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Interactions of Physicochemical Parameters with Snails in Dutsin-Ma Reservoir

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ABSTRACT

Background and Objective: Physicochemical parameters of freshwater ecosystem play vital role in the abundance and distribution of snails. This study investigates the intricate interplay between physicochemical parameters and the abundance and distribution patterns of aquatic snails in various aquatic habitats. **Materials and Methods:** Field surveys were conducted across different locations to collect data on snail populations and to measure key physicochemical parameters. Statistical analyses were employed to assess correlations between these parameters and the abundance and distribution of aquatic snail species. This preliminary investigation was carried out to expose additional information on the abundance and distribution of freshwater snails about selected water quality parameters of the reservoir. **Results:** Temperature and dissolved oxygen emerged as influential factors, with certain snail species displaying preferences for specific ranges within these parameters. This research contributes valuable insights into the ecological drivers shaping the abundance and distribution of aquatic snails, aiding in the development of informed conservation and management strategies for freshwater ecosystems. **Conclusion:** The study's outcomes have implications for broader aquatic biodiversity conservation and underscore the need for holistic approaches to freshwater ecosystem management. Only one species of freshwater snail, *Lymnaeidae* was observed in Dutsin-Ma reservoir.

KEYWORDS

Aquatic snails, water quality, species richness, species abundance, artificial lake, physicochemical parameters

INTRODUCTION

Nigeria has an abundance of water resources, including streams, rivers and reservoirs. In addition, concerted attempts have been made in the country to dam reservoir streams and rivers to create man-made lakes/reservoirs to accommodate human demands for water and its resources. Katsina State, with over 40 reservoirs, is one of the states with the most man-made reservoirs in the country. The Dutsin-Ma reservoirs in the Dutsin-Ma Local Government Area are among the most important in the state. Reservoir development in Nigeria to create man-made reservoirs for irrigation and other uses resulted in safe havens for species of freshwater snails to form flourishing colonies[1,2].

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Reservoir up aquatic bodies such as reservoirs, lakes and ponds offers numerous communal as well as profitable benefits, comprising dry season farming, fishing, transport, visiting the attractions, in addition to electricity generation. On the other hand, blocking tributaries and rivers to produce reservoirs causes extreme variations in the natural environment of the original aquatic bodies. For example, it develops novel biotopes that are more suitable for the breeding of freshwater snails, including those of medical and veterinary relevance[3]. Water quality is a critical issue in fisheries and aquaculture. Water is a changing system composed of living and non-living components, organic, inorganic soluble and insoluble substances, with the potential for frequent alterations in its quality[1,4]. In order to survive and grow, aquatic species require a well-balanced habitat that is rich in nutrients. Regular monitoring of water quality parameters is necessary since the physicochemical features of the water body affect the productivity of the water, as per the findings of [1,5].

Snails are found in nearly every kind of freshwater habitat and are important to the ecology of the area. They feed on a wide variety of algae and detritus, provide food for a multitude of other animals and aid in the breakdown and recycling of nutrients in aquatic environments[3]. Snails are a class of invertebrate organisms belonging to the Gastropods family and they are found in many aquatic environments worldwide. Freshwater environments, including lakes, rivers, streams, ponds and reservoirs, are home to about 5000 species[6]. Research on the ecology and population dynamics of freshwater snails has revealed that these animals are influenced by a multitude of factors, including the physical geography of the area, land contours, soil composition, type of bottom soil sediment, hydrography and climate change[3,7]. Additionally, physicochemical parameters, such as temperature, pH, dissolved gases, alkalinity and calcium ions, are also important factors[3,8] and biological elements include competition, predator-prey relationships and the number of macrophytes (food)[9].

Freshwater snails are an essential part of the food web and chain in the majority of freshwater habitats[10]. It is recognized that certain freshwater snails found in freshwater environments including lakes, ponds and reservoirs have medicinal and veterinary use. Approximately 350 species are thought to be significant for veterinary and medicinal purposes. Human schistosomiasis intermediate hosts are classified into three genera: *Biomphalaria*, *Bulinus* and *Oncomelania*. In creatures, the *Bulinus* species causes urinary schistosomiasis, the *Biomphalaria* species produces intestinal schistosomiasis and the *Oncomelania* species causes fascioliasis or liver rot[10]. Snails in freshwater environments have received a lot of attention since they are intermediary hosts for a variety of trematodes that are capable of producing infestation in animals as well as human beings[11]. Children are more likely to become infected and re-infected in endemic areas[12]. It is estimated that 2.4 million people are infected with fascioliasis worldwide, with another 180 million at risk[13].

