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Research Article

Exploring Bivalve Community on the Southern Beaches of Bangkalan Madura Regency, Indonesia

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ABSTRACT
The southern beaches of Bangkalan Madura Regency are located in the Madura Strait, near the harbour of Surabaya. The areas have various substrates and mangrove vegetation, rich in invertebrates' diversity such as bivalve. This study aimed to identify the species, to analyse the diversity, and the importance value index of bivalve, as well as to describe the ecological characteristics on the southern beaches of Bangkalan Madura Regency, Indonesia. The sampling was conducted in the intertidal zone of the southern beaches of Bangkalan, namely Rongkang Beach, Kwanyar Beach, and Modung Beach. The quadrant transect method was applied for the sampling process using 270 plots of 1 x 1 m^2, located at upper intertidal, middle intertidal, and lower intertidal of beaches. Furthermore, samples were identified based on morphological characters and diversity was analysed using the Shannon-Wiener diversity index. The importance value index of each species was calculated and the ecological characteristics of the habitat were analysed by using Principal Component Analysis (PCA). The results showed that the South Beach of Bangkalan Madura Regency had 19 bivalve species from 10 families and 7 orders. Bivalve in this area were diverse, with a diversity index of 2.16. The highest importance value index was *Solen* sp. at 58.87 % followed by *Tegillarca granosa* at 30.34 %. Additionally, the PCA results showed that substrate pH, water pH, salinity, temperature, sand of substrate, and clay of substrate affected bivalve community. This showed that the southern beaches of Bangkalan were favourable for bivalve habitat.

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INTRODUCTION

Bivalves are benthic animals in shallow (littoral) or deep water (deep zone) living by sinking their bodies into the mud or sand substrate, sheltering behind rocks, wood, and marine plants. Some are attached to rocks, corals, and wooden pillars, or crawl freely on the surface of the substrate (Setyono 2006; Vaughn & Hoellein 2018; Abdulla-AI-Asif et al. 2021). The mussel group can be found in estuaries, rivers, mud flats, and rocky shores to the deep sea (Lim et al. 2018). Furthermore, bivalves are biological resources with high economic value, such as raw materials for food (Lim et al. 2018; Huang et al. 2023), crafts, as well as bioactive resources (Mona et al. 2021), and building materials (Sudhakaran & Poulose 2021). The species of bivalves are mostly consumable because of the ability to be directly processed into traditional food, such as *lorjuk rengginang* in Kamal District, Bangkalan (Kalsum et al. 2013; Susena & Yanuwiadi 2015). The typical coastal community of Modung Beach, Bangkalan earns a living as bivalve fishermen and collectors for both consumption and trade, including *lorjuk* (bamboo clams), blood cockles, and oysters (Ambarwati et al. 2016). A previous study showed that *lorjuk* could be processed into various kinds of food (Wahyurini 2017). Apart from being an ingredient, bivalves play an important role in the environment, such as recycling organic matter, facilitating the mineralization process, and as bioindicators of water quality because of sensitivity to changes in the aquatic environment (Zarkasyi et al. 2016; Vaughn & Hoellein 2018; Abdulla-AI-Asif et al. 2021). Some species have ecological roles as filter feeders and food for predators (Lim et al. 2018). The presence of bivalves is affected by several factors, including pollution, type of bottom substrate, composition of organic matter, predators, and competitors, as well as parameters of the aquatic environment (Dame 2012; Glaspie & Seitz 2017; Craeymeersch & Jansen 2019; Rahardjanto et al. 2020).

Studies on bivalve diversity have been conducted on the southern beaches of Madura Island. Ambarwati et al. (2016) listed 38 species of bivalves found on Modung Beach, while 8 species were reported in Barung Toraja Beach (Bening & Purnomo 2019). Another study found 15 species associated with lamp shells (Phylum Brachiopoda) in the Madura Strait (Rakmawati & Ambarwati 2020). Additionally, 21 species of bivalves were reported from the southern beaches of Pamekasan, Madura (Kurniawan et al. 2024). These studies showed that beaches on Madura Island had a high bivalve' diversity.

