



Composition of Freshwater Gastropods (Mollusca) in the Midstream of the Cisadane River, West Java, Indonesia

Muhammad Ridwan¹, Muh. Kadri S¹, Moh. Reza Sese¹, Muhammad Iqram³, Windra Priawandiputra^{1,2*}

¹Animal Biosciences, Department of Biology, Faculty of Mathematics and Natural Sciences, Institut Pertanian Bogor. Jl. Raya Dramaga, Babakan, Dramaga, Bogor 16680, West Java, Indonesia

²Department of Biology, Faculty of Mathematics and Natural Sciences, Institut Pertanian Bogor. Jl. Raya Dramaga, Babakan, Dramaga, Bogor 16680, West Java, Indonesia

³Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Science, Berlin, Germany

*Corresponding author, e-mail: priawandiputra@apps.ipb.ac.id

Article History

Received : 24 June 2025
Revised : 5 August 2025
Accepted : 27 September 2025
Published : 30 September 2025

Keywords

Biodiversity assessment; Bioindicator species; Freshwater ecosystems; Invasive molluscs

ABSTRACT

Gastropods are important components of freshwater ecosystems, but their diversity and distribution in the Cisadane River, West Java, had not been previously documented. This study investigated the composition and distribution of gastropods at four stations using purposive sampling with 1×1 m quadrats. Data were analyzed with the Shannon–Wiener diversity index, Simpson dominance index, Pielou's evenness index, Kruskal–Wallis test, and ANOSIM to compare community structures among stations, while Spearman's correlation was applied to examine relationships between species abundance and environmental factors. A total of seven species were recorded: *Melanoides tuberculata*, *Tarebia granifera*, *Sulcospira testudinaria*, *Mieniplotia scabra*, *Clea helena*, *Radix rubiginosa*, and *Filopaludina javanica*. Station 1 showed the highest diversity ($H' = 1.30$) and evenness ($E = 0.73$), while *T. granifera* was the most abundant and invasive species. These findings provide the first comprehensive data on freshwater gastropods in the Cisadane River and highlight their potential as bioindicators for conservation and management.

How to cite: Ridwan, M., Kadri, M., Sese, M.R., Iqram, M & Priawandiputra, W. (2025). Composition of Freshwater Gastropods (Mollusca) in the Midstream of the Cisadane River, West Java, Indonesia. *Jurnal Riset Biologi dan Aplikasinya*, 7 (2): 118-127. DOI:10.26740/jrba.v7n2.p.118-127.

INTRODUCTION

Biodiversity serves as a key indicator of ecosystem health and stability. In freshwater ecosystems, gastropods are a prominent group of macroinvertebrates that play vital ecological roles, particularly in nutrient cycling, energy flow, and habitat structure (Strong et al., 2008). As primary consumers and detritivores, freshwater gastropods contribute to the decomposition of organic matter, regulate alga growth, and provide a food source for various aquatic predators (Dudgeon et al., 2006). These functions underscore their importance in maintaining the functional integrity of freshwater systems.

Beyond their ecological roles, freshwater gastropods are also recognized as effective bioindicators due to their sensitivity to environmental parameters such as dissolved oxygen,

pH, temperature, and pollutant concentrations (Purwati, 2015; Azizah et al., 2023). Their benthic lifestyle and limited mobility render them particularly vulnerable to localized environmental disturbances. Consequently, shifts in gastropod abundance and diversity often reflect broader changes in aquatic habitat quality (Bahtiar et al., 2022; Foster et al., 2022; Mawardi et al., 2023). Previous studies have reported that pollution, eutrophication, and sedimentation can substantially alter the composition and structure of gastropod communities (Camargo & Alonso, 2006; Akindele et al., 2019; Fitria et al., 2023). Moreover, invasive gastropods such as *Tarebia granifera* are increasingly recognized for their global ecological and economic impacts (Jiang et al., 2022).

In Indonesia, research on freshwater gastropods remains limited in both spatially and temporally. For

instance, Putra et al. (2023b) reported low gastropod diversity in the Ciapus River, Bogor, with only seven species identified, dominated by *Tarebia granifera* and *Melanoides tuberculata*, both recognized for their tolerance to polluted conditions. In contrast, *Glyptophysa stagnalis* was found only in the upstream areas, likely due to cooler temperatures and habitat disturbances from sand mining activities. A broader study by Marwoto & Isnaningsih (2014) documented 13 species of gastropods and three species of freshwater bivalves across 36 reservoirs in the Ciliwung and Cisadane River Basins, but also noted a 73% reduction in gastropod diversity in the Cisadane Basin, presumably due to pollution and sedimentation. Similar findings have been reported in Borneo, where studies revealed varying gastropod richness in riverine habitats (Bidat et al., 2023).

