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Malacological Study of Snail from some Fresh Water Bodies in Kano State, Nigeria

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Abstract

A malacological survey was conducted to assess the molluscan fauna, occurrence, and distribution of freshwater snail species in selected water bodies within Kano State, Nigeria. Three dams, Watari, Guzu-Guzu, and Tiga, located across three local government areas, were selected, comprising a total of 21 sampling sites. Seven freshwater snail species were identified, with* Bulinus globosus *exhibiting the highest occurrence (193 individuals; 44.3%), followed by Lymnaea natalensis (77; 19.5%),* Pirenella conica *(15.5%),* Biomphalaria pfeifferi *(69; 12.4%),* Bulinus rohlfsi *(20; 5.1%), Bellamya bengalensis (18; 4.6%), and Pila globosa showing the lowest occurrence (10; 2.6%). Chi-square analysis revealed significant differences in species distribution across the dams ($x^2 = 148.6$, $df = 12$, $p < 0.001$). Watari and Tiga dams harbored the largest snail populations, while Pirenella conica was the most widely distributed species, present at all sampling sites. Cercarial shedding rates varied significantly among snail species and locations, with Fisher's exact test indicating significant associations between snail species and Schistosoma cercarial infection prevalence ($p = 0.002$). Although Tiga Dam recorded the highest abundance of snail hosts for* Schistosoma haematobium, *cercarial shedding was relatively low, likely due to the presence of immature cercariae during sampling. These findings suggest that increases in snail populations may elevate the risk of human schistosomiasis through greater exposure to cercariae during water contact activities. Further longitudinal studies are recommended to elucidate seasonal infection dynamics and the spatial distribution of snail intermediate hosts in the region.

Keywords: Freshwater snail, Schistosomiasis, Dam, Cercaria, Kano State

INTRODUCTION

Freshwater snails serve as essential intermediate hosts in the lifecycle of schistosomes, facilitating the development and release of infective cercariae that penetrate human skin and transmit schistosomiasis, a neglected tropical disease caused by parasitic trematodes of the genus *Schistosoma* (Rollinson *et al.*, 2018; World Health Organization, 2022). Schistosomiasis remains a major public health challenge across sub-Saharan Africa, including Nigeria, where millions, particularly in rural and peri-urban areas, are affected (Colley *et al.*, 2017; World Health Organization, 2022). The distribution and abundance of these snail hosts are critical determinants of schistosomiasis epidemiology (Rollinson *et al.*, 2018).

In Nigeria, the primary schistosome species infecting humans are *Schistosoma haematobium*, responsible for urogenital schistosomiasis, and *Schistosoma mansoni*, which causes intestinal schistosomiasis. These parasites depend on different snail genera as intermediate hosts: *Bulinus* species for *S. haematobium* and *Biomphalaria* species for *S. mansoni* (Ekpo *et al.*, 2010; Tchuentéet *al.*, 2019). Environmental factors such as water quality, vegetation, temperature, and human activities significantly influence the presence, abundance, and distribution of these snails, making their study vital for designing effective

control strategies (Stensgaard *et al.*, 2013; Mutuku *et al.*, 2021).

Freshwater bodies play a pivotal role in schistosomiasis transmission. These include streams, dams, irrigation canals, and stagnant or slow-flowing waters created by human activities such as dam construction and irrigation projects (Madsen *et al.*, 2020; Steinmann *et al.*, 2020). While main river channels may not directly support transmission, seasonal flooding and impoundments create suitable habitats for snail hosts (Steinmann *et al.*, 2020). Water bodies also provide the environment necessary for cercariae survival and facilitate human contact with infective stages. Human behaviors, including unsafe disposal of urine and feces, contaminate these waters with schistosome eggs, perpetuating transmission cycles (World Health Organization, 2017). Globally, approximately 900 million people lack access to improved water sources, and 2.5 billion lack adequate sanitation, with rural and agricultural communities disproportionately relying on potentially contaminated water sources, increasing their exposure risk (United Nations, 2019).

Kano State, Nigeria, contains an extensive network of freshwater bodies, including rivers, dams, ponds, and irrigation canals, that provide favorable habitats for snail vectors (Akinwale *et al.*, 2015). However, recent data on the occurrence and distribution of these intermediate hosts in the state remain limited. Previous studies indicate that the distribution of *Bulinus* and *Biomphalaria* snails varies with ecological conditions and water management practices (Utzinger *et al.*, 2009; Mutuku *et al.*, 2021). Understanding these distribution patterns is essential for identifying schistosomiasis transmission hotspots and implementing targeted control measures, such as snail control, health education, and improved water management (Sow *et al.*, 2011; Rollinson *et al.*, 2018).