The southern beaches of Bangkalan, Madura are covered by mangrove vegetation and has various substrates, namely muddy sand and rocky (Ramadhani et al. 2022; Ambarwati et al. 2024). This environmental condition provides potential habitats for bivalve community, located near a large harbour where local and international ships dock. Therefore, beach can have additional species from other areas, because aquatic animals such as bivalves spread easily due to larvae carried through ship ballast water. Some invasive species can spread to other places through ship ballast water (Arif et al. 2016). According to Irawan and Soegianto (2006), there were two additional orders and two crab species in the Madura Strait that had not been recorded in previous surveys in Indonesia. The addition of crab species is because the Madura Strait is a shipping traffic lane, allowing accidental migration through ship ballast water (Irawan & Soegianto 2006). This was supported by a study that showed *Mytella strigata*, a brackish water mussel from America was found to spread for the first time in Singapore through ship ballast water (Lim et al. 2018; Yip et al. 2021). Based on the described background, there is a need to explore bivalve community and their important contributions to the economy. Therefore, this study aims to identify the species, to analyse the diversity, and the importance value index of bivalve, as well as to describe the ecological

characteristics on the southern beaches of Bangkalan Madura Regency, Indonesia.

MATERIALS AND METHODS

Materials

This explorative study used 70 % alcohol to preserve the sample of bivalves.

Methods

Field Work

This study was conducted on the southern beaches of Bangkalan Madura Regency consisting of three stations, namely Rongkang Beach (7°09'52 "N and 112°50'30 "E), Kwanyar (7°09'52 "N and 112°50'58 "E), and Modung Beach (7°11'53 "N and 112°57'57 "E) (Figure 1). Rongkang Beach has rocky upper intertidal zone, without mangrove vegetation. Kwanyar Beach has thick mangrove vegetation and the substrate is muddy sand. Modung Beach has thin mangrove vegetation with muddy sand substrate. The sampling was conducted during the period when beach receded to the utmost low tide. Furthermore, the quadrant transect method was used by placing one transect line vertically on the coastline, which was divided into three intertidal, including upper, middle, and lower intertidal. A total of three quadratic plot sizes of 1 x 1 m^2 were placed in the middle of each intertidal area, as shown in Figure 2. Each station consisted of 10 transect lines, with a distance between transects of approximately 10 m. The substrate in the plot was dug using a trowel to collect the living bivalves. Initially, all bivalves found in the quadrant plots were cleaned and preserved using 70 % alcohol in collection bottles and labeled. The samples were deposited at the Laboratory of Animal Systematics, Universitas Negeri Surabaya, for further study.

The sample of substrates was taken from each intertidal area and kept in a plastic bag for further analysis in the laboratory. The composition of substrate was analysed using the sieving method (Test Sieve) and the salinity was measured using a hand refractometer (Atago, master-S28M, Japan). The pH and temperature of water were measured by using a pH56 meter (Milwaukee, Romania). The pH of substrate was measured by using a soil tester.

Identification

The observation was conducted on the morphological characteristics of bivalve such as shell shape, colour, and sculpture, including ligament colour, adductor muscle scars, umbo position, umbo colour, pallial lines, pallial sinuses, and dentition. Bivalve samples were identified using the Lamprell and Whitehead (1992), Lamprell and Healy (1998), Dharma (2005), Huber (2010, 2015), Tan et al. (2022), and the World Register of Marine Species (WoRMS) database website.

Data Analysis

Diversity data were analyzed based on the Shannon-Wiener diversity index (H') (Odum 1993):

$$H' = -\sum \frac{(ni)}{N} ln \frac{(ni)}{N}$$

Where: H': Diversity index; ni: Number of individuals of the i-th species; N: Total individual population. The results of the diversity index calculation are divided into three categories, namely $H'<1$, $1<H'<3$, and $H' >3$, representing low, medium, and high levels of species diversity, respectively.