The Cisadane River is one of the major rivers in West Java, flowing from its headwaters in Bogor Regency to its downstream reaches in Tangerang. The river traverses a mosaic of land-use zones, including semi-natural areas, residential settlements, agricultural lands, and industrial zones. The upstream segment remains relatively pristine, characterized by rocky substrates and fast-flowing currents, although it is increasingly affected by household and agricultural activities. In contrast, the middle and downstream reaches are subjected to more intense anthropogenic pressures, including domestic wastewater, agricultural runoff, and industrial effluents. These inputs have contributed to a decline in water quality, increased sedimentation, and degradation of benthic habitats (Siahaan et al., 2011; Akbari et al., 2020).

The Cisadane watershed, particularly in densely populated and industrialized regions such as Bogor and Tangerang, experiences significant environmental stress. One of its important tributaries is the Ciapus River, which flows adjacent to the IPB University campus in Dramaga and serves as a major inflow to the upper Cisadane. This area exemplifies the initial transition from semi-natural conditions to zones increasingly influenced by human activities.

Despite the substantial environmental pressures within the Cisadane River system, no comprehensive studies have yet specifically evaluated the diversity and spatial distribution of freshwater gastropods along the river. To address this knowledge gap, the present study aims to assess the current status of freshwater gastropod communities through analyses of species composition and abundance at selected

stations along the Cisadane River. The findings are expected to provide essential baseline data to support biomonitoring initiatives, conservation planning, and ecological management of freshwater systems in West Java.

MATERIALS AND METHODS

Time and Location of the Study.

The research was conducted from late October to early November 2024 in the Cisadane River, West Java (Figure 1). Sampling was carried out at four stations. Each sampling station was characterized based on environmental parameters (Table 4). Station 1 (6°32'42.78"S, 106°42'57.27"E) is located in the upper reaches of the Cisadane River and has relatively intact vegetation cover. The surrounding environment is relatively natural, with minimal anthropogenic influence. Station 2 (6°33'54.08"S, 106°45'30.13"E) is located further downstream from Station 1, near residential and agricultural areas. Signs of human activities, such as waste disposal and farming, are evident, making it a transitional zone between natural and impacted environments. Station 3 (6°38'8.61"S, 106°48'43.89"E) is located in the midstream section of the Cisadane River, closer to urban areas such as southwestern Bogor City. Human activity is relatively high, with potential sources of domestic, agricultural, and small-scale industrial waste, and Station 4 (6°40'18.56"S, 106°49'8.66"E) is the most downstream site, located in an area with high human impact. The river here likely receives pollution from household waste, small industries, and upstream sedimentation load.

Research Tools and Sampling Method. The tools used in this study included a Global Positioning System (GPS), camera, measuring tape, thermohygrometer, hand net, and a digital pH meter. The material used was 96% alcohol. Sampling was conducted using a purposive sampling method along the riverbank, employing 1 × 1 m quadrats (Chantima et al., 2020). Four stations were selected, and at each station five quadrats were established at 10 m intervals along transects positioned parallel to the riverbank, resulting in 20 quadrats overall (Figure 2). Each quadrat was observed for 15 minutes, during which systematic searches were performed on the substrate surface and within sediments, and all gastropod specimens found were collected and preserved for subsequent identification in the Laboratory of Biosystematics and Animal Ecology, Department of Biology.

