

First documentation of mangrove-associated gastropods highlights the status of early mature stands in the mangrove ecosystem of Pramuka Island, Jakarta Bay, Indonesia

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Abstract. Yasman, Cham M. 2025. First documentation of mangrove-associated gastropods highlights the status of early mature stands in the mangrove ecosystem of Pramuka Island, Jakarta Bay, Indonesia. *Biodiversitas* 26: 1453-1460. This study examined the gastropod community in the Pramuka Island mangrove ecosystem, Jakarta Bay, Indonesia, focusing on species composition, ecological indices, and the influence of abiotic factors across different mangrove zones. A total of five gastropod species associated with mangroves were identified, with *Cerithium corallium* and *Terebralia palustris* being the most frequent and abundant. The presence of *T. palustris*, *Telescopium telescopium*, *Nerita planospira*, and *C. corallium* marks the first recorded occurrence of these species in the Pramuka Island mangrove ecosystem. The ecological indices revealed low diversity (H' : 0.57), low evenness (E : 0.35), and high dominance (C : 0.78), thereby indicating an imbalanced gastropod community. These findings suggest that the island's mangrove ecosystem is in the early stages of maturity in the form of a planted mangrove habitat. Abiotic parameters, including temperature, pH, salinity, and light intensity, were assessed, with light intensity showing significant variation between areas inside and outside the mangrove canopy. While other abiotic factors remained relatively stable, gastropod distribution appeared to be more influenced by feeding preferences and resource availability than by differences in light intensity. These results highlight the importance of understanding the ecological dynamics of mangrove-associated gastropods and their interactions with environmental factors, providing valuable insights for future mangrove restoration and management efforts.

Keywords: Kepulauan Seribu National Park, mangrove-associated gastropods, mangrove ecosystem, planted mangrove

INTRODUCTION

Mangrove forests are important ecosystems, providing numerous social, economic, and environmental benefits to both ecosystems and humans; their intricate root systems stabilize coastlines, preventing erosion and providing vital habitats for diverse species (Hasan et al. 2023). In addition, mangrove forests play a crucial role in carbon sequestration and storage, making them key allies to mitigate climate change. Recognizing their importance, Indonesia prioritized sustainable mangrove management and incorporated their conservation into national climate commitments (Arifanti et al. 2022; Wirabuana et al. 2025).

Despite their ecological and economic importance, Indonesia's mangrove forests have been extensively exploited since the 1800s, primarily for shrimp coastal aquaculture and timber harvesting. By the late 1960s, more than 200,000 hectares of mangrove forest had been lost, primarily in Java and Sumatra, with the destruction later expanding to Kalimantan and Sulawesi. The 1997 Asian financial crisis further accelerated this trend, as rising shrimp prices incentivized aquaculture expansion. Over the next three decades, nearly 800,000 hectares of mangrove forest were destroyed, much of which was converted into low-productivity or abandoned shrimp and fish ponds (Ilman et al. 2016).

Human activities continue to be the primary cause of mangrove degradation, leading not only to a significant reduction in mangrove coverage but also to alterations in species composition that undermine ecosystem resilience. Furthermore, global climate change and rising sea levels pose additional threats, emphasizing the urgent need for comprehensive conservation and restoration initiatives (Ilman et al. 2016; Jia et al. 2018; Cahyaningsih et al. 2022). To address these challenges, various strategies have been implemented in Indonesia, including public awareness campaigns, large-scale restoration programs, and sustainable management practices such as ecotourism (Cahyaningsih et al. 2022); mangrove plantation programs in protected areas have been particularly impactful, with notable initiatives undertaken in Pramuka Island, Kepulauan Seribu National Park (KSNP), Jakarta, Indonesia.