The importance value index (IVI) was calculated by using the following formulas:

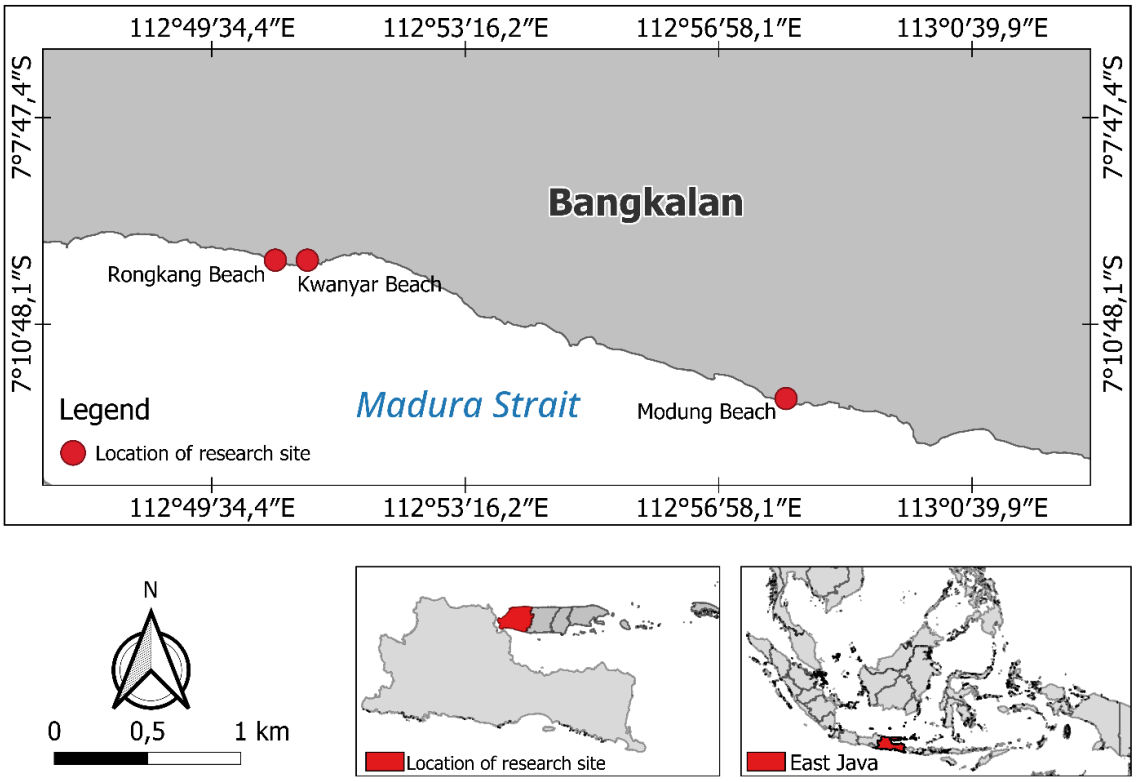

Figure 1. Bivalve sampling stations in the southern beaches of Bangkalan, Madura.

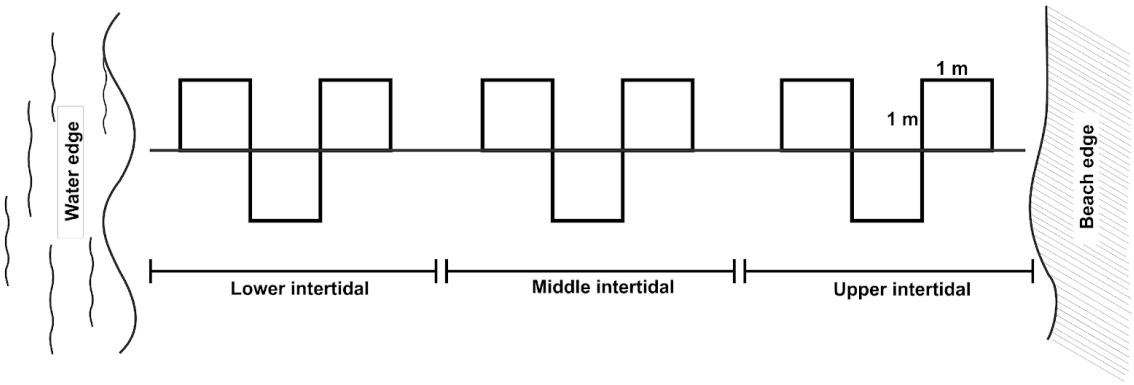

Figure 2. Bivalve sampling design of one transect line.

