Freshwater Gastropoda in Diyala River: A Study on Diversity, Distribution, and Environmental Variation

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Abstract: This field study investigated the diversity, spatiotemporal distribution, and environmental relations of freshwater gastropods in the Diyala River (Iraq). Monthly surveys were conducted from September 2024 to March 2025 at three stream sites (Mahroot, Al-Saria, Rose), recording gastropod densities and water quality variables (temperature, pH, dissolved oxygen, and electrical conductivity). Six gastropod species were identified: *Physa acuta*, *Melanopsis costata*, *Theodoxus jordani*, *Melanoides tuberculata*, *Bellamya bengalensis*, and *Lymnaea* sp., with species richness varying from 4 to 6 across sites. The most abundant taxa were *Melanoides tuberculata* and *Bellamya bengalensis*. In contrast, *Melanopsis costata* and *Theodoxus jordani* were exclusive to Al-Saria in late winter. Community structure changed seasonally, with *Melanoides tuberculata* peaking in autumn and *Bellamya bengalensis*, *Lymnaea* sp., and *Physa acuta* increasing in winter. Temperature ranged from ~29°C to ~9°C, with slight changes in pH (7.2–8.8), dissolved oxygen (6.3–8.8 mg/L), and conductivity (520–680 µS/cm). Results highlight the value of combining seasonal biological surveys with physico-chemical monitoring for biodiversity conservation and biomonitoring.

1 INTRODUCTION

The phylum Mollusca is considered one of the most important phyla belonging to invertebrate animals. Generally, the animals of this phylum are characterized by their soft, unsegmented bodies and a calcareous shell (shell) consisting of a head, foot, visceral mass, and mantle [1]. The phylum Mollusca, in terms of the number of described species, is one of the largest and most common groups, ranking second after Arthropoda and Vertebrates [2]. Mollusks are highly heterogeneous in terms of size, shape, and adaptation to various environments (terrestrial, marine, aquatic), except for air, nutrition, and behavior, in addition to the significant radiation exposure this phylum experienced during the Cambrian period [3] and others. Mollusks have a high adaptability, as they can be found in almost all types of water bodies and are present in (Stygobiont) animals (for example, animals that live in water-saturated caves). In many natural water bodies, the class Gastropoda is considered one of the most important classes belonging to the phylum Mollusca, as it includes more than 25,000 genera and groups such as snails, clams, and bivalves. Gastropods are characterized by a well-defined head and foot and asymmetrical organs, a feature resulting from the unique torsion process that occurs during genetic development [4]. The types of snails that live in freshwater vary significantly in their adaptation to the different biotic and abiotic factors that control their distribution and abundance in space and time. Therefore, the goal is to understand how the communities of different species living in freshwater are structured and how environmental factors affect their distribution [5]. Freshwater snails have immense health and veterinary importance because they serve as intermediate hosts for parasitic infections in humans and animals, such as schistosomiasis, fascioliasis, and many other trematode infections. Many of these species belong to the class Gastropoda. Additionally, species from the families Pilidae and Thiaridae have been recorded as habitats for trematode larvae [6]. Therefore, identifying them has become extremely important for zoologists and malacologists [7]. The dynamics of serious parasitic diseases worldwide are influenced by several factors, such as climate change and temperature, dissolved oxygen, and rainfall patterns, in addition to important physiological factors, which can affect the distribution and abundance of snail species and consequently the transmission of diseases [8]. The dual-gene perforated mollusks are characterized by complex life cycles that involve intermediate hosts (mollusks and vertebrates) and a final host to complete their life cycle [9]. In addition to the commercial importance of aquatic snails for human consumption, they are also considered very important from an economic, ecological, and environmental monitoring perspective due to their unique biological characteristics and their ability to adapt to changing environments [10].