Mangrove planting on Pramuka Island began in 2003 under the leadership of the then Head of the KSNP Office. The initiative utilized a spaced clump system for initial planting and was independently funded. By 2004, his team had successfully planted 1.81 million mangroves across 15 islands in the Thousand Islands, achieving a survival rate of 70-80% (ITJEN KLHK 2018). This program has significantly contributed to mangrove habitat restoration in the region and serves as a model for future initiatives.

Monitoring the maturity and ecological status of the planted mangroves is essential for evaluating restoration success (Chen et al. 2015; Salmo et al. 2017). One effective method involves analyzing shifts in gastropod assemblages, which serve as bioindicators of habitat development (Li et al. 2017; Wang et al. 2021; Isoni et al. 2023). As mangroves mature, they develop structural complexity and environmental stability, supporting diverse communities of mangrove-associated gastropods (Salmo et al. 2017; Islamy and Hasan 2020); in turn, these gastropods contribute to nutrient cycling within the mangrove ecosystem by utilizing fresh and decayed mangrove leaves along with other organic matter. Through their digestive and metabolic processes, they help to recycle essential nutrients, thus supporting overall ecosystem function (Kabir et al. 2014; Raw et al. 2017; Samsi et al. 2020). Studies have shown that gastropod communities in planted mangrove forests often differ from those in natural forests. While planted mangroves are typically dominated by eurybiotic species, natural mangroves harbor more specialized taxa, particularly those from the Potamididae, Littorinidae, and Ellobiidae families (Zvonareva et al. 2015).

Monitoring efforts on Pramuka Island were conducted in 2014, 2016, 2017, and 2019 by Syahrial et al. (2019), Assuyuti and Rijaluddin (2016), Piranto et al. (2019), and Jalaludin et al. (2020), respectively; these studies reported varying gastropod compositions. Assuyuti and Rijaluddin (2016) and Jalaludin et al. (2020) documented only *Terebralia* sp. and *Littorina* sp., whereas Syahrial et al. (2019) identified additional species, including *Atilia* (*Columbella*) *scripta* and *Nerita albicilla*. Piranto et al. (2019) reported 19 gastropod species; however, none were associated with mangroves.

Terebralia sp. and *Littoraria scabra* are widely recognized as mangrove-associated gastropods (Tomascik et al. 1995; Salmo et al. 2017). However, the identification of *Terebralia* sp. by Assuyuti and Rijaluddin (2016) and Jalaludin et al. (2020) lacked precision, possibly due to the juvenile stage of the specimens. This limitation underscores the need for intensive research on mangrove gastropods on Pramuka Island, highlighting the gaps in local biodiversity studies.

This study revisited the gastropod species inventory in the Pramuka Island mangrove ecosystem, which was planted in 2004 to build upon previous findings. The research question addresses whether Pramuka Island's mangrove ecosystem supports a diverse assemblage of gastropods characteristic of and associated with mangrove habitats. This study aims to reassess the maturity of the planted mangroves within the KSNP, Jakarta, contributing to broader knowledge on mangrove restoration and informing future conservation efforts.

Furthermore, the study examined the structure of the gastropod community using ecological indices such as density, biodiversity, evenness, and dominance, following the approach of Wiraatmaja et al. (2022). To provide a comprehensive understanding of the ecosystem's status, abiotic parameters, including seawater and air temperature,

were also measured. The study hypothesizes that Pramuka Island's mangrove ecosystem supports mangrove-associated gastropods that represent the early mature stage. However, the biodiversity index is expected to be lower than that of mainland mangroves owing to differences in sediment composition, organic matter availability, and the predominance of sandy substrates. Furthermore, the abiotic factors are expected to align with those typical of coral island ecosystems.

MATERIALS AND METHODS

Study period and location

Data on gastropod and abiotic parameters were collected from Pramuka Island's mangrove ecosystem, located within the Kepulauan Seribu National Park (KSNP), Jakarta, Indonesia (Figure 1), on November 2024.