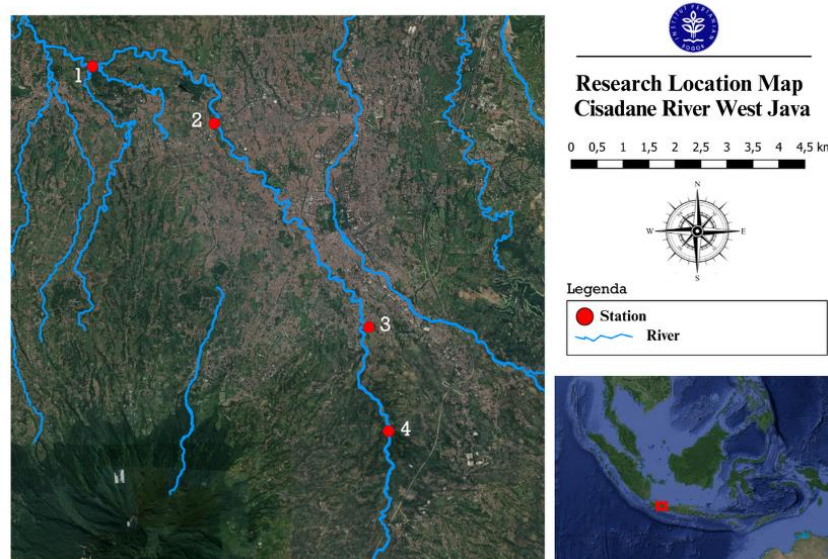


Figure 1. Sampling locations of gastropods in the Cisadane River, West Java

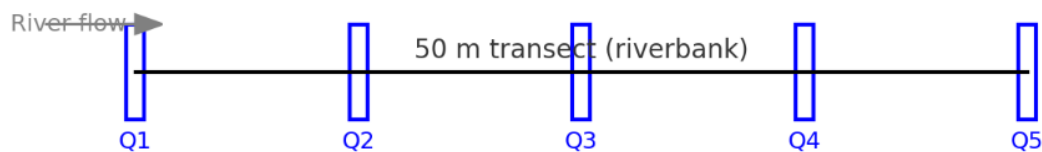


Figure 2. Sampling design and quadrat placement along the Cisadane River

Sample Identification. Sample identification was carried out by comparing the shell morphology of the specimens with the morphological characteristics of species listed on the website MolluscaBase and the field guide by Marwoto et al. (2020). Once a morphological match was found, the specimen was assigned to the corresponding species. Morphological observations and identification were conducted using a stereo microscope. Subsequently, the samples were deposited in the Biology Laboratory of IPB University for further reference and storage.

Environmental Parameter Measurement
Environmental parameters measured at each sampling station included water temperature, water pH, current velocity, water depth, and substrate type. Substrate characteristics were categorized based on visual observation into several types, including rocky, muddy-rocky, and muddy-sandy substrates.

Data Analysis. Data were analyzed using R software (Core Team, 2016) with the “vegan” package version 2.6-10 (Oksanen et al., 2013). Community diversity, dominance, and evenness were quantified using the Shannon-Wiener diversity index, Simpson’s

dominance index, and Pielou’s evenness index, respectively, following standard formulas described by Odum (1996). To test for significant differences in species diversity among sampling stations, the non-parametric Kruskal-Wallis test was applied, as it is suitable for ecological data. Differences in community composition among stations were evaluated using Analysis of Similarities (ANOSIM), including pairwise comparisons to identify which stations differed significantly. Additionally, Spearman’s rank correlation analysis was conducted to examine relationships between gastropod abundance and environmental parameters.

RESULTS AND DISCUSSION

Composition of Gastropod Species in the Cisadane River

Gastropods found in the Cisadane River consisted of 7 species from 5 families, comprising 278 individuals (Table 1). The lowest gastropod composition was observed at Station 3, with 11 individuals representing 4 species from 4 families. The highest composition occurred at Station 2, with 117 individuals comprising 5 species from 3 families. Station 1 had 110 individuals representing 5 species

from 3 families, while Station 4 recorded 40 individuals with 5 species from 3 families.

Station 2 (Table 1) recorded the highest abundance (117 individuals) dominated by *T. granifera*, indicating its adaptation to disturbed habitats. In contrast, Station 3 had the lowest density (2.2 individuals/m²), suggesting higher sensitivity of native species to anthropogenic pressure.

The identified gastropods belonged to five families: Thiariidae, Lymnaeidae, Pachychilidae, Nassariidae, and Viviparidae, comprising a total of seven species (Figure 3). The family Thiariidae included three species—*Melanoides tuberculata*, *Mieniplotia scabra*, and *Tarebia granifera*—with *Tarebia granifera* being the most abundant species (140 individuals), particularly at Station 2 (80 individuals). *T. granifera* is known as an invasive species capable of adapting to a wide range of conditions and influencing benthic community structures (Isnainingsih et al., 2018). The family Lymnaeidae was represented by a single species, *Radix rubiginosa*, which had relatively low abundance (10 individuals) and was distributed across all stations, suggesting its tolerance to varied freshwater conditions (Azizah et al., 2023; Allan et al., 2024).

