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Research

Distribution and Community Structure of Tropical Gastropod In The Intertidal Area of Bintulu, Borneo

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ABSTRACT

Marine gastropods can be considered a biological indicator of the ecosystem's health, such as intertidal areas. The objectives of this study are to identify marine gastropod species, diversity, and distribution along the coastal area of the Bintulu Division. The study was conducted in December 2021. A 50 m transect was laid perpendicular to the coastal line, and three quadrats were set up at each transect at all four stations. The specimen of gastropod were counted and collected from each sampling station, then preserved in ice and taken to the laboratory for the species identification. The gastropods subject to an analysis for their diversity index and morphological characteristics. Forty-three species of marine gastropods were discovered, representing 25 families and 39 genera. The, Shannon-Weiner diversity index (H'), evenness index (J') and Simpson index (1-D) index were assessed, whereas the station 4 indicated higher diversity of Gastropods followed by stations 3,2 and 1. The dominance index (D) showed an inverse relationship, with the highest value observed at station 1, followed by stations 2, 3, and 4.The information presented in this paper might be helpful for ecological wealth studies and considered as the baseline data for the intertidal ecosystem in Sarawak, Malaysia.

Key words: Bintulu, Borneo, diversity, intertidal, marine gastropod

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INTRODUCTION

The intertidal zone, located between land and sea, is a dynamic and transitional ecosystem characterised by periodic variations in water levels induced by tides. This dynamic nature exposes organisms to both aquatic and terrestrial environments. Remarkably, the intertidal zone appears as a one of the biodiversity hotspot, supporting a diverse range of marine organisms capable of managing the harsh environmental circumstances that exist here (Sheaves et al., 2016). These species include various types of algae, hardy invertebrates such as crabs snail, mussels and oyster, polychaetas, oligochaetes and tiny fish (Wahle & Balcom, 2020). It also serves as a platform for excellent study into species adaptations, community ecology, and the effects of environmental variability (Chen et al., 2021).

Adaptations to environmental variability are critical in the intertidal zone, where species such as periwinkle have developed thick, coiled shells that protect them from desiccation, temperature extremes, and predators (Buckley & Kingsolver, 2021). Notably, several species have evolved adaptive traits, like as protective shells or water-retention strategies, to overcome obstacles provided during low tide. These evolutionary adaptations demonstrate intertidal creatures' persistence with capability in dealing with the dynamic and ever-changing character of their environment (Schulte, 2014).

One of the organisms that live in the intertidal ecosystem is the gastropod. Generally, gastropods, also known as snails or slugs, are a class of animals that belong to the phylum Mollusca (Wanninger & Wollesen, 2019). Gastropods, despite being categorized into relatively few taxonomic groups, have successfully colonized a wide range of environments from an ecological perspective. Within marine habitats, they demonstrate remarkable adaptability, thriving in diverse ecological niches. Their physiological and morphological traits, such as gills for underwater respiration and tolerance for varying salinity levels, enable them to inhabit environments ranging from shallow intertidal zones to deep-sea ecosystems. Gastropod species can also be discovered in marine, freshwater, and terrestrial environments (Baharuddin et al., 2018). Gastropods are known for having a single shell or valve where the shells are coiled or spiralled. According to Lobo-da-Cunha, (2019), the gastropod body cavity is divided into three parts, namely the visceral mass, muscular foot and organ system. Typically, gastropods have a single helical coiled shell, whereas the aperture can be closed by an operculum.

