

Bivalvia Community Structure In The Ecosystem Of Jenggalu Mangrove Tourism Park, Bengkulu Province

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Abstract

Mangrove ecosystems are important habitats for various benthic organisms, including bivalves, which play a role in maintaining the ecological balance of aquatic environments. The Jenggalu Mangrove Forest Tourism Park in Bengkulu City has high potential for biodiversity, but information on the structure of the bivalve community in this area is still limited. This study aims to determine the structure of the bivalve community, including species composition, abundance, and environmental conditions that influence their existence in the Jenggalu mangrove ecosystem. The study was conducted using a survey method with direct sampling techniques at several observation points in the mangrove area. Each bivalve individual found was then identified based on morphological characteristics, counted, and analysed for community structure using ecological indices such as diversity, evenness, and dominance. The results showed that the bivalve community in the Jenggalu mangrove area consisted of several species with different abundance levels at each observation location. The diversity index value was in the moderate category, indicating that environmental conditions were still sufficiently supportive of bivalve life. The relatively stable evenness value indicated a fairly even distribution of individuals between species, while the low dominance value indicated that no species was overly dominant. The results of this study indicate that the mangrove ecosystem in this area still has environmental conditions that are sufficient to support bivalve life. This information is expected to form the basis for efforts to manage and conserve the mangrove ecosystem and preserve the diversity of aquatic biota in the area.

Keywords: Bivalves; Community; Community; Diversity; Mangrove Ecosystems

INTRODUCTION

Indonesia is an archipelagic country with the longest coastline of 18,719 km, which is rich in the diversity of marine life. These vast waters and long coastline make them an ideal habitat for various types of shellfish (Muthoharoh & Nugroho, 2023). Mangrove forests, typical vegetation of tropical regions such as Indonesia, have important ecological and economic functions for living things (Khatulistiwa *et al.* 2025). Ecologically, mangroves act as spawning grounds and nursery grounds for fish, shrimp, shellfish, and other species (Zakia *et al.* 2024). In addition, mangroves provide feed and nutrients that support the productivity of marine fisheries in front of them (Yanti *et al.* 2022).

Mangrove ecosystems function as habitats for living, sheltering, spawning, and foraging. Its main food chain involves detritus from fallen and rotting mangrove leaves and twigs. Bivalves depend on this detritus (Bahri *et al.* 2020) This animal settles on the bottom of the water, with its abundance influenced by environmental factors and its biological needs (Sundari *et al.* 2023).

The structure of the bivalve community is influenced by environmental parameters such as substrate, temperature, salinity, and organic content. Understanding this relationship supports the management of mangrove habitats to maintain the diversity of bivalves and related organisms. Members of the Bivalvia Class have special adaptations that allow them to survive in intertidal areas under physical pressure. These organisms are also adaptive to currents and waves. However, bivalves cannot move quickly so they are easy to catch (Erika *et al.* 2022)

Bivalves are scattered in coastal waters such as estuaries with mud bottoms mixed with sand. Some live on hard substrates such as clay, wood, or rock, freshwater, as well as a little on land. Marine bivalves such as mussels, clams, and oysters are three types of bivalves that live in the ocean with striking differences in terms of shells, habitat, and lifestyle. Kapah has an elongated and erect shell, attached to a stone or hard substrate with fine threads byssal bysso (Zakia *et al.* 2024). The shellfish is symmetrical oval-shaped, digging themselves into the sand or mud of the seabed for protection. Oysters have an irregular corrugated shell, latent to hard substrates such as rocks or harbor poles, often forming colonies or reefs (Putri *et al.* 2025). Bivalves that live in estuarine areas, namely several types of shellfish such as *Scrombicularia plana*, *Macoma balthica*, *Rangia flexosa* dan *tiram jenis Crassostrea* (Putri *et al.* 2025). Because life is settled in the substrate and sensitive to environmental changes, the structure of the bivalve community can detect changes in water quality as well as human impacts such as pollution and overexploitation.