This study aims to investigate the occurrence, distribution, and cercarial shedding of snail intermediate hosts in selected freshwater bodies in Kano State.

MATERIALS AND METHODS

Sampling sites Locations

The study was conducted at three major dams within Kano State: Tiga Dam, Guzu-Guzu Dam, and Watari Dam. **Tiga Dam** is located in Bebeji Local Government Area at approximately **12°03′N latitude and 8°12′E longitude**. As one of the largest reservoirs in Kano State, it serves multiple purposes, including irrigation, domestic water supply, and fisheries. However, **Guzu-Guzu Dam** is situated in Gwarzo Local Government Area, near **11°56′N latitude and 8°15′E longitude**. This dam supports irrigation activities and provides essential water resources for the surrounding communities. Finally, **Watari Dam** is located in Bagwai Local Government Area at around **12°05′N latitude and 8°03′E longitude**. The dam is primarily used for irrigation and plays a vital role in enhancing agricultural productivity within the LGA (Bichi *et al.*, 2023).

Snail Sampling Method

Snails were collected from suspected transmission sites to assess their presence and screen for potential infection, aiding in local bilharzia surveillance. The collection method used in this study was qualitative sampling, which aims to identify snail species in response to reports of infection within the community. Qualitative collection typically involves hand collecting and netting, as described by previous studies (Chris and Nelson, 2015; Moodley *et al.*, 2003).

i- Hand Collecting

Hand collecting involved manually searching for snails on or beneath floating and submerged objects, such as logs, rocks, stones, and aquatic vegetation. Snails were also collected from specially deployed floating materials like empty fertilizer bags, which can effectively trap them (Brown, 1994). Protective gear, including hand gloves, a lab coat, and boots, was worn to minimize the risk of infection, and forceps were used to handle snails safely (WHO, 2017).

ii- Netting

Netting was conducted using a long-handled scoop net, designed according to standard recommendations (Moodley *et al.*, 2003). The scoop net had the following specifications: handle length 1.3 m, frame dimensions 320 mm × 300 mm, net material 2.7 mm stainless steel mesh, net depth 60 mm. The net was firmly pushed into or beneath vegetation, followed by repeated upward jerks to dislodge snails, which then settled at the back of the net for collection.

Sample Collection and Labeling

Snails collected from each sampling site were placed in separate bottles filled with water from their habitat to preserve their natural conditions. Each bottle was clearly labeled with a unique sample number corresponding to site-specific parameters such as date, temperature, pH, and turbidity (Sturrock, 1993).

Snail Identification

Collected snail samples were taken to the Biological Sciences Laboratory at Bayero University, Kano, for identification and cercarial shedding. The snails were washed with tap water to remove debris and examined under a dissecting microscope using identification manuals, including: Invertebrate Identification Guide (Easton *et al.*, 2012), an Identification Manual for the Freshwater Snails of Florida (Thompson and Hershler, 2002), and ESGR Aquatic Snail Identification Key (2014).

Cercarial Shedding

Live snails were placed individually in a tissue culture tray under a bench lamp for 1–2 hours or on a windowsill (but not in direct sunlight) for up to 4 hours. Cercariae were observed as tiny, wriggling specks in the water when examined with a 10× hand lens or a dissecting microscope.

Cercariae Examination

A water drop from shedding snails was placed on a glass slide, covered with a cover slip, and examined under a compound microscope using 10× objective lens for identification and 40× objective lens for confirmation. To immobilize cercariae for better examination, dilute formalin was added at the edge of the coverslip, or the slide was gently passed through a Bunsen flame.

Data Analysis

The data collected on freshwater snail species and their cercarial infection status were analyzed using both Chi-square and Fisher's exact tests to assess the association between snail species, sampling locations, and infection prevalence. The Chi-square test was employed to evaluate differences in the distribution of snail species across the different freshwater bodies. Fisher's exact test was used where sample sizes were small or expected frequencies were less than five, particularly in the analysis of cercarial infection rates among snail species. All statistical analyses were performed using **R software version 4.3.0** (R Core Team, 2023). Statistical significance was set at $p< 0.05$. Additionally, 95% confidence intervals were calculated for infection prevalence to provide measures of precision.

RESULTS

Table 1: Species distribution and abundance across study sites

Snail species	Watari Dam	Guzu-Guzu Dam	Tiga Dam	Total	x^2 (p-value)
Bulinus globosus	31	36	92	159	
Bulinus rohlfsi	13	6	0	19	
Biomphalaria pfeifferi	46	22	1	69	
Lymnea natalensis	15	62	0	77	
Pirenella conica	6	19	0	25	
Bellamya unicolor	0	3	15	18	
Pila globosa	6	0	4	10	
Total	117	148	112	377	$x^2 = 148.6$ ($p < 0.001$)

Chi-square test revealed significant differences in species distribution across dams ($x^2 = 148.6$, df = 12, $p < 0.001$).