The family Pachychilidae consisted of one species, *Sulcospira testudinaria*, which was relatively dominant at Station 1 (30 individuals) but less abundant at the other stations, typically inhabiting flowing waters with rocky substrates (Strong et al., 2008). The family Nassariidae was represented solely by *Clea helena*, with a very low total abundance (7 individuals). The family Viviparidae was represented by *Filopaludina javanica*, with a total of 8 individuals.

The gastropod community structure in the Cisadane River is currently dominated by the invasive species *Tarebia granifera*, which accounts for 50.4% of the total population. In contrast, the Bengawan Solo River shows an even more severe invasion, with *T. granifera* and *Melanoides tuberculata* collectively dominating over 65% of the community (Reza et al., 2024). The impact on native species is evident—in Cisadane, *Filopaludina javanica* has been reduced to just two individuals, while Bengawan Solo has experienced a 42% decline in native populations over the past five years.

The key difference lies in the invasion stage: Cisadane remains in the early phase, with seven native species still persisting, whereas Bengawan Solo has reached a critical phase with stable dominance of invasive species. Distribution patterns also differ significantly—Cisadane maintains spatial

variation in density (2.2–23.4 individuals./m² across stations), unlike Bengawan Solo, where invasives have homogenized across all locations. These findings suggest that Cisadane is following the same trajectory observed in Bengawan Solo before its ecosystem reached a critical state, underscoring the need for immediate conservation measures.

The overall moderate species diversity across Cisadane stations aligns with patterns observed in various Indonesian freshwater ecosystems. Putra et al. (2023b) reported comparable gastropod diversity and distribution in the Ciapus River, highlighting a balanced community structure under relatively stable environmental conditions. Similarly, Theofilus et al. (2021) observed moderate diversity levels in Situ Ciburuy, and Afwanudin et al. (2019) noted a balanced composition in the Krueng Aceh River.

Moreover, Priawandiputra et al. (2017) emphasized that seasonal variation serves as a key driver of mollusc community structure in the Situ Gede System, Bogor. Their study found that although mollusc abundance was generally higher in the rainy season, species richness was greater during the dry season. Dominant species such as *Filopaludina javanica* and *Melanoides tuberculata* displayed clear seasonal shifts in abundance, further confirming the sensitivity of freshwater mollusc assemblages to environmental changes.

These findings collectively reinforce the role of gastropods as sensitive bioindicators of freshwater ecosystem health in tropical regions. They also suggest that continuous monitoring, particularly with particular focus on invasive species dynamics and seasonal variations, is critical for safeguarding native biodiversity and maintaining ecological balance in Indonesia's river systems. The comparison of gastropod diversity across the Cisadane River, Ciapus River, and the Ciliwung–Cisadane watershed lakes revealed notable differences in species composition, abundance, and dominance (Table 2). Both the Cisadane and Ciapus rivers recorded 7 gastropod species, with *Tarebia granifera* identified as the dominant species in both sites, accounting for 140 individuals in Cisadane and 329 individuals in Ciapus. This suggests that *T. granifera* is well-adapted to lotic (flowing water) environments and may function as an ecological generalist with high reproductive success. In contrast, the watershed lakes exhibited a higher

Table 1. List of gastropod species in the Cisadane River

Family	Genus	Species	Station				Total
			1	2	3	4	
Thiaridae	<i>Melanoides</i>	<i>Melanoides tuberculata</i> (Muller, 1774)	4	20	3	21	44
	<i>Mieniplotia</i>	<i>Mieniplotia scabra</i> (Muller, 1774)	13	7		3	23
	<i>Tarebia</i>	<i>Tarebia granifera</i> (Lamarck, 1816)	53	80		7	140
Lymnaeidae	<i>Radix</i>	<i>Radix rubiginosa</i> (Michelin, 1831)		3	5		8
Pachychilidae	<i>Sulcospira</i>	<i>Sulcospira testudinaria</i> (von dem Busch, 1842)	30	7	2	7	46
Nassariidae	<i>Clea</i>	<i>Clea Helena</i> (von dem Busch, 1847)	10			2	12
Viviparidae	<i>Filopaludina</i>	<i>Filopaludina javanica</i> (E. von Martens, 1860)			1		1
Total Individuals			110	117	11	40	278
Total Species			5	5	4	5	7
Density (ind./m ²)			22.0	23.4	2.2	8.0	13.9

