Diversity of Bivalvia at Panggung Beach, Pasuruan Regency

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Abstract
Bivalvia are organisms characterized by two approximately symmetrical shell parts. They can be used as bioindicators to assess water quality. Panggung Beach is a coastal area on the northern coast of Pasuruan Regency, developed as a port. This study aims to inventory bivalve diversity, abundance, dominance, and analyze the bivalve habitat profile at Panggung Beach, Pasuruan. Bivalve samples were collected using the transect method at three designated stations. The habitat profile parameters examined included water pH, salinity, temperature, turbidity, and total dissolved solids. The collected data were analyzed using descriptive statistical methods.The results showed that the bivalves found at Panggung Beach were Tegillarca granosa, Anadara inaequivalvis, Marcia hiantina, Glauconome virens, Modiolus sp., Callista chione, and Placuna placenta. The bivalve diversity index at Panggung Beach was categorized as moderate, while the evenness index was high, and the dominance index was classified as moderate. The highest species abundance was Glauconome virens with 27 individuals, whereas the lowest was Placuna placenta with 8 individuals. The bivalve habitat profile at Panggung Beach, Pasuruan, recorded a temperature of 32–34°C, a salinity of 21.3 ppt, a water pH of 7.2, turbidity of 68.2 NTU, and total dissolved solids of 78.5. These conditions indicate that Panggung Beach is suboptimal for the bivalve community.

Keywords: Bivalvia, marine biota, mollusca, Panggung Beach
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INTRODUCTION

Biodiversity in coastal marine areas encompasses major communities such as coral reefs, seagrass, algae, and various other fauna, including organisms associated with coastal habitats such as mollusks, echinoderms, crustaceans, worms, and fish (Bahri, 2020). Bivalvia, or bivalves, are a group of mollusks with dual shells commonly found in coastal and marine areas. They play a crucial role in coastal ecosystems as bioindicators of water quality and as a food source for various other organisms (Purba et al., 2018). The diversity of bivalves is influenced by several factors, including substrate type, which ranges from sandy to muddy; water quality parameters such as temperature, salinity, pH, and dissolved oxygen content; and the availability of food sources like phytoplankton and dissolved organic matter, as bivalves are generally filter feeders (Suryono et al., 2017; Wijayati, 2019; Nurjanah et al., 2020).

Pasuruan is one of the northern coastal regions of East Java, known for its many beach tourism destinations. This region has significant coastal tourism potential, including beaches and marine environments, as seen in Panggung Beach, located in Panggung Village, Panggungrejo District, Pasuruan City (Ramadhani, 2022). However, the development of a port and the accumulation of severe waste pollution in the Panggung Beach area have led to critical conditions in the coastal ecosystem (Akhmad et al., 2021). Port activities and pollution from waste have the potential to negatively impact the presence and survival of bivalves, which are essential components of coastal ecosystems (Widyastuti & Pratiwi, 2019). Despite these conditions, research on biodiversity in the Panggung coastal area remains limited.

Previous studies have shown that bivalves play an important ecological role, particularly in environmental sustainability (Abdillah et al., 2019). They act as primary decomposers, breaking down organic matter into smaller particles, which are then further decomposed by microorganisms (Arief,

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2003). Additionally, bivalves serve a significant role as filter feeders, removing organic materials from the water (Bahri et al., 2020). Bivalves can also be used as biological indicators of water quality, as they spend their entire lives in the same habitat. When pollution occurs, contaminants accumulate in their bodies, and their mortality can serve as a sign of environmental contamination (Putri et al., 2011). Given the importance of bivalves in maintaining environmental health, further research on their diversity in natural habitats is necessary.

Bivalve diversity can be measured through three main parameters: species richness, species diversity, and evenness (Irni, 2021). These measurements are crucial for understanding current conditions, comparing, analyzing relationships, predicting trends, and determining appropriate management actions. Knowledge of the philosophy, methods, and implementation of species diversity assessments is essential for species conservation. The lack of research on bivalve diversity in natural habitats forms the basis of this study, which aims to assess the diversity of bivalves at Panggung Beach, Pasuruan.

