

# A Survey of the Distribution and Abundance of Snail Vectors in Selected Areas of Rivers State, Nigeria

Akpan, Christiana Maxwell (M.Sc.), G. D. B. Awi-waadu (Ph.D)

Department of Animal and Environmental Biology, University of Port Harcourt

DOI: <https://doi.org/10.51584/IJRIAS.2026.11010080>

Received: 25 January 2026; Accepted: 30 January 2026; Published: 09 February 2026

## ABSTRACT

Freshwater snails have been reported to act as vectors of parasitic infections, causing hardship to infected persons. Surveying the distribution and abundance of snail vectors of parasites in selected areas of Rivers State, Nigeria was assessed in three study sites; Odau, Mbiama and Akinima respectively. Field work was conducted once a month for three consecutive months from June to August 2024. A scoop net and handpicking method was used for snail collection and water samples were collected also for physico-chemical parameter analysis. Physico-chemical parameters analyzed were; temperature, dissolved oxygen (DO), pH, total dissolved solids (TDS), biological oxygen demand (BOD, conductivity and water salinity using standard methods. A total of 539(78.34%), 109(15.84%) and 40(5.81%) snails were gotten from Odau, Mbiama and Akinima respectively. Thus a total of 688 freshwater and land snails made up of *Pila ovata*, *Bulinus forskali*, *Archachatina marginata* and *Limicolaria* spp. comprising 514 (74.71%), 135(19.62%), 27(3.92 %) and 12(1.74%) were collected respectively during the study in the three locations. The data analyzed showed that water physico-chemical parameters recorded skewed impact on the abundance of snails. The study areas had a high abundance of freshwater snails, and may be at risk of an outbreak of snail-borne parasitic diseases. Odau had the highest in terms of abundance and species diversity than other locations. The physico-chemical parameters indicated different relationships with snail abundance.

**Keywords:** Distribution, Abundance, Snail vectors, Physico-chemical parameters

## INTRODUCTION

### Background to the Study

Snails are fascinating creatures that have captured the curiosity of humans for centuries. These small, slow-moving creatures belonging to the class Gastropoda are found in diverse habitats worldwide, including terrestrial, freshwater, and marine environments. With their unique anatomy, behavior, and ecological significance, snails have become subjects of study in various scientific disciplines, including biology, ecology, and paleontology.

The distribution and abundance of snail populations can be influenced by temperature, oxygen availability, food supply, predators, parasites, rainfall and water composition. Sunlight, flowering aquatic weeds, abundance of micro-flora and high dissolved oxygen also contribute to the abundance of freshwater snails (Hosea et al., 1998). Snail abundance, distribution and density vary significantly with season (WHO, 1993).

Biotic factors such as availability and density of aquatic macrophytes have also been reported to play vital roles in the distribution of freshwater snails in different parts of Africa (Ofoezie, 1999). Physico-chemical factors of the water body that are considered as most important factors in the aquatic environment particularly for freshwater snails are temperature, pH, turbidity, dissolved oxygen, calcium, magnesium and phosphate (Abbasi et al., 2011).

Trematodes exhibit apparent and marked relationship to temperature in their developmental stages and transmission cycle (Miller, 2007). Over-abstraction of water, pollution, eutrophication, damming of rivers and

streams, anthropization, urbanization and industrialization are some of the human activities threatening the existence of many ecosystems. This has affected the physico-chemical parameters of the water bodies thereby affecting the presence and intensity of these snail vectors (Gabriel et al., 2014). Their reproductive capacity is high, the abundance and distribution of these snails show marked seasonal variation in infection rate and density with rainfall and temperature being the most determining factors. Control of most snail borne diseases in the sub-Saharan Africa has been based on chemotherapy and use of molluscicides, but this have failed over the years as transmission continues to spread (Nagi et al., 2014). Prevention of infection remains the best option and this is only achievable by snail control (Mkoji et al., 2014) and snail control is best achieved when the ecology and distribution of snail vectors are known. This study evaluated the abundance and distribution of snail vectors of public health importance in selected areas of Rivers State, the key physico-chemical parameters that affects their distribution, abundance and also provide information that will help initiate an effective snail vector control programme.