Procedures

Survey of research location

Based on previous data showing a limited number of gastropod species in Pramuka Island's mangrove ecosystem, we conducted a survey to update the gastropod species checklist and assess their general distribution within the mangrove area. Then, we determined the number of transects and quadrats necessary to collect the data. Two transects were established to represent the open and canopy-covered areas of the mangrove. Quadrats were placed at 5 m intervals, starting from the 0 m point and extending to 30 m, ensuring a comprehensive assessment of gastropod distribution across different habitat conditions.

Transect establishment and quadrat placement

The two transects were established during low tide and positioned perpendicular to the coastline at predetermined locations based on the survey results described above. Each transect extended 30 m from the land-sea boundary toward the sea to assess shifts in the presence of mangrove-associated gastropods that rely on the interior mangrove ecosystem. Quadrats measuring 1×1 m (Mawardi et al. 2023) were placed at 5 m intervals, starting from the 0-m point, ensuring data collection from a total of seven quadrats per transect.

Gastropod and abiotic parameter measurements

Gastropod species found on the sediment floor, as well as those found on mangrove roots, stems, and leaves within each quadrat, were collected by hand. Then, the specimens were identified and counted to assess their distribution and abundance within the mangrove ecosystem. Abiotic parameters, such as air and water temperature, water pH, salinity as reported by Wiraatmaja et al. (2022), and light intensity, were measured at three distinct locations along the transect line; these locations represent open areas and areas beneath the mangrove canopy.