MATERIALS AND METHODS

Research Location

The study was conducted at Panggung Beach, Panggungrejo District, Pasuruan Regency, East Java. The coordinates of the research location are at 7.624172° S and 112.902223° E (Figure 1). This beach was selected as the research site due to its characteristic presence of extensive mangrove forest along the coastline.The research location was determined using purposive sampling, where observation stations were selected based on specific environmental conditions at the study site. The sampling area is divided into three stations, each station has 3 plots, each measuring 1m x 1m with characteristics Station 1 has a muddy substrate, station 2 has a sandy mud substrate, and station 3 has a type of sand substrate and there are also several mangrove trees providing shade.

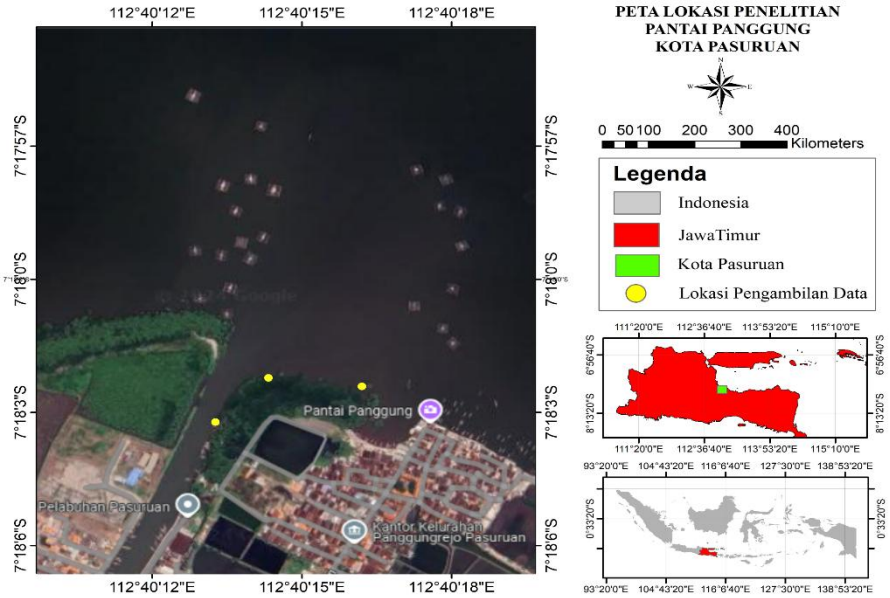


Figure 1. Research location at Panggung Beach Pasuruan

Research Procedure

a. Sample Collection

The tools and materials used for collecting bivalve samples included collection bottles, storage containers, measuring tape, gloves, a small shovel, label paper, millimeter paper, 70% alcohol, and writing instruments. The sampling technique used the transect method. Three stations were determined at the study site, each consisting of three plots. Bivalves in each plot were collected from both the surface and within the substrate up to a depth of 30 cm. The collected bivalves were sorted and counted in each plot. Environmental parameters measured

included substrate type, water pH, turbidity, salinity, and temperature. Water pH using a pH meter, salinity using a refractometer, water temperature using a water thermometer, turbidity using a turbidimeter, and Total dissolved solids (TDS) using a TDS meter.

b. Bivalve Identification

The bivalve shells were cleaned before identification using Huber (2010), Huber (2015), and Dharma (2005). Morphometric measurements of the bivalves were conducted using a ruler, and the data were analyzed descriptively and presented as mean values. The measured bivalve shell dimensions included: shell length, the perpendicular distance from the anterior to the posterior end of the bivalve shell. Shell height, the distance from the highest dorsal part to the lowest ventral part of the shell. Shell width, the distance between the most prominent lateral sides of both shell valves (Ambarwati & Faizah, 2017).

c. Calculation of Species Diversity Index, Evenness Index, and Dominance Index

Biodiversity Index (H')

The Shannon-Wiener Diversity Index was used to calculate bivalve species diversity, following Odum (1993):

$$\mathbf{H'} = -(\sum \boldsymbol{pi}\ \mathbf{ln}\ \boldsymbol{pi})$$

Descriptions: H′ = species diversity index, Pi = ni/N, ni = number of individuals of each species, N = total number of individuals.