The infections are spread through recurrent contact with freshwater during cleaning, swimming or fishing[14]. However, little research has been undertaken on the parameters influencing the occurrence and abundance of freshwater snail intermediate hosts in the Dutsin-Ma reservoir. Consequently, the purpose of this study was to establish the distribution and variety of freshwater snail intermediate hosts, as well as the effect of water quality parameters on their occurrence and abundance in the Dutsin-Ma reservoir. The findings of this study may be useful in developing effective preventive and control measures against snail intermediate hosts in the Dutsin-Ma reservoir in Katsina, Nigeria.

MATERIALS AND METHODS

Study of the area: The study area, Dutsin-Ma reservoir is an earth-fill structure completed in 1974 at the coordinates 12°11'11"N (Latitude) and 7°20'21"E (Longitude) in Katsina State's Dutsin-Ma LGA. The reservoir has a circumference of 5.05 km and covers an area of 1.10 square kilometres[15]. Dutsin-Ma has a wet/rainy season and a dry season. The rainy season lasts from June to September, with an annual rainfall range of 1500-1800 mm[1,16]. The reservoir was built in 1974 primarily for home water supply. During the rainy season, it is only fed by three main sources: Korama from the west, Darawa-Korama from the east, Hadari-Korama and surface runoff from the neighbouring catchment areas. It flowed past the main control overflow structure towards Dantsido and through an uncontrolled channel along the west axis. The reservoir has a single landing place where all catches are landed[15].

Study duration: This preliminary investigation was carried out between July to September, 2023 to expose additional information on the abundance and distribution of freshwater snails in relation to selected water quality parameters of the reservoir.

Sampling stations: A total of 126 freshwater snails were collected at the following sample stations: A, B and C. Location A is at the reservoir's entrance on the river channel. Location B lies in the middle of the reservoir, where human activity is low except for agricultural and irrigational activities. Location C is at the reservoir's end or at the end, where human activity occurs. Location D is located where fishing activities are minimal.

Snail sampling and identification: Different microhabitats in the reservoir and main waterway were thoroughly explored for snails monthly between 7 am and 12 pm using a long-handled scoop net and pair of forceps, as reported by Auta *et al.*[3] and Meshack *et al.*[17]. Snails were also collected in large numbers along irrigation ditches and farm fields using a scoop net and handpicking. Snails taken from each habitat were maintained in marked specimen bottles and brought to the Federal University Dutsin-Ma laboratory in Katsina State for further study. The caught snails were then identified based on their morphological traits using standard keys[18].

Collection of water sample: Water samples were obtained in four sample bottles using 2 L plastic bottles from snail collection sites. The selected water quality parameters, including temperature, pH, turbidity, DO, BOD, total hardness, electrical conductivity and total dissolved oxygen, were determined in the biological laboratory using the methods described by Dauda and Akinwole[19]. All the methods followed the standard procedures[1,20].

Statistical analysis: Data to be obtained are presented in tables, figures and charts. Results will be summarised using descriptive analysis and data will be subjected to One-way Analysis of Variance (ANOVA) to test for differences in means Duncan's Multiple Range Test (DMRT) will be done for separation of means of physicochemical parameters with months and stations of sample at p = 0.05, 95% CI. Correlation analysis will be carried out to test for the relationship between physicochemical parameters and the abundance of freshwater snails. Burlakova *et al.*[21], will be used to determine the species richness and diversity of freshwater snails in the Dutsin-Ma reservoir.

RESULTS

The results of physicochemical parameters of the Dutsin-Ma reservoir (Table 1). Between July to September, the temperature was highest in July (29.70°C), while the lowest was in September (26.75°C) and showed significant variation with month during the period of sampling (p = 0.015). The highest pH was recorded in August (8.31), while the lowest was in September (6.7), with no significant difference in a month (p = 0.711). Turbidity has its highest values in August (452.50±43.01 unit), while its lowest values in September (461.25±41.89 unit), with no significant difference with month (p = 0.901). Dissolved oxygen was found to have the highest values in August (8.15 mg/L), while the lowest values were in July (3.04 mg/L), with a significant difference with the month (p = 0.000).

Table 1: Mean±SD of the physicochemical parameters recorded in Dutsin-Ma reservoir by months

Parameter	July	August	September	p-value
Temperature (°C)	29.70±2.55[b]	27.77±1.18[a]	26.75±1.17[b]	0.015
pH	8.10±0.23	8.31±0.45	6.70±0.14	0.711
TB (NTU)	461.63±49.93	452.50±43.01	461.25±41.89	0.901
DO (mg/L)	3.04±0.04[a]	8.15±0.36[b]	3.26±0.57[b]	0.000
BOD (mg/L)	0.55±0.20[a]	2.11±0.43[b]	1.54±0.34[c]	0.000
EC (dS/m)	0.06±0.05[ab]	0.05±0.07[a]	0.06±0.02[b]	0.092