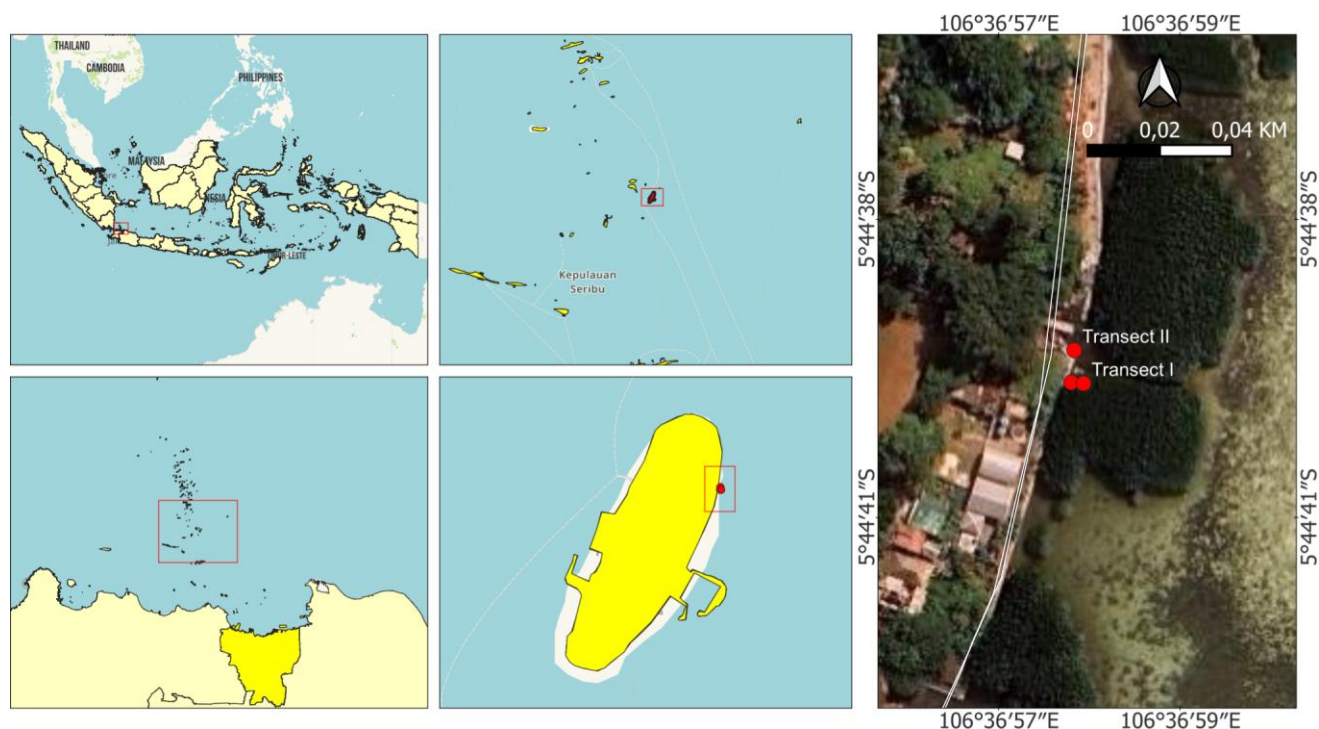


Figure 1. Sampling locations for gastropod and abiotic parameter data collection within Pramuka Island's mangrove ecosystem, Kepulauan Seribu National Park, Jakarta, Indonesia (source: GoogleMaps)

Species identification

The gastropods observed at the research site were identified directly in the field and photographed; their characteristics were compared with descriptions in the literature by Zvonareva and Kantor (2016), Islamy and Hasan (2020), and Isoni et al. (2023).

Data analysis

The obtained data were tabulated. Gastropod data were analyzed using the formula described by Imamsyah et al. (2020), Wiraatmaja et al. (2022), Dewi et al. (2023), and Purnama et al. (2024) to obtain the values of frequency, density, biodiversity index, species richness index, evenness, and dominance. All data were presented descriptively.

RESULTS AND DISCUSSION

Species composition, frequency, and density

A total of 508 mangrove gastropod individuals representing four families and five species were identified: *Terebralia palustris* and *Telescopium telescopium* (Family Potamididae), *Nerita planospira* (Family Neritidae), *L. scabra* (Family Littorinidae), and *Cerithium coralium* (Family Cerithiidae) (Figure 2). Among these species, *C. coralium* was the most frequent, exhibiting the highest density, followed by *T. palustris*, *L. scabra*, and *T. telescopium* (Table 1).

Barnes (2003) reported that coralline islands, which feature coral terraces, may support marine mangrove

ecosystems. These environments are associated with mudflats that contain rich deposit-feeding epifauna, including potamidid mangrove mud whelks and an abundance of cerithiid species such as *C. coralium*. According to Barnes (2003), *C. coralium* is the only species in the genus *Cerithium* (Family Cerithiidae) that is recognized as mangrove-associated.

Four gastropod species identified in the present study, *T. palustris* and *T. telescopium* (Potamididae), *N. planospira* (Neritidae), and *L. scabra* (Littorinidae), are considered true mangrove inhabitants (Zvonareva et al. 2015). Of these four species, *N. planospira* is infrequently reported, whereas *T. palustris*, *T. telescopium*, and *L. scabra* are among the most commonly found species in mangrove ecosystems. These species have been documented in numerous studies, including those by Tomascik et al. (1997), Barnes (2003), Zvonareva et al. (2015), Salmo et al. (2017), Baderan et al. (2019), Ginantra et al. (2020), Hasidu et al. (2020), Islamy and Hasan (2020), Wiraatmaja et al. (2022), Isoni et al. (2023), Ernawati et al. (2024), and Purnama et al. (2024). In contrast, *N. planospira* has been reported in relatively fewer studies, such as those by Tomascik et al. (1997), Salmo et al. (2017), Baderan et al. (2019), Ginantra et al. (2020), Hasidu et al. (2020), and Ernawati et al. (2024). *Terebralia palustris* and *T. telescopium* are essential components of the mangrove ecosystem, representing the largest and most conspicuous mangrove gastropods (Yadav et al. 2019); these species are found exclusively in mangrove habitats across the Indo-West-Pacific region (Barnes 2003).