The species diversity index was categorized into three levels:

a. H′ ≤ 1 : low diversity, low distribution, low community stability,
b. 1<H′ < 3 : moderate diversity, moderate distribution, moderate community stability,
c. H′ ≥ 3 : high diversity, high distribution, high community stability.

Evenness Index (E)

The Evenness Index was analyzed descriptively using the following formula:

$$\mathbf{E} = \frac{\mathbf{H'}}{\mathbf{ln\ S}}$$

Descriptions: H′ = species diversity index, S = number of species.

The evenness index was categorized into three levels:

a. 0< E ≤ 0,4 : low evenness, stress community,
b. 0,4 < E ≤ 0,6 : moderate evenness, unstable community,
c. 0,6 < E ≤ 1,0 : high evenness, stable community.

Dominance Index (C)

The Dominance Index represents the dominance of a species group over others. The Simpson Dominance Index (1949) was used to calculate species dominance:

$$(\mathbf{C}) = \sum (\boldsymbol{pi})^2$$

Descriptions: C = Dominance Index, Ni = Number of individuals of species i, N = total number of individuals of all species.

a. 0 < C < 0,5 : low dominance,
b. 0,5 < C ≤ 0,75 : moderate dominance,
c. 0,75 < C ≤ 1,0 : high dominance.

RESULTS

The identification results show that bivalves that can be found on the Pasuruan Panggung beach include Tegillarca granosa (Linnaeus, 1758), Anadara inaequivalvis (Bruguiere, 1792), Marcia hiantina (Lamarck, 1818), Glauconome virens (Linnaeus, 1767), Modiolus Sp (Iredale, 1939), Callista chione (Linnaeus, 1758), and Placuna placenta (Linnaeus, 1758) (**Figure 2**). The total number of bivalve individuals found was 107 with the highest number of bivalve species is Glauconome virens with 27 individuals, and the lowest species is Placuna placenta with 8 individuals. The highest number of specimens was collected from station 2 with 46 individuals, while station 1 had the least number of specimens with 23 individuals.

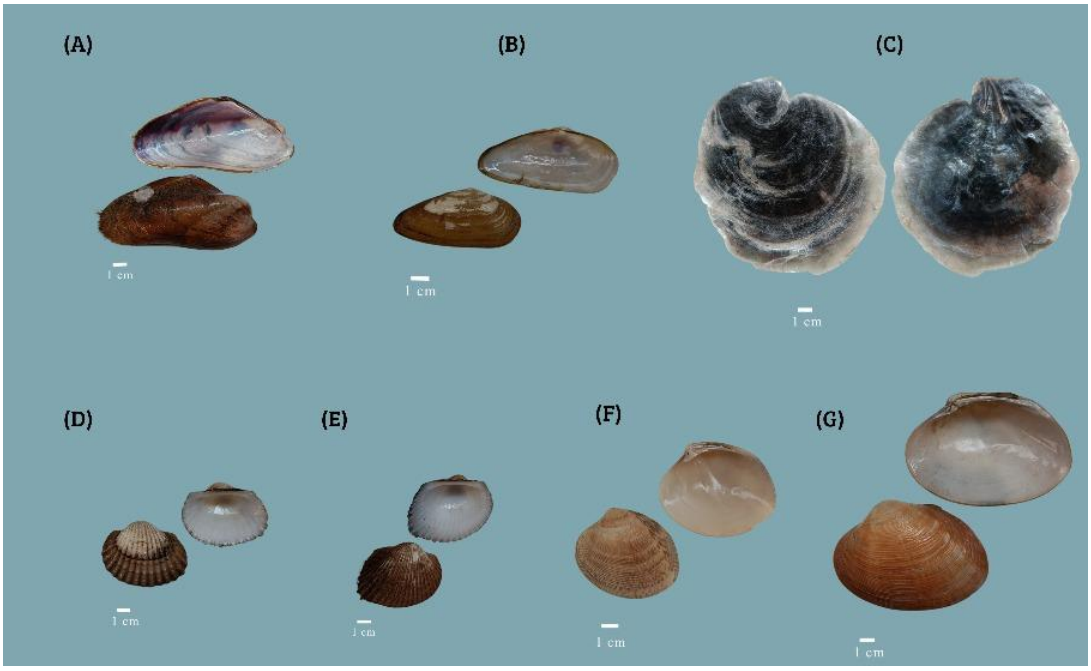


Figure 2. Research location at Panggung Beach Pasuruan Bivalves found in Panggung Beach Pasuruan: (A) Modiolus Sp; (B) Glauconome virens; (C) Placuna placenta; (D) Tegillarca granosa; (E) Anadara inaequivalvis (F)Marcia hiantina; (G) Callista chione.

