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Ecological index of gastropods in the Tananan River, Mamasa Regency

Andi Nur Samsi[1*], Irnayanti Bahar[1]

[1] Universitas Patompo, Faculty of Teacher Training and Education, Biology Education Study Program, Makassar, Indonesia.

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Corresponding Author:
Andi Nur Samsi
andinursamsi89@gmail.com

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Abstract: Research on gastropod ecological indices is important for determining ecosystem stability. Previous research only focused on the abundance of gastropods. The purpose of this study was to analyze the diversity index (H'), evenness index (J'), and dominance index (C) of gastropods in the Tananan River, the research location. The method used included transect and plot sampling at two observation stations, with random sampling. Station A had a sandy substrate, and Station B had a rocky substrate, close to residential areas. Species identification was carried out morphologically, and the data were analyzed using the Shannon-Wiener, Pielou, and Simpson ecological indices. The results showed that gastropod diversity was in the moderate category (H' = 1,785 – 2,265), evenness values (J' = 0,893 – 0,975) indicated an even distribution of species, and no specific species were dominant (C = 0,213 – 0,318). These findings indicate a moderate ecosystem condition. Local communities utilize gastropods, particularly *Pila ampulacea* and *Pomacea canaliculata*, as side dishes. The processing is still simple and adds to the uniqueness of local cuisine. In conclusion, gastropod ecological indices can be effective biological indicators of ecosystem health. The use of gastropods for public consumption requires further research due to the discovery of *Indoplanorbis exustus* in the river.

Keywords: Ecology Index; Ecosystem; Gastopods; Tananan River

Introduction

Gastropoda are soft-bodied animals that live on land, in the sea, and in freshwater. Gastropods are animals with threaded and twisted shells(Nge et al., 2023; Rusmidin & Samsi, 2022; Samsi & Karim, 2019). Many gastropod groups evolved and diversified in marine environments. Some lineages that now live on land or in freshwater are descended from marine ancestors (Fernández-Simón et al., 2025; Neubauer, 2024a; Neubauer & Harzhauser, 2022). The worldwide fossil record shows over 5,000 species of freshwater gastropods spanning approximately 340 million years, with a significant increase in diversity during the Neogene, particularly in large, long-lived lakes. Some gastropod lineages lived independently. A single transition to land in the group Stylommatophora resulted in approximately 22,400 species of land snails living today (±79% of the diversity of land snails) (Neubauer, 2024b). Furthermore, repeated terrestrialization has been found in Acochlidimorpha and other groups (Brenzinger et al., 2021; Fernández-Simón et al., 2025).

Freshwater gastropods live in rivers. Various ecological and biodiversity studies indicate that rivers and streams are the primary habitats of many freshwater gastropods. In South Korea, a national survey identified 30 species of freshwater gastropods in rivers and streams, including two invasive apple snail species (*Pomacea canaliculata* and *Physa acuta*), which are now widespread in streams (Bae & Park, 2020). In Malaysia, these two species were found only in waterfalls, but not in rivers (Hah et al., 2022). The genus Helicostoa is unique, found attached to limestone in large rivers in China. This suggests a specialized adaptation to rocky substrates in high-velocity rivers (L.-J. Zhang et al., 2024).

One of the gastropod locations is the Tananan River in Mamasa Regency, West Sulawesi Province. Only one gastropod study has been conducted in the Tananan

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River in West Sulawesi. *Pila ampullacea, Pomacea canaliculata, Sulcospira testudinaria, Lymnaea rubiginosa,* and *Indoplanorbis exustus* are some of the gastropod species found (Anggrini et al., 2024). Ecological indices and the local community's use of gastropods have not been discussed. This is the reason for this study. Ecological index research is also important because it can describe the condition of the ecosystem. Gastropods play an ecological role in water bodies, including as bioindicators. Several species of gastropods are consumed by residents living near rivers. This further supports the importance of research, specifically identifying the relationship between gastropods and river conditions.