2 MATERIAL AND METHODS

2.1 Study Site

Diyala River is a major River in Iraq, one of the most important tributaries of River Tigris. It is a main water resources of Iraq that provides supplies for drinking and agriculture purposes. Many cities are closely situated along its banks. Unfortunately, the river gradually became dump site for fluid and solid wastes produced from agricultural and industrial activities [11].The site that chosen Regarded as the down stream part of Diyala river, particularly at the Diyala Dam at Al Sudor area, the river is divided to several branches of small size Rivers including Al-Rose, Mahroot,and Al-Saria [12]

2.2 Collection and Identification of the Sample

The samples were collected monthly with 3 replicates from three Sites (map 1), including the Al-saria stream in the Baqubah district, the Mahroot stream in the Muqdadiyah district, and the Rose stream in the Baladruz district. And this is for the period from the beginning of Sep. 2024 until March 2025. Samples were collected at 1-2 meter from the river bank with depth 0.5 meter by use quadrate (1*1) m and pick up the snails were then transported to the laboratory in plastic containers with some of the

Figure 1 illustrates the Diyala River Basin, highlighting the locations of the study sites.

River water to preserve them for a longer period during transportation. Preserved samples of Mollusks were identified according to the shell features, and in some cases depending on internal parts. Well-known key references were used in this process: [13]

Environmental factors were measured monthly directly by used WalkLAB instrument at all study sites, including temperature, pH, electrical conductivity, dissolved oxygen.

2.3 Statistical Analysis

To determine the differences between environmental factors in each month and sites and Pearson's correlation analysis between density of species and environmental factors, use of the Statistical Analysis System(SAS).

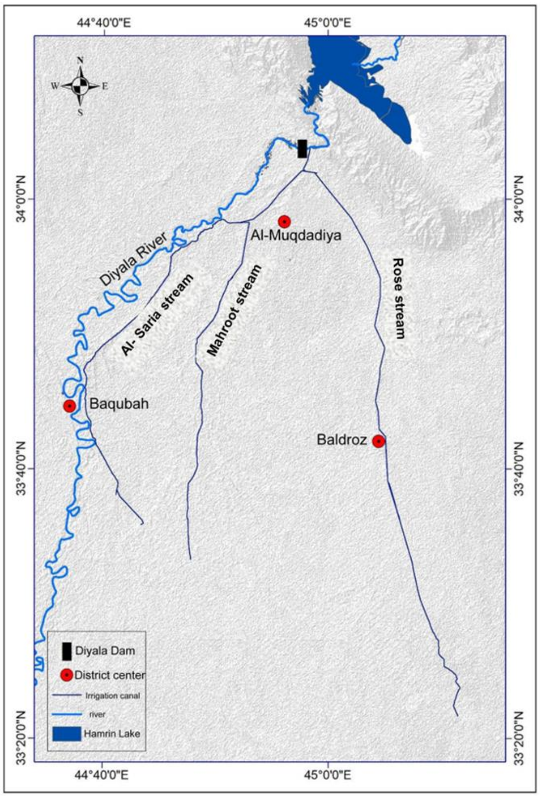

Figure 1: Diyala river.

3 RESULTS AND DISCUSSION

3.1 Ecological Study

As it appear in Figure 2 environmental factors during the study period at the three sites (Mahroot, Al-Saria, and Al-Rose) showed variations between months and sites. A gradual decrease in water temperatures was observed from the autumn months to the winter months, with the lowest temperature recorded in February (9.8°C at the Al-Saria site). This decrease is likely to have an adverse effect on the physiological and reproductive activities of snails, as temperature is a determining factor in the presence and growth of mollusks [14]

As for pH values, they ranged from moderate to weakly alkaline, as is the case in all Iraqi water bodies, with the highest level recorded in Al-Saria Creek during September (8.85). These values are suitable for many freshwater snail species, most of which thrive in environments with a pH between 7 and 9, due to the presence of calcium ions necessary for building their shells [15]. The significant increase in pH values at the Mahroot site during January (8.64) provided more stable conditions for the growth of species such *as B. bengalensis* and *M. tuberculata*, which were abundant during this period.

