



Research Article

Population Dynamics of Freshwater Snails in Relation to Physicochemical Parameters in Hayin Gada Stream of Dutsin-Ma, Katsina State, Nigeria

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ABSTRACT

Freshwater ecosystems are sensitive to variations in physicochemical parameters that influence the abundance and distribution of aquatic organisms, including freshwater snails, which are key bioindicators and intermediate hosts of schistosomes. This study assessed the physicochemical properties of Hayin Gada Stream, Dutsin-Ma LGA, Katsina State, Nigeria, and their relationship with snail abundance and distribution. Monthly sampling was conducted from March to May 2024 at four stations representing human contact and irrigation sites. Snails were collected by hand-picking and scooping, identified to species level, and quantified, while water samples were analysed for temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), turbidity, total dissolved solids (TDS), and conductivity following APHA (2012) standards. Results showed temperature (23.67–27.33 °C), pH (6.17–6.83), DO (7.00–8.33 mg/L), and BOD (1.50–2.00 mg/L) were within WHO permissible limits. Turbidity (20–48 NTU) and TDS (216–627 mg/L) indicated moderate organic and ionic content. Statistical analysis revealed significant spatial variation in temperature ($p = 0.021$), while other parameters showed no significant differences ($p > 0.05$). Three snail taxa, *Melanoides*, *Bellamya*, and *Clams* were identified, with *Melanoides* being dominant (41%), followed by *Bellamya* (31%) and *Clams* (28%). Snail abundance correlated negatively with temperature and pH, but positively with DO and BOD, suggesting physicochemical influences on population structure. The study concludes that Hayin Gada Stream sustains moderate biodiversity under favourable ecological conditions. Continuous monitoring of snail populations alongside water quality indices is recommended to detect early environmental degradation and manage schistosomiasis transmission risk.

Keywords: Dutsin-Ma Stream; Freshwater snails; *Melanoides*; Physicochemical parameters; Water quality

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INTRODUCTION

The freshwater ecosystem, which includes rivers, lakes, ponds, dams, reservoirs, and streams, is under pressure from a variety of physicochemical parameters and causes. Temperature, dissolved

oxygen, pressure, and pH can all have a significant impact on fauna and flora, altering their distribution, richness, and diversity (Nasir *et al.*, 2024; Auta *et al.*, 2023; Ibrahim *et al.*, 2023). Freshwater is one of nature's most vital gifts to humanity, as it is also required for human survival and the provision of basic

necessities (Sadauki *et al.*, 2022). Water, a key environmental resource, is essential for supporting natural life as well as meeting the needs of humans on a daily basis, ranging from home water supply to industrialised uses (Sadauki *et al.*, 2022; Ibrahim *et al.*, 2023; Auta *et al.*, 2024a). In addition to meeting daily human needs, such as home water supply and industrialized uses, water is an essential environmental resource that supports natural life (Sadauki *et al.*, 2022; Ibrahim *et al.*, 2023; Auta *et al.*, 2024a). The distribution and quantity of snails are significantly influenced by the physicochemical characteristics of the freshwater ecosystem. Snails are vital to the local ecology and can be found in almost any type of watery habitat. They help break down and recycle nutrients in aquatic settings, eat on a diverse range of algae and debris, and supply food for numerous other animals (Auta *et al.*, 2024b). Water temperature, pH, dissolved oxygen, and conductivity all affect planorbid fecundity, mortality, and death (Oso and Odaibo, 2021). Light, water velocity, vegetation, and water depth are additional elements that influence the dispersal of freshwater snails (Oso and Odaibo, 2021).