Sarawak has long been regarded as one of Southeast Asia's most important biodiversity areas. There have been a few studies on the ecology, diversity (Bidat et al., 2023), distribution (Idris et al. 2021), and shell dimension of gastropods in Sarawak (Hamli et al., 2020). However, the study only focuses on the edible and freshwater gastropods. Besides, the updated information on the marine gastropod species that live in Bintulu's intertidal area is currently limited. The variety of species and their distribution pattern of marine gastropods at the intertidal, particularly rocky shore Bintulu division, are still mostly unknown. Therefore, the present study aims to assess the species, diversity, and distribution of marine gastropods from the Bintulu intertidal area. The documented data has the potential to guide sustainable conservation efforts and support environmental health monitoring, as marine gastropods are key bioindicators. Additionally, the findings establish a baseline for future research, ensuring the preservation of biodiversity and ecological balance in the region.

MATERIALS AND METHODS

Study Location

The study was performed in December 2021 at the intertidal area of the Bintulu division, which primary characterized by rocky shoreline (Figure 1). Four study locations was selected namely Station 1 (Tanjung Batu, 03°12.482 N, 113°02.650 E), Station 2 (Tanjung Batu 2, 03°12.697 N, 113°02.854 E), Station 3, (Telekom, 03°18.924 N, 113°06.887 E) and Station 4, (Kuala Nyalau, 03°38’0505.5 N, 113°22’23.6 E).

Fig. 1. Sampling location for gastropod diversity at the Bintulu intertidal area (modified from Google Earth)

Study Approach

Sampling was carried out for 1 hour during low tide at every station. Each sampling site was measured from low to high rocky shore using transecting. A total of three transects, each with three 1m² quadrats spaced 10 meters apart, were used to collect and count individual gastropod species at each station. The collected gastropods were taken to the laboratory for cleaning and visceral mass removal.

Gastropod Species Identification

Each sample shell was cleaned using a brush under running water to remove the dirt. Cleaned samples were recorded using photographs of the ventral and dorsal views. The species identification was focused on morphological features, with particular emphasis on size, form and colour based on (Idris et al., 2021). Species names were validated against the World Register of Marine Species (WoRMS) database.

Data Analysis

The data of the total number of individuals and the species from every station were compute using Paleontological Statistics (PAST) version 4.10, for species diversity according to Shannon-Weiner diversity index (H') (Shannon & Waever, 1949):

$$H = \frac{n \log 10\, n - \Sigma\, fi \log 10\, fi}{n}$$

where n = total number of individuals
fi = number of individuals in species I, i=1,2,3…, n

to quantify the species evenness, Pielou's evenness index (J') (Pielou, 1966):

$$J' = \frac{H}{\log 10\, S}$$

where H = diversity of species
S = total number of species

to quantify species dominance and diversity, Dominant index (D) and Simpson diversity index (1-D) (Simpson, 1949):

$$D = \Sigma \left(\frac{n_i}{N}\right)^2$$

where n_i = number of individuals of species i
N= Total number of individuals of all species

RESULTS

The present study highlighted the number of recorded species at each station. Based on diversity and distribution, the station with the highest diversity and most favourable conditions was identified.

Species Composition and Distribution

There are 442 individuals representing 25 families with 43 species of gastropod documented during the study period (Table 1, Figure 2).

Five species was recorded distributed at all stations namely *Clypeomorus bifasciata*, *Planaxis sulcatus*, *Nerita chamaeleon*, *Trochus radiatus*, and *Lunella cinerea*, belonging to 5 families namely Cerithiidae, Planaxidae, Neritidae, Trochidae, Turbinidae respectively. The present study indicated that a total of 22 unique species can be found at 1 station which signifies 14 Families. Muricidae represents the most dominant family in the present study, with 14 species recorded from the Bintulu intertidal area. Station 4 recorded the highest number of species recorded, with 29 species, followed by Stations 3, 1, and 2, with 19, 18 and 13 species, respectively (Figure 3). The highest individual number was found from Station 1 (138), followed by Stations 4,2 3 with 104, 107 and 84 individuals correspondingly.