a. ***Modiolus* sp** (Iredale, 1939)

Modiolus sp has a shell length of up to 50 mm, with an elongated oval shape. The shell thickness is approximately 0.8 cm, and its surface has fine concentric lines. The umbo is small and protrudes forward, while the ligament is strong and thick. The hinge teeth are small and few in number. The shell color is dark brown to blackish.

b. ***Glauconome virens*** (Linnaeus, 1767)

Glauconome virens has a shell length ranging from 30 to 40 mm. The shell is elongated and thin, resembling a blade, with a thickness of around 0.5 cm. The anterior part is broad and rounded, while the posterior part is elongated and slightly pointed. The shell surface is smooth, with irregular grooves on the outer shell. The umbo is small and not prominent. The ligament is external and elongated, and the hinge teeth are either simple or absent. The shell color varies from yellowish-white to light brown.

c. ***Placuna placenta*** (Linnaeus, 1758)

Placuna placenta has a shell length ranging from 60 to 70 mm. The shell is nearly circular and very flat, with a thickness of about 0.4 cm. The surface is smooth with slight concentric lines. The umbo is small and not prominent, and the ligament is thin. The species lacks hinge teeth. The shell color is transparent to silvery white.

d. ***Tegillarca granosa*** (Linnaeus, 1758)

Tegillarca granosa has a shell length of 20 to 30 mm. The shell is oval and slightly rounded, with a thickness of approximately 0.8 cm. The shell surface is rough, with distinct radial lines. The umbo is prominent and slightly rounded. The ligament is strong and thick, and the hinge teeth are evenly distributed and numerous. The shell color is whitish-gray.

e. ***Anadara inaequivalvis*** (Bruguière, 1792)

Anadara inaequivalvis has a shell length ranging from 20 to 30 mm. The shell is oval and relatively thick, with a thickness of about 1 cm. The surface has coarse radial lines. The umbo is large and protruding. The ligament is strong, and the hinge teeth are evenly distributed and numerous. The shell color is brownish-white.

f. ***Marcia hiantina*** (Lamarck, 1818)

Marcia hiantina has a shell length ranging from 30 to 35 mm. The shell is oval and slightly flattened, with a thickness of approximately 0.7 cm. The shell surface is smooth, with concentric lines. The umbo is tilted and pointed. The ligament is circular, and the lateral hinge teeth are elongated. The shell color is brown with striped patterns.

g. ***Callista chione*** (Linnaeus, 1758)

Callista chione has a shell length of 45 to 60 mm. The shell is rounded and slightly flattened, with a thickness of about 0.6 cm. The shell surface is smooth, with thin concentric lines. The umbo is small and located in the center. The ligament is thin, and the hinge teeth are small and delicate. The shell color is yellowish-white with brown stripe patterns.

The presence of bivalves in Panggung Beach, Pasuruan, reveals an interesting species diversity, with a total of 7 species from 5 orders and 5 families. The results of this study on the diversity, evenness, and dominance indices of bivalves along the Panggung Beach showed variations across the three observed stations (**Table 1**). Each research station at Panggung Beach, Pasuruan, exhibited different environmental conditions, station one had a muddy substrate and was heavily polluted with waste, station two is an area with high human activity for shellfish collection, with a muddy-sandy substrate, and station three is a mangrove area with a sandy substrate.

