Science World Journal Vol. 19(No 1) 2024
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University
https://dx.doi.org/10.4314/swj.v19i1.18

ECOLOGICAL OBSERVATIONS OF FRESHWATER SNAILS IN THE VICINITY OF AN ARTIFICIAL LAKE

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ABSTRACT
This investigation delves into the ecological dimensions of freshwater snails in the vicinity of an artificially created lake. The aim of this research was to comprehend the distribution, prevalence, and variety of freshwater snail species within the ecosystem surrounding the manmade lake. The study spanned from August to November 2023, conducted at three distinct sample stations (I, II, and III), with bi-weekly sample collections. Standard keys were employed for the identification of snails, and the Shanon-Weiner and Simpson's similarity indices were used to explore the diversity of snail species. Throughout the study, a total of 311 individuals representing three distinct species encountered in this study were documented. *Acathina fulica* exhibited the highest abundance (129 individuals), while *Pomacea bridgesii* displayed the lowest abundance (66 individuals). The month of August registered the highest population (122 individuals), contrasting with the lowest count in November (37 individuals). Abundance varied across stations, with Station II recording the lowest (77 individuals) and Station III the highest (116 individuals). Regarding diversity, *Pomacea bridgesii* emerged as the most diverse species (0.3670 & 0.3662), while *Littorina littorea* exhibited the least diversity (0.0000) across the stations. This investigation contributes valuable insights into the dynamics of freshwater snail populations in the periphery of artificial lakes, shedding light on their distribution patterns and ecological interactions.

Keywords: Bakolori Reservoir; Environmental Biology; Freshwater Ecology; Species; Abundance; Species Distribution; Species Diversity.

INTRODUCTION

Mollusks, a diverse group that includes freshwater snails, constitute a vast category of creatures characterized by protective shells. With well over 50,000 distinct species, this category encompasses freshwater, marine, and terrestrial snails. Snails, being soft-bodied organisms, are shielded by their calcareous shells, formed from minerals ingested and solidified within. These shells, in addition to ligaments and soft tissues, serve as defence mechanisms against predators and environmental threats (Paul *et al*., 2019). While some species transitioned from terrestrial to freshwater habitats, the majority of freshwater snails originally emerged from saltwater environments. Playing a vital role in freshwater ecology, snails contribute to various ecological functions by feeding on algae and detritus, influencing water quality and serving as indicators of aquatic ecosystem health. Despite their significance, these creatures often bear curious names, such as interrupted rock snail, banded mystery snail, and apple snail, which may obscure their importance in water quality assessment and as food sources for aquatic species (Paul *et al*., 2019).
As gastropods, snails inhabit freshwater, marine, and terrestrial environments, exhibiting diverse behaviours and adaptations. Some, like *Theba pisana*, pose agricultural threats, damaging crops significantly (AReservoir son *et al*., 2015). Mollusks, constituting a vast and diverse group, have evolved into various species with distinct feeding preferences, impacting ecosystems differently. The intimate association between mollusks and humans dates back through history, with these creatures serving as food, medicine, and sometimes pests causing financial losses to farms (son *et al*., 2015).

Freshwater snails, constituting 80% of mollusks, play pivotal roles in complex ecological interactions. Besides their ecological significance, they exhibit a range of adaptations, from physiological and metabolic processes to morphological traits (Okafor and Nyange, 2014; Charles *et al*., 2022). However, freshwater snails face a grave threat of extinction, particularly those inhabiting streams and rivers. Over the past 80 years, their diversity and abundance have significantly declined, with over 60 species believed to be extinct. This decline is particularly concerning as certain freshwater snails act as disease vectors to humans and animals, underscoring their critical role in public health (Strayer, 2014; Dogara *et al*., 2020; Charles *et al*., 2022).
Despite the ecological roles of freshwater snails, little is known of its presence and ecology in Bakolori Reservoir of Zamfara State. Hence, this study focused ecological observations of freshwater snails in the vicinity of an artificial lake (Bakolori Reservoir in Zamfara State, Nigeria), which included abundance, distribution and diversity.