Method

Research Design

The site of this investigation was the Tananan River in Aralle Village, Aralle District, Mamasa Regency. Random sampling was used at two research stations. The study was conducted in July 2023, with coordinates of station A at 2°53'04.0" S 119°09'00.1" E and station B at 2°53'06.0" S 119°09'03.5" E. Common methods for identifying mollusks used the Javanese Mollusc Identification Book (Gastropoda and Bivalvia) (Marwoto et al., 2020) and the World Register of Marine Species (WoRMS) digital taxonomy resource.

Two research stations were used. The river flows through two research stations: Station A has a sandy substrate, and Station B has a rocky substrate, both close to residential areas. To increase the accuracy of species abundance and richness estimates at the small-scale plot, each research station used 10 plots measuring 1 x 1 m, each replicated 10 times (Anggrini et al., 2024; Candri et al., 2023; Samsi et al., 2020; Samsi & Karim, 2019; J. Zhang et al., 2021). Furthermore, species with more than 50% of their bodies plotted were considered included in the count plot. This was done using the general principle of presence recording, which refers to body parts within the boundaries of the sample plot (J. Zhang et al., 2021).

Data Analysis

Diversity Index (H')

Formula:

$$H' = -\sum\left(\frac{n_i}{N}\log_2\frac{n_i}{N}\right) \quad (1)$$

Where:

H' = Shannon-Wiener diversity index

n_i = Number of individuals of the i-th species

N = Total Number of individuals of all species

Interpretation of H' Values:

- H' < 1 = Low Dominated community One species
- 1 ≤ H' ≤ 3 = Moderate Several dominant species, community is quite balanced
- H'> 3 = High Community is very diverse and stable

Evenness Index (J')

The general formula used is:

$$J' = \frac{H'}{\log_2 S} \quad (2)$$

Where:

J′ = Evenness Index

H' = Shannon-Wiener Diversity Index

S = Total Number of species found

The J' value ranges from 0 to 1, where values closer to 1 indicate an even distribution, while values closer to 0 indicate dominance by one or a few species (Chao & Acosta, 2019).

Dominance Index (C)

The general formula used is:

$$C = \sum\left(\frac{n_i}{N}\right)^2 \quad (3)$$

Where:

C = Simpson's dominance index

n_i = Number of individuals of the i-th species

N = Total Number of individuals of all species

The C value ranges from 0 to 1. The closer to 0, the more diverse the community. The closer to 1, the more dominated by a single species.

Result and Discussion

Gastropods Found

Gastropods are a group of soft-bodied, shelled animals. This group of animals can also be found in rivers. Several gastropods were also found in this river (Table 1).

Table 1. Species found in the Tananan River

Family	Genus	Species
Ampullariidae	*Pila*	*Pila ampulacea*
	Pomacea	*Pomacea canaliculate*
Pachychilidae	*Sulcospira*	*Sulcospira testudinaria*
Lymnaeidae	*Lymnaea*	*Lymnaea rubiginosa*
Bulinidae	*Indoplanorbis*	*Indoplanorbis exustus*

A total of five gastropod species were found at both research stations: *Pila ampulacea, Pomacea canaliculata, Sulcospira testudinaria, Lymnaea rubiginosa,* and *Indoplanorbis exustus*. Indoplanorbis exustus was found only at the second station, suggesting that the environmental conditions at the other stations do not support its presence.

I. exustus is a freshwater snail that is highly resistant to stressful environmental conditions, such as polluted and organic-rich waters, allowing it to thrive in waters affected by human activity. Research shows that this snail can survive in waters of degraded quality and can even accumulate various pathogenic bacteria in its body,

making it a bioindicator (Kavitha et al., 2018). This also requires further research.

Furthermore, *I. exustus* is often associated with habitats near rice fields, ponds, irrigation canals, and stagnant water in densely populated areas. It is also an important intermediate host for various trematodes (including schistosomes) that cause disease in humans and livestock (Devkota et al., 2015; Dumidae et al., 2024; Saijuntha et al., 2021). This species is frequently found in agricultural landscapes and shallow waters around settlements and cultivated fields in South Asia. Domestic waste and livestock activities are widely accepted in these landscapes (Devkota et al., 2015; Dumidae et al., 2024; Saijuntha et al., 2021).