Gastropod Diversity

The present study showed Station 4 consists of high Shannon diversity (H') with 2.729, followed by Stations 3 (2.25), Station 2 (1.942) and Station 1 (1.874) (Figure 4). This pattern is counterpart to the evenness index (J') which recorded the highest value from Station 4 (0.8106), followed by Stations 3 (0.7942), Station 2 (0.7571) and Station 1 (0.6615). Results on the Simpson index (1-D) indicated similar findings with the Shannon diversity (H') with the highest Station 4 (0.8997), followed by Stations 3,2 1 with 0.8475, 0.7964 and 0.7506, respectively. Dominance index (D) recorded inversely finding with the highest value represented by Station 1 (0.2494), followed by Station 2 (0.2036), Station 3 (0.1525) and the lowest Station 4 (0.1003).

Table 1 Gastropod species distribution from the Bintulu intertidal area

Family	Species	Stations			
		S1	S2	S3	S4
Babyloniidae	*Babylonia japonica* (Reeve, 1842)	-	-	-	+
Bursidae	*Bufonaria crumena* (Lamarck, 1816)	-	-	-	+
Cerithiidae	*Cerithium* sp.	-	-	+	-
	Clypeomorus bifasciata (G. B. Sowerby II, 1855)	+	+	+	+
Columbelidae	*Pictocolumbella ocellata* (Link, 1807)	-	-	-	+
Conidae	*Conus flavidus* Lamarck, 1810	+	-	-	+
Cymatiidae	*Gyrineum natator* (Röding, 1798)	-	+	+	+
	Gyrineum gyrinum (Linnaeus, 1758)	+	-	+	+
Cypraeidae	*Lyncina carneola* (Linnaeus, 1758)	+	-	-	-
	Mauritia arabica (Linnaeus, 1758)	-	-	-	+
Littorinidae	*Littoraria strigata* (R. A. Philippi, 1846)	-	-	+	+
Marginellidae	*Cryptospira ventricosa* (Fischer von Waldheim, 1807)	-	-	-	+
Melongenidae	*Volegalea cochlidium* (Linnaeus, 1758)	-	-	-	+
Mitridae	*Strigatella fulvescens* (Broderip, 1836)	+	+	-	-
Muricidae	*Claremontiella nodulosa* (C. B. Adams, 1845)	-	+	-	-
	Drupella margariticola (Broderip, 1833)	-	+	+	-
	Indothais lacera (Born, 1778)	-	-	-	+
	Murex falsitribulus Ponder & E. H. Vokes, 1988	+	-	-	+
	Orania dharmai Houart, 1995	+	+	+	-
	Purpura panama (Röding, 1798)	-	-	-	+
	Purpura persica (Linnaeus, 1758)	-	-	+	+
	Reishia clavigera (Küster, 1860)	-	-	+	-
	Reishia luteostoma (Holten, 1802)	-	-	-	+
	Semiricinula muricoides (Blainville, 1832)	+	-	-	-
	Stramonita rustica (Lamarck, 1822)	-	+	-	-
	Tenguella granulata (Duclos, 1832)	-	+	+	+
	Tylothais aculeata (Deshayes, 1844)	-	-	-	+
Nassariidae	*Nassarius stolatus* (Gmelin, 1791)	-	-	+	-
Naticidae	*Polinices flemingianus* (Récluz, 1844)	-	-	-	+
Neritidae	*Nerita albicilla* Linnaeus, 1758	-	-	+	+
	Nerita chamaeleon Linnaeus, 1758	+	+	+	+
Neritopsidae	*Neritopsis radula* (Linnaeus, 1758)	+	-	-	-
Olividae	*Agaronia gibbosa* (Born, 1778)	+	-	+	+
Planaxidae	*Planaxis sulcatus* (Born, 1778)	+	+	+	+
Potamididae	*Pirenella cingulata* (Gmelin, 1791)	+	+	-	-
Strombidae	*Canarium urceus* (Linnaeus, 1758)	+	-	-	-
Tonnidae	*Tonna tessellata* (Lamarck, 1816)	-	-	+	+
Trochidae	*Monodonta labio* (Linnaeus, 1758)	+	-	-	-
	Trochus radiatus Gmelin, 1791	+	+	+	+
Turbinellidae	*Vasum ceramicum* (Linnaeus, 1758)	-	-	-	+
Turbinidae	*Lunella cinerea* (Born, 1778)	+	+	+	+
	Turbo crassus W. Wood, 1828	+	-	+	+
Turritellidae	*Turritella terebra* (Linnaeus, 1758)	-	-	-	+
	TOTAL	18	13	19	29