MATERIALS AND METHODS

Study Area

Bakolori Reservoir is a manmade lake located in Talata Mafara Local Government Area of Zamfara State, Nigeria. It is located on the longitudes 120°30'43"N and latitude 60°11'0"E (Yahaya, M, K. 2002). Samples were collected from three different points of the lake: Station I (12°23'30''N - 6°10'30''E), where rice cultivation, fish farming, fruit farming and livestock rearing are major human activities; Station II (12°29'0''N - 6°10'30''E), with rice farming, sugarcane farming, fruits farming, cassava farming, and sorghum farming and laundry as major anthropological activities and Station III (12°34'30''N - 6°16'0''E), with sugarcane farming, fishing, sorghum farming, rice farming, cassava farming, rarely fruit farming and laundry as major human activities (Figure 1).

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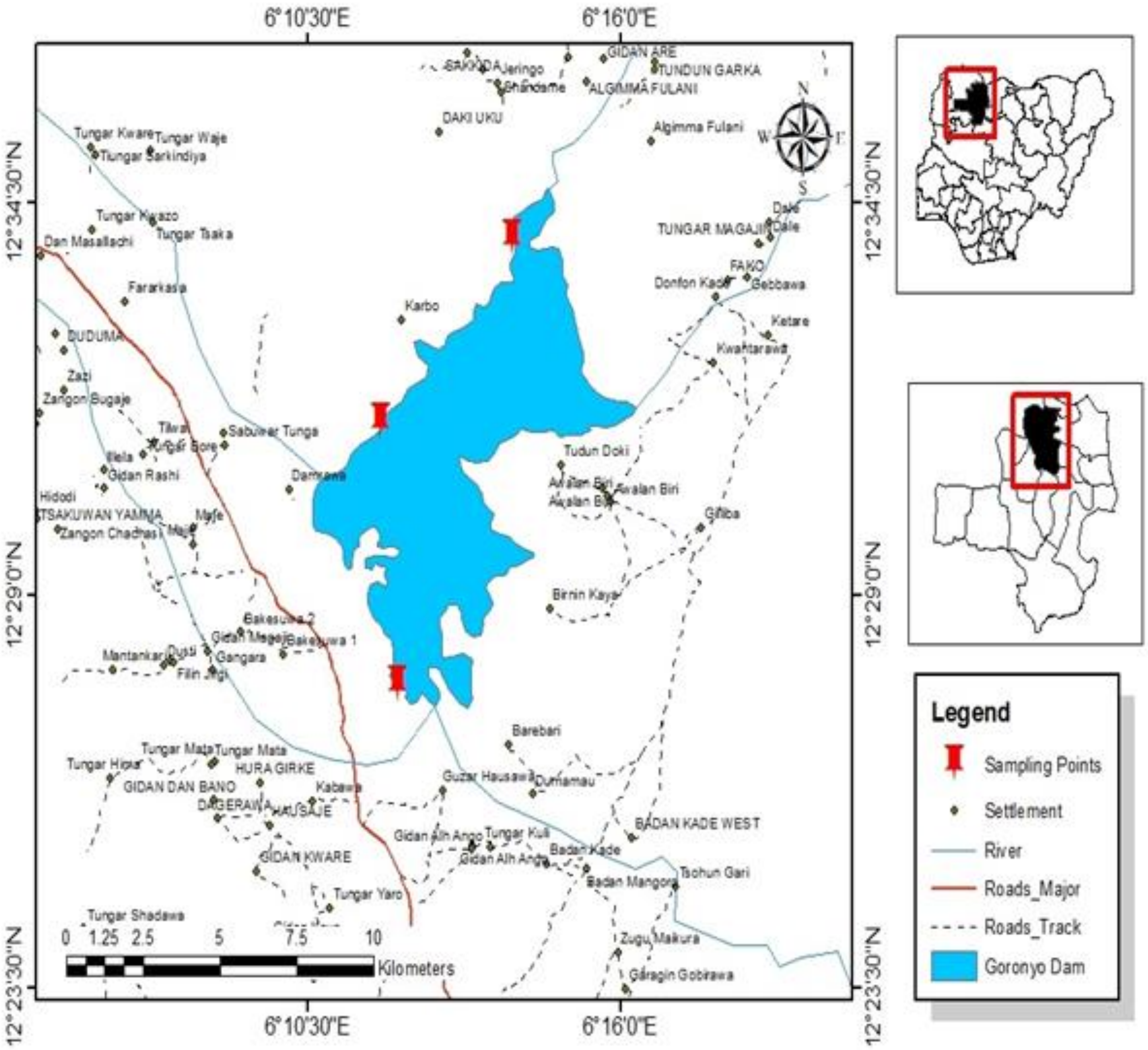