$$Di = \frac{Ni}{A}$$

$$DRi = \left(\frac{Di}{DN}\right) \times 100\ \%$$

$$FRi = \left(\frac{Fi}{FN}\right) \times 100\ \%$$

$$IVIi = DRi + FRi$$

Where: Di: density of individuals of the i species (ind m^{-2}), Ni: number of individuals of the i species, A: total area of sampling (m^2), DRi: relative density of i species (%), DN: total density of all species, FRi: relative frequency of i species (%), Fi: frequency of i species, FN: total density of all species, IVIi: importance value index of i species.

Ecological characteristics data were analysed using Principal Component Analysis (PCA). Several stages were carried out in PCA, including the calculation of Bartlett's test of sphericity, Kaiser-Meyer-Olkin (KMO), Measure Sampling Adequacy (MSA), communalities, and determination of the main factors formed.

RESULTS AND DISCUSSION

Bivalve Community

The southern beaches of Bangkalan had different substrate types, namely Rongkang Beach with dominant rocky substrate, while Kwanyar Beach and Modung Beach had sandy mud substrate. The identification results in Figure 3 showed that 19 bivalve species belonging to 10 families and seven orders were obtained in the southern beaches of Bangkalan. Among all samples collected, the order Veneroida had the most members, consisting of three families and seven species. The family with the largest number of species is Veneridae with four species, as shown in Table 1.