This study aims to determine the structure of the bivalve community in the Jenggalalu Mangrove Tourism Forest Park, Bengkulu City. This study aims to fill the gap through a comprehensive analysis of the bivalve community structure and environmental correlation models, while simultaneously identifying the potential of new indicator species for sustainable mangrove ecosystem conservation. This location was chosen because the potential of the mangrove ecosystem is still rarely explored scientifically, especially bivalves as indicators of ecological conditions. The structure of the bivalve community in Jenggalalu will be analyzed. The bivalve community shows diversity, density, dominance, and distribution patterns of species that reflect the stability and health of the coastal environment (Timur *et al.* 2022).

Bivalves as sedentary organisms and sensitive to environmental changes are useful for detecting the impacts of human activities such as pollution and overexploitation (Sundari *et al.* 2023). Therefore, this study examines the composition, dynamics of bivalve communities, and the relationship of environmental parameters that affect them. so that the results become the basis for sustainable coastal resource management and conservation of mangrove ecosystems in the area.

METHODS

The researcher conducted a thorough exploration survey in the Jenggalalu Mangrove Tourism Forest Park Ecosystem, Bengkulu (214.62 ha) at a certain depth to observe the presence and distribution of bivalves directly. The survey is exploratory and systematic, providing an overview of the bivalve community without an area limit. After finding the bivalves, the sample was taken manually using hand picking from mangrove or sand substrates. Samples are then collected, identified by genus/species, and counted the number of individuals (Wardana *et al.*, 2023).

The researcher observed 3 repetitions per week. The sampling technique uses hand picking directly with the survey method of exploring the plot line of the transect. Bivalve sampling was carried out on a 10x10 m² quadrant transect with 5 randomly placed 1x1 m² sub plots (Wardana *et al.* 2023). Samples are taken with a shovel 10-20 cm deep. Environmental parameters (temperature, salinity, pH, depth, base substrate) are measured at each sample point (Sundari *et al.* 2023).

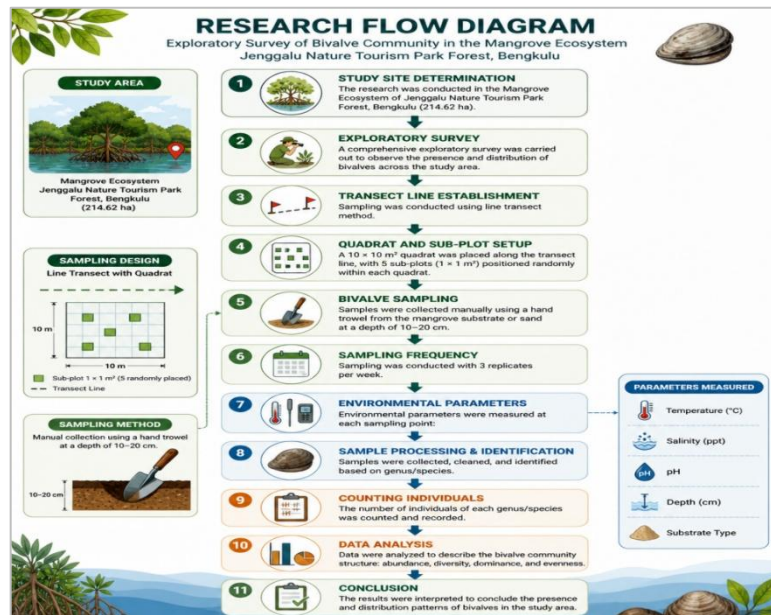


Figure 1. Research flow

Community Structure Analysis

Preliminary observations show that ecological factors such as water temperature, salinity, substrate type, depth, and ocean currents play an important role in the structure of the Bivalvia community in the Jenggalalu Mangrove Tourism Forest Park. The type of substrate is the dominant factor that affects the existence of Bivalves. This is in line with the finding that "Bivalve's habitat preferences are influenced by substrate texture, availability of space to attach, and environmental stability" (Wiratmaja *et al.* 2022).

Relatively stable salinity favors the abundance of individual Bivalves, as most marine species are stenohalin (sensitive to changes in salinity). As stated, "Bivalves in mangrove tourism forest parks tend to be physiologically stressed if salinity fluctuates sharply" (Zakia *et al.* 2024) In addition, ocean currents affect the distribution of Bivalve's larvae and food particles. Areas with moderate currents are more inhabited by filter feeder species because the food supply is stable (Sigh *et al.* 2023).