Figure 1. Sampling Points of Freshwater Snails at the Downstream of Bakolori Reservoir

Snail Sample Collection

A cross sectional survey of fresh water Snail samples was conducted by collecting of the snail samples using scoop net and manual picking as described by Alhassan *et al*. (2020). The sample collection had being once every two week (biweekly), for the consecutive four months period between August and November 2023. Three sampling sites were selected around Talata Mafara to Bakura Local Governments Areas, which are the irrigational areas of the Reservoir and some part of the floodplain. The collection had being maintained between 8:00 am to 12: 00pm, around which the snail come out to search for food as adopted by Salawo and Odaibo (2014).

Sample Handling and Preservation

The snails used to be handled in a pre-labelled containers containing wet cotton, then covered with a perforated lid and took to the laboratory where its segregated (based on shell morphology like aperture, broad shell as adopted by Salawo & Odaibo (2014) and also shell color basis (black, white, golden) as adopted by Okon *et al.* (2013).

Study of the Snail Diversity

Shannon-Wiener Index (H') was used as an approach to calculate the snail species diversity indices, adopted from Salawo & Odaibo (2014).

It is the most commonly used index in ecological studies
Values range from 0 to 5, usually ranging from 1.5 to 3.5.
It was calculated as:

$$H' = -\sum\left[\left(\frac{n_i}{N}\right)\times\ln\left(\frac{n_i}{N}\right)\right]$$

Where n_i = number of individuals or amount (e.g. biomass) of each species (the *ith* species) and N = total number of individuals (or amount) for the site, and ln = the natural log of the number.
Similarity Index also used to determine the similarity indices (relative abundance) of the snail species
The values range from 0 to 1 with the higher value suggesting greater similarity (relative abundance)
It' was calculated as:

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$$Sim = \frac{2\sum nc}{\sum n1 + \sum n2}$$

Where *nc* = the common species between sites; *n1*= the species of site 1 and *n2* = species of site 2
When cover is being used, similarity is simply 3 cover in common for each spp.

Species Physical Identification
Phenotypic identification was made based on shell (black & white shell ecotypes) as described by Okon *et al.* (2013) or golden and morphologically (aperture more than half of the body or broad shell as described by Salawo and Odaibo (2014).

Data Analysis
Using Shanon-weiner index and Simpson's similarity index, the variation in snail spp abundance, distribution and diversity was analyzed with respect to the sampling months and three sampling stations (station I, station II and station III) at the downstream of the Reservoir.

RESULTS
The findings on the study on ecological observations of freshwater snails in the vicinity of an artificial lake (Bakolori Reservoir in Zamfara State, Nigeria), which included abundance, distribution and diversity documented a total of 311 freshwater snails representing three distinct species across the study period. In August, *Acathina fulica* dominated with 88 individuals, while *Littorina littorea* recorded no abundance. September saw *A. fulica* again as the most abundant species (29), with *Pomacea bridgesii* at the lowest (20). October and November witnessed a shift, with *L. littorea* being the most abundant (68 and 22, respectively), and *P. bridgesii* reaching its lowest abundance in October. The lowest distributed species throughout the sampling months was *L. littorea* (Table 1).