## MATERIALS AND METHOD

### Study Area

This research was carried out in three communities which includes; Oda, Mbiama and Akinima. Oda also known as Odua is a populous and nucleated community located in Rivers State, Nigeria, with an estimated terrain elevation of 10 meters above sea level. It is situated at Latitude: 4°54'16.404"N and Longitude: 6°26'25.566"E, within the Abua/Odual Local Government Area of Rivers state. Most families engage in subsistence farming and freshwater fishing, relying on various ponds and streams for their water-related activities. The community lacks a well-developed road network, making it difficult for residents to move out of the community or transport their farm produce to markets. The absence of latrines in the village exposes the inhabitants to a high risk of parasitic infections, as urination and defecation often occur in the surrounding bushes and gutters. Oda is surrounded by swamps, which further enable the survival of aquatic life. These environmental and socio-economic factors contribute to the high prevalence of parasitic infections, such as urinary schistosomiasis, among the inhabitants of Oda. The presence of suitable habitats for freshwater snails, which act as intermediate hosts for parasites, coupled with the lack of proper sanitary facilities, increases the risk of disease transmission within the community. Understanding the geographical, demographic, and environmental characteristics of Oda is crucial for developing targeted interventions to address the health challenges faced by the community and promote sustainable development in the region. The sites visited in Oda included:

- i. Oboogu (Burrow pit)
- ii. Oda health center road (stagnant water)
- iii. Obaghini (swamp)
- iv. Edemawum (pond)
- v. Oda health center (gutter)
- vi. Eboom Obedum (gutter)
- vii. Oda main road (gutter)

Mbiama is a town in Ahoada Local Government Area, Rivers State. It is situated at Latitude: 5°02'04.7"N and Longitude: 6°27'11.3"E. In Mbiama, the sites visited includes;

- i. Adivilla (water canal)
- ii. Beside Model Health center (water canal)

Akinima is a town in the region of Ahoada West Local Government Area in Rivers State, Nigeria. Akinima is the headquarter of Ahoada West, and in the north western part of Rivers State with a Latitude: 5°05'34.2"N and

Longitude: 6°28'21.3"E, according to ("Ahoada West LGA". www.finelib.com. Retrieved 2023-04-30.). Below is the map indicating the different study areas;

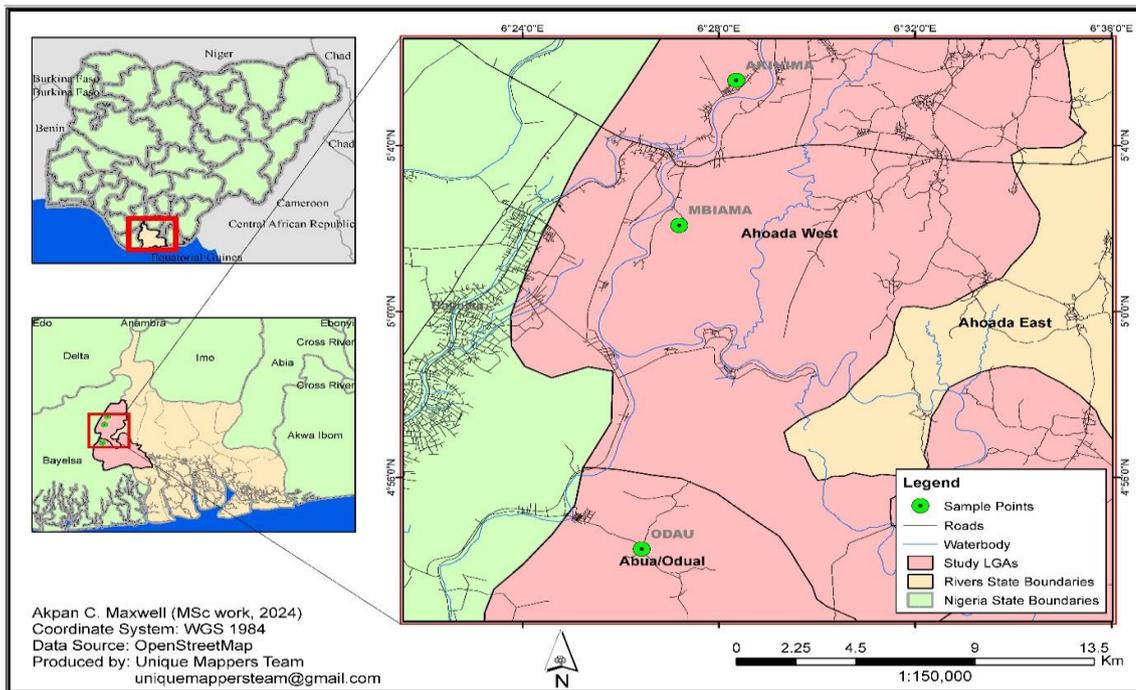


Figure 3.1.: Showing a map of, (i) Nigeria where my sample areas are found, (ii) an extraction indicating the study areas, (iii) Study areas, Abua/Odua and Ahoada West LGAs (Mbiama and Akinima) shown distinctively and clearly

### Sampling Techniques

The collection of snails was conducted systematically across various sites, with each location being visited in the morning, starting at 10 AM. The collection process lasted for 45 minutes at each site, utilizing a specialized scoop net designed for effective harvesting.