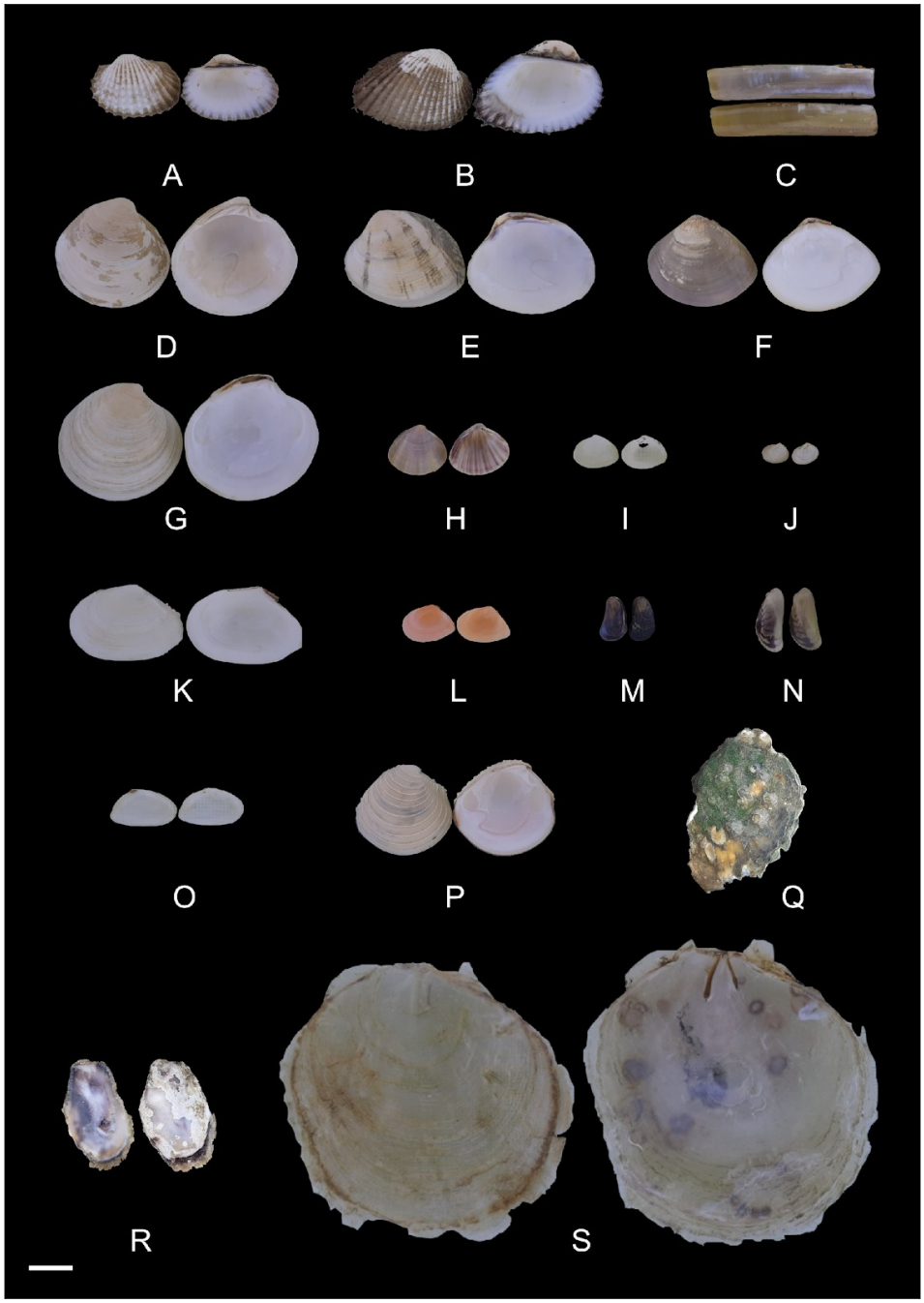

Figure 3. Bivalves on the southern beaches of Bangkalan Madura, A: *Tegillarca granosa* (Linnaeus, 1758), B: *Anadara rhomboidalis* (Schumacher, 1817), C: *Solen* sp., D: *Dosinia dilecta*

A. Adams, 1856, E: *Marcia hiantina* (Lamarck, 1818), F: *Meretrix* sp., G: *Semele cordiformis* (Holten, 1802) H: *Mactra incarnata* Reeve, 1854, I: *Heterocardia gibbosula Deshayes*, 1855, J: *Amarilladesma* sp., K: *Psammacoma gubernaculum* (Hanley, 1844), L: *Jitlada philippinarum* (Hanley, 1844), M: *Vignadula mangle* (Ockelmann, 1983), N: *Arcuatula senhousia* (W. H. Benson, 1842), O: *Tellinides timorensis Lamarck*, 1818, P: *Placamen isabellina* (R. A. Philippi, 1849), Q: *Crassostrea* sp., R: *Saccostrea* sp., S: *Placuna placenta* (Linnaeus, 1758). Scale bar: 10 mm.

The number of bivalves found on the southern beaches of Bangkalan is almost similar with the one in Pamekasan Madura (Kurniawan et al. 2024). However, the species composition on the two beaches was different. This study found new records that had not been reported in previous surveys conducted in Bangkalan Madura (Ambarwati et al. 2016; Rakmawati & Ambarwati 2020; Wahyuni et al. 2016) including *Placamen isabellina*, *Mactra incarnata*, *Amarilladesma* sp., *Semele cordiformis*, *Placuna placenta*, *Vignadula mangle*, and *Arcuatula senhousia*. One of the newly discovered records in the intertidal area of Bangkalan Beach was *Arcuatula senhousia*, which was previously known as *Musculita senhousia* and commonly found in the Madura Strait (Santi et al. 2021). The Asian mussel had spread to New Zealand, Australia, the Mediterranean, and the Pacific Beach of the United States (GISD 2024). The species could grow rapidly and lived in groups on soft substrates, with the ability to dominate benthic communities and exclude. Additionally, the species invaded the Oristano Lagoon-Gulf System (W Sardinia, Italy) at moderate densities (<1000 m^2), without impacting sediment structure and local macrozoobenthic assemblages (Como et al. 2015).