As presented in Table 2, stations I and II, *A. fulica* exhibiting the highest abundance with 51 and 78 individuals, respectively, while *L. littorea* recorded no abundance in both stations. Station III exclusively hosted *L. littorea* with 116 individuals, making it the least distributed species across the sampling stations (Table 2).

Analysing diversity and similarity indexes, *A. fulica* displayed the lowest diversity in August (0.2359), while *P. bridgesii* showcased the highest (0.3562). In September, *P. bridgesii* had the lowest diversity (0.3502), and *A. fulica* exhibited the highest (0.3679). October saw *L. littorea* with the lowest diversity (0.1537), and *A. fulica* with the highest (0.1777). November witnessed *L. littorea* with the lowest diversity (0.3090) and *P. bridgesii* with the highest (0.3310). The similarity index was lowest in *P. bridgesii* (0.4200) and highest in *A. fulica* (0.8300), as presented in Table 3.

Station-wise, *A. fulica* displayed the lowest diversity in station I (0.2780), while *P. bridgesii* exhibited the highest (0.3670). In station II, *A. fulica* had the lowest diversity (0.2703), and *P. bridgesii* displayed the highest (0.3662), with *L. littorea* recording no diversity in both stations. Station I exclusively hosted *L. littorea* (0.0000). The similarity index was lowest in *P. bridgesii* (0.4244) and highest in *A. fulica* (0.8300), as presented in Table 4.

Table 1. Snail Species Abundance and Distribution from August-November-2023

Snail Species	August	September	October	November
A. fulica	88	29	5	7
P. bridgesii	34	20	4	8
L. littorea	0	26	68	22
Total	**122**	**75**	**77**	**37**
GRAND TOTAL = 311				

Table 2. Snail Species Abundance and Distribution within sampling stations from August-November-2023

Snail spp	Station I	Station II	Station III
A. fulica	51	78	0
P. bridgesii	**27**	39	0
L. littorea	0	0	116
Total	**78**	**77**	**116**
GRAND TOTAL= 311			

Table 3: Shannon-Wiener Index (H') and Similarity index of monthly Snail spp diversity index in Bakolori Reservoir

Snail spp	August	September	October	November	Similarity index
A. fulica	0.2359	0.3679	0.1777	0.3150	0.8300
P. bridgesii	0.3562	0.3502	0.1537	0.3310	0.4200
L. littorea	-	0.3672	0.1099	0.3090	0.7500

Shanon-weiner index range from 0-5, its suggested that, the more indexes move closer to zero, the less diverse and more abundance spp, and vice versa. Simpson similarity index range from 0-1, the more it move closer to 1 the high relative abundance in species, and vice versa.

https://dx.doi.org/10.4314/swj.v19i1.18

Table 4: Snail diversity index across the sampling stations in Bakolori Reservoir

Snail spp	Station I	Station II	Station III	Similarity index
A. fulica	0. 2780	0. 2703	-	0.8300
P. bridgesii	0.3670	0.3662	-	0.4244
L. littorea	-	-	0.0000	0.7460

Shanon-weiner index range from 0-5, its suggested that, the more indexes move closer to zero, the less diverse and more abundance spp, and vice versa. Simpson similarity index range from 0-1, the more it move closer to 1 the high relative abundance in species, and vice versa.