The scoop net employed for this task had a diameter of 18 cm and was supported by a sturdy frame mounted on a long handle. This design allowed for efficient maneuvering under the water's surface. The technique involved pulling the net beneath the substratum, which facilitated the collection of snails that were clinging to aquatic plants, embedded in mud, or floating on the water's surface.

In certain areas where the scoop net was impractical particularly in shallow, stagnant waters where snails were visible from the surface, alternative methods were utilized. Manual searches were conducted through visual inspection, and hand-picking was employed to gather snails. To ensure safety and minimize the risk of infection, all personnel involved wore a pair of hand gloves and safety boots during the collection process.

All snails collected from each site were carefully placed into containers equipped with perforated lids to allow for ventilation. Each container was clearly labeled with the corresponding sampling location to maintain organization and traceability. The collected specimens were then transported to the Animal and Environmental Biology laboratory at the University of Port Harcourt for further analysis.

Upon arrival at the laboratory, the snail population from each site was recorded meticulously. The counting process was conducted at the species level, following the methodology established by Abe et al., (2017). This detailed approach ensured accurate data collection and contributed to a comprehensive understanding of the snail populations across the sampled locations.



Figure 3.2. Picture of a Scoop Net

### **Sample collection**

Snail samples were systematically collected from seven distinct locations in Odau and two locations in Mbiama and one site in Akinima, which included a variety of aquatic environments such as ponds, swamps, burrow pits, earthen gutters, and stagnant waters. This comprehensive sampling effort took place within the period June to August 2024. Each site was visited three times during this timeframe to ensure a robust dataset and to account for any temporal variations in snail populations.

During each visit, detailed observations were made regarding the nature of the substratum at each collection site. The substratum types recorded included rocky, sandy, and muddy compositions. This information is crucial as it can influence the habitat suitability for different snail species. Additionally, various physico-chemical parameters of the water were measured and documented, providing insights into the environmental conditions that may affect snail distribution and abundance.

The fresh water snails collected from these locations were carefully transported in wide-mouth plastic containers. This type of container was chosen to minimize stress on the snails during transit while allowing for adequate ventilation. Upon arrival at the Animal and Environmental Biology laboratory at the University of Port Harcourt, the samples were prepared for counting and identification.

### **Water Sample Analysis**

In conjunction with the snail collection, water samples were also collected from each site. These samples were analyzed in the laboratory to assess the physical and chemical parameters of the water. Understanding these parameters is essential for evaluating the environmental conditions that support snail survival and proliferation. This dual approach of collecting both snails and water samples provides a comprehensive understanding of the ecological dynamics at play in the habitats studied. By integrating the data on substratum types, weather conditions, and water quality, researchers can gain valuable insights into the factors influencing snail populations, ultimately contributing to broader ecological assessments and conservation efforts.

### **Methods of Data Collection**

Data collection in the field was conducted through a thorough survey, search, and observation of water bodies to obtain snail samples. Examination of various water bodies, such as swamps, burrow pits, gutters, and ponds, to locate and collect the necessary snail specimens was carried out in this study.

Measurement of physico-chemical parameters was carried out in the Department of Animal and Environmental Biology laboratory. The following parameters were determined:

1. Water temperature
2. Dissolved oxygen (DO)

3. pH
4. Total dissolved solids (TDS)
5. Biological oxygen demand (BOD)
6. Conductivity
7. Water salinity

These parameters were measured using an electronic combined meter, which provided accurate and reliable readings. The meter was capable of simultaneously measuring multiple parameters, ensuring consistency and efficiency in data collection. Additionally, dissolved oxygen (DO) was determined using a dedicated DO meter. This specialized instrument was used to measure the amount of oxygen dissolved in the water samples, which is a crucial factor in aquatic ecosystems. By conducting thorough field work and precise laboratory analysis, it was easy to be able to gather a comprehensive data on the snail samples and their associated water quality parameters. This information is essential for understanding the ecological relationships and environmental conditions that influence the distribution and abundance of snail populations in the studied water bodies.

### Identification of snail specimens

Freshwater snails were identified to species in the laboratory using identification of the conchological society of Great Britain with the assistance of an experienced technologist. The Snail was positioned with apex pointing upward. The direction of the shell opening below the body whorl was used as an identification marker. Other shell components considered during identification include: number of whorls, shape of shell, type of apex (pointed or blunt) and shape of peristome on the aperture using standard keys, Christensen (1993) and Brown (1994).

### Methods of Data Analysis

Results were expressed as mean and  $\pm$  SD for continuous variables and percentage (%) for categorical variables. One-way Analysis of variance (ANOVA) was used to compare mean abundance of snails within snail species. The correlation coefficient was calculated to determine the relationship between snail abundance and physicochemical parameters, and also the relationship between snail species. The  $P < 0.05$  was considered statistically significant. Statistical Package for Social Sciences (SPSS) software for windows (version 2023) was used for the analysis.