Arcuatula senhousia has spread to West Africa, where there is accidental transportation with oysters or other bivalves traded for shellfish farming or carried by ship ballast water (Lourenco et al. 2018). This is supported by other studies where larvae of aquatic animals such as bivalve can spread through passive transport such as hull (biofouling) with ballast water (Phillips et al. 2012; Lim et al. 2018).

On the southern beaches of Bangkalan, certain groups of bivalves comprising the Veneridae, Arcidae, Solenidae, Mactridae, and Tellinidae families, coexist in the same habitat with lamp shells (Brachiopoda) (Rakmawati & Ambarwati 2020). The Veneridae species dominate the sampling area on the southern beaches of Bangkalan. This result was similar to the mollusk diversity in Modung Beach Bangkalan Madura, where most of bivalve species found were members of the Veneridae family (Ambarwati et al. 2016). Other studies reported that the Veneridae family was found in the Madura Strait with the highest number of species compared to others (Rakmawati & Ambarwati 2020). Moreover, substrate dominated by sandy mud is considered suitable for Veneridae (Rakmawati & Ambarwati 2020; Takar et al. 2023).

The majority of bivalves discovered on the southern beaches of Bangkalan were in the middle and lower intertidal areas. The species in the upper intertidal area were mostly the Ostreidae (*Saccostrea* sp. and *Crassostrea* sp.) and the Mytilidae (*Vignadula mangle* and *Arcuatula senhousia*) attached to rock and coral substrates. *Saccostrea* and *Crassostrea* attach their shells to the rock, while *Vignadula mangle* and *Arcuatula senhousia* attached using byssus.

In the middle and lower intertidal, bivalves were found to live by migrating (infauna). The species possessed long siphons that could support their lives as infauna (Zwarts & Wanink 1989; Poutiers 1998). Approximately all bivalves on the South Beach of Bangkalan were obtained at depths between 0-15 cm, but *Solen* sp. was found to be very deep at a depth of 20 cm. Each taxon has a distinctive morphology as a form of adaptation to its habitat (Ambarwati et al. 2016). For example, *Solen* sp. has a very deep pallial sinus that shows the size of the siphon and the ability to dig into the substrate. This species has a slender and small body with modified parts to dig the substrate faster (Trisyani et al. 2016).

Based on bivalve found on the southern beaches of Bangkalan, approximately all species can be consumed with high economic value. This causes a significant increase in the exploitation of bivalve by coastal community, particularly *Solen* sp. The species is often called *lorjuk* or bamboo clams, which is usually used as an ingredient for making *rengginang*, *lorjuk* rice cracker, and fried *lorjuk* (Kalsum et al. 2013; Susena & Yanuwiadi 2015; Wahyurini 2017). In addition to *lorjuk*, clams that are often caught by coastal community are blood cockles (*Tegillarca granosa*), due to delicious taste and high economic value. Previous studies have shown that *Tegillarca granosa*, *T. nodifera*, and *Anadara rhomboidalis* are consumed by coastal community (Dharma 2023).

Bivalve Diversity Index

Bivalve diversity analysis was carried out to determine the distribution level on three stations and was calculated using the Shannon-Wienner diversity index formula. The diversity index value on the southern beach of Bangkalan was 2.16, which is classified as medium. Each station had a different value, where Rongkang Beach had the highest index value of 1.84, followed by Kwanyar and Modung at 1.41 and 1.21, respectively.

Based on the diversity index calculation (H'=2.16), bivalve on the southern beaches of Bangkalan was on the medium level. Moreover, the presence of species with high abundance, equal, or approximately equal, in community showed high diversity (Odum 1993). The calculation of the Shannon-Wienner diversity index ranged from 1.5 to 3.5, suggesting a moderate level (Magurran 2004). Generally, two factors that affect the diversity index value include the number of species and relative abundance (McNaughton & Wolf 1992).

Rongkang Beach had the highest diversity index value compared to Kwanyar and Modung. This was because the substrate of Rongkang Beach was more varied, with rocky predominating in the upper intertidal alongside sandy mud in the middle and lower intertidal. Additionally, this beach had several bivalve species with high relative abundance, including *Solen* sp., *Vignadula mangle*, *Arcuatula senhousia*, and *Saccostrea* sp.