Bulinus and *Biomphalaria* species are intermediate hosts of *Schistosoma haematobium* and *Schistosoma mansoni*, respectively, and can be found in a variety of freshwater settings throughout Nigeria. Snail species like water bodies with a wide variety of dissolved chemical concentrations, and their abundance is proportional to water chemical content. Rainfall, among other things, influences the distribution of freshwater snails in various places (Oso and Odaibo, 2021). Snails are invertebrate organisms of the Gastropoda class that live in watery habitats all over the world. Approximately 5000 species have been discovered in freshwater ecosystems such as lakes, rivers, streams, ponds, and dams. Some freshwater snails are important for medical and veterinary health because they serve as parasite vectors. Snail-borne infections are major parasitic diseases that continue to be significant public health concerns around the world, particularly in impoverished nations (Lu *et al.*, 2018). Schistosomiasis is a widespread parasitic sickness affecting almost 240 million peoples globally, and an additional 700 million people are at risk of infection (Min *et al.*, 2022; Min *et al.*, 2022). Six blood fluke species have been documented to infect humans and cause schistosomiasis; the primary pathogenic species are *Schistosoma haematobium*, *Schistosoma mansoni*, and *Schistosoma japonicum*. Schistosoma eggs are the primary pathogenic factors

of schistosomiasis; by parasitizing host tissues, they cause immune pathological reactions that result in urinary and reproductive system inflammation (*Schistosoma haematobium*) and obstructive or intestinal diseases, liver and spleen inflammation, and liver fibrosis (*Schistosoma mansoni* and *Schistosoma japonicum*) (Wang and Liu, 2020; Min *et al.*, 2022). The biology, range, and, most importantly, abundance of this species has grown in relevance in the field of study, including water quality monitoring (Oloyede *et al.* 2016). Water clarity is reported to be improved by freshwater snails in the environment, which release chemicals that cause suspended particles to coagulate. Snails, on the other hand, can produce sediment resuspension and increased nutrient release into water, hence worsening eutrophication. Thus, the presence of snails has both good and negative effects on water quality (Mo *et al.*, 2017). This study attempts to evaluate the distribution and quantity of snail species, as well as the stream's physicochemical properties.

MATERIAL AND METHODS

Study Area

The work was carried out in Hayin Gada communities in Dutsin-Ma Local Government Area (coordinates $12^{\circ}27'18\text{ N}$ $7^{\circ}29'29\text{ E}$) Total area (527 km² – 203 sq mi) elevation (605m (1,985 ft) of Kastina State (Rabe, 2019). The towns, the communities have tropical climate with typical rainforest vegetation characterized by freshwater swamps. The average daily temperature is 30.60C. Hayin Gada stream which is located at Dutsin-Ma Katsina State is approximately there are other feeder streams (available only during the rainy season) that serve as the major water bodies in the area. People visit these stream farming. They overflow during the rainy season covering a larger area of land. The streams are surrounded by different types of vegetation's. Activities on the stream decrease drastically to almost halting during the months of March to June as most people have insufficient water supply from the Dam. Activities such as farming and irrigation take place mostly during the raining season

Study period and Sampling locations

This preliminary investigation was carried out between March to May, 2024 to expose additional information on the abundance and distribution of freshwater snails in relation to selected water quality parameters of the stream. Snail abundance and distribution was a field survey of the stream in the area to determine the snail species, their distribution and abundance. Monthly snail sampling was collected

at five samples locations –irrigation site, fishing site, close to the main Stream starting of the stream and the middle sides of the stream because of accessibility and human water contact points of the areas

Snails sampling and Identifications

The scooping net techniques and hand picking of snails were employed. Samples were collected monthly between 7 am and 12 pm using a long-handled snail sieve net (mesh size 3 mm – 4 mm) as reported by (Auta *et al.*, 2018 and Meshack *et al.*, 2020). Snails collected from each point were kept in separate labelled specimen bottles containing 70% ethanol as preservative. Subsequently, examination, identification and classification of specimens were done based on African freshwater snails of medical and their medical importance (Brown, 1994) followed by separation of specimens into species which were then counted. Visual forms of the specimens were captured using an Android phone's camera.

Collection of Water Sample and Physicochemical Analysis Water

Samples were collected in four plastic sample bottles (2L) at points where snails were collected. The sample bottles were properly washed with detergent, rinsed with distilled water and air-dried prior to sampling, subsequently, sampling bottles were then rinsed with sampled water just before sampling began. Physicochemical parameters of the water body were determined using methods described by Sadauki *et al.* (2022). All the methods followed the standard procedures (APHA, 2012).