The Ecological Indices

Ecological indices are formulas used quantitatively to describe ecosystem conditions. Ecological indices include the diversity index, evenness index, and dominance index (Table 2).

Table 2. Ecological index value

Ecological Indices	Station A	Station B
Diversity index (H')	1.785	2.265
Evenness index (J')	0.893	0.975
Dominance index (C)	0.318	0.213

One of the ecological indexes is used to determine the condition of the ecosystem (Mantiri et al., 2026). The gastropod diversity index at both stations showed a fairly balanced community, with moderate values (1.785 and 2.265), consistent with previous studies of gastropods in river ecosystems. The H' values of gastropods in the upstream and downstream sections of the Jangkok River, Mataram, were very low in the upstream (H'=0), low in the middle (H'=0.91), and moderate in the downstream (H'=1.29). Communities with a moderate H' are considered to have moderate diversity and a more balanced structure compared to highly stressed segments (Ferisandi et al., 2018).

The mollusk community (dominated by gastropods) in the upper Choen River watershed, Thailand, has a Shannon–Wiener index H' of 2.27 and is considered to have moderate diversity. This condition is due to the stable river habitat and the weak dominance of a few species, such as *Filopaludina martensi*; thus, the community is considered balanced (Nahok et al., 2017). Furthermore, a study of river mollusks in the Teteriv Basin, Ukraine, found that sites with H values between 2.2 and 2.3 and a high evenness index (E between 0.75 and 0.83) were considered biotopes with high species richness and low dominance, indicating ecologically stable mollusk communities (including gastropods) (Pazilov & Umarov, 2021). A similar pattern was found in a study of gastropods in the Andijan springs, Uzbekistan. The highest Shannon values were found in springs with more diverse and balanced communities, possibly due to undisturbed habitat conditions (Pazilov & Umarov, 2021).

Therefore, the moderate H values at both stations in this study are consistent with patterns across rivers. A moderate diversity index and low-moderate dominance index are generally considered indicative of a relatively balanced gastropod community in an environment that has not experienced extreme pollution stress (Ferisandi et al., 2018; God et al., 2021; Nahok et al., 2017; Pazilov & Umarov, 2021; Yermoshyna, 2020).

The gastropod evenness index at both stations was close to 1 (0.893 and 0.975), indicating a balanced community with no highly dominant species. The gastropod dominance index showed values close to zero (0.316 and 0.213), indicating a very even gastropod community at both stations, with no highly dominant species. While high evenness and low dominance are considered signs of a stable and diverse community, this pattern is comparable to those observed in several studies of river benthos and related waters.

In a study of river mollusks in the Teteriv River Basin, Ukraine, Simpson and Berger–Parker dominance indices decreased as community structure shifted. The relatively balanced distribution of individuals among species and the high Pielou's evenness index (E) indicate a stable river mollusk community without any particular taxon dominating (Yermoshyna, 2020). Furthermore, research on the Lubuk Kertang mangrove macrobenthos indicated that the community was "fairly stable," with no single species dominating, and evenness (E) ranging from 0.51 to 0.54 and dominance (D) from 0.33 to 0.35. The authors asserted that the closer the evenness index is to 1, the more evenly distributed individuals are across species. Conversely, low dominance indicates the absence of any species inhibiting the presence of other species (Basyuni et al., 2018).

Consequently, a balanced community, a relatively stable trophic structure, and a non-extreme level of ecological pressure are indicated by gastropod evenness values approaching one and dominance indices approaching zero at both research stations.

Environmental parameter observations were not conducted in this study. This will be developed in future research. Several research results indicate that water quality affects the balance of gastropod populations (Harahap & Hutasuhut, 2025). One of the environmental factors that affects macrozoobenthos is phosphate and nitrate in water (Muntafi'ah et al., 2026).

Utilization of Gastropods

Molluscs have implications for the economic potential of coastal communities (Ibrahim et al., 2025).