Legend: (+) Present, (-) Absent

Fig. 2. Gastropod species found associated with intertidal and rocky shores of Bintulu. **A**. *Cerithium* sp., **B**. *Clypeomorus bifasciata,* **C**. *Planaxis sulcatus,* **D**. *Pirenella cingulata,* **E**. *Pictocolumbella ocellata,* **F**. *Nerita albicilla,* **G**. *Nerita chamaeleon,* **H**. *Neritopsis radula,* **I**. *Bufonaria crumena,* **J**. *Lyncina carneola,* **K**. *Mauritia arabica,* **L**. *Littoraria strigata*, **M**. *Polinices flemingianus,* **N**. *Canarium urceus,* **O**. *Tonna tessellata,* **P**. *Babylonia japonica,* **Q**. *Conus flavidus,* **R**. *Cryptospira ventricose,* **S**. *Strigatella fulvescens*

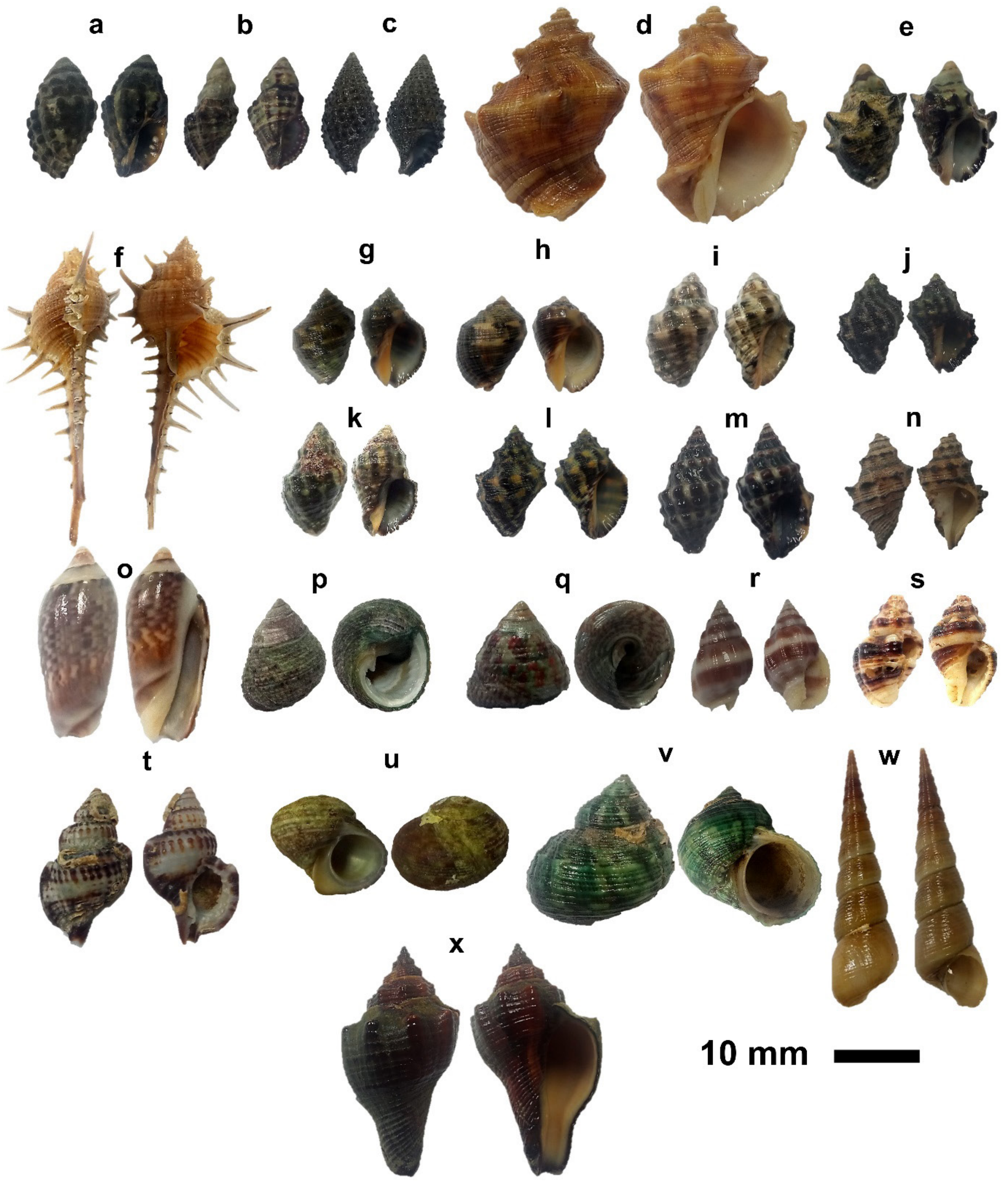