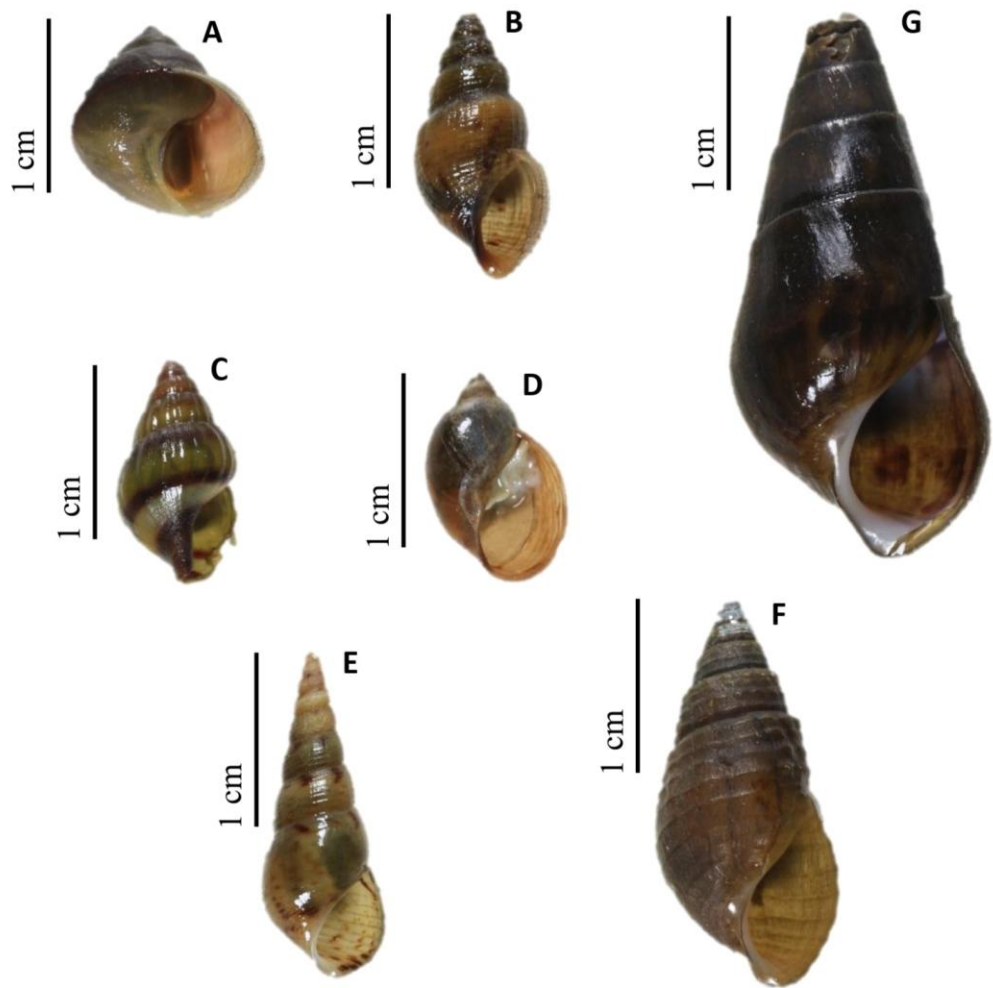


Figure 3. Seven gastropod species found in the Cisadane River: (A) *Filopaludina javanica*, (B) *Mieniplotia scabra*, (C) *Clea helena*, (D) *Radix rubiginosa*, (E) *Melanoides tuberculata*, (F) *Tarebia granifera*, (G) *Sulcospira testudinaria*. All specimens are shown with a 1 cm scale bar

Table 2. Gastropod diversity in rivers and lakes of the Ciliwung–Cisadane Rregion