### Ethical Approval

Before the commencement of this study, Informed consent was duly gotten from the University of Port Harcourt Ethical Committee. Additionally, the leaders of the community were properly informed.

## RESULT AND DISCUSSION

### Overall species of Snail vectors identified in the Study Areas

A total of 688 snail vectors belonging to three (3) families and four (4) species were identified and recorded during the sampling. The families include the following; Achatinidae, Ampullaridae, Planorbidae.

The species in this families include the following;

1. Family Achatinidae, species *Pila ovata* and *Archachatina marginata*;
2. Family Planorbidae, specie *Bulinus forskali*;
3. Family Ampullaridae, *Limicolaria* spp.

### Overall abundance of snail vectors in the study areas

A total number of six hundred and eighty-eight (688) snail vectors were recorded as abundant in the study areas. The relative abundance of the four species identified included; *Pila ovata*, 514, *Bulinus forskali*, 135, *Archachatina marginata* 27 and *Limicolaria* spp. 12.

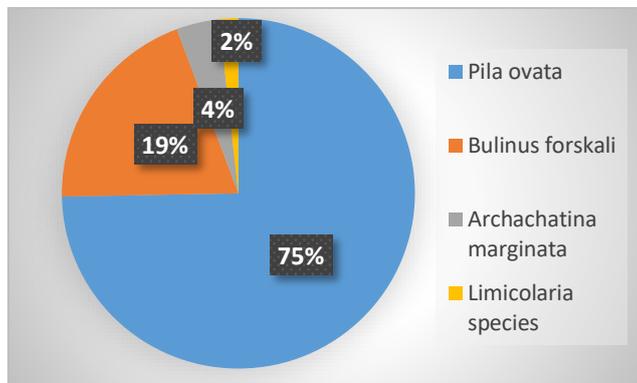


Fig 4.2 shows the relative percentage abundance of the species as *Pila ovata* 514 (74.71%), *Bulinus forskali*, 135(19.62%), *Archachatina marginata* 27(3.93%) and *Limicolaria* spp 12(1.74%).

### Relative abundance of individual species of snail vectors in the different study locations

*Pila ovata* recorded the highest abundance in the study area with a percentage abundance of 74.71%, observed more in the gutters close to the Health center with a relative abundance of 18.87%, followed by Edemawum, 90(17.51%), while the least abundance was recorded in Akinima with a relative abundance of 9(1.75).

*B. forskali* recorded the highest percentage in Mbiama with a relative abundance of 84(62.22%), followed by Akinima with the relative abundance of 28(20.74) while the least was recorded in the Health center road with a relative abundance of 23(17.04)

*A. marginata* was recorded in three locations, health center gutters, Oboogu and health center road with a relative abundance of 12(44.44%), 10(37.04%) and 5(18.52%) respectively.

*Limicolaria* spp. had the least overall percentage abundance of 12(1.74%), it was recorded in Oboogu, Akinima, Main Road and Mbiama with a relative abundance of 7(58.33%), 3(25%), 1(8.33%) and 1(8.33%) respectively.

The highest population of snail vectors was found in Mbiama with 129(18.75%), followed by health center gutters, with 109 snail vectors, making up 15.84% of the overall snail population. This was followed by Edemawum, 90(13.08%), and Main road with 88(12.79%), while Obaghini recorded the least, 13(1.89%) as shown in Table 4.3.

Table 4.3. Relative abundance of individual species of snail vectors in the different study locations

Locations	<i>B. forskali</i> (%)	<i>P. ovata</i> (%)	<i>A. mar-ginata</i> (%)	<i>Limi-colaria</i> spp. (%)	Total (%)
Eboom-Obedum	0(0)	77(14.98)	0(0)	0(0)	77(11.19)
Edem-awum	0(0)	90(17.51)	0(0)	0(0)	90(13.08)
Obaghini	0(0)	13(2.58)	0(0)	0(0)	13(1.89)
H/center gutters	0(0)	97(18.87)	12(44.44)	0(0)	109(15.84)
Oboogu	0(0)	39(7.59)	10(37.04)	7(58.33)	56(8.14)

<b>Main road</b>	<b>0(0)</b>	<b>87(16.93)</b>	<b>0(0)</b>	<b>1(8.33)</b>	<b>88(12.79)</b>
<b>H/center road</b>	<b>23(17.04)</b>	<b>58(11.28)</b>	<b>5(18.52)</b>	<b>0(0)</b>	<b>86(12.5)</b>
<b>Mbiama</b>	<b>84(62.22)</b>	<b>44(8.56)</b>	<b>0(0)</b>	<b>1(8.33)</b>	<b>129(18.75)</b>
<b>Akinima</b>	<b>28(20.74)</b>	<b>9(1.75)</b>	<b>0(0)</b>	<b>3(25)</b>	<b>40(5.81)</b>
<b>Total</b>	<b>135(19.62)</b>	<b>514(74.71)</b>	<b>27(3.92)</b>	<b>12(1.74)</b>	<b>688</b>