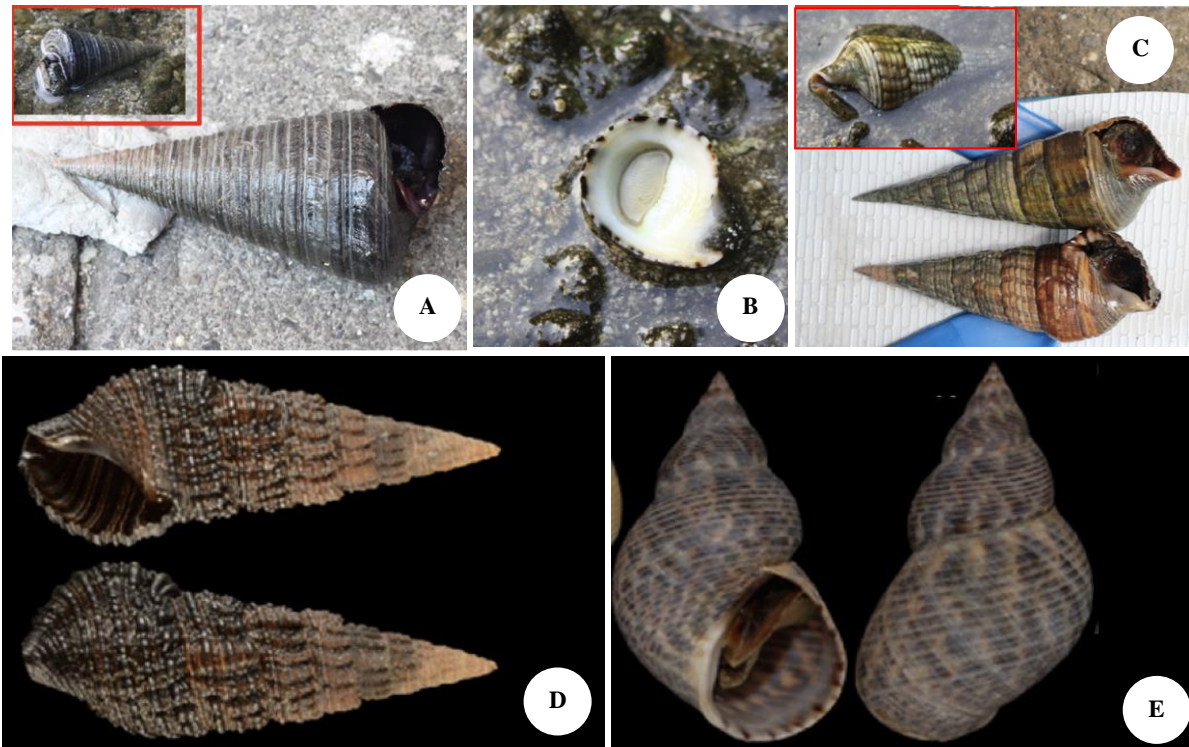


Figure 2. Five gastropod species found in Pramuka Island, Jakarta Bay, Indonesia. A. *Telescopium telescopium* (insert is photograph in situ); B. *Nerita planospira*; C. *Terebralia palustris* (insert is photograph in situ); D. *Cerithium coralium*; E. *Littoraria scabra*. Note: D and E are taken from Zvonareva and Kantor (2016)

Table 1. Species list, frequency, and density of mangrove gastropods on Pramuka Island, Jakarta Bay, Indonesia

Family	Species	No. of individuals	No. of quadrats in which the species were found	Total quadrats assessed	Frequency	Density (ind/m ²)
Potamididae	<i>Telescopium telescopium</i>	6	2	12	16.67	0.5
	<i>Terebralia palustris</i>	45	3	12	25	3.75
Cerithiidae	<i>Cerithium coralium</i>	444	11	12	91.67	37
Neritidae	<i>Nerita planospira</i>	1	1	12	8.33	0.08
Littorinidae	<i>Littoraria scabra</i>	12	3	12	25	1