Aspect	Cisadane River (recent study)	Ciapus River (Putra et al., 2023b)	Ciliwung–Cisadane Watershed Lakes (Marwoto & Isnaningsih, 2014)
Number of Individuals	±278 individuals	587 individuals	Not specified in total; described per lake
Number of Species	7 species	7 species	13 species
Dominant Species	<i>Tarebia granifera</i> (140 individuals)	<i>Tarebia granifera</i> (329 individuals)	No single dominant species; however, <i>Filopaludina javanica</i> , <i>Melanoides tuberculata</i> , and <i>Pomacea canaliculata</i> were most frequently found
Number of Stations / Lakes	4 stations (along the Cisadane River)	4 stations (from upstream to downstream of the Ciapus River)	36 lakes (13 in the Ciliwung watershed, 23 in the Cisadane watershed)
Species List	<i>Melanoides tuberculata</i> , <i>Mieniplotia scabra</i> , <i>Tarebia granifera</i> , <i>Radix rubiginosa</i> , <i>Sulcospira testudinaria</i> , <i>Clea Helena</i> , <i>Filopaludina javanica</i>	<i>Filopaludina javanica</i> , <i>Melanoides tuberculata</i> , <i>Glyptophysa stagnalis</i> , <i>Pomacea canaliculata</i> , <i>Sulcospira testudinaria</i> , <i>Tarebia granifera</i> , <i>Mieniplotia scabra</i>	<i>Melanoides tuberculata</i> , <i>Thiara scabra</i> , <i>Pila ampullacea</i> , <i>Pomacea canaliculata</i> , <i>Anentome Helena</i> , <i>Physastra sp.</i> , <i>Tarebia granifera</i> , <i>Filopaludina javanica</i> , <i>Bithynia (Digoniostoma) truncatum</i> , <i>Sulcospira testudinaria</i> , <i>Lymnaea rubiginosa</i> , <i>Indoplanorbis exustus</i> , <i>Wattebledia crosseana</i>

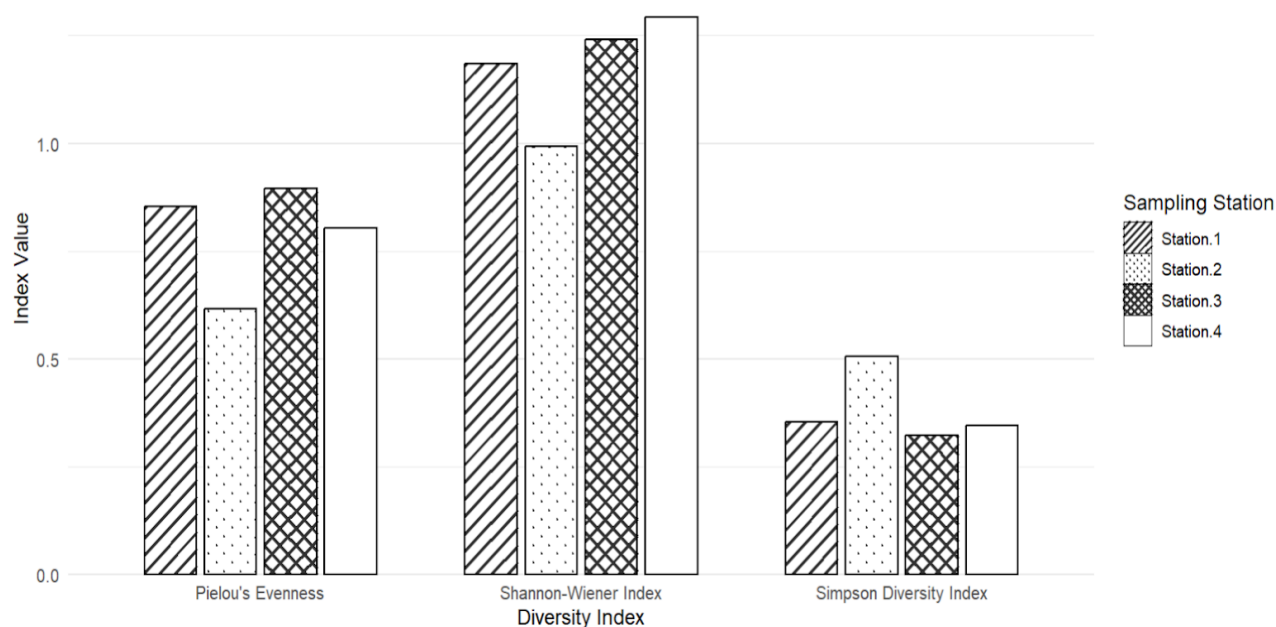
**Figure 4.** Gastropod community diversity indices

Table 3. Pairwise ANOSIM results of gastropod community composition between stations

Station Pair	R Statistic	p-value	Interpretation
1 vs 2	0.132	0.146	Not significantly different
1 vs 3	0.444	0.034*	Significantly different
1 vs 4	0.200	0.069	Not significantly different
2 vs 3	0.472	0.024*	Significantly different
2 vs 4	0.402	0.030*	Significantly different
3 vs 4	0.276	0.078	Not significantly different

Note : R values close to 1 indicate greater dissimilarity in community composition. A p -value < 0.05 denotes a statistically significant difference based on Bray-Curtis dissimilarity. Significance levels are indicated as follows: $p < 0.05$ (*), $p < 0.01$ (**).