Table 2: Cercarial infection rates at Watari Dam

Snail species	No. examined	Schistosoma spp. infection	Non-Schistosoma infection	Total infected (%)
Bulinus globosus	31	8 (25.8%)	0	8 (25.8%)
Bulinus rohlfsi	13	3 (23.1%)	0	3 (23.1%)
Biomphalaria pfeifferi	46	10 (21.7%)	0	10 (21.7%)
Lymnea natalensis	15	0	4 (26.7%)	4 (26.7%)
Pirenella conica	6	0	1 (16.7%)	1 (16.7%)
Total	111	21 (18.9%)	5 (4.5%)	26 (23.4%)

Note: Fisher's exact test shows that Schistosoma infection varied significantly by species (95% confidence intervals, p = 0.002).

Table 3: Cercarial infection rates at Guzu-Guzu Dam

Snail species	No. examined	Schistosoma spp. infection	Non-Schistosoma infection	Total infected (%)
Bulinus globosus	36	7 (19.4%)	0	7 (19.4%)
Biomphalaria pfeifferi	22	4 (18.2%)	0	4 (18.2%)
Lymnea natalensis	62	0	11 (17.7%)	11 (17.7%)
Pirenella conica	19	0	2 (10.5%)	2 (10.5%)
Total	139	11 (7.9%)	13 (9.4%)	24 (17.3%)

Notes:No significant difference between Schistosoma and non-Schistosoma infections (Fisher's exact test, p = 0.45).

Table 4: Cercarial infection rates at Tiga Dam

Snail species	No. examined	Schistosoma spp. infection	Non-Schistosoma infection	Total infected (%)
Bulinus globosus	92	13 (14.1%)	0	13 (14.1%)
Bulinus rohlfsi	0	0	0	0
Biomphalaria pfeifferi	1	0	0	0
Total	93	13 (14.0%)	0	13 (14.0%)

Notes: *Bulinus globosus* was the sole Schistosoma host at Tiga Dam. Fisher's exact test shows that infection rates did not differ significantly from other dams (p = 0.12).

DISCUSSION

The malacological survey conducted across Watari, Guzu-Guzu, and Tiga Dams in Kano State shows the critical role freshwater snails play in the transmission of schistosomiasis in northern Nigeria. The identification of seven snail species, with *Bulinus globosus* dominating at 44.3%, confirms the widespread presence of key intermediate hosts for *Schistosoma haematobium*, the causative agent of urinary schistosomiasis (Rollinson *et al.*, 2018; World Health Organization, 2022). This finding aligns with recent studies emphasizing the dominance of *Bulinus* species as primary vectors in sub-Saharan Africa (Colley *et al.*, 2017).

The high density of *Bulinus globosus* is consistent with findings from contemporary surveys in Nigeria and neighboring countries, which continue to identify this species as a principal vector for *S. haematobium* (Adewale *et al.*, 2020; Tchuenté *et al.*, 2019). The abundant presence of *Lymnaeanatalensis*, although not a host for human schistosomes, suggests potential ecological interactions such as competition or facilitation among snail species, which may influence transmission dynamics (Stothard *et al.*, 2020; Mutuku *et al.*, 2021). Understanding such interspecific relationships remains crucial for effective snail control strategies (King *et al.*, 2021).

Interestingly, *Pirenella conica* was the most widespread species, occurring at all sampling sites. While not traditionally recognized as a schistosome host, its broad distribution may reflect ecological adaptability and potential as a bioindicator of freshwater ecosystem health (Nguyen *et al.*, 2020; Sokolow *et al.*, 2017). Recent studies also suggest that non-host snail species can indirectly affect transmission by competing with host snails or altering habitat conditions (Sokolow *et al.*, 2017).

Tiga Dam exhibited the highest abundance of schistosome-transmitting snails but paradoxically low cercarial shedding. This discrepancy may result from environmental factors such as predation, water quality, or the timing of sampling relative to cercarial maturation cycles (Adriko *et al.*, 2018; Madsen *et al.*, 2020). It underscores the importance of longitudinal monitoring, as cercarial shedding is known to vary seasonally and diurnally (Zhou *et al.*, 2018; Sokolow *et al.*, 2017). Temporal variability in cercarial output significantly affects transmission risk assessments and control program effectiveness (Sokolow *et al.*, 2017).