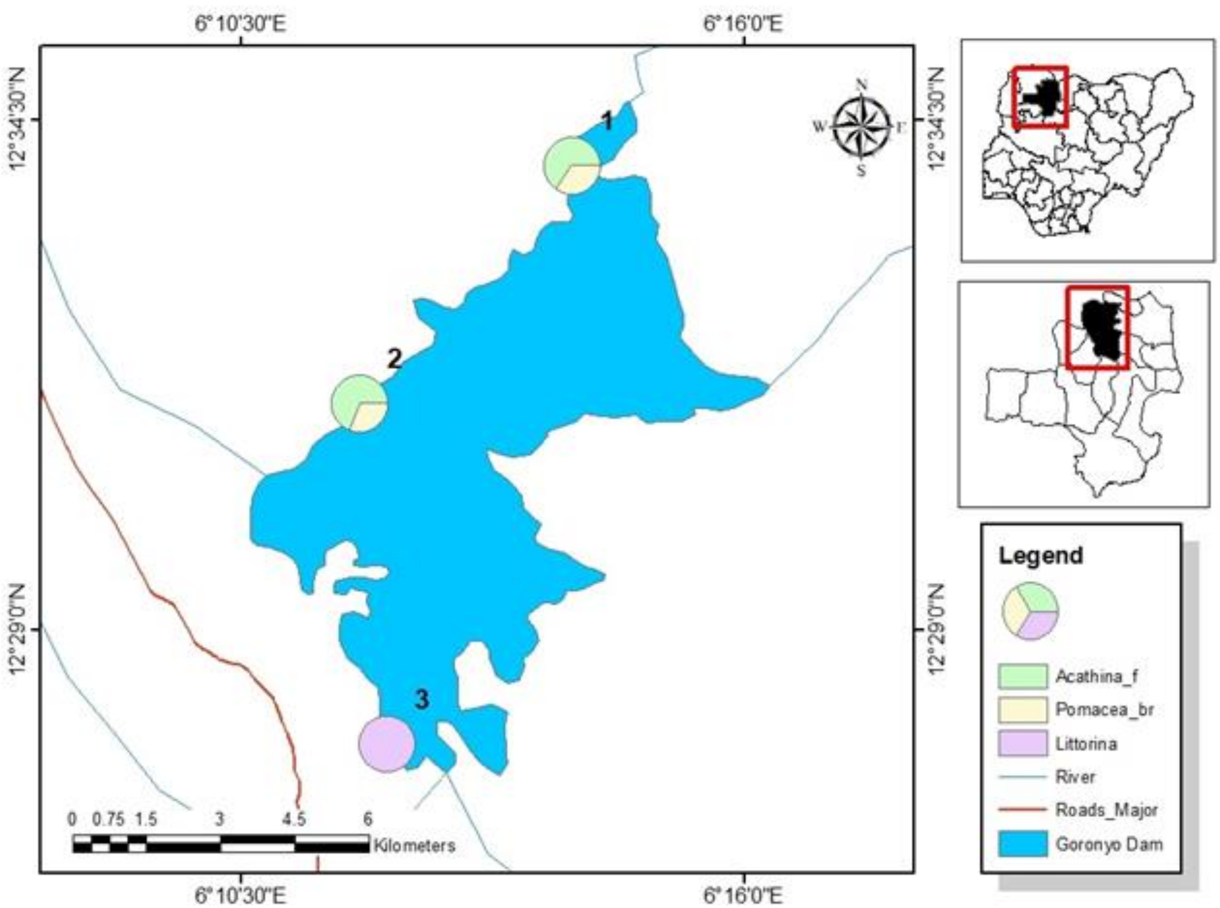

Figure 2. Spatial and Temporal Distribution of Freshwater Snails across the Sampling Stations in Bakolori Reservoir

DISCUSSION

The ecological study conducted around Bakolori Reservoir in Zamfara State, Nigeria, revealed noteworthy findings on the abundance, distribution, and diversity of freshwater snails. A total of 311 snails representing three distinct species were documented during the study period. In August, Acathina fulica dominated the population with 88 individuals, while Littorina littorea showed no recorded abundance. September continued to showcase *A. fulica* as the most abundant species, with *Pomacea bridgesii* being the least abundant (20). However, in October and November, there was a notable shift, with *L. littorea* becoming the most abundant species, while *P. bridgesii* reached its lowest abundance in October.

This study aligns with previous research on freshwater snails in Nigeria and other African countries. The dominance of *Acathina fulica* in the study area is consistent with reports by Okeke *et al.* (2016) in Awka, Nigeria, and Silver *et al.* (2022), who consider *A. fulica* as the most invasive snail species. The coexistence and interaction observed between *P. bridgesii* and *A. fulica* are reminiscent of studies by Dong *et al.* (2011) in China, emphasizing the impact of ecological factors on species composition. The variation in abundance and distribution across different months and sampling stations resonates with the diverse ecological dynamics reported by various researchers in different water bodies across Nigeria, such as Dogara *et al.* (2020), Sanu *et al.* (2020), and Tela and Usman (2021).