Table 4. Environmental parameters at each observation station

Environmental Parameter	Station 1	Station 2	Station 3	Station 4
Water Temperature (°C)	28.36±0.86	28.00±1.05	27.66±0.42	24.78±0.65
Water pH	8.24±0.15	7.90±0.41	8.06±0.09	8.14±0.05
Current Velocity (m/s)	0.45±0.06	0.33±0.05	0.33 ±0.03	0.64±0.04
Water Depth (cm)	6.80±1.30	11.80±8.14	6.00±2.12	9.00±6.28
Substrate	Rock	Muddy sand	Muddy rock	Muddy rock

Table 5. Spearman's rank correlation coefficients (ρ) between gastropod species abundance and environmental parameters

Species	Water Temperature (ρ)	Water pH (ρ)	Current Velocity (ρ)	Water Depth (ρ)
<i>Clea Helena</i>	0.051	-0.544*	0.399	0.008
<i>Melanooides tuberculata</i>	-0.303	-0.429*	-0.147	0.603**
<i>Mieniplotia scabra</i>	-0.199	0.138	0.450*	0.254
<i>Radix rubiginosa</i>	0.094	-0.028	-0.203	0.042
<i>Sulcospira testudinaria</i>	-0.037	0.468*	-0.407*	0.043
<i>Tarebia granifera</i>	0.286	-0.084	-0.042	0.452*
<i>Filopaludina javanica</i>	-0.020	0.203	-0.060	-0.384

Notes: Correlation coefficients marked with asterisks indicate statistical significance (* $p < 0.05$, ** $p < 0.01$). Values range from -1 (perfect negative correlation) to +1 (perfect positive correlation). Species names are italicized following taxonomic convention

gastropod diversity, with 13 species recorded but no single dominant species. Instead, *Filopaludina javanica*, *Melanooides tuberculata*, and *Pomacea canaliculata* were frequently encountered. The presence of various species with different ecological preferences reflects the heterogeneity of lake habitats, which likely provide a range of microhabitats and more stable conditions compared to rivers.

Ecological Index

Ecological index analysis revealed variations in diversity and evenness of gastropod community across the study sites (Figure 4). The Shannon-Wiener diversity index (H') ranged from 0.99 to 1.30, with the highest value recorded at Station 1 (1.30)

and the lowest at Station 2 (0.99). These values indicate a moderate level of diversity, commonly observed in freshwater ecosystems under mild environmental stress (Salwiyah et al., 2022). Evenness index (J) values ranged from 0.62 to 0.90, with the most equitable species distribution at Station 3 (0.90) and the least at Station 2 (0.62). This pattern aligns with previous studies reporting fluctuating evenness in tropical streams due to localized disturbances or environmental filtering (Purnama & Salwiyah, 2022). Meanwhile, the Simpson diversity index (1-D) remained relatively stable across stations, ranging from 0.66 to 0.68, suggesting the absence of pronounced species dominance. Such values reflect a balanced community structure, typically associated with

ecosystems of moderate environmental quality (Oetama & Purnama, 2023).

An initial analysis of gastropod diversity among stations was conducted using the Kruskal-Wallis test on Shannon-Wiener index values. The results showed no statistically significant differences among the stations ($\chi^2 = 4.225$, $df = 3$, $p = 0.2382$), indicating that the levels of gastropod diversity and evenness were relatively uniform across all sampling sites. However, Analysis of Similarities (ANOSIM) revealed significant differences in species composition between stations ($R = 0.375$, $p = 0.001$). This suggests that while overall diversity levels were statistically similar, the species composition of gastropod communities varied markedly among locations.

Further pairwise ANOSIM comparisons indicated that certain station pairs exhibited significant differences in community composition (Table 3). Specifically, station pairs 1 vs 3 ($p = 0.034$), 2 vs 3 ($p = 0.024$), and 2 vs 4 ($p = 0.030$) showed statistically significant dissimilarity based on Bray-Curtis indices. In contrast, pairs such as 1 vs 2, 1 vs 4, and 3 vs 4 did not differ significantly. Higher R values in the significantly different pairs indicate a greater degree of dissimilarity in species composition between those stations.