The relatively low cercarial output despite high host snail density highlights the complexity of schistosome transmission. Environmental variables such as water temperature, light exposure, and circadian rhythms critically influence cercarial emergence and infectivity (King *et al.*, 2021; Mutuku *et al.*, 2021). Moreover, human water-contact behavior remains a pivotal determinant of infection risk, emphasizing the need for integrated control

strategies combining snail management with behavioral interventions (Adriko *et al.*, 2018; Colley *et al.*, 2017).

High snail populations in Watari and Tiga Dams are likely linked to favorable ecological conditions including abundant aquatic vegetation, stagnant or slow-moving water, and nutrient enrichment, which promote snail proliferation (World Health Organization, 2022; Adewale *et al.*, 2020). Such habitats are typical breeding grounds for *Bulinus* and *Biomphalaria* species, the primary intermediate hosts for schistosomes in Africa (Tchuenté *et al.*, 2019; Steinmann *et al.*, 2020). Recent environmental studies continue to highlight the role of anthropogenic changes, such as dam construction and irrigation, in expanding suitable snail habitats (Madsen *et al.*, 2020).

The observed spatial distribution of snail species across local government areas indicates that control strategies must be tailored to local ecological and socio-economic contexts (King *et al.*, 2021). Approaches including environmental modification, molluscicide application, and biological control using competitor snails or predators have been tested with varying success (Sokolow *et al.*, 2017; Colley *et al.*, 2017). Recent advances advocate for integrated snail control embedded within broader schistosomiasis elimination programs (Rollinson *et al.*, 2018).

This study underscores the critical need for seasonal and longitudinal investigations, as snail abundance and infection rates fluctuate significantly with rainfall, temperature, and other climatic factors (Zhou *et al.*, 2018; Mutuku *et al.*, 2021). Improved understanding of these temporal patterns is essential for predictive modeling and optimizing the timing of interventions (King *et al.*, 2021).

CONCLUSION

In conclusion, this study reveals the diversity and distribution of freshwater snails in Kano State, with *Bulinus globosus* identified as the dominant intermediate host, particularly in Watari and Tiga Dams. However, despite low cercarial shedding at the time of sampling, the large snail populations suggest ongoing risk for urinary schistosomiasis transmission, especially with increased human contact and favorable environmental conditions. Equally, the widespread presence of *Pirenella conica* highlights important ecological patterns that merit further attention.

RECOMMENDATION

To effectively control and prevent schistosomiasis in Kano State, the study recommends a multi-pronged approach. First, regular and seasonally timed surveillance of snail populations is essential to understand the dynamics of disease transmission. This includes tracking species abundance, infection status, and cercarial output. Second, public health education should be intensified to raise awareness among at-risk communities, especially those living near water bodies, about safe water contact and hygienic practices.

Environmental management strategies, such as clearing vegetation around snail-infested areas and improving sanitation infrastructure, should be implemented to reduce snail habitats. These efforts should be complemented by integrated vector control, including the use of molluscicides and biological agents like snail-eating fish to directly reduce snail populations.

There is a need to strengthen diagnostic and treatment services in local health facilities to ensure early detection and prompt management of schistosomiasis cases. Providing safe alternative water sources, such as boreholes, will help reduce human dependence on contaminated water bodies.

Engaging government agencies and NGOs is vital for developing and implementing effective policies and providing sustained funding for control programs. Importantly, community participation should be encouraged through local involvement in snail control efforts to enhance ownership and sustainability of the interventions.

Further research and capacity building are recommended to better understand the ecological and social drivers of transmission. Finally, school-based interventions, including health education and mass deworming, are crucial to protect children who are most vulnerable to infection due to frequent exposure to water sources.

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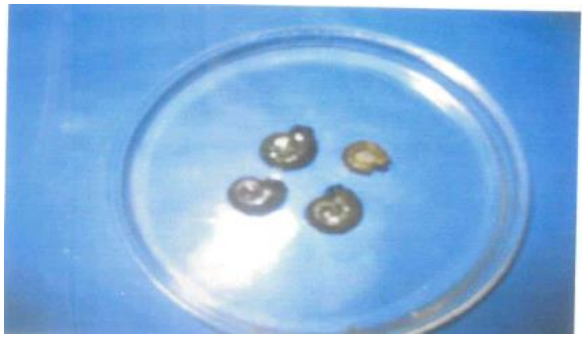

Plate 1: *Biomphalaria spp*. Found from the Watari dam.

Plate 2: *Lymnea spp*. Found from Guzu-Guzu dam.

Plate 3: *Bulinus species* found from Tiga Dam.

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