The index value of bivalve diversity in Kwanyar Beach was 1.40, while the lowest was Modung at 1.21. This lower value was because there were suburban areas around beach with several activities including fishing. According to D'Souza and Shenoy (2023), human activities such as settlement and fishing could affect the diversity of macrozoobenthos including bivalve.

Solen sp. from the Solenidae family is a species that dominated the three stations, as shown in Figure 4. The high relative abundance value showed that the southern beaches of Bangkalan dominated by sandy mud substrate were a suitable habitat for *Solen* sp. Although sand can facilitate the movement or shift of biota, mud offers a stable substrate and serves as an attachment for organisms (Wahyuni et al. 2016; Craeymeersch & Jansen 2019). Therefore, a sandy mud substrate supports Solen sp. in growth and development (Wahyuni et al. 2017). These results were in line with previous studies, where Solen sp. dominated the waters of Bangkalan (Wahyurini 2017).

In three stations, the least common species were *Anadara rhomboidalis*, *Amarilladesma* sp., *Semele cordiformis*, and *Placuna placenta*, as shown in Figure 4. This study was conducted in the intertidal area, which contributed to the low distribution of *Placuna placenta*. Malacofauna studies at Selayung Beach, Tarakan City, North Kalimantan showed that *Placuna placenta* was commonly found in the subtidal area (Zainuddin et al. 2018). Since these clams are more valuable economically compared to others, over-exploitation can occur causing a decrease in population. Due to numerous human activities on Kwanyar and Modung Beach including fishing, these two places have potentially been overused.

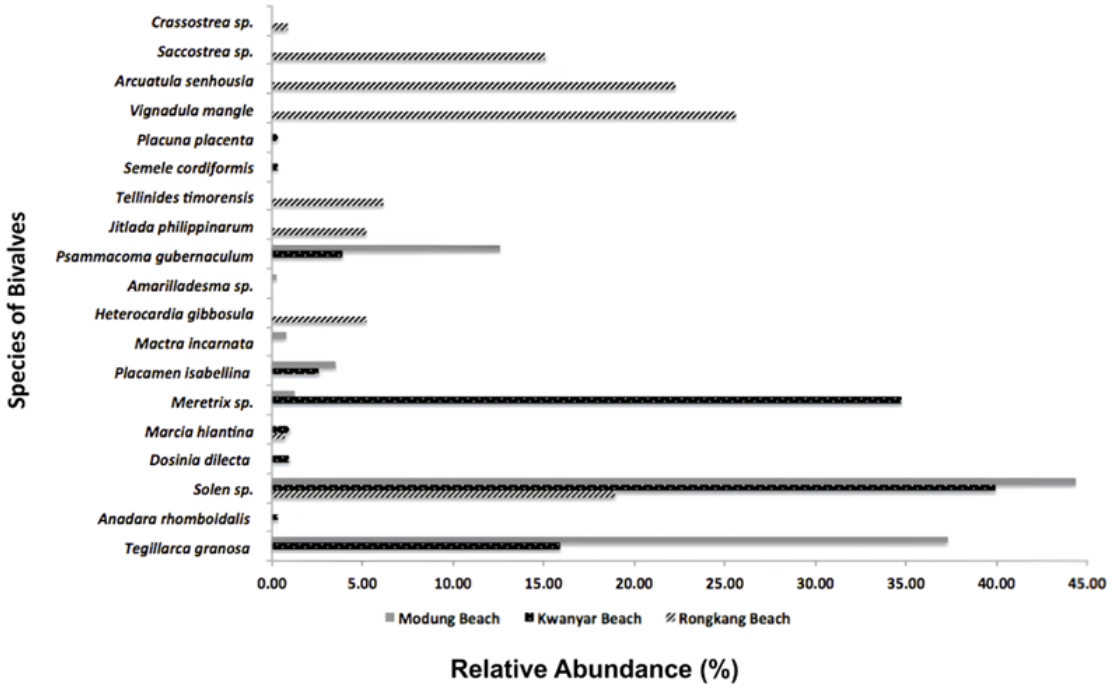

Figure 4. Bivalve species relative abundance (%) of each station.