Fig. 2. continues: Gastropod species found associated with intertidal and rocky shores of Bintulu. **a**. *Claremontiella nodulosa,* **b**. *Drupella margariticola,* **c**. *Orania dharmai,* **d**. *Indothais lacera,* **e**. *Tylothais aculeata,* **f**. *Murex falsitribulus,* **g**. *Purpura Panama*, **h**. *Purpura persica,* **i**. *Reishia luteostoma*, **j**. *Reishia clavigera,* **k**. *Semiricinula muricoides*, **l**. *Stramonita rustica,* **m.** *Tenguella granulata*, **n**. *Vasum ceramicum*, **o**. *Agaronia gibbosa*, **p**. *Monodonta labio,* **q**. *Trochus radiatus,* **r**. *Nassarius stolatus,* **s**. *Gyrineum gyrinum*, **t**. *Gyrineum natator*, **u**. *Lunella cinerea,* **v**. *Turbo crassus,* **w.** *Turritella terebra,* **x**. *Volegalea cochlidium*.

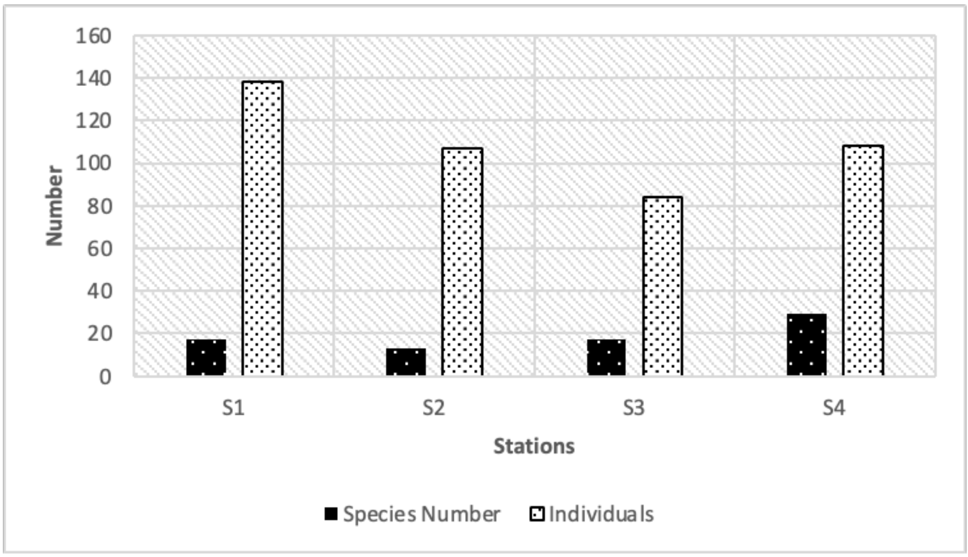

Fig. 3. Species and individual number of gastropods from the Bintulu intertidal area

