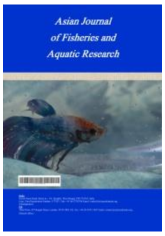

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Abundance and Diversity of Snails in Relation to Physicochemical Parameters along Kwadom Stream, Gombe State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Authors MT and AU designed the study. Author MT performed the statistical analysis. Authors MT and AU wrote the protocol and the first draft of the manuscript. Author MT managed the analyses of the study. Authors MT and AU managed the literature searches. Author MT managed the critical revision of manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of the study is to investigate the abundance and diversity of snails along Kwadom stream, Gombe state, Nigeria.
Study Design: Snails were collected using a benthic scoop net with mesh size of 0.2 mm and hand picking from three sampling stations (home, farmlands, and fishponds sites) along Kwadom stream; between 6:30 am to 11:00 am weekly. In addition, physicochemical parameters (temperature, dissolved oxygen, conductivity, alkalinity, water depth and pH) were measured fortnightly to determine their effect on the diversity of snail species.
Place and Duration of Study: The study was conducted along Kwadom stream in Yamaltu Deba Local Government Area of Gombe State, Nigeria from March to July 2021.
Methodology: Snails were collected from each of the three stations and identified to species level using hand lens and taxonomy keys. Water physicochemical parameters: temperature, dissolved oxygen, conductivity, alkalinity, water depth and pH were measured using standard method. General linear models (GLM) were used to compare the abundance and diversity of the snails

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across the sampling station, as well as the effect of physicochemical parameters on the diversity of snails.
Results: 160 individual snails were recorded from 11 species, including *Biomphalaria pfeifferi*– the intermediate host of *Schistosoma mansoni*. The result showed there was a significant difference in the abundance of snails ($p<0.01$) across the three study sites – home site 68 (42.5%), farmlands site 56 (35%) and fishpond site 36 (22.5%). The home site had a higher diversity of snail species ($p<0.01$) relative to the farmlands and fishponds sites. Temperature, conductivity, and alkalinity had a significant effect on the diversity of snails.
Conclusion: Overall, Kwadom stream harbors many individual snail species, suggesting the need for educating the public on the mode of transmission of diseases that are caused by these snails.

Keywords: Snails; Kwadom stream; abundance; diversity; physicochemical parameters.

1. INTRODUCTION

Snails are organisms of the class Gastropoda [1], that form an important component of food chain and food web in most ecosystems [2]. Globally, about 5000 species of snails are spread across the world [3], and they are mostly associated with water bodies e.g., lakes, ponds, streams, and dams playing significant roles in medical and veterinary health [2,4,5]. For example, in tropical countries, schistosomiasis and fascioliasis are zoonotic diseases with a complex transmission cycle involving snails as intermediate hosts [5-7].

Schistosomiasis, when compared to other snail-borne disease is a major public health concern with about 800 million people being at risk [8], and majority of these people are mainly in sub-Saharan Africa [8,9]. Although drugs and molluscicide have been used to contain the spread of this disease in the tropics [10], the prevalence still persist [11]. In Nigeria, previous studies have shown that the prevalence rate is between 14.2% and 91.4% [12,13].

The transmission of snail-borne diseases is dependent on the distribution of specific snail intermediate hosts [7,8]. Hence, one way to counter the spread of these diseases is to investigate the presence of snails in human-dominated landscapes and educate the public on the mode of transmission of snail-borne diseases. This approach has been successful in some part of Africa, e.g., in Sudan [14], Ethiopia [8], and South Africa [15]. However, in Nigeria a dearth of studies means very little evidence is available to the public to suggest that the presence of the snails may increase the spread of any of the diseases. Only few studies that we are aware of, e.g., Omudu and Iyough [16] on river Benue, Dogara et al. [2] on Warwade Dam in Jigawa State, and Alhassan et al. [6] on different water bodies in Zaria, Kaduna state. No study has reported on the abundance and diversity of snails in the Northeastern part of Nigeria, making our study a unique and important one.

Here, we aimed at investigating the abundance and diversity of snail species in Kwadom stream, Yamaltu Deba Local Government Area, Gombe state, Northeastern Nigeria. Our specific objectives are (i) to determine the abundance and distribution of snail species, and (ii) to examine the effect of physicochemical parameters (temperature, dissolved oxygen, conductivity, alkalinity, water depth and pH) on the diversity of snails. This is important because several ecological studies have shown that biotic and abiotic factors affect the distribution and habitat preference of organisms, e.g., snails [17, 18]. Therefore, it is important that we identify the factors driving the occurrence and diversity of snail in Kwadom stream. We hope that the findings of this study may be useful for the development of preventive and control measures against snail intermediate hosts in the Kwadom stream.