Table 1. Abundance of bivalves found in Panggung Beach, Pasuruan

Species	Famili	ST1	ST2	ST3
Anadara inaequivalvis	Arcidae	3	7	5
Tegillarca granosa	Arcidae	6	5	2
Modiolus sp	Mytilidae	0	5	8
Callista chione	Veneridae	0	8	9
Marcia hiantina	Veneridae	2	4	8
Glauconome virens	Glauconomatidae	9	12	6
Placuna placenta	Placunidae	3	5	0
	Number of individuals	23	46	38
	Diversity Index (H')	1,45	1,69	1,58
	Dominance Index (C)	0,22	0,16	0,19
	Evenness Index (E)	0,90	0,96	0,95

The calculations of the three community indices showed varying values, but they generally fell within the moderate category. The diversity index ranged from 1.45 to 1.69, with Station 2 exhibiting the highest diversity value (1.69), while Stations 1 and 3 had slightly lower values but were still categorized as moderate. This indicates that the distribution of individuals at these stations was relatively even, with a community that was fairly stable but still vulnerable to environmental changes. The observed moderate diversity index aligns with the findings of Septiana (2017) in the coastal area of Pasuruan, East Java, where the bivalve diversity index ranged from 1.52 to 1.78. Similarly, Nurjanah et al. (2019) reported a diversity index of 1.62 to 1.88 in the Probolinggo mangrove area, indicating a consistent pattern in East Java.

The dominance index ranged from 0.16 to 0.22, falling within the moderate category at all stations. This index detected the presence of a dominant species, but the difference in individual numbers was not highly significant. Data analysis showed that *Glauconome virens* had a higher number of individuals compared to other species, especially at Station 1, suggesting that this species dominated the community at this station. The dominance of *Glauconome virens* found in this study aligns with the findings of Budi et al. (2020) in the Kendal estuary, where this species was also dominant. A similar pattern was reported by Wahyuni et al. (2018) in the Brantas Delta, East Java, with a dominance index ranging from 0.18 to 0.25.

The evenness index ranged from 0.90 to 0.96, indicating that individual distribution was relatively even across stations. Station 2 had the highest evenness value (0.96), signifying that the

number of individuals per species was nearly equal, with no species overwhelmingly dominating. However, the evenness values at all stations were still classified as moderate to high, meaning that species numbers were fairly balanced. A more evenly distributed population at Station 2 suggests that its ecosystem was more stable than Stations 1 and 3. The lower evenness index at Station 1 was likely due to the dominance of *Glauconome virens*, while at Station 3, species distribution was more varied but remained unstable. Magurran (2004) and Isnaningsih & Patria (2018) stated that communities with moderate or high evenness values are still susceptible to environmental changes.

Species Distribution and Habitat Preferences

The variation in species distribution and evenness among stations highlights the importance of preserving diverse habitats to support bivalve biodiversity. For example, *Placuna placenta* was only found at Stations 1 and 2 (3 and 5 individuals, respectively), suggesting a preference for muddy to sandy-mud substrates. This finding supports Sukimin et al. (2007), who stated that *Placuna placenta* inhabits coastal areas with soft sediment habitats at depths of up to 9 meters. In contrast, *Modiolus* sp was absent at Station 1 but abundant at Station 3 (8 individuals), indicating a strong preference for sandy substrates. These findings reinforce the recommendations of Printrakoon et al. (2018) for mangrove ecosystem conservation and its associated bivalves, emphasizing substrate variation as a key factor in maintaining species diversity.

The diversity of bivalves is closely linked to environmental factors, particularly physicochemical properties of the water. The habitat profile in this study included parameters such as pH, salinity (‰), total dissolved solids (TDS), turbidity, and water temperature (°C). Substrate type plays a crucial role in the development of coastal-dwelling organisms. Sandy substrates facilitate bivalve movement and relocation, whereas muddy substrates contain lower oxygen levels compared to sandy substrates (Lindawaty, 2016) (**Table 2**).

Table 2. Bivalvia habitat profile of each station at Panggng Beach, Pasuruan

Locations	Substrate Type	Temperature (°C)	Salinity (ppt)	pH	Turbidity (NTU)	Dissolved solids
Stasion 1	Mud	32	22	7,2	101	85,2
Stasion 2	Sandy mud	34	30	7,7	0,67	78,1
Stasion 3	mud	34	12	6,8	103	72,3

The research results indicate that substrate composition varies across stations. Station 1 has a muddy substrate, Station 2 consists of sandy-mud, and Station 3 features a sandy substrate with the presence of mangrove trees providing shade. The water temperature in Panggung Beach during the study ranged from 32–34°C, which falls within the normal range. According to Suwondo et al. (2006), bivalves can optimally metabolize at temperatures between 25–35°C. In addition to temperature, salinity is another crucial factor influencing bivalve survival. The average salinity recorded was 21.3 ppt, which is suboptimal as it does not meet the Indonesian Environmental Quality Standards (Government Regulation No. 51 of 2004), which states that optimal salinity ranges from 28–34 ppt. This finding is further supported by Riniatsih & Edi (2009), who reported that bivalve mollusks and gastropods thrive within a salinity range of 29–32 ppt.