The status of *C. coralium* as a mangrove-associated species remains unclear. To date, only a few studies, including Barnes (2003), Susintowati et al. (2019), and Ernawati et al. (2024), have documented its presence. Barnes (2003) observed that *C. coralium* occurs in similar abundance across microhabitats preferred by *T. palustris*, suggesting potential interactions between the two species and concluding that *C. coralium* is a mangrove-associated gastropod. However, Zvonareva and Kantor (2016) reported the presence of *C. coralium* exclusively in mangrove zones dominated by *Avicennia* species, with its absence noted in zones dominated by other mangrove species. In contrast, Susintowati et al. (2019) documented *C. coralium* at the edge of a mud bed near the mangrove ecosystem on Jatipapak Beach, Indonesia. This discrepancy may explain why Tomascik et al. (1997) excluded *C. coralium* from their comprehensive list of 278 gastropod species associated with mangrove forests in Asia and Oceania, which includes 180 species recorded from Indonesia.

In this study, where *C. coralium* was the most frequently encountered species and exhibited the highest density, we support Barnes' (2003) conclusion that *C. coralium* is a mangrove-associated gastropod. Although Zvonareva et al. (2015) did not explicitly classify *C. coralium* as a mangrove-associated species, they documented its presence in a 4-year-old planted mangrove and a natural mangrove at Dam Bay, Tre Island, Khanh Hoa Province, Vietnam. This finding further reinforces Barnes' (2003) assertion regarding the mangrove association of *C. coralium*. In Pramuka Island, this species was observed in significant numbers on the mud floor of the mangrove ecosystem and on the roots of mangrove trees, particularly in areas not covered by the mangrove canopy.

The presence of these five mangrove-associated gastropod species suggests that Pramuka Island's mangrove ecosystem has reached maturity. In younger, planted mangrove communities, gastropod communities are often dominated by eurybiotic species that are adaptable to various intertidal habitats. In contrast, mature mangroves

typically host specialized gastropod species, particularly those from the Potamididae, Littorinidae, Neritidae, and Ellobiidae families (Zvonareva et al. 2015).

Mangrove planting efforts on Pramuka Island began in 2003. In 2014, three gastropod species were recorded, of which only one was a mangrove-associated species (Syahrial et al. 2019). Two years later, two gastropod species were found, both of which were associated with mangrove forests (Assuyuti and Rijaluddin 2016). In 2017, 19 gastropod species were identified; however, none were associated with mangrove forests (Pirianto et al. 2019). By 2019, the same two mangrove-associated species previously reported by Assuyuti and Rijaluddin (2016) were found again (Jalaludin et al. 2020). In this study, five mangrove-associated gastropod species were identified, two of which were previously reported by Assuyuti and Rijaluddin (2016) and Jalaludin et al. (2020). The presence of these gastropods is likely influenced by the muddy sand substrate, which is stabilized by the mangrove root system and enriched with organic material from fallen mangrove debris (Li et al. 2017; Salmo et al. 2017). This favorable habitat condition may have contributed to the identification of five additional mangrove-associated gastropod species that had not been documented in previous studies.

This shift in mollusk species composition underscores the value of gastropods as reliable indicators of restoration progress in planted mangrove ecosystems (Salmo et al. 2017; Lin et al. 2024). Owing to their sensitivity to habitat quality and ecological changes, gastropods can provide insights into mangrove ecosystem recovery following restoration efforts. Research indicates that it often takes over 15 years for planted mangroves to develop the structural complexity and environmental stability necessary to support diverse communities of mangrove-associated gastropods (Salmo et al. 2017) and other macrobenthic fauna (Li et al. 2017). The findings from Pramuka Island suggest that the 21-year-old mangrove stands have reached a maturity level capable of fostering such biodiversity, reflecting the restoration progress achieved over the past two decades.