To explore potential environmental drivers of these spatial differences, Spearman's rank correlation analysis was conducted to assess the influence of environmental parameters on gastropod community structure. Collectively, these analyses indicate that while species diversity was relatively consistent across all sites, variations in community composition likely reflect the effects of local environmental conditions. This suggests that gastropod communities maintain a relatively balanced structure overall, while being shaped by site-specific ecological factors.

Environmental parameters

Environmental parameters varied across the four observation stations (Table 4). Water temperature showed differences among stations, with the highest value recorded at Station 1 (28.36 °C) and the lowest at Station 4 (24.78 °C). Water temperature plays a critical role in influencing the metabolism of aquatic organisms, including gastropods. It affects their metabolic rates and distribution patterns (Ridwan et al., 2020).

Water pH ranged from 7.90 at Station 2 to 8.24 at Station 1, indicating slightly alkaline conditions that remain within the tolerance limits for freshwater

gastropods. Stable pH values are generally favorable for the survival of species sensitive to fluctuations in water chemistry. A pH closer to neutral tends to support higher gastropod abundance (Putra et al., 2023a).

Current velocity also varied, with the lowest value of 0.33 m/s observed at Stations 2 and 3, and the highest at Station 4 (0.64 m/s). Slower river currents, such as those in Stations 2 and 3, may lead to greater sediment accumulation, creating muddy substrates that serve as suitable habitats for species such as *Tarebia granifera* (van Benthem Jutting, 1956). Water depth ranged from 3 to 18 cm, with Stations 1 and 2 showing greater variability than the others. This range provides diverse microhabitats for species with specific depth preferences.

The substrate types across the stations (Table 1) included rock, muddy sand, and muddy rock. Station 2 was characterized by muddy sand, while Stations 3 and 4 were dominated by muddy rock. Substrate composition significantly affects gastropod diversity, as it influences shelter availability and food resources. Species such as *Melanoides tuberculata* are often associated with muddy substrates, as members of the Thiaridae family commonly inhabit soft-bottomed environments with mud and sand (Basit, 2019).

Significant Correlations Between Gastropod Abundance and Aquatic Environmental Parameters

The Spearman correlation analysis revealed significant associations between gastropod abundance and specific environmental parameters (Table 5). Most notably, *Melanoides tuberculata* showed a strong positive correlation with water depth ($\rho = 0.603$, $p < 0.01$), suggesting this species' preference for deeper benthic habitats. In contrast, its negative correlation with pH ($\rho = -0.429$, $p < 0.05$) may indicate avoidance of alkaline conditions. Three species (*Clea helena*, *Sulcospira testudinaria*, and *Mieniplotia scabra*) demonstrated significant relationships with current velocity ($\rho = 0.399$ – 0.450 , $p < 0.05$), highlighting adaptations to flowing water environments. The inverse correlation between *S. testudinaria* and current velocity ($\rho = -0.407$, $p < 0.05$) is particularly intriguing, potentially reflecting niche partitioning among species.

Water temperature showed no significant correlations, suggesting it may be less influential than chemical and physical habitat features in this ecosystem. These patterns align with known gastropod microhabitat preferences, where species

like *Tarebia granifera* ($p=0.452$, $p<0.05$ with depth) typically occupy stable substrates in deeper zones. The results emphasize water depth and flow dynamics as key factors influencing the structure of gastropod communities in this system.

CONCLUSION

This study provides baseline data on the composition and distribution of freshwater gastropods in the Cisadane River. Seven species were recorded, with *T. granifera* being the most abundant and invasive. Species diversity and evenness were highest at Station 1, while differences in community composition reflected local environmental conditions. These findings confirm the potential of gastropods as bioindicators for freshwater ecosystem monitoring in West Java.

ACKNOWLEDGMENTS

The authors would like to thank Nur Rohmatin Isnainingsih, M.Sc. from BRIN (National Research and Innovation Agency) for her assistance in clarifying the identification results. We also extend our gratitude to Windra Priawandiputra, Ph.D., for his role as the coordinator of the mollusk biology course, as well as to all the lecturers involved in this course at the Animal Biosciences Study Program, Department of Biology, FMIPA IPB.

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