The average pH level of the water in Panggung Beach was 7.2, which is optimal and aligns with the Indonesian Environmental Quality Standards, which recommend a pH range of 6.0–9.0. Water pH significantly affects bivalve survival, as an optimal pH supports efficient metabolic processes. If pH levels fall below or exceed the optimal threshold, bivalves may struggle to survive, leading to potential mortality. Suwondo et al. (2006) stated that the ideal pH range for bivalve survival is 6–9. The turbidity of Panggung Beach's waters had an average value of 68.2 NTU, while total dissolved solids (TDS) were recorded at 78.5 mg/L. Excessively high TDS levels may indicate the presence of harmful contaminants

that could degrade bivalve habitats and disrupt their physiological functions. The highest TDS level was observed at Station 1 (85.2 mg/L), which contributed to the lower bivalve population in this area.

DISCUSSION

Bivalve Diversity and Habitat Characteristics

Overall, the study revealed that all three stations exhibit moderate bivalve diversity, although species composition and evenness vary based on substrate type. Sandy-mud substrates at Station 2 supported a higher species count, while the presence of mangroves at Station 3 provided an additional habitat beneficial for certain bivalve species. The moderate dominance levels across all stations indicate a relatively even species distribution, with one species occasionally dominating. Nurdin et al. (2008) emphasized that biodiversity indices are not solely influenced by species count variations but also by population evenness within a community. This study demonstrated that bivalve populations in Panggung Beach are not evenly distributed across stations. For example, *Placuna placenta* was exclusively found at Station 2.

The presence of aquatic vegetation, particularly mangroves, plays a crucial role in influencing bivalve diversity and abundance. Mangroves contribute organic material to the ecosystem, serving as an important food source for detritus-feeding bivalves. In Boom Beach, Tuban, the absence of aquatic vegetation has been linked to low bivalve diversity and abundance. As filter feeders, bivalves depend on a sufficient organic matter supply in their habitats. Additionally, Panggung Beach is located near residential areas, making it susceptible to pollution from household waste, which negatively affects bivalve diversity and abundance. Local shellfish harvesting activities further contribute to population fluctuations. Rahmasari et al. (2014) reported that Panggung Beach contains lower organic matter levels compared to muddy sediment habitats, which may influence bivalve distribution patterns.

Bivalve species in Panggung Beach exhibit varying abundance levels, making this study a valuable baseline for assessing bivalve diversity and population dynamics. The findings provide critical data for local government authorities to enhance coastal resource management strategies. Moreover, this research serves as a reference for sustainable coastal development and conservation efforts to ensure the long-term ecological and economic viability of bivalve populations. Raising public awareness about the importance of marine ecosystem conservation is crucial. This includes promoting waste reduction efforts to maintain clean coastal environments and preserve aquatic biodiversity. The sustainable management of Panggung Beach ecosystem is essential to ensure that bivalves and other marine organisms continue to thrive while maintaining economic benefits for local communities.

CONCLUSION

Based on the research conducted in Panggung Beach, Pasuruan, seven bivalve species were identified: Anadara inaequivalis, Modiolus sp, Glauconome virens, Marcia hiantina, Tegillarca granosa, Placuna placenta, and Panopea generosa. These species belong to five different orders and five families. The bivalve diversity index in Panggung Beach falls within the moderate category, while the evenness index is classified as high and the dominance index as moderate. The most abundant species was Glauconome virens, with 27 individuals, while the least abundant was Placuna placenta, with only 8 individuals. The bivalve habitat profile in Panggung Beach, Pasuruan, indicates suboptimal conditions; however, the presence of bivalves in this area suggests their ability to adapt to the environment.

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CONFLICT OF INTEREST

There is no conflict of interest.

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