This research focuses on species composition, abundance, diversity, degree of dominance, and spatial distribution patterns of bivalve mollusks in mangrove ecosystems. Community structure analysis includes identification of bivalve mollusk species, interspecies interactions, as well as the influence of environmental factors such as substrate, water temperature, salinity, and organic matter on community dynamics. The study also examined the adaptation of bivalve mollusks to the physical stresses of the intertidal zone, including resistance to currents and waves (Kalimantan, 2023).

Diversity

Diversity describes the state of bivalves mathematically to make it easier to observe population diversity in a community. The calculation of the diversity of a type of bivalve uses the Shannon-Wiener diversity index formula (Odum 1993):

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

Simpson's Dominance Index (D)

The ideological value in a community can be determined by using the simpson dominance index (Odum 1993), namely:

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

Equality Index

The value of the equality index (E) is calculated using the formula from (odum 1993):

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

Bivalve Density

The density of an organism in a body of water can be expressed as the number of individuals, the unity of the area or volume (Brower, *et al* 1997). The calculation of bivalve density can be formulated as follows :

$$D = \frac{n_i}{A}$$

Material

The materials used consist of sample bottles, 50-70% alcohol as a preservative, label paper, bivalve identification books, and bivalves as the main object.

Tools

The tools used in this study include calipers, DO meters, pH meters, water thermometers, cameras, roll meters, salinometers, stationery, boots, ropes, scissors, meters, gloves, buckets, and mini shovels for sampling, tweezers, strerof foam.

RESULT AND DISCUSSION

Species Composition and Abundance of Bivalves

A total of 554 bivalve individuals were recorded from three observation stations in the Jenggalu Mangrove Tourism Park, Bengkulu Province. The identified bivalves consisted of four species, namely *Geloina expansa*, *Corbicula fluminea*, *Mactra maculata*, and *Saccostrea cucullata*. The number of individuals varied among stations, with Station 1 recording the highest abundance (196 individuals), followed by Station 3 (189 individuals) and Station 2 (169 individuals). This spatial variation indicates that bivalve distribution was not uniform across the mangrove area and may be associated with differences in microhabitat conditions, substrate characteristics, mangrove-root availability, organic matter accumulation, and local environmental conditions.

Table 1. Species composition, abundance, relative abundance, and density of bivalves in the Jenggalu Mangrove Tourism Park

Species	Station 1	Station 2	Station 3	Total individuals	Relative abundance (%)	Density (ind/m ²)
<i>Geloina expansa</i>	41	23	66	130	23.47	0.43
<i>Corbicula fluminea</i>	29	19	17	65	11.73	0.22
<i>Mactra maculata</i>	7	5	19	31	5.60	0.10
<i>Saccostrea cucullata</i>	119	122	87	328	59.21	1.09
Total	196	169	189	554	100.00	1.85

Among the recorded species, *Saccostrea cucullata* was the most abundant, contributing 328 individuals or 59.21% of the total bivalve community. This species was consistently found at all stations, with the highest number at Station 2, followed by Station 1 and Station 3. The dominance of *Saccostrea cucullata* suggests that the Jenggalu mangrove ecosystem provides suitable hard substrates, such as mangrove roots, woody debris, and compact surfaces, which support the attachment and survival of oyster species.

The second most abundant species was *Geloina expansa*, with 130 individuals or 23.47% of the total community. This species was most abundant at Station 3, where 66 individuals were recorded. The relatively high abundance of *Geloina expansa* at Station 3 may indicate the presence of softer muddy or sandy-mud substrates, which are generally preferred by burrowing mangrove clams. Meanwhile, *Corbicula fluminea* accounted for 65 individuals or 11.73% of the total abundance and was found at all stations, although its number slightly decreased from Station 1 to Station 3. The least abundant species was *Mactra maculata*, with only 31 individuals

or 5.60% of the total community, suggesting that suitable habitat conditions for this species may be limited in the study area.