2. MATERIALS AND METHODS

2.1 Study Area and Location of Sampling Sites

Kwadam stream is in Yamaltu Deba Local Government Area of Gombe State, Northeastern Nigeria. The stream is about 2000m long, situated between latitudes 10º26'67"N and longitude 11º28'33"E. There is no map with sufficient detail of the study area, but the stream is surrounded by different communities, and serves as a very important source of domestic water supply, farming, fishing, and other local usage by the communities. We selected three sampling stations along the stream based on observed frequency of activities: home site (dominated by houses, swimming and washing of clothes), farmland site (dominated by farming activities), and fishpond sites (dominated by fishing activities).

2.2 Snail Sampling

We collected snail data weakly from March to July 2021 between 6:30 am to 11:00 am from each of the sampling station. We sampled snail using a benthic 0.2mm scoop net with a long handle and handpicked those that were attached to objects as per methods of [2,5,19] with modifications. After collection, the snails were preserved in a labelled container containing 70% ethanol and transferred to the biological science laboratory, Gombe State University for identification of snails. Individual snail were sorted and morphologically identified to species level using hand lens and appropriate taxonomy key as described by Brown, [20].

2.3 Physicochemical Parameters

We measured the physicochemical parameters of the water both onsite during sampling and in the laboratory fortnightly using standard methods. Water temperature, dissolve oxygen, pH, water depth and conductivity were measured onsite, while alkalinity was measured in the laboratory. We measured the water temperature using mercury-in-glass thermometer and the values recorded in ºC, dissolved oxygen using meter model-40 and recorded the values in mg/L, water depth using a metre rule calibrated in centimetres, pH and conductivity using electrodes and a multi-probe meter. We collected water samples from each sampling station in 1L plastic bottles and transported to the laboratory for analysis of the other physicochemical parameter. The concentration of alkalinity was determined according to the standard method [21] at the laboratory of the Gombe State Water Cooperation (GSWC), Nigeria.

2.4 Statistical Analysis

We analyzed all data using the R statistical software version 4.0.1 (R core Team, 2018). To address the objectives of our study, we used general linear models (GLMs) to compare the abundance and diversity of snails across the tree sampling stations (Table 1, Table 2). We also calculated the effect of physicochemical parameters on the diversity of snails using GLMs (Table 3). In all cases, statistical test was performed at the significance level of p <0.05.

3. RESULTS

We recorded a total of 160 individual snails from 11 species across the three study sites; home site 68 (42.5%), farmlands site 56 (35%) and fishpond site 36 (22.5%), see Table 1 for checklist of snails recorded at Kwadom stream.

The result to compare the abundance of snails across sites showed there was a significant difference in the abundance of snails (p<0.001) across the three sites, with home site having the highest abundance relative to farmlands and fishpond sites (Table 2).

The result to compare the diversity of snail species across sites showed that the home site had the highest diversity of snail species (p<0.001) relative to the farmlands and fishponds sites (Table 3).

Table 1. Checklist of snail species at the Kwadom Stream, Yamaltu Deba LGA, Gombe State, Nigeria

S/N	Family name	Scientific name	Number identified
1	*Bellamyinae*	*Bellamya unicolor*	19
2	*Planorbidae*	*Biomphalaria pfeifferi*	8
3	*Planorbidae*	*Bulinus forskalii*	14
4	*Paludomidae*	*Cleopatra colbeaui*	34
5	*Bithyniidae*	*Gabbiella humerosa*	19
6	*Ampullariidae*	*Lanistes labycus*	9
7	*Ampullariidae*	*Lanistes varicus*	12
8	*Ampullariidae*	*Lnistesli bycus*	5
9	*Lymnaeidae*	*Lymnaea natalensis*	18
10	*Thiaridae*	*Melanoides tuberculata*	8
11	*Ampullariidae*	*Pila weini*	14

Table 2. Mean abundance of snail species across three sites (home site, farmlands site and fishponds sites)

Parameters	Estimate	SE	T value	P value
Intercept	1.64	0.17	9.83	**<0.001**
Farmland site	1.51	0.21	-0.61	0.541
Fishpond site	1.19	0.21	-1.50	0.134

Note: Home site was set as the intercept. P value in bold show significant difference. Model; abundance = site, family = Poisson. Null deviance: 58.552 on 36 degrees of freedom.