**Effects of physico-chemical parameters on snail abundance in June**

In the month of June, the effect of physico-chemical parameters on snail abundance in Odau showed that BOD recorded a positive linear relationship with snail abundance with an equation of  $(y = 12.869x + 8.845)$ . With a coefficient of determination of 0.4696, it means that BOD accounted for 46.96% of the variation in abundance (figure 4.4a). Also, TDS  $(y = 0.5696x + 1.8607)$ , temperature  $(y = 17.105x - 461.63)$ , salinity  $(y = 0.5827x + 1.1516)$  and electrical conductivity  $(y = 0.2314x + 8.6896)$  recorded positive relationships with snail abundance (figure 4.4b)

On the other hand, pH and DO recorded negative relationships with snail abundance with linear equations of  $y = -9.3616x + 78.058$  and  $y = -0.6533x + 25.27$  respectively (figure 4.4a).

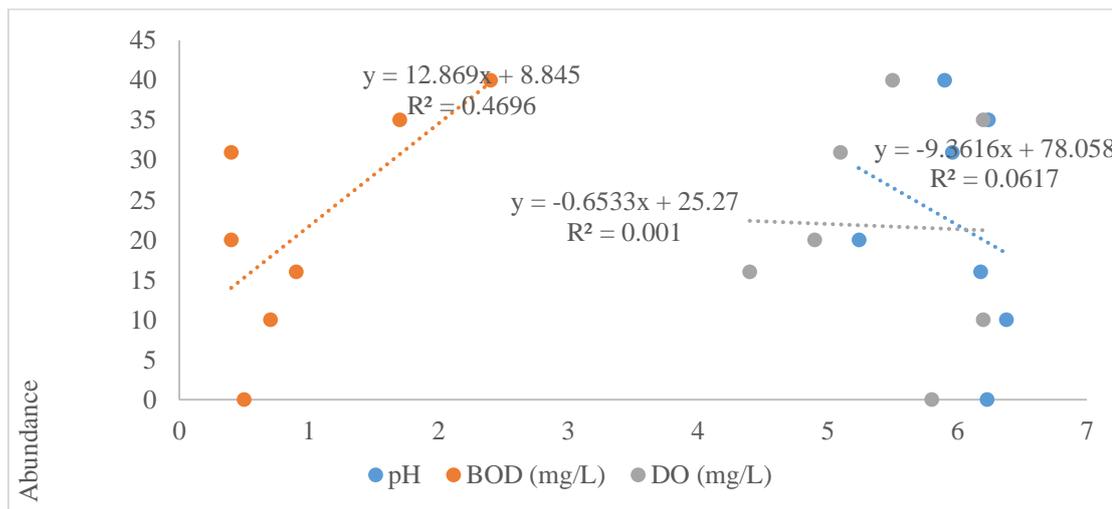


Figure 4.4a. Shows the effects of pH, BOD and DO on the abundance of fresh water snails.