Significant level ($p<0.05$). The keys used include; TB: Turbidity, DO: Dissolved oxygen, BOD: Biological oxygen demand and EC: Electric conductivity

Table 2: Mean±SD of the physicochemical parameters recorded in the Dutsin-Ma reservoir sampling point

Parameter	Station A	Station B	Station C	Station D	p-value
Temperature (°C)	23.97±2.84	24.20±1.38	25.80±2.66	25.33±1.51	0.360
pH	6.48±0.37	6.40±0.30	6.61±0.21	6.65±0.26	0.434
TB (NTU)	422.00±34.64[a]	488.50±22.57[b]	458.00±41.46[ab]	465.33±49.42[ab]	0.050
DO (mg/L)	3.13±1.36	3.60±0.50	1.40±0.65	1.70±0.96	0.953
BOD (mg/L)	1.23±0.83	1.30±0.50	1.40±0.65	1.70±0.96	0.723
EC (dS/m)	0.06±0.01	0.06±0.008	0.05±0.012	0.05±0.015	0.534

The keys used include; TB: Turbidity, DO: Dissolved oxygen, BOD: Biological oxygen demand and EC: Electric conductivity

Biological oxygen demand was found with the highest value in August (2.11 mg/L) and the lowest value in July (0.55 mg/L), BOD had a significant variation with the month ($p = 0.000$). Electrical conductivity was found with the highest value in August (0.05±0.07 mS/cm), while lowest was in September (0.06±0.02 mS/cm), with no significant variation within months ($p = 0.092$). These are presented in Table 1. Turbidity has the highest p-value (0.901), pH (0.771) and EC (0.092 mS/cm). Water temperature ($p = 0.015$ degrees), dissolved oxygen ($p = 0.0000$) and biological oxygen demand ($p = 0.0000$). Turbidity ($p = 0.901$), pH ($p = 0.771$) and EC ($p = 0.092$) showed insignificant variation during the months of sampling.

Among the four sampling stations sampled, the highest temperature (25.80°C) was recorded at station C, while station A recorded the lowest temperature (23.97°C), with no significant variation ($p = 0.360$). The pH recorded its highest value at station D (6.65), while the lowest was at station B (6.40), it also had no significant variation ($p = 0.434$). Turbidity had its highest value at station B (488.50 NTU) and lowest at station A (422.00 NTU), with no significant variation ($p = 0.050$). Dissolved oxygen also had its highest record at station B (3.60 mg/L), but lowest at station C (1.40 mg/L), with no significant variation with the sampling station ($p = 0.953$). Biological oxygen demand was highest at station D (1.70 mg/L) and lowest at station A (1.23 mg/L), with no significant variation with sampling stations ($p = 0.723$). Electrical conductivity was highest at both stations A and B (0.06 Ds/m) and lowest at both stations C and D (0.05 dS/m), with no significant variation ($p = 0.534$). These results are presented in Table 2.

The mean monthly variation about months and stations of sampling shows that July has the highest mean monthly variation in the number of Lymnaeidae in station C (30±13), while the least is in station D (14). During August the highest mean monthly variation is in station A (26±8), while the least is in station D (15±8). During September, the highest mean month variation is in station C (35), while the least is in station B (15±4).

During the three months of study (July to September, 2023), only one species of freshwater snail, Lymnaeidae was observed in Dutsin-Ma reservoir. September recorded the highest number (27±7) of Lymnaeidae in Dutsin-Ma Reservoir, while the lowest number was recorded in July (25±13), with no significant variation with stations of sampling ($p = 0.15$).

Table 3: Correlation coefficient (r) of physicochemical parameters and Lymnaeidae abundance in Dutsin-Ma reservoir

Parameter	Temp	pH	TB	DO	BOD	EC
pH	1.66					
TB (NTU)	0.199	-0.091				
DO (mg/L)	-0.304	0.122	-0.046			
BOD (mg/L)	-0.327	0.211	-0.093	0.789**		
EC (dS/m)	0.301	-0.052	0.302	-0.154	-0.279	
Lymnaeidae	0.496*	-0.014	-0.275	-0.270	-0.435*	0.169

*Correlation is significant at 0.05 levels (2-tailed), **Correlation is significant at 0.01 level (2-tailed), TB: Turbidity, DO: Dissolved oxygen, BOD: Biological oxygen demand and EC: Electrical conductivity

As shown in Table 3, pH and turbidity (TB) had a negative correlation (-0.091), with DO also having a negative correlation with temperature (-0.304) and TB (-0.046). Though BOD had a negative correlation with temperature (-0.327) and turbidity (-0.093) and a very strong positive correlation with DO (0.789**). Electrical conductivity (EC) had a negative correlation with pH (-0.052), DO (-0.154) and BOD (-0.279). Lymnaeidae only had a significant positive correlation (0.496*) with temperature, while it was negative with pH (-0.014), TB (-0.275) and DO (-0.270), with a significant negative correlation with BOD (-0.435*).