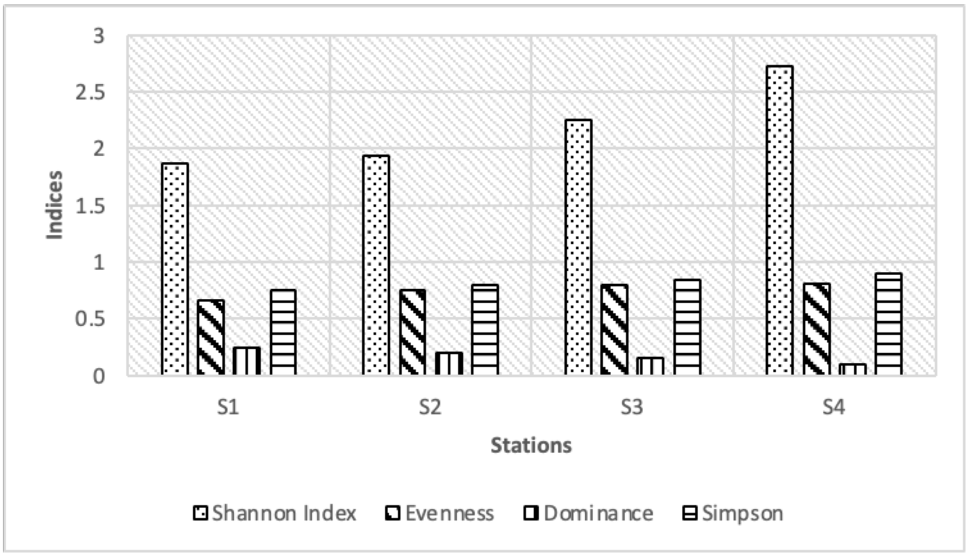

Fig. 4. Diversity indices of gastropods from the Bintulu intertidal area

DISCUSSION

The aquatic gastropods of Malaysian Borneo have been studied for 255 years, with the first record by Carl Linnaeus in 1767 (Al-Asif et al., 2022). After this initial record, several studies on gastropods in Malaysian Borneo were conducted by experts in malacology, such as Han Raven and Nur Leena Wong (Raven, 2021; Wong & Arshad, 2011). However, these studies primarily focus on species identification. The status of gastropod diversity, evenness, richness, and distribution, particularly in specific divisions of Borneo such as Sarawak, remains poorly documented. Previous study conducted at the rocky shore area of Kuala Similajau, Sarawak, was discovered to have 13 families with 40 species (Moklas, 2010). Another study at the rocky shore area of Bintulu documented 29 gastropod species belonging to 15 families (Yusop, 2014). Both studies are still fewer compared to the current gastropod recorded, which covers the wider intertidal area. A study in the same state by Mohd Long et al. (2014) and Hamli et al. (2013) only discovered 33 and 21 different gastropod species respectively, which recorded from intertidal, mangrove, and freshwater habitats. The alternative study from Terengganu and Sabah recorded 28 species (9 families) and 36 species (15 families), respectively, from the intertidal area (Baharuddin et al., 2018; Madin et al., 2021).

Five major gastropods are widely distributed at all the study locations, which are Cerithiidae, Planaxidae, Neritidae, Trochidae, and Turbinidae. Neritidae were also previously documented as most distributed in selected locations in Terengganu and Melaka (Baharuddin et al., 2018; Siti-Balkhis, 2014).