The environmental conditions observed in the mangroves on Pramuka Island facilitated the establishment of the five mangrove-associated gastropod species identified in this study. These conditions are indicative of a mature and well-functioning mangrove ecosystem, which is consistent with the observations of Gorman and Turra (2016), Salmo et al. (2017), Li et al. (2017), and Pan et al. (2021), who emphasized the role of mature mangroves in supporting diverse faunal communities, including macrobenthic species. The successful development of these mangrove stands suggests that the planting and maintenance efforts on Pramuka Island have been effectively managed. This case could serve as a model for mangrove restoration programs across Indonesia, demonstrating how sustained efforts can yield ecologically robust and biodiverse habitats over time.

Biodiversity index, evenness, and dominance

The ecological indices of Pramuka Island's mangrove gastropod community, including diversity, evenness,

dominance, and species richness, are presented in Table 2. The diversity index (H') was categorized as low ($H' < 1$), consistent with the findings by Wiraatmaja et al. (2022) in their study of gastropods in the Siwil and Grindulu mangrove ecosystems in Pacitan District, East Java, Indonesia.

The evenness index indicates that Pramuka Island's mangrove gastropod community is unevenly distributed, with values ranging from 0.26 to 0.50. This pattern is consistent with the observations of Wiraatmaja et al.'s (2022) in the Siwil mangrove ecosystem. This uneven distribution was further supported by the dominance index, which showed high dominance, with values ranging from 0.75 to 1.00. This high level of dominance was primarily attributed to the presence of *C. coralium*, a species also reported by Barnes (2003) in the mangrove ecosystem of Hoga Island, Wakatobi Marine National Park.

The low diversity index observed on Pramuka Island can be attributed to the combined effects of a high dominance index and a low evenness index, reflecting an ecosystem in which a few species dominate and others are underrepresented. This pattern suggests that specific environmental conditions or ecological interactions may favor certain gastropod species while limiting the presence of others. The species richness index for mangrove gastropods on the island was below 3.5 ($R < 3.5$), further confirming the limited diversity and aligning with previous findings in other mangrove ecosystems. For instance, Hasibuan et al. (2021) reported similarly low species richness indices in the mangrove forest of Percut Sei Tuan, North Sumatra, where environmental factors such as salinity, sediment composition, and anthropogenic disturbances contributed to the limited diversity.

Wiraatmaja et al. (2022) also documented low species richness indices across three mangrove research sites in the Pacitan District, East Java, Indonesia, citing environmental stressors, including tidal variations, habitat fragmentation, and human activities, as significant factors influencing gastropod diversity. These findings suggest that low species richness is a common characteristic of mangrove ecosystems experiencing ecological stress or at specific developmental stages. On Pramuka Island, this may be attributed to the relatively young age of the restored mangroves, ongoing environmental changes, or localized disturbances. Further research into environmental parameters, interspecies dynamics, and anthropogenic influences on gastropod communities in these ecosystems could provide deeper insights into factors driving low biodiversity and inform strategies for enhancing biodiversity through targeted conservation and management efforts.

Table 2. Ecological Indices of Pramuka Island's mangrove gastropod community, Jakarta Bay, Indonesia

Ecological indices of the gastropod community	Values
Diversity index (H')	0.57
Evenness (E)	0.35
Dominance (C)	0.78
Species richness (R)	0.64

Table 3. Abiotic parameters of Pramuka Island's mangrove ecosystem, Jakarta Bay, Indonesia

Location	Temperature (°C)		Light intensity (lux)	pH	Salinity (ppt)
	Air	Water			
Outside the mangrove canopy	29.9±0.0	28.1±0.4	188.63±5.4	7.23±0.2	35.5±0.0
Inside the mangrove canopy	29.9±0.0	27.9±0.1	30.03±2.7	7.43±0.0	35.5±0.0