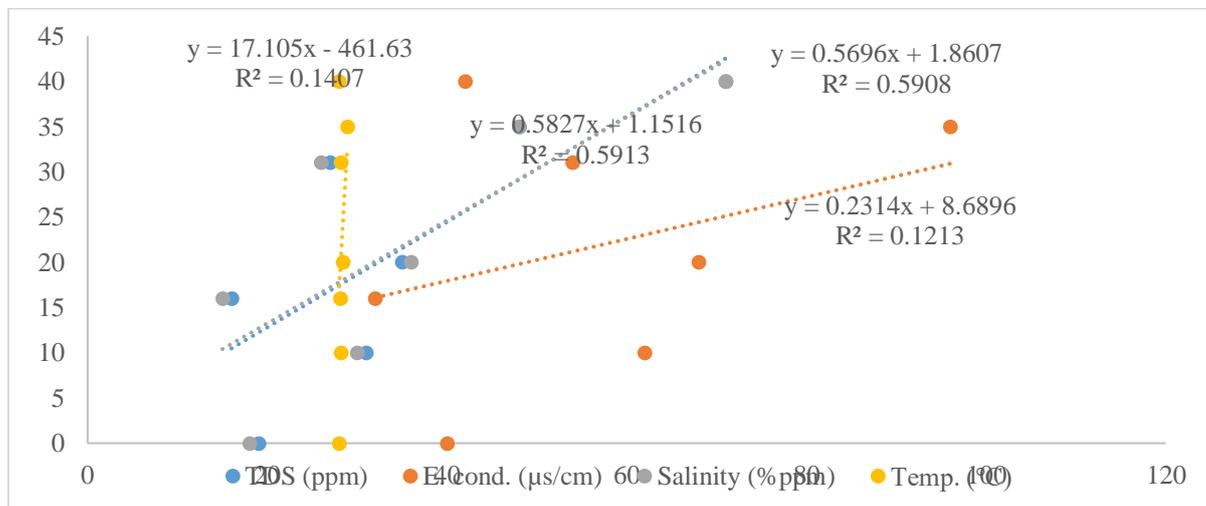


Figure 4.4b. Shows the effects of TDS, conductivity, salinity and temperature on the abundance of fresh water snails

### Effects of physico-chemical parameters on snail abundance in August

In the month of August, the effect of pH on the abundance of fresh water snails indicated a negative correlation, as demonstrated by the equation  $y = -11.551x + 110.5$ . This downward slope suggests that as pH increases, the abundance of the snail decreases. The R<sup>2</sup> value of 0.0541 indicates a very weak correlation between pH and abundance as shown in figure 4.5a.

BOD recorded a positive linear relationship with snail abundance, with a trend line equation,  $y = 3.9678x + 21.387$ , implying that as BOD increases, so does snail abundance. However, with an R<sup>2</sup> value of 0.0484, this correlation is also weak.

DO recorded a positive linear correlation with snail abundance with a linear equation  $y = 0.3378x + 23.421$ . The R<sup>2</sup> value of 0.0005 reveals an extremely weak correlation (figure 4.5a)

TDS, conductivity, and salinity recorded positive linear relationship with snail abundance with linear equations of  $y = 0.2081x + 15.189$ ,  $y = 0.1014x + 15.387$  and  $y = 0.6048x + 32.301$  respectively; while temperature recorded a negative linear relationship with abundance ( $y = -132.46x + 3545.7$ ) (figure 4.5b).

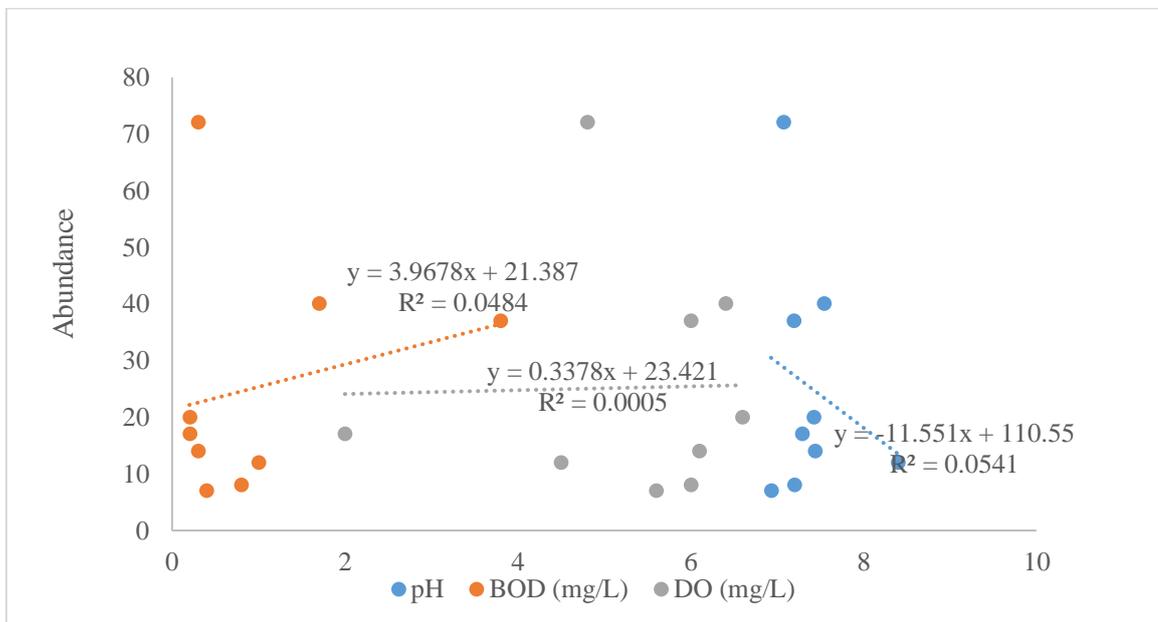


Figure 4.5a. Effects of pH, BOD and DO on snail abundance in August.