Data Analysis

Analysis of variance (ANOVA) was used to test for significant mean difference of physicochemical parameters during the months of sampling. Correlation analysis was carried out to test for

relationship between species abundance and physicochemical parameters

RESULTS

The physicochemical parameters of water samples collected at different area of the stream are as shown in Table 1. The highest mean water temperature was recorded at the riverine ($25.33 \pm 2.18^\circ\text{C}$). The overall pH level of the stream recorded was (6.63 ± 65). The dissolved oxygen levels vary from 5.00 mg/L to 10.00 mg/L, indicating a healthy oxygen concentration for aquatic life, and BOD is 1.79 mg/L, with a standard deviation of 0.59 mg/L. BOD values range from 1.00 mg/L to 3.00 mg/L, which are relatively low, indicating low levels of organic pollution. TDS values range from 216 mg/L to 627 mg/L, indicating varying levels of dissolved substances in the water. While conductivity is 0.67 $\mu\text{s}/\text{cm}$, with a standard deviation of 0.48 $\mu\text{s}/\text{cm}$. Conductivity values range from 0.00 $\mu\text{s}/\text{cm}$ to 1.00 $\mu\text{s}/\text{cm}$, reflecting the water's ability to conduct electricity, which correlates with the concentration of dissolved ions (Table 1).

Monthly, the highest water temperature was recorded in March and May ($26.00 \pm 1.31^\circ\text{C}$ and 26.00 ± 2.78) when compared with the April (24.00 ± 1.77) as shown in Table 2. The mean values recorded for pH were higher during the month of May (6.75 ± 0.71) than the months of March and April (6.50 ± 0.54 and 6.63 ± 0.74). DO levels show a decreasing trend from March to May. The p-value of 0.347 suggests that the differences in DO levels across these months are not statistically significant ($p > 0.05$) and the BOD levels are highest in April. However, the p-value of 0.146 indicates that the differences in BOD levels across these months are not statistically significant ($p > 0.05$).

Table 1. Physicochemical Parameters of Hayin Gada Stream, showing mean, standard deviation (S.D.) and range values

Parameters	Mean \pm S.D	Range Values	
		Minimum	Maximum
Temperature ($^\circ\text{C}$)	25.33 ± 2.18	22.00	30.00
pH	6.63 ± 65	6.00	8.00
Dissolved Oxygen (mg/L)	7.71 ± 1.52	5.00	10.00
BOD (mg/L)	1.79 ± 0.59	1.00	3.00
Turbidity (NTU)	35.46 ± 9.44	20.00	48.00
TDS (mg/L)	394.54 ± 112.85	216	627
Conductivity ($\mu\text{s}/\text{cm}$)	0.67 ± 0.48	0.00	1.00

Table 2. Mean Monthly Physicochemical Parameters of Hayin Gada Stream, Dutsin-Ma

Parameter	March	April	May	P-value
Temperature (°C)	26.00±1.31	24.00±1.77	26.00±2.78	0.102
pH	6.50±0.54	6.63±0.74	6.75±0.71	0.759
Dissolved Oxygen (mg/L)	8.25±1.58	7.75±1.49	7.13±1.46	0.347
BOD (mg/L)	1.63±0.74	2.13±0.35	1.63±0.52	0.146
Turbidity (NTU)	35.63±8.21	31.38±10.04	39.38±9.38	0.246
TDS (mg/L)	402.75±95.30	421.50±146.50	359.38±94.77	0.549
Conductivity (µs/cm)	0.63±0.52	0.75±0.46	0.63±0.52	0.848