Acathina fulica emerged as the most abundant species, with substantial numbers observed in both stations I and II, recording 51 and 78 individuals, respectively. This finding suggests that *A. fulica* thrived in these specific environments. Contrastingly, station III exhibited a distinct pattern, exclusively hosting *Littorina littorea* with a substantial count of 116 individuals. This highlights a localized prevalence of *L. littorea* in station III compared to the other two stations. Notably, *L. littorea* was absent in stations I and II during the study period. This distribution pattern could be attributed to variations in environmental conditions, habitat preferences, or ecological interactions among snail species. The exclusive presence of *L. littorea* in station III may be influenced by specific factors unique to that location.

Comparing these findings with previous studies, it's essential to note that snail distribution is highly influenced by environmental variables. Similarly, previous studies have reported similar patterns of dominance and exclusivity among freshwater snail species such as Abdulkareem *et al.* (2013), Amawulu and Assumpta (2021), Vexinath, *A.* (2022), Ibrahim *et al.* (2023), Tadena, *E.* (2023) and Danjuma *et al.* (2023). These variations underscore the complex interplay of ecological factors shaping snail communities in different aquatic environments. Further research and comparative analyses could provide deeper insights into the mechanisms influencing these distribution patterns.

The diversity and similarity indexes provided valuable insights into the ecological dynamics of freshwater snails in the Bakolori Reservoir. The observed variations in diversity and similarity among different species and sampling stations contribute to our understanding of the complex interactions within this ecosystem.
In August, *A. fulica* exhibited the lowest diversity, while *P. bridgesii* displayed the highest diversity. This trend shifted in September, with *A. fulica* showcasing the highest diversity, and *P. bridgesii* presenting the lowest. The subsequent months, October and November, continued to reveal fluctuations, with *L. littorea* and *P. bridgesii* alternating as the least and most diversified species. These variations might be attributed to seasonal changes, habitat preferences, or competitive interactions. The similarity index reinforced these findings, indicating a lower similarity in *P. bridgesii* and a higher similarity in *A. fulica.* This suggests that *P. bridgesii* differs more significantly from the other species, while *A. fulica* demonstrates a greater degree of similarity.

Comparing these results with existing literature, reports from other tropical regions reported similar dynamics in freshwater snail communities such as Auta *et al.* (2018), Atsuwe *et al.* (2019), Ronakl and Ogorode (2021), Amawulu and Asumpta (2021) and Obisike *et al.* (2022) . The variations in diversity and similarity observed in this study align with the complexity of snail ecology, emphasizing the need for context-specific investigations.
However, it's important to note that this study brings unique insights into the specific ecological conditions of Bakolori Reservoir, contributing valuable data to the broader understanding of freshwater snail populations in the region. Future research could further explore the factors influencing these variations and their implications for the overall aquatic ecosystem.

Conclusions

This investigation has unveiled that the snail types identified in the Bakolori Reservoir throughout the research duration included *A. fulica*, *P. bridgesii*, and *L. littorea*. *A. fulica* emerged as the most plentiful species, while *P. bridgesii* exhibited a lower abundance. In terms of distribution and diversity, *P. bridgesii* emerged as the most widespread and varied species, whereas *L. littorea* was the least distributed and diversified. Comparatively, these findings contribute valuable insights into the ecological dynamics of freshwater snail communities in artificial lake, showcasing variability in abundance, distribution, and diversity across both temporal and spatial scales. However, further studies are warranted to explore the factors influencing these variations and their potential ecological implications. The results are also notable for their deviation from previous studies in other regions, emphasizing the need for region-specific ecological assessments.

Acknowledgment

The authors acknowledge all those who contributed in one way or the other in making this research work a success.

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