Table 3. Diversity of snail species across three sites (home site, farmlands site and fishponds sites)

Parameters	Estimate	SE	T value	P value
Intercept	1.67	0.27	6.079	**<0.001**
Farmland site	0.038	0.33	1.17	**<0.001**
Fishpond site	0.042	0.32	1.27	**<0.001**

Note: Home site was set as the intercept. P values in bold show significant difference. Model; diversity = site. Null deviance: 0.941 on 36 degrees of freedom.

Table 4. Effects of water physicochemical parameters on the diversity of snail species

Parameters	Estimate	SE	T value	P value
(Intercept)	0.46	0.91	0.51	0.614
Water depth (m)	-0.79	0.52	-1.52	0.138
Temperature (°C)	0.052	0.023	2.24	**0.032**
Dissolved oxygen	-0.0092	0.0077	-1.19	0.242
Conductivity	0.012	0.0038	3.16	**0.004**
pH	-0.13	0.10	-1.25	0.222
Alkalinity (mg/L)	0.0045	0.0015	-3.003	**0.005**

Note: P value in bold show significant difference. Model; diversity = temperature + water depth + dissolved oxygen + conductivity + pH + alkalinity. Null deviance: 0.941 on 36 degrees of freedom.

The result to determine the effect of physicochemical parameters on the diversity of snail species showed that temperature, conductivity, and alkalinity had a significant effect on the diversity of snail species (Table 4). The diversity of snail species positively increased with an increase in temperature (p=0.03), alkalinity (p=0.05), and conductivity (p=0.04).

4. DISCUSSION

Our study adds to only a handful of previous studies from West Africa into abundance and diversity of snails e.g., [2,6,16], and is the first from Gombe State Nigeria, to investigate the abundance and diversity of snails in relation to physicochemical parameters. We have shown that the kwadom stream in Gombe state harbors many individual snail species, including the *Biomphalaria pfeifferi*; the intermediate host of *Schistosoma mansoni*, and *Bulinus forskalii* the intermediate host of *Schistosoma haematobium.* Indeed, the presence of these snail species may strongly suggest on-going transmission of schistosomiasis in the area, but this needs further research. An interesting observation from our study is the human activities at the study area, particularly swimming, car washing, bathing, clothes washing, farming and livestock grazing resulting in a direct water contact; an important epidemidogical factor that may enhance the transmission of the disease [22].

A reason for the high abundance and diversity of snails in the home site (which is dominated by domestic activities) when compared to the farmlands and fishpond sites may be that vectors as transmitters of diseases position themselves where they are likely to come into contact with their suitable hosts [2,8], which is the home site in our study. From our interactions with the residents from that community, we found that they were ignorant of the health risks associated with the snail intermediate hosts and unable to identity these species within the environment. Hence the need to educate and enlighten the community on health risk associated with intermediates host species.

With regard to physiochemical parameters, we have identified water temperature, alkalinity and conductivity as important factors that determine the diversity of snails along Kwadom stream, a result that is consistent with other studies [8,23, 24]. This may be explained by the fact that higher temperature increases food availability [23], increases snail metabolic rate [17], and thus increasing the population size of the snail by reducing the time in its developmental periods [8]. Furthermore, the survival of snail species is dependent on favorable conditions e.g., water bodies polluted by sewerage from domestic waste and human excreta [5,25], both of which are common in our study sites. Perhaps, this is the case because our study also show high alkalinity positively affecting snail diversity, making it favorable and conducive for the snails [5,26]. Moreover, increasing organic matter increases the growth of some aquatic flora e.g., algae; a primary diet for most snails [27].

5. CONCLUSION

Our study fills a crucial knowledge gap around the abundance and diversity of snail in Kwadom stream. This is especially timely for Nigeria because we identified schistosomiasis transmitting snails, as well as various physicochemical factors influencing the diversity of snails along Kwadom stream. It is therefore important for both community health workers and policy makers to come up with the best strategies towards the prevention and control efforts of snail-borne disease, while conserving the snail species. For example, regulation of human settlement in the area may reduce the concentration of organic matter from anthropogenic activities, which makes the habitat conducive for snails [8,26]. Providing a safe water supply to the community may likely reduce direct water contact with the stream water.

Further research should scale up our investigation on diseases in snail intermediate hosts from water bodies in other regions of Nigeria, and epidemiology of schistosomiasis among local communities living at the shores of rivers, streams and lakes [8], to ascertain whether active transmission is occurring within these areas.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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