bulinus globosus, Bulinus truncatus, Bellamya unicolor, Cleopatra bulimoides, Lymnaea natalensis, Lanistes ovum, Melanoides tuberculata* and *Pila ovata*. All snails encountered are common freshwater snails which have been reported from various parts of Nigeria by Ngele *et al*. (2012) in Bende Local Government Area, Abia State, Omonijo *et al*. (2016), in Ado-Ekiti Local Government Area of Ekiti State, Awosolu (2016), in Rural Communities of South-Western Nigeria and Sunday *et al*. (2019), in Dadinkowa man made Reservoir, Gombe State. The total number of freshwater snails collected in this study (1,602) is greater than the number collected in other areas in previous studies (Okoye *et al*., 2022; Isah *et al*., 2019), which could be due to differences in geographical location, time, place and season of collection. The dominance of *Melanoides tuberculata* could be attributed to the fact that the snail is known to thrive only in standing or slow flowing water bodies compared to other snail species as opined by Rader *et al*. (2003), and the superior natural adaptation they have over other snails such as the presence of their hard protective shell that can withstand harsh

Table 3: Monthly Mean Variation of Physico-chemical Parameters for Lake Njoboliyo, Adamawa State, Nigeria

Parameters	Months				
	November	December	January	February	March
Temperature (°C)	27.5 ± 0.5	23.5 ± 0.5	25.0 ± 1.0	24.0 ± 1.0	24.5 ± 0.5
pH	6.73 ± 0.13	6.50 ± 0.30	7.07 ± 0.17	7.02 ± 0.22	6.30 ± 0.21
Transparency (cm)	20.5 ± 0.5	25.5 ± 1.5	33.5 ± 0.5	19.5 ± 0.5	18.5 ± 0.5
Water Depth (cm)	95.5 ± 49.5	148.0 ± 2.0	130.0 ± 1.0	100.5 ± 0.5	100.0 ± 2.0
Conductivity (μS/cm)	179.7 ± 4.7	173.5 ± 17.5	96.5 ± 1.5	85.0 ± 2.0	79.0 ± 1.0
Dissolved Oxygen (DO) (mg/L)	3.95 ± 0.05	3.85 ± 0.35	4.75 ± 0.65	5.62 ± 0.42	6.52 ± 0.50
Biological Oxygen Demand (BOD) (mg/L)	3.10 ± 0.50	3.30 ± 0.40	3.10 ± 0.30	4.00 ± 0.20	3.35 ± 0.05
Total Dissolved Solids (TDS) (mg/L)	126.4 ± 2.4	105.5 ± 4.5	108.0 ± 10.0	100.0 ± 1.0	90.66 ± 0.36

Table 4: Relationship between Water Parameters and Abundance of Snail Species at Lake Njoboliyo Adamawa State, Nigeria

Water Parameter	Correlation	P-value
Temp.(°c)	-0.037	0.953
pH	0.410	0.493
Transparency(cm)	0.994	0.001
Water depth (cm)	0.692	0.195
Conductivity (μS/cm)	0.107	0.864
Dissolved oxygen (DO)(mg/L)	-0.352	0.562
Biological Oxygen demand (BOD)(mg/L)	-0.113	0.856
Total Dissolved Solid (mg/L)	0.513	0.376

Figure 2: Shell morphology of snails encountered at Lake Njoboliyo, Adamawa State, Nigeria.

environmental conditions and also protect them against predators and drought (Supian and Ikhwannuddin, 2002 and Sharma *et al*., 2013). Dogara *et al*. (2022), asserted that *M. tuberculata* possess the ability to tolerate and explore different environmental and limnological variations. This might also explain its high abundance in Lake Njoboliyo.

Spatial distribution and abundance of freshwater snails' varied across the three sites within the period of study. Site C, being the most populated could be as a result of its slow-flowing water and rich vegetation, thereby providing a suitable environmental condition for the survival and reproduction of the snails. Conversely, sites A and B might have environmental factors such as habitat disturbance or water flow dynamics that limits snail population which explains why these sites had low number of snails.

The highest prevalence of snails observed in the Month of January might probably be because, these snail species thrive more during the dry months when there is no influx of rain water that can easily flush them away. However, there is statistically significant difference in the distribution of snails across the sampling months ($P<0.05$). This is in consonance with the work of Ezeagwuna (2015), who collected more snails during the dry months in Iyiegwu Lake, Anambra State, Nigeria.

The overall abundance of eight snail intermediate host influenced by transparency might be an indication that clearer water supports higher snail abundance, possibly due to better conditions for photosynthetic food sources. This is supported by findings from El-Kady *et al*. (2000), who noted that turbidity was the most effective ecological factor acting on snail abundance. However, our findings differs from those of Abe *et al*. (2017), in Nassarawa State, Nigeria, who found that pH influenced the pooled abundance of snail intermediate host of Water bodies and Urude *et al*. (2021), in the Federal Capital Territory, Abuja, Nigeria, who found that Dissolved oxygen content and salinity of the water bodies influenced the distribution of freshwater snails.

Conclusion

This study had shown that Lake Njoboliyo habours a variety of freshwater snails co-existing in and around the water body, some of which are known intermediate host of medical and veterinary importance. The spatial distribution of snails in the study area shows that *Melanoides tuberculata* was the most abundant snail species observed. The study equally revealed that January was the month with the highest abundance of snail population. More so, transparency was the only significant water parameter influencing the abundance of snails in the Lake. However, the presence of these snail species is an indication of possible transmission of snail-borne diseases especially schistosomiasis in the nearest feature. Hence, public awareness on the role of snails in transmitting diseases is highly recommend.

Author's contributions

Elijah, M.I.: Conceptualization, Data collection, samples analysis, Methodology, Writing-original draft preparation, Writing-reviewing and editing. Chessed, G.: Conceptualization, Writing-reviewing, editing and Supervision.

Conflict of Interest

The authors declare no conflict of interests.

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