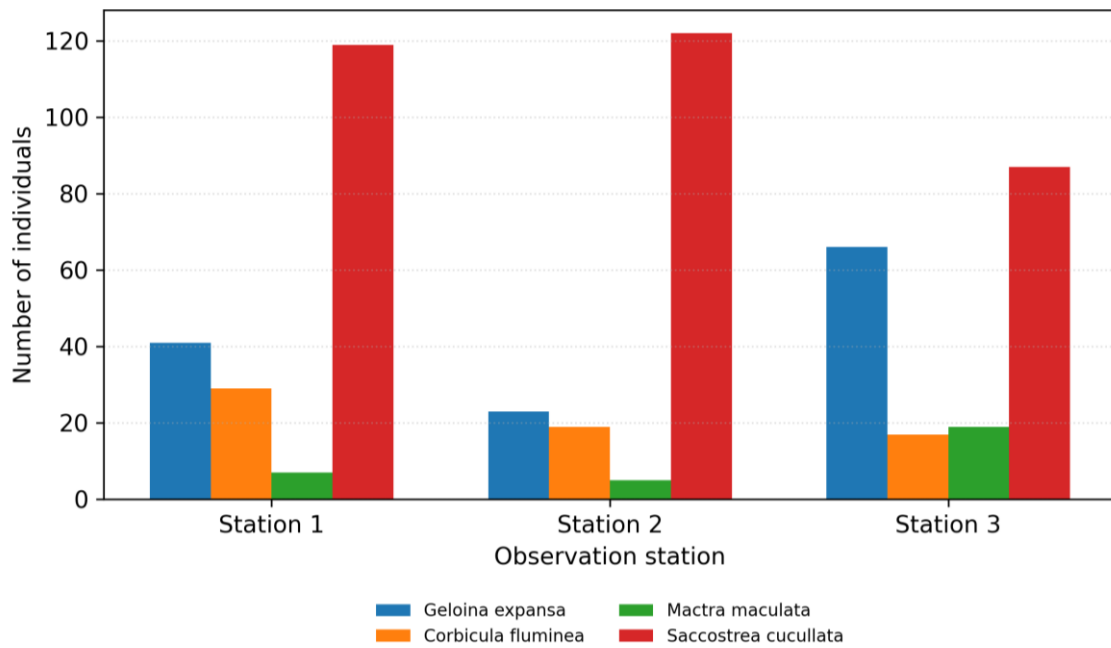


Figure 1. Bivalve abundance by species and observation station.

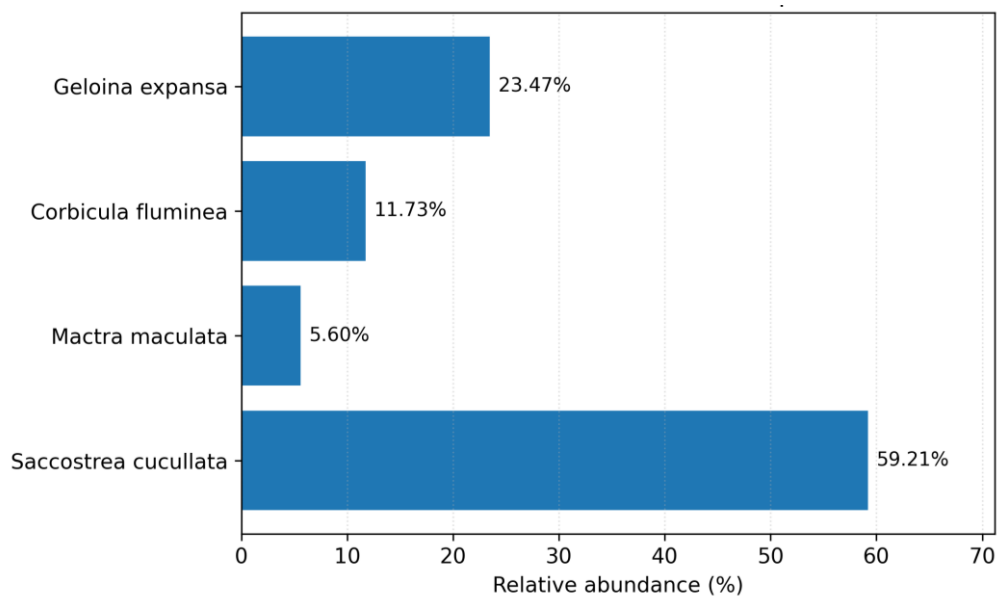


Figure 2. Relative abundance of bivalve species in the Jenggalu Mangrove Tourism Park.