Dissolved oxygen (DO) concentrations varied slightly between sites and months, with the highest values recorded in November (8.8 mg/L in Al-Rose). Lower temperatures are known to lead to water retaining more oxygen [16], which may explain the increased density of some lung snail species in the colder months, particularly *P. acuta* and *Lymnaea sp*., which are often found in well-ventilated environments.

Electrical conductivity (EC) values varied between months and sites, ranging from 520 µS/cm (in Al-Rose during September) to 680 µS/cm (in Mahroot) during March. These changes reflect variations in ion concentrations, which may be due to changes in surface runoff or evaporation levels, as well as rainfall and the leaching of sediments from adjacent river areas. Some species, such as *M. tuberculata*, are known to tolerate a wide range of electrical conductivity values [17], which explains their continued presence at the Mahroot site despite changing conditions.

3.2 Biological Study

The results of the snail survey revealed differences in the density and distribution of freshwater snail species. Six species were recorded: Physa acuta, Melanopsis costata, *Theodoxus jordani*, *Melanoides tuberculata*, *Bellamya bengalensis*, and *Lymnaea sp*.

Melanoides tuberculata recorded the highest density at the Mahrot site during the first months (September and October), reaching 80 and 78 individuals/m², respectively, before declining significantly in December and January. This may be due to the invasive nature of this species and its ability to withstand varying environmental conditions. Recent studies have indicated that this species is an invasive species capable of rapidly colonizing new environments due to its high adaptability to varying environmental conditions, such as high temperatures and conductivity [18], [19].

B. bengalensis showed relatively high densities at the Mahroot and Rose sites in December (50 and 20 individuals/m², respectively), indicating a preference for mid-winter conditions. This aligns with findings by [20] in Southeast Asia, where the species favored moderate temperatures and stable oxygen levels.

Physa acuta, a widespread species, peaked during colder months (e.g., 12 individuals/m² at Rose in March), consistent with its tolerance for unstable conditions and moderate water quality (Fig. 3) [21].

Rare species (Melanopsis costata, Theodoxus jordani) occurred at low densities exclusively at Al-Sari in February–March, likely due to specific habitat requirements linked to benthic sediments and water quality [22]. In contrast, Lymnaea sp. thrived across sites, peaking at Rose (20 and 17 individuals/m² in February/March), demonstrating adaptability to low temperatures (Table 1) [23].

Pearson's correlation analysis between the monthly densities of the studied snail species and the average values of the environmental factors revealed variations in the direction and strength of the relationship. The results showed a strong relationship between *P.acuta* and electrical conductivity ($r = 0.895$, $p = 0.0065$), indicating that increased concentrations of dissolved ions in the water positively affect the density of this species. Physa acuta is known for its high adaptability to chemically variable environments and its ability to exploit resources in waters rich in dissolved substances.

The relationship between *Physa acuta* and other environmental factors, such as temperature, pH, and DO, was not statistically significant. Although the negative relationship with temperature ($r = -0.688$, $p = 0.0872$), it may indicate that this species prefers cooler temperatures, which is consistent with observations of seasonal distribution during the study period.

As for the other species, *Melanoides tuberculata* and *Bellamya bengalensis*, the statistical analysis results recorded some moderate relationships with environmental factors, but they cannot be considered statistically significant ($p > 0.05$). This may be due to their unbalanced distribution among sites or their influence by local environmental factors that were not measured in this study.