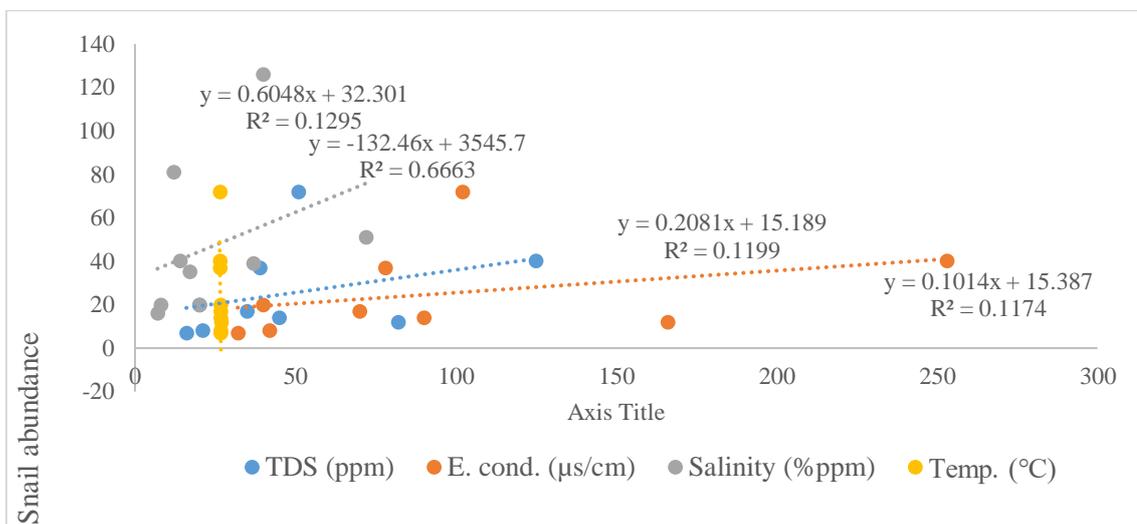


Figure 4.5b Effects of TDS, conductivity, salinity and temperature on snail abundance in August

## DISCUSSION OF FINDINGS

In the present study, the distribution of freshwater snails revealed that *Pila ovata* dominated the snail population, making up 74.71% of the total abundance across the three locations. This is consistent with other research in West Africa, such as Adewale et al., (2016), who found *Pila ovata* to be the most dominant species in southwestern Nigeria's freshwater bodies. Similarly, in studies conducted in Ghana by Mensah et al., (2021), *Pila ovata* was also the predominant species in freshwater systems, contributing to over 70% of the total snail population. This recurring dominance across regions suggests that *Pila ovata* thrives in varied environmental conditions in the African continent. *Achatina marginata* is recorded exclusively at the Odau site, making up 3.92% of the total abundance, a result that resonates with Chukwuka et al., (2020) findings in the Niger Delta region. Their study also reported that *Achatina marginata* was relatively scarce, with a presence below 5%. This could indicate that while *A. marginata* is present in various freshwater ecosystems, it tends to occupy specific niches, which could account for its limited distribution in most studies. *Limicolaria* spp. and *Bulinus forskali* are less abundant in the present study, accounting for 1.74% and 19.62% of the total population, respectively. These results can be compared to Kareem and Adelowo (2019), who found *Limicolaria* spp. to be sensitive to environmental changes, thus exhibiting limited abundance in environments with significant pollution or human impact. Similarly, Ochieng et al. (2017) reported that *Bulinus forskali* is widespread across Kenyan freshwater systems, though its population density fluctuates depending on environmental factors such as temperature, pH, and oxygen levels. The moderate abundance of *B. forskali* in this study (19.62%) is comparable to Ochieng's findings, where *B. forskali* accounted for 21% of the snail population.

In terms of location-specific differences, the table highlights that the Odau location had the highest total abundance of snails (78.34%), followed by Mbiama (15.84%) and Akinima (5.81%). These discrepancies can be attributed to local environmental factors. For example, studies by Adewale et al. (2016) suggest that sites with more vegetation cover, less pollution, and adequate water quality tend to harbor larger snail populations. Conversely, areas with higher human activities, pollution, or disturbed ecosystems often support lower snail populations, which might explain the reduced snail abundance in Akinima.

Furthermore, Chukwuka et al. (2020) also emphasized that the proximity of water bodies to agricultural or industrial areas could negatively impact snail populations due to runoff contamination, reduced oxygen levels, and habitat destruction. This is consistent with the lower abundance of snails observed in Akinima.

Recent studies have shown similar trends regarding the influence of water quality parameters on freshwater mollusks. Thorp and Rogers (2015) explored how environmental stressors, including pH, BOD, and DO, affect aquatic invertebrate populations, and their findings align with the moderate positive correlation between BOD and snail abundance in this graph. They noted that BOD levels often reflect organic pollution, which provides food sources for snails. The increase in organic matter can lead to greater availability of nutrients, allowing snail populations to thrive. Similar results were found by Kalyoncu et al. (2018), where elevated BOD levels in freshwater ecosystems were linked to higher densities of snails due to an increase in detritus, on which snails feed.