Table 2. Station-level abundance, density, and contribution to total bivalve abundance

Station	Total individuals	Density (ind/m ²)	Contribution to total abundance (%)
Station 1	196	1.96	35.38
Station 2	169	1.69	30.51
Station 3	189	1.89	34.12

Bivalve Community Structure Indices

The ecological indices showed that the bivalve community in the Jenggalu Mangrove Tourism Park was characterized by moderate diversity, low dominance, relatively even distribution, and low density. The Shannon-Wiener diversity index (H') was 1.06, indicating moderate species diversity. The Simpson dominance index (D) was 0.42, suggesting that no single species completely dominated the community, although *Saccostrea cucullata* showed the highest numerical abundance. The evenness index (E) was 0.77, indicating a relatively even distribution of individuals among species. Meanwhile, the total density was 1.85 ind/m², which can be categorized as low.

Table 3. Ecological indices of the bivalve community

Ecological index	Value	Category	Ecological interpretation
Shannon-Wiener diversity index (H')	1.06	Moderate	The community contains several species, but diversity remains limited.
Simpson dominance index (D)	0.42	Low	No species shows absolute dominance in the community.
Evenness index (E)	0.77	Relatively even	Individuals are distributed fairly evenly among species.
Density	1.85 ind/m ²	Low	Individual abundance per unit area remains limited.

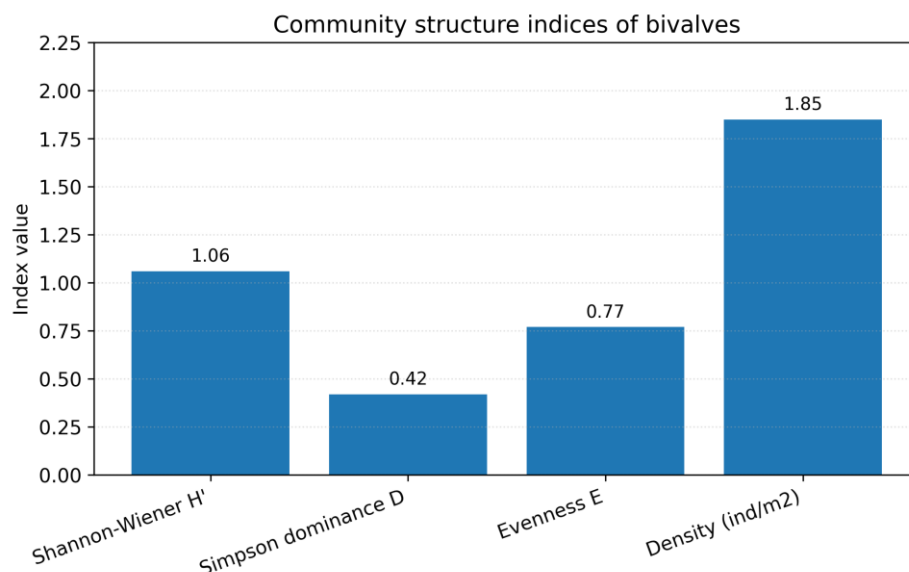


Figure 3. Community structure indices of bivalves.

Environmental Parameters of the Mangrove Habitat

The measured environmental parameters consisted of pH, temperature, salinity, and dissolved oxygen (DO). The pH values ranged from 7.10 to 7.38, with an average of 7.21, indicating neutral to slightly alkaline water conditions. Water temperature ranged from 21.44°C to 26.03°C, with an average of 24.44°C. Salinity ranged from 10.0 to 11.5‰, indicating brackish water conditions typical of estuarine mangrove ecosystems. Dissolved oxygen ranged from 7.50 to 7.95 mg/L, with an average of 7.72 mg/L, suggesting that the waters still had sufficient oxygen availability to support benthic organisms.

Table 4. Environmental parameters at the three observation stations

Parameter	Station 1	Station 2	Station 3	Mean	Interpretation
pH	7.10	7.14	7.38	7.21	Neutral to slightly alkaline
Temperature (°C)	26.03	21.44	25.86	24.44	Suitable for tropical estuarine organisms
Salinity (‰)	11.5	10.0	11.5	11.0	Brackish water condition

Dissolved oxygen / DO (mg/L)	7.95	7.70	7.50	7.72	High / optimal for aquatic organisms
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Overall, the environmental parameters indicate that the Jenggalu mangrove waters were still within a range that can support bivalve survival. The neutral pH, brackish salinity, and high DO values suggest that water quality was not the main limiting factor for the presence of bivalves. However, the low density of bivalves indicates that other ecological factors, particularly substrate condition, habitat disturbance, mangrove-root structure, sediment stability, and tourism-related pressure, may play an important role in shaping the bivalve community structure.