Table 3 presents the mean values, standard deviations, and p-values for various physicochemical parameters of the Hayin Gada Stream across four different sampling stations (A, B, C, and D). The p-values indicate the statistical significance of the differences between the values at these stations. The average temperature varies across the stations, with Station C having the highest temperature (27.33°C) and Station A the lowest (23.67°C). The p-value of 0.021 indicates that the differences in temperature between the stations are statistically significant ($p < 0.05$) and pH levels are relatively similar across the stations, with the lowest at Station A (6.17) and highest at Stations C and D (6.83). The p-value of 0.239 indicates that the differences in pH are not significant ($p > 0.05$) and also the DO levels vary slightly, with the highest at Station D (8.33 mg/L) and lowest at Station C (7.00 mg/L). The p-value of 0.472 indicates that the differences in DO levels are not statistically significant ($p > 0.05$).

Table 4 provides information on the abundance and distribution of three types of freshwater snails (*Mellanoides*, *Bellamya*, and Clams) in the Hayin Gada Stream, Dutsin-Ma, across different months (March, April, May) and sampling stations (A, B, C, D). *Mellanoides* snails are most abundant in April (76) and least abundant in May (45). March has an

intermediate abundance (49). This indicates a peak in the population of *Mellanoides* snails in April. While *Mellanoides* snails are most abundant at Station B (55) and least abundant at Station C (37). Stations A and D have the same number (39), indicating that Station B is a more favorable habitat for *Mellanoides* snails and *Bellamya* snails are most abundant in April (53) and least abundant in May (28).

Table 5 presents the correlation coefficients between various physicochemical parameters (Temperature, pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Turbidity, Total Dissolved Solids (TDS), and Conductivity) and the abundance of three types of freshwater snails (*Mellanoides*, *Bellamya*, Clams) at the Hayin Gada Stream, Dutsin-Ma. Temperature shows a moderate negative correlation with *Bellamya* snails, indicating that higher temperatures might negatively impact their abundance. Correlations with other snails and parameters are generally weak and pH has a moderate positive correlation with BOD and Turbidity, and a moderate negative correlation with *Bellamya* snails, suggesting that higher pH levels may negatively impact *Bellamya* snails. While DO show a moderate negative correlation with TDS, indicating that higher TDS levels might reduce dissolved oxygen.

Table 3. Mean Sampling Station Physicochemical Parameters of Hayin Gada Stream, Dutsin-Ma

Parameter	Station A	Station B	Station C	Station D	P-value
Temperature (°C)	23.67±1.03	25.33±1.75	27.33±2.94	25.00±0.89	0.021
pH	6.17±0.41	6.67±0.82	6.83±0.75	6.83±0.41	0.239
Dissolved Oxygen (mg/L)	7.50±1.05	8.00±1.27	7.00±2.10	8.33±1.51	0.472
BOD (mg/L)	1.50±0.55	1.83±0.41	1.83±0.75	2.00±0.63	0.543
Turbidity (NTU)	33.67±9.09	35.67±11.29	41.33±5.89	31.17±9.89	0.298
TDS (mg/L)	400.00±84.54	420.00±159.00	400.17±124.57	358.00±90.47	0.831
Conductivity (µs/cm)	0.50±0.55	0.83±0.41	0.83±0.41	0.50±0.52	0.434

Table 4. Abundance and Distribution of Freshwater Snails in Hayin Gada Stream, Dutsin-Ma, with Months and Sampling Stations

Snails	Months				Sampling Stations			
	March	April	May	Station A	Station B	Station C	Station D	
<i>Mellanoides</i> (170)	49	76	45	39	55	37	39	
<i>Bellamya</i> (125)	44	53	28	39	26	27	33	
Clams (117)	35	50	32	27	21	27	42	

Table 5. Correlation Coefficient of Physicochemical Parameters with the Freshwater Snails at Hayin Gada Stream Dutsin-Ma