The inverse relationship between DO and snail abundance is also supported by other research. For instance, Bott et al. (2016) found that while snails can tolerate lower oxygen levels, prolonged periods of low DO can limit their survival, leading to fluctuating populations. High DO levels are often associated with clearer waters and lower organic material, which reduces food availability for snails, explaining the negative correlation seen in the graph.

As for pH, the weak correlation observed in the figure is consistent with recent literature. Kumar et al. (2017) examined freshwater ecosystems and noted that pH has limited direct effects on snail populations unless it falls into extreme ranges. Most freshwater snail species are resilient to a wide range of pH levels, as supported by Palmer and Calderon (2019), who found that pH levels between 6 and 8 are generally well-tolerated by freshwater snails, with little impact on their population densities unless the pH becomes highly acidic or basic.

In a related study, Hofmann et al. (2014) found that snail abundance is more strongly influenced by nutrient availability and organic pollutants than by pH levels, which further supports the findings in this graph. While

snails are sensitive to very low or high pH, within normal freshwater ranges, their population is primarily driven by food availability (as reflected by BOD) and water quality conditions.

In the present study, TDS recorded a positive relationship with snail abundance. This suggests that as TDS increases, there is a slight increase in snail abundance. Studies such as those by Eriksen et al. (2015) have reported similar findings, where the TDS levels in freshwater ecosystems influence the distribution of snails, as higher concentrations of dissolved solids can promote certain algae growth, providing a food source for snails. However, beyond a certain threshold, elevated TDS levels may become detrimental, which aligns with the relatively low R<sup>2</sup> value, indicating that other factors may also significantly contribute to snail abundance.

Salinity showed a moderate positive relationship with snail abundance. Burke et al. (2017) similarly observed that while many freshwater snails can tolerate low levels of salinity, increased salinity can either support or reduce their population depending on species-specific tolerances. However, in environments where the salinity surpasses tolerance limits, snail abundance significantly declines.

Freshwater ecosystems host a variety of organisms, including snails, whose abundance and distribution are influenced by a complex interplay of environmental factors. Electrical conductivity (EC) is one such factor, representing the ability of water to conduct electricity. Electrical conductivity is primarily determined by the concentration of ions in water, which come from dissolved salts, minerals, and organic matter. In freshwater systems, conductivity levels tend to vary depending on natural sources like weathering rocks, and human activities, such as agricultural runoff or urban pollution. Nath et al. (2016) explained that moderate levels of conductivity are essential for sustaining aquatic life since many freshwater species, including snails, require a certain level of dissolved minerals to maintain their physiological functions. The positive relationship between electrical conductivity and snail abundance in the present study could be due to the fact that freshwater snails, like other mollusc, rely on dissolved minerals, such as calcium, for building their shells and maintaining physiological processes. Smith and Jones (2017) found that in regions with moderate electrical conductivity, there is a higher concentration of essential ions like calcium, which supports shell growth and repair. This availability of necessary nutrients can increase the reproductive success of snails and subsequently lead to higher population densities. Furthermore, the presence of these ions can enhance the growth of algae, a primary food source for many snail species, thus creating favorable conditions for their survival and proliferation (Burke et al., 2017; O'Connor et al., 2018; Gonçalves et al., 2019)

Temperature is a critical environmental factor that affects the abundance and distribution of freshwater snails. In the present study, temperature recorded a negative relationship with the snail abundance, causing snail population to decrease as it increases. As temperatures rise, the metabolic rates of freshwater snail increase, which can lead to higher energy demands. Eriksen et al. (2016) found that at elevated temperatures, snails need more food to sustain their metabolic functions. However, if the food supply remains constant or declines, snails can experience stress, reduced growth, and lower reproductive rates, ultimately leading to a decrease in population size. Smith and Jones. (2017) also highlighted that higher temperatures can reduce the availability of calcium in the water, an essential element for shell formation. As a result, snails face difficulties in maintaining their shells, making them more vulnerable to predation and environmental stressors. Additionally, warmer waters tend to have lower oxygen levels, which can be detrimental to many freshwater organisms, including snails. Deguenon et al. (2020) reported that low oxygen levels associated with increased temperatures can lead to hypoxic conditions, causing snail mortality. Furthermore, O'Connor et al. (2018) found that higher temperatures can promote the growth of harmful algal blooms, which can release toxins that negatively affect snail populations

## CONCLUSION

The study area has a high abundance of freshwater snails, and may be at risk of an outbreak of snail-borne parasitic diseases. Odau has a higher abundance and species diversity than other locations. The physico-chemical parameters indicated different relationships with snail abundance.

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