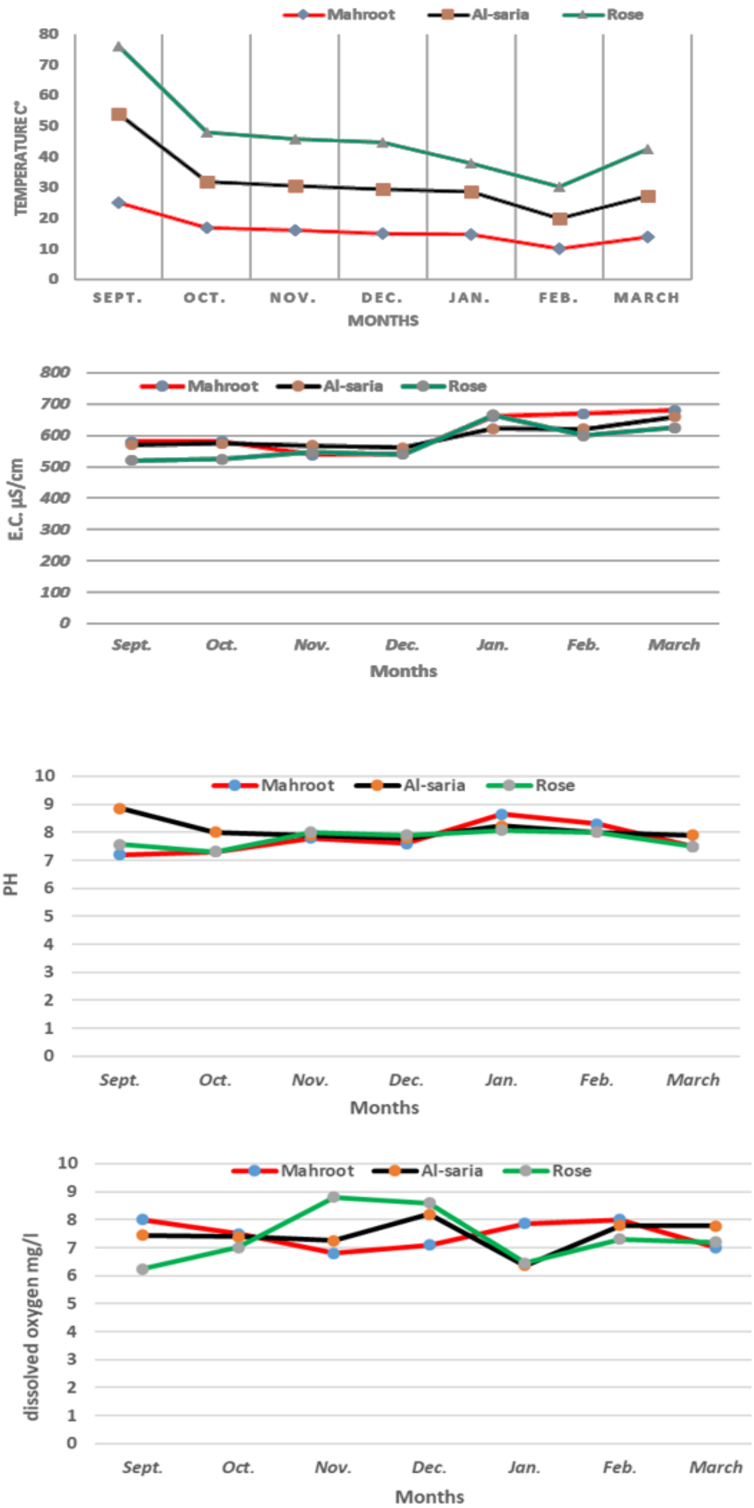

Figure 2: Monthly average of ecological factors of study sites from September 2024 to March 2025.