In mature mangrove forests, invertebrate fauna exhibit higher diversity indices but lower abundance and biomass than newly planted stands. Changes in species diversity among invertebrates can result from disturbances, exploitation, or rehabilitation of mangrove habitats. Adjacent ecosystems, such as intertidal and subtidal zones or mudflats, which often co-occur with dominant mangrove species, also influence species diversity within mangrove ecosystems (Zvonareva et al. 2015). Furthermore, the composition of mangrove-associated gastropods is influenced by the mangrove's position relative to the shoreline. For instance, gastropods from the families Ellobiidae, Assimineidae, and Neritidae are commonly found in the landward zones of mangrove forests, whereas species from the family Potamididae typically inhabit the seaward fringes (Zvonareva et al. 2015). Consistent with these findings, the presence of two Potamididae species and one Neritidae species in this study further supports the conclusion that Pramuka Island's mangrove ecosystem represents an early mature and well-established stand.

Abiotic parameters

The recorded abiotic parameters, including air and water temperature, water pH, salinity, and light intensity, are presented in Table 3. All parameters remained relatively stable, as indicated by the low standard deviation values. The pH and temperature measurements align closely with those reported by Setiawan et al. (2021) and Wiraatmaja et al. (2022), while the salinity values, which are characteristic of a marine habitat, are consistent with the findings from Ernawati's study on fringe mangroves at Lembongan Island, Province of Bali. These favorable marine environmental conditions are consistent with the gastropod species identified in this study. Zvonareva et al. (2015) observed that gastropods from the family Potamididae, including *P. palustris* and *T. telescopium*, are commonly found in the seaward fringe of mangroves, where water temperatures of 30°C are considered optimal for *T. telescopium* (Adamu et al. 2024). Similarly, Barnes (2003) reported high abundances of *C. coralium* and *T. palustris* in the mangroves of Hoga Island, Wakatobi Marine National Park. Furthermore, Ernawati et al. (2024) documented the exclusive presence of *C. coralium* in mangrove zones dominated by *Avicennia* species, which are typically located in the mangrove fringe.

The only abiotic parameter that significantly differed between areas outside and inside the mangrove canopy was light intensity. Interestingly, more juvenile *T. palustris* were observed outside the canopy, whereas adults were found exclusively within the canopy. This distribution may be attributed to feeding preferences and resource availability rather than differences in light intensity. Adults

of *T. palustris* are frequently seen feeding in clusters on fresh fallen mangrove leaves, which are more abundant within the canopy. In contrast, juveniles prefer decomposed mangrove leaves, which are more prevalent outside the canopy owing to tidal action within the mangrove ecosystem (Kabir et al. 2014; Raw et al. 2017; Samsi et al. 2020).

This study underscores the ecological importance of Pramuka Island's mangrove ecosystem as a habitat for gastropods, particularly *C. coralium*, *T. palustris*, *T. telescopium*, and *L. scabra*. The dominance of *C. coralium* and *T. palustris* highlights the mature and well-established nature of mangrove stands, which provide essential resources and environmental stability for these species. The recorded ecological indices indicate low diversity and evenness but high dominance, reflecting the unique environmental conditions and interspecies interactions within this mangrove ecosystem, which has developed on a coral island substrate. The presence of gastropod families such as Potamididae, Littorinidae, and Neritidae further supports the ecological maturity of the mangrove stands, consistent with observations from other mangrove ecosystems in the Indo-West-Pacific region. Abiotic parameters, including temperature, pH, salinity, and light intensity, align with typical marine habitats and corroborate findings from other studies on mangrove ecosystems established on coral island substrates, contributing to the suitability of habitats for gastropod communities. These results emphasize the critical role of mangrove forests as biodiversity hotspots and call for sustained conservation efforts to protect these ecosystems from human-induced disturbances and environmental degradation. Future research should focus on long-term ecological dynamics and broader species interactions to enhance our understanding of the resilience and ecological functions of mangrove-associated gastropod communities.

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