Meanwhile, Planaxidae and Cerithidae were the most distributed families for a study conducted in Sabah (Madin et al., 2021). A recent scientific analysis that used Turbinidae distribution as an indication of climate change indicated a poleward expansion of habitat along the coastlines (Son et al., 2020). The occurrence of tropical gastropods in temperate regions suggests that the climate is becoming warmer. Furthermore, Turbinidae are often used in ecological studies because their distribution patterns can reflect changes in marine environments, such as habitat shifts and biodiversity loss (Williams, 2007).

This study documented the dominance of the Muricidae family observed in the study locations. The shells of Muricidae are characteristically thick and sturdy, offering robust protection to the organism inside. The shells are popular among the shell collectors because of the facinating colours and interesting shapes (Kumar et al., 2017). A vast variety of environments, including rocky shorelines, coral reefs, sandy bottoms, and seagrass meadows, are habitats for muricids (Albert et al., 2022; Steger et al., 2017). Though they may be found in temperate waters as well, tropical and subtropical environments are origins habitat for them in particularly large numbers (Cahyadi et al., 2021). The majority of muricids are carnivorous, feeding on tiny fish as well as other molluscs and crustaceans (Herbert et al., 2016). They break through their prey's shells by scraping or drilling using a specialised feeding device known as a radula (Kosyan, 2016). Certain Muricidae species have historical and contemporary economic importance. Ancient societies employed some species, such as the purple dye murex (*Bolinus brandaris* and *Hexaplex trunculus*), to make a highly valued purple dye (Allen, 2017). While certain muricid species are maintained in marine aquariums, others are collected for food or their shells nowadays.

Station 4 in the present study showed it as a suitable habitat for marine gastropods. This was supported by the high values recorded in the diversity indices. Furthermore, Station 4 at Kuala Nyalau is still pristine and far from the city and development. Meanwhile, Stations 1, 2, and 3 are located near Bintulu town, which is known as an industrial town. Therefore, the marine gastropods that inhabit this area are vulnerable to anthropogenic effects. Gastropod distribution is greatly influenced by the availability of habitat, which includes the existence of appropriate substrate, cover, and food supplies (Linares et al., 2022; Susintowati et al., 2019). Various species have varying needs for habitat, which can range from rocky shorelines to freshwater streams. Their distribution is also influenced by salinity, water chemistry, climatic patterns and preferred temperatures, particularly in marine and estuary habitats where these variables are highly variable (Adekiya et al., 2020; Rumahlatu & Leiwakabessy, 2017; Uwadiae, 2013). Predation, herbivory, competition with other creatures, and food availability all have an impact on the distribution of gastropods and how they survive, behave, and interact with their surroundings (Chiba & Sato, 2012; Susintowati et al., 2019). In addition, human impacts like habitat destruction, pollution, overharvesting, and climate change pose serious threats to gastropod populations, requiring conservation efforts to maintain their biodiversity (Nasution, 2014; Nasution et al., 2021).

CONCLUSION

In conclusion, the present study reveals Station 4 (Kuala Nyalau) in the Bintulu Division as a key habitat for marine gastropods, exhibiting significant diversity compared to other surveyed stations. This finding adds valuable data to the understanding of marine gastropods in Sarawak and Borneo, with the high gastropod diversity at Kuala Nyalau suggesting its potential as a reference point for evaluating intertidal ecosystem health, which could guide future development and management strategies. Moving forward, research could focus on long-term monitoring of species diversity in response to environmental stressors, as well as comparative studies in other coastal regions of Sarawak and Malaysia to uncover broader ecological trends. Investigating anthropogenic impacts, such as pollution and coastal development, alongside exploring habitat restoration strategies, would further bolster conservation efforts. Additionally, genetic and morphological research could enhance our understanding of species adaptation and resilience, helping to shape future conservation approaches and improve ecological knowledge.

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ETHICAL STATEMENT

Not applicable

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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