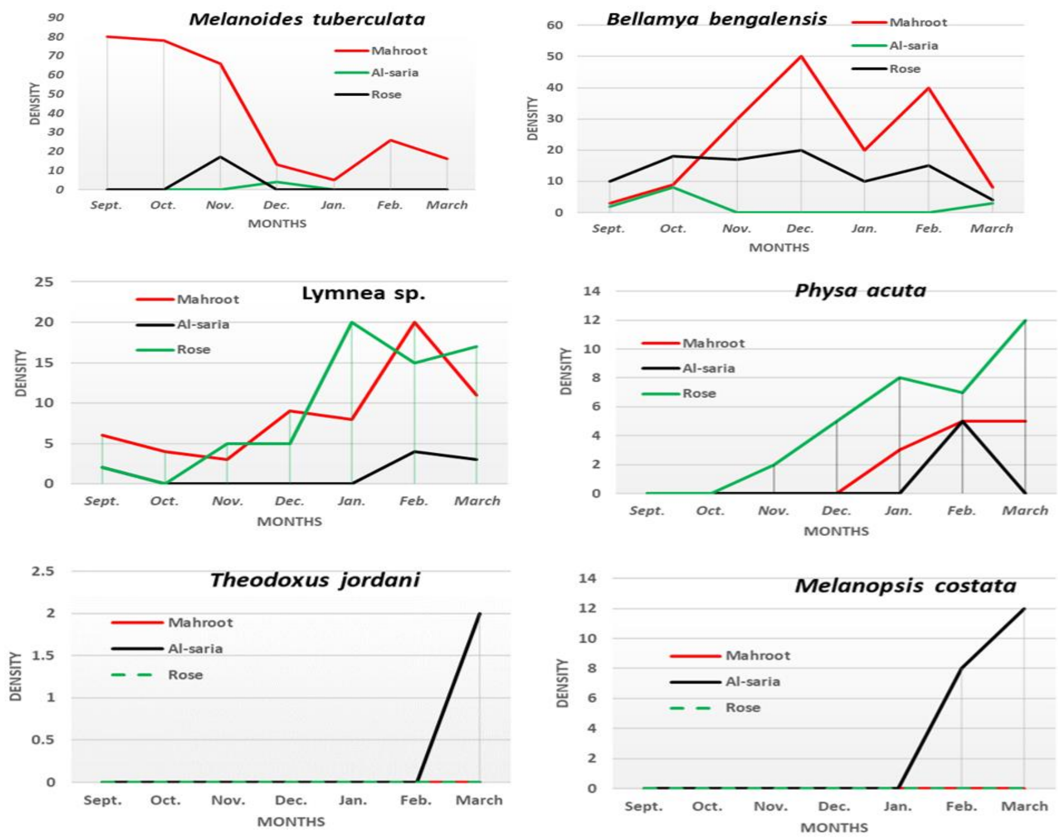

Figure 3: Monthly Average of density of freshwater gastropods in the studied sites from September 2024 to March 2025.

Table 1: Pearson's correlation analysis between the densities of the snail species and the environmental factors.

Species	Temperature	pH	DO	EC
Physa acuta	-0.688	0.339	0.08	0.703
Melanopsis costata	-0.411	-0.134	0.08	0.703
Theodoxus jordani	-0.121	-0.396	-0.133	0.555
Melanoides tuberculata	0.624	-0.397	0.002	-0.717
Bellamaya benglensis	-0.491	0.115	0.806	-0.354
Lymnea sp	-0.626	0.51	-0.058	0.882

4 CONCLUSIONS

This study highlights the diversity of freshwater Gastropod communities in the Diyala River, based on field surveys conducted monthly from September 2024 to March 2025 at three sites along the Diyala River. Six species were recorded, including *Melanoide tuberculat*, which had its highest density at Mahrut in early autumn (80 and 78 individuals/m² in September and October, respectively), demonstrating its ability to invade studied environments and its resilience to high temperatures and electrical conductivity. In contrast, *Physa acuta* and *Lymnaea* showed increased density during the colder months, particularly at the Rose site in February and March, where *Lymnaea* reached 20 individuals/m², indicating a preference for lower temperatures and higher oxygen levels. *Melanopsis costata* and *Theodoxus jordani* were only recorded in the Saria area in late winter, confirming their environmental sensitivity and potential exposure to habitat changes. Pearson correlation analysis revealed a statistically significant positive relationship between *Physa acuta* density and electrical conductivity (r = 0.895, p = 0.0065), confirming this species' ability to adapt to changing environmental conditions at the selected sites. The results of this study emphasize the importance of combining biological monitoring with the assessment of certain environmental parameters to better understand species distribution and distribution patterns, as well as ecosystem health. These findings underscore the value of these communities as bioindicators of environmental stress.

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