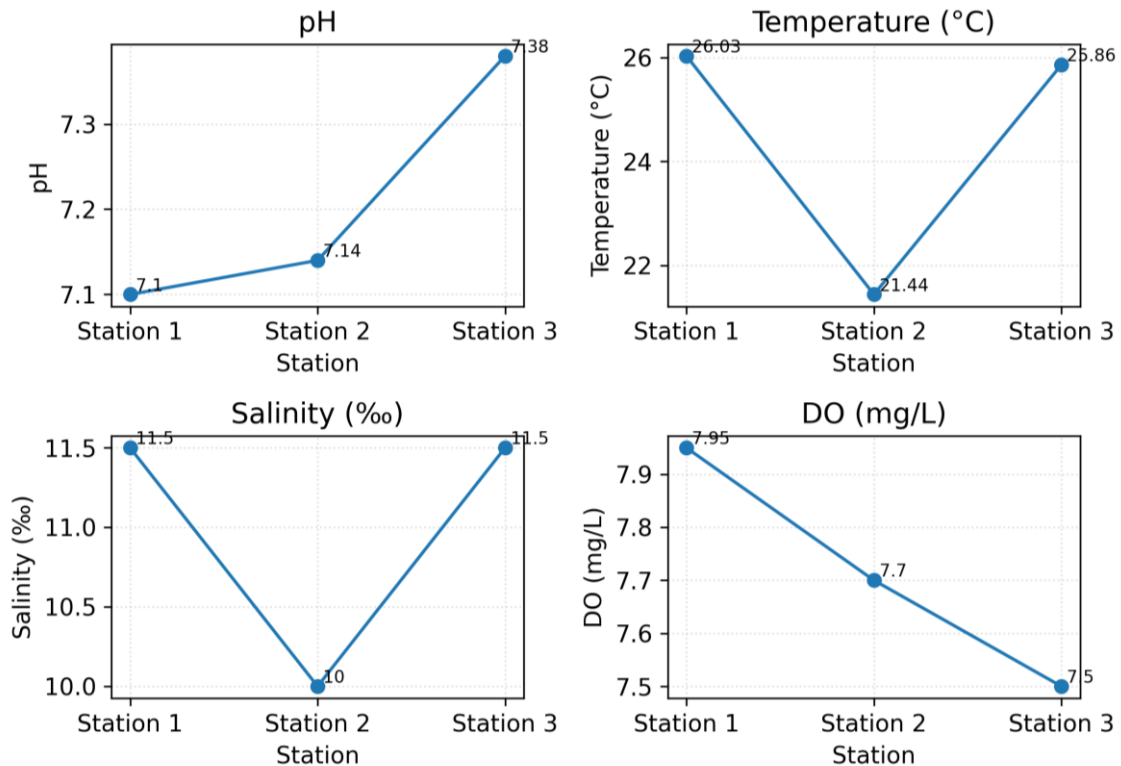


Figure 4. Environmental parameters across observation stations.

Discussion

The results indicate that the bivalve community in the Jenggalu Mangrove Tourism Park consisted of four species, with clear variation in abundance among stations. The total number of 554 individuals shows that the mangrove habitat still supports bivalve life, although the number of species was relatively limited. The presence of *Geloina expansa*, *Corbicula fluminea*, *Mactra maculata*, and *Saccostrea cucullata* reflects the ecological heterogeneity of the mangrove ecosystem, where different microhabitats provide different ecological niches for burrowing, attached, and filter-feeding bivalves.

The highest total abundance was recorded at Station 1, followed by Station 3 and Station 2. This pattern suggests that Station 1 may provide more favorable habitat conditions for bivalves, particularly in terms of substrate availability, root complexity, and food resources. In mangrove ecosystems, bivalve abundance is strongly associated with substrate texture, sediment stability, mangrove vegetation, and organic matter accumulation. Mangrove litter contributes organic material to the substrate and supports benthic food webs, thereby providing food resources for filter feeders and deposit feeders. This interpretation is in line with Yanti et al. (2022), who emphasized that gastropod and bivalve community structure in mangrove ecosystems is closely related to environmental characteristics and habitat conditions.