Macroinvertebrates such as gastropods are also consumed by residents in Aceh (Sarjani et al., 2025). Gastropods are also consumed by residents on Pannikiang Island (Samsi & Rusmidin, 2021). Communities around the river also consume Gastropoda. The gastropods consumed are *Pila ampullacea* and *Pomacea canaliculata*, which are also sold in local markets, but only residents purchase them. Using river gastropods as daily food, such as *Pila ampullacea* and *Pomacea canaliculata*, aligns with several studies that highlight the nutritional benefits and ecological and health risks of consuming freshwater snails.

Nutritionally, *P. canaliculata* meat is known to have high-quality protein and fat. It has a high proportion of unsaturated fatty acids (±60.5%), and almost all essential amino acids meet the recommended intake (Ghosh et al., 2017). As a "mini livestock," this species can contribute to food security and address malnutrition in impoverished areas (Ghosh et al., 2017). This aligns with the practice of riverside communities, which use it as a local source of protein and sell it in local markets, although the primary customers are residents.

However, *P. canaliculata* is a significant agricultural pest. It disrupts aquatic biodiversity due to its rapid growth rate, high appetite, and broad environmental adaptability, which has earned it a place among the world's 100 worst invasive species (Chen et al., 2025; Faria et al., 2025; Liu et al., 2018; Yang et al., 2018). Due to its role as an intermediate host for the parasitic worm *Angiostrongylus cantonensis*, consumption of this snail has been linked to eosinophilic meningitis in several Asian countries. This occurs primarily when consumed raw or undercooked (Liu et al., 2018). A worldwide meta-analysis also showed that invasive gastropods, such as *P. canaliculata*, consume resources at a much higher rate than native gastropods, suggesting they have significant potential to alter aquatic food webs (Faria et al., 2025).

Simply cooked or sautéed with spices, these snails are often used. Due to its small size, the *Pila ampulacea* species is cooked with its shell. Unlike *Pomacea canaliculata*, these snails are usually only cooked in soups, stir-fries, and rica-rica dishes. The meat and shell must be removed before cooking. Stir-frying, making satay, making rica-rica dishes, and deep-frying are some simple ways to prepare them.

The simple processing methods (boiling, stir-frying, rica-rica dishes, or frying) are well-suited to the way gastropods are used in many places. Snails are usually cooked by heat without sophisticated processing technology. Gastropod meat is commonly used in traditional household and culinary dishes because it is rich in protein and minerals and low in fat, making it an attractive, inexpensive side dish (Khan & Liu, 2019; Pissia et al., 2021). Freshwater and inland snails are often boiled, stir-fried, or fried with local spices in various cultures. This method is sufficient to maintain nutritional value and enhance microbiological safety (Khan & Liu, 2019; Pissia et al., 2021).

Food safety recommendations for freshwater snails state the same treatment for *Pomacea canaliculata*, whose meat is removed from the shell before cooking: the meat and shell must be separated, then thoroughly cooked (stir-fried, fried, or grilled) to reduce biological and chemical contaminants (Khan & Liu, 2019; Pissia et al., 2021).

Conclusion

Gastropoda found in the Tananan River belong to the families Ampullariidae, Pachychilidae, Lymnaeidae, and Bulinidae. The river's diversity index is moderate, indicating a fairly balanced community. The gastropod evenness index at both stations was close to 1, indicating a balanced community with no highly dominant species. The gastropod dominance index was close to zero, indicating a very even gastropod community at both stations, with no highly dominant species. The use of *Pila ampulacea* and *Pomacea canaliculata* as side dishes for the community remains relatively straightforward. Apart from that, *I. exustus* was found in the Tananan River. *I. exustus* is also an important intermediate host for various trematodes that cause disease in humans and livestock, so it requires further research.

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Author Contributions

The researchers involved are A. N. S. and I. B. Conceptualization, A. N. S.; data curation, A. N. S.; formal analysis, A. N. S.; funding acquisition, A. N. S. and I. B.; investigation, A. N. S.; resources, A. N. S. and I. B.; methodology, A. N. S.; project administration, A. N. S.; resources, A. N. S. and I. B.; software, A. N. S.; validation, A. N. S. and I. B.; visualization, A. N. S.; supervision, A. N. S.; writing - original draft, A. N. S.; writing - review & editing, A. N. S.

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Conflicts of Interest

The authors declare no conflict of interest.

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