	Temp	pH	DO	BOD	Turbidity	TDS	Cond	<i>Mellanoides</i>	<i>Bellamya</i>
pH	0.247								
DO	-0.088	0.149							
BOD	-0.011	0.357	0.124						
Turbidity	0.284	0.392	0.195	-0.154					
TDS	-0.264	-0.287	-0.401	0.098	-.484*				
Conductivity	0.152	0	-0.139	-0.256	0.073	0.258			
<i>Mellanoides</i>	-0.088	-0.049	0.181	0.369	-0.308	-0.072	-0.068		
<i>Bellamya</i>	-0.376	-0.334	-0.104	0.169	-0.224	0.209	-0.251	0.211	
Clams	-0.06	0.083	0.272	.456*	-0.094	-0.257	-0.078	0.37	0.012

* Correlation is significant at the 0.05 level (2-tail)

DISCUSSION

The study provided a thorough examination of water quality measures assessed monthly in streams, indicating significant differences. Water quality characteristics in aquatic biota can be altered by a variety of human activities as well as natural sources that affect the aquatic environment. The reported water temperature in this study fell within the range known for inland water bodies in the tropical region (Adesakin *et al.* 2020; Anyanwu *et al.* 2021). The water temperature varied between 23.67°C and 27.33°C, with the greatest value observed at site C. This finding was consistent with previous observations by Auta *et al.* (2018), who found fluctuating water temperatures across all stations during the study period. The average pH ranged from 6.17 to 6.83, showing that the reservoir water was slightly alkaline. However, the pH obtained for this study differed from the findings of Sadauki *et al.* (2022b) and Sadauki *et al.* (2022a), who found pH values ranging from 7.14 to 7.18 in Daberam reservoir, Ajiwa, and Zobe. During the study period, the average dissolved oxygen concentration ranged from 7.00±1.05mg/L to 8.33±1.51. The DO levels in the reservoir were consistent with the findings of Auta *et al.* (2024). In this study, the mean TDS value ranged from 359.38±94.77 to 421.50±146.50 mg/L, which was within the WHO recommended limit for

drinking water. The turbidity revealed in this study is significantly higher than that of other water bodies previously reported by Agbazue *et al.* (2015) for River Jakara and Jakara Dam in Kano, Auta *et al.* (2018) for Zobe Dam, Oparaku *et al.* (2022) for Adada River, and Sadauki *et al.* (2022ab). Jibia Lake's high turbidity can be linked to significant turbulence, which introduces clay, silt, and other particles into the water. Excessive turbidity or cloudiness in drinking water is visually undesirable and may pose a health risk (Agbazue *et al.*, 2015). Electrical conductivity is a key indicator of salt levels in water. High salt concentrations may harm aquatic biota (Agbazue *et al.*, 2015). The low EC indicates a low salt concentration in the lake. All of the snail species observed in this study have been recorded from various locations of Nigeria (Awosolu, 2016). As a result, no unusual snail species were identified. This highlights the fact that all of the snails belong to Nigeria's most prevalent freshwater gastropod species. Snails' overall abundance and population density vary among locations. Previous study in Africa has related such variance to differences in vegetation type and substratum, as well as the presence or absence of other freshwater snail species between sites. Local rainfall, seasonal water flows, and water temperature are all important sources of variability between sites (Oso *et al.*, 2021). Previous research indicated that water depth was an

important ecological element influencing snail species distribution (Olkeba *et al.*, 2020). During the sampling period, 412 snails were collected. *Mellanoid*, *bellamia*, and clams were discovered at every sampling site. The spatial distribution of snails reveals that sample location B had the highest proportion of snail abundance and richness with *Mellanoid* (55), followed by sample locations A and D with 39% and (*Mellanoid*), respectively. *Melanoides* can be found in both the main stream and irrigation canals, which is fascinating. This could be ascribed to its quick generation period, size, and the fact that it is a competitive snail capable of outperforming a number of Pulmonates.

CONCLUSION

The present study reveals that Dutsin-Ma stream harbours several species of freshwater snails. It indicates that the river environmental parameters, together with anthropogenic activity, support the existence of three freshwater snail species, with varying abundance and distribution over time among the four sampling sites. *Melanoides* was the most dominant species, followed by *Bellamya*, whereas Clam had the least distribution and abundance.

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