The dominance of *Saccostrea cucullata* is one of the most important findings of this study.

This species contributed more than half of the total individuals, indicating that the Jenggalu mangrove ecosystem provides suitable attachment substrates. As an oyster species, *Saccostrea cucullata* is commonly associated with hard substrates, including mangrove roots, rocks, wood, and other stable surfaces. Its sessile lifestyle allows it to colonize available hard substrates effectively, especially in intertidal and estuarine areas. A recent study by Umami, Karnan, and Santoso (2024) similarly reported that *Saccostrea cucullata* is frequently found attached to rocks and mangrove roots and that its abundance pattern is closely linked to substrate availability.

The relatively high abundance of *Geloina expansa*, particularly at Station 3, indicates the availability of muddy or sandy-mud substrates that support burrowing bivalves. *Geloina expansa* is commonly associated with mangrove sediments and is often found in habitats with relatively high organic matter content. Meanwhile, the presence of *Corbicula fluminea* may reflect the influence of freshwater input into the estuarine mangrove area, as this species is generally tolerant of variable salinity conditions. The low abundance of *Mactra maculata* suggests that its preferred habitat may be less available or less stable in the study area.

The Shannon-Wiener diversity index value of 1.06 indicates moderate bivalve diversity. This value suggests that the community was not extremely poor in species, but it also did not show high species richness. The moderate diversity may be caused by the limited number of species recorded and the numerical dominance of *Saccostrea cucullata*. In ecological terms, moderate diversity often indicates that the habitat is still capable of supporting several species, but certain environmental or anthropogenic pressures may limit species richness and population expansion.

The Simpson dominance index value of 0.42 indicates low dominance. Although *Saccostrea cucullata* was the most abundant species, the presence of other species across the stations reduced the possibility of complete dominance. This means that the bivalve community still retained a degree of ecological balance. However, the high relative abundance of *Saccostrea cucullata* should still be interpreted carefully because numerical dominance by attached oyster species may indicate greater availability of hard substrates than soft sediment habitats. Therefore, dominance in this study should not only be interpreted as a species-level pattern but also as a reflection of habitat structure.

The evenness index value of 0.77 indicates a relatively even distribution of individuals among species. This category should not be written as low because a value approaching 1 generally indicates higher evenness. Therefore, the previous interpretation in the manuscript needs correction. A more appropriate interpretation is that the bivalve community showed relatively even distribution, although one species, *Saccostrea cucullata*, remained numerically dominant. This distinction is important because evenness helps explain whether community composition is balanced or strongly skewed toward one species.

The low density value of 1.85 ind/m² indicates that individual abundance per unit area was limited. This result is ecologically important because moderate diversity and relatively even distribution do not necessarily indicate high population density. Low density may result from several factors, including limited suitable substrate, physical disturbance, harvesting pressure, sediment instability, or tourism-related activities. Sundari, Nurrahman, and Nurdiansyah (2023) also reported that bivalve community structure in mangrove areas is influenced by environmental parameters and habitat conditions, supporting the interpretation that community indices must be read together with local ecological context rather than interpreted separately.

The environmental parameters recorded in this study indicate that the water quality of the Jenggalu mangrove area was generally suitable for bivalve life. The pH values ranged from 7.10 to 7.38, which falls within a neutral to slightly alkaline range. Such pH conditions are generally favorable for aquatic organisms because extreme acidity or alkalinity can interfere with physiological processes, including respiration, metabolism, and shell formation in mollusks.

The salinity values ranged from 10.0 to 11.5‰, indicating brackish water conditions. This is typical of mangrove ecosystems located in estuarine areas, where seawater mixes with

freshwater runoff. The presence of both *Saccostrea cucullata* and *Corbicula fluminea* reflects the ecological character of this habitat, where species with different salinity tolerances may coexist. Brackish salinity can support estuarine bivalves, but fluctuations in salinity may still influence growth, reproduction, and survival.