DISCUSSION

During the sampling period, 126 snails from the family Lymnaeidae, also known as the snail ponds, were gathered. Lymnaeidae were found at all sampling sites. The spatial distribution of snails shows that sample location A had the highest percentage of snail abundance and richness with only Lymnaeidae, followed by sample location C with 29.66% of Lymnaeidae species, sample location B with 15.17% of Lymnaeidae and sampling station D with 15.16% of Lymnaeidae species. The once-a-month variation in the composition as well as the richness of freshwater snail accumulations shows that delegates of the Lymnaeidae were the most plentiful snails during the sampling time. The maximum quantity of snails was seen between July and September (late rainy season); this finding accorded with Auta *et al.*[3], who reported higher snail abundance between July, August and September in spring during the late wet season. This gastropod environmental study aimed to discover environmental and biotic parameters that influence the occurrence and abundance of freshwater snail intermediate hosts in the Dutsin-Ma reservoir. This study discovered that freshwater snail species' habitat preferences are influenced by physicochemical water quality measures, physical habitat characteristics, biological factors and domestic or human activities.

The overall abundance of snails varied and population density varied between places. Previous research in Africa has linked such variation to changes in vegetation types, substratum and the presence or lack of other freshwater snail species between sites. Local rainfall, seasonal water flows and water temperature are also key sources of variance between sites[22]. A higher nitrate concentration indicates eutrophication and consequently encourages the presence of snails. Previous research found that water depth was a significant ecological factor influencing the distribution of snail species[23]. The water temperature varied between 26.75 and 29.70°C, with the greatest value observed at site C. This finding was consistent with previous observations by Auta *et al.*[3], who found fluctuating water temperatures across all stations during the study period.

The dissolved oxygen concentration in the reservoir fluctuated during the study period, with an average of 4.83 mg/L over the monitoring period and ranging from 3.04 to 8.15 mg/L. These values were within the suggested range for aquatic life production, which was consistent with the findings of Eyo *et al.*[24]. In all sampling sites, the pH values obtained were within the ranges required for freshwater snail survival. The results were consistent with those obtained by researchers[25-27]. According to the literature, the leaves of floating plants protect snails from direct sunshine and high temperatures[28] hence offering a breeding place for freshwater snails. According to Odeniran *et al.*[29], the oxygen provided by the plant also stimulates the ovipositor.

CONCLUSION

The assessment of water quality parameters in relation to freshwater snails is of paramount importance for understanding and safeguarding aquatic ecosystems. The presence and abundance of snail populations serve as valuable indicators of environmental health, reflecting the intricate balance of various water quality components. Water quality parameters such as pH, dissolved oxygen, temperature and nutrient levels directly influence the survival, reproduction and overall well-being of freshwater snails. These gastropods play a crucial role in ecosystem dynamics by contributing to nutrient cycling and algal control and serving as a vital food source for various organisms. Therefore, monitoring and analyzing water quality parameters become essential in managing and conserving both snail populations and the broader aquatic environment.

Moreover, the impact of pollutants and contaminants on freshwater snails underscores the need for vigilant monitoring and regulatory measures to mitigate potential threats. Human activities, including industrial discharge, agricultural runoff and urban development, can introduce harmful substances into freshwater ecosystems, negatively affecting snail populations and by extension, the entire ecosystem. Incorporating the study of water quality parameters in the context of freshwater snails into broader ecological research allows for a comprehensive understanding of ecosystem health. Such knowledge can inform conservation strategies, guide sustainable resource management and contribute to the preservation of biodiversity. As we strive to maintain and restore the health of freshwater habitats, recognizing the intricate relationship between water quality parameters and freshwater snails serves as a crucial step toward ensuring the resilience and sustainability of these ecosystems for future generations.

SIGNIFICANCE STATEMENT

This survey's outcomes are of paramount importance as they make available a comprehensive appraisal of the water quality parameters in the Dutsin-Ma reservoir, Katsina, Nigeria, shedding light on the impact of physicochemical parameters of the reservoir with snails. The observed differences in turbidity, temperature, dissolved oxygen, electric conductivity, BOD and pH across the three-month study period tender valuable insights into the seasonal fluctuations within the aquatic environment. The recognized associations between these parameters and snails additionally enrich our understanding of possible ecological impacts. This survey offers an initial dataset for upcoming surveys targeting to optimize reservoir situations, improve aquaculture practices as well as lessen possible ecological agents. The understandings gained have effects on both environmental investigations in addition to practicable applications in aquaculture as well as ecological management.

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