The DO values ranged from 7.50 to 7.95 mg/L, indicating high oxygen availability. These values suggest that oxygen concentration was not a major limiting factor in the study area. High DO levels can support respiration and metabolic activity of benthic organisms, including filter-feeding bivalves. However, the low density of bivalves despite favorable DO values suggests that water quality alone cannot fully explain the community structure. Other habitat variables that were not directly measured, such as sediment grain size, organic matter content, root density, canopy cover, and human disturbance intensity, may have stronger effects on bivalve abundance.

The temperature values ranged from 21.44°C to 26.03°C. Although this range remains generally suitable for many estuarine organisms, the relatively lower temperature at Station 2 may have contributed to differences in species abundance. Temperature can influence filtration rate, metabolic activity, reproduction, and larval development in bivalves. However, because this study did not conduct statistical testing between environmental parameters and bivalve abundance, the relationship should be interpreted cautiously.

One important issue that should be discussed more critically is the possible influence of anthropogenic pressure. The Jenggalu area functions as a mangrove tourism park; therefore, human activities such as visitor movement, facility development, trampling, waste disposal, and disturbance of sediment surfaces may affect benthic habitats. Bivalves are relatively sedentary organisms; therefore, they are sensitive to physical changes in substrate and habitat quality. Even when pH, salinity, temperature, and DO remain suitable, physical disturbance to the substrate may reduce the ability of bivalves to settle, burrow, feed, and reproduce.

However, the claim that anthropogenic activities are the main cause of low density must be presented carefully. The present study did not directly measure tourism intensity, waste load, sediment organic matter, heavy metals, substrate grain size, or mangrove vegetation density. Therefore, anthropogenic pressure should be framed as a plausible explanatory factor rather than a confirmed causal factor. To strengthen this argument, future studies should include quantitative indicators of human disturbance, such as visitor frequency, distance from tourism facilities, litter density, sediment compaction, organic matter content, and substrate texture.

Comparison with previous studies supports this interpretation. Wiraatmaja et al. (2022) found that mollusk composition in mangrove ecosystems varies across sites and is shaped by habitat characteristics and local ecological conditions. Similarly, Yanti et al. (2022) emphasized that changes and pressures in mangrove environments can influence the number of species and community structure of gastropods and bivalves. Therefore, the low density observed in the present study may indicate that the Jenggalu mangrove ecosystem remains capable of supporting bivalve life but may be experiencing habitat limitations or localized ecological pressure.

The findings of this study have important implications for mangrove conservation and coastal ecosystem management. The presence of four bivalve species indicates that the Jenggalu mangrove ecosystem still functions as a habitat for benthic organisms. However, the moderate diversity and low density suggest that habitat quality should be monitored continuously. Bivalves can serve as useful ecological indicators because they are closely associated with substrate conditions, water quality, and environmental disturbance. Changes in their abundance, diversity, and distribution may reflect broader ecological changes in mangrove habitats.

The dominance of *Saccostrea cucullata* also suggests that hard substrates, especially mangrove roots and woody structures, are important microhabitats that must be protected. Damage to mangrove roots or removal of woody substrates may directly reduce available habitat for oyster species. At the same time, the presence of *Geloina expansa* and *Macra maculata* indicates the importance of maintaining soft sediment habitats. Conservation efforts should therefore not only focus on mangrove vegetation cover but also on sediment stability, substrate diversity, and the reduction of physical disturbance in intertidal areas.

CONCLUSION

The structure of the bivalve community in the mangrove ecosystem of the Jenggalu Mangrove Tourism Forest Park, Bengkulu City, shows differences in composition and species dominance in each observation plot. This difference is influenced by environmental conditions such as the type of substrate, the density of mangrove vegetation, and the availability of organic matter that supports the life of benthic organisms. The results of the study found 4 species of bivalves, namely *Geloina expansa*, *Corbicula fluminea*, *Mactra maculata*, and *Saccostrea cucullata* with a total of 554 individuals. The most dominant species is *Saccostrea cucullata* because it attaches a lot to the roots and stems of mangroves. The variation in the number of individuals in each plot suggests that mangrove ecosystems play an important role as habitats, shelters, and food sources for bivalves. In general, this condition shows that the mangrove ecosystem in the area is still quite good in supporting the sustainability of the bivalve community

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