Importance Value Index of Bivalve

Each bivalve species had different density and frequency values. The species with the highest density was *Solen* sp. at 1.78 ind m^{-2} with a relative frequency of 30 %, as shown in Table 1. Meanwhile, the lowest was *Anadara rhomboidalis*, *Amarilladesma* sp., *Semele cordiformis*, and *Placuna placenta* comprising only one individual during the sampling. Based on the results, each species had a different distribution. *Solen* sp. was found on all beaches, while

Table 1. Bivalve species on the southern beaches of Bangkalan Madura Regency.

No.	Order	Family	Species	Ni	Ni/A (ind m^{-2})	DRi (%)	F	FRi (%)	IVI (%)
1.	Arcida	Arcidae	*Tegillarca granosa* (Linnaeus, 1758)	197	0.73	11.82	0.37	18.52	30.34
2.			*Anadara rhomboidalis* (Schumacher, 1817)	1	0.00	0.06	0.00	0.19	0.25
3.	Ada-pedonta	Solenidae	*Solen* sp.	481	1.78	28.87	0.60	30.00	58.87
4.	Venerida	Veneridae	*Dosinia dilecta* A. Adams, 1856	3	0.01	0.18	0.01	0.56	0.74
5.			*Marcia hiantina* (Lamarck, 1818)	10	0.04	0.60	0.03	1.30	1.90
6.			*Meretrix* sp.	112	0.41	6.72	0.24	12.22	18.94
7.			*Placamen isabellina* (R. A. Philippi, 1849)	22	0.08	1.32	0.07	3.70	5.02
8.		Mactridae	*Mactra incarnata* Reeve, 1854	3	0.01	0.18	0.01	0.56	0.74
9.			*Heterocardia gibbosula* Des-hayes, 1855	50	0.19	3.00	0.13	6.48	9.48
10.		Mesodes-matidae	*Amarilladesma* sp.	1	0.00	0.06	0.00	0.19	0.25
11.	Cardiida	Tellinidae	*Psammacoma gubernaculum* (Hanley, 1844)	62	0.23	3.72	0.16	7.78	11.50
12.			*Jitlada philippinarum* (Hanley, 1844)	50	0.19	3.00	0.11	5.37	8.37

Table 1. Contd.

No.	Order	Family	Species	Ni	Ni/A (ind m^{-2})	DRi (%)	F	FRi (%)	IVI (%)
13.			*Tellinides timorensis* Lamarck, 1818	59	0.22	3.54	0.13	6.67	10.21
14.		Semelidae	*Semele cordiformis* (Holten, 1802)	1	0.00	0.06	0.00	0.19	0.25
15.	Pectinida	Placunidae	*Placuna placenta* (Linnaeus, 1758)	1	0.00	0.06	0.00	0.19	0.25
16.	Mytilida	Mytilidae	*Vignadula mangle* (Ockelmann, 1983)	246	0.91	14.77	0.03	1.30	16.06
17.			*Arcuatula senhousia* (W. H. Benson, 1842)	214	0.79	12.85	0.02	0.93	13.77
18.	Ostreida	Ostreidae	*Saccostrea* sp.	145	0.54	8.70	0.06	2.96	11.67
19.			*Crassostrea* sp.	8	0.03	0.48	0.02	0.93	1.41

Crassostrea sp. was discovered on Rongkang Beach due to the presence of a rock substrate. Generally, *Crassostrea* sp. prefers habitats in tidal and subtidal areas, which have fine or coarse substrates including rocks (Harris 2008).

Solen sp. was the species with the highest Important Value Index (IVI) (58.87 %), playing a significant role in the ecosystem. A species' significance in the habitat is generally influenced by compatibility with the substrate characteristics, as showed by IVI value (Rohmayani et al. 2021). *Solen* sp. such as sandy mud substrates (Dharma 2023; Kurniawan et al. 2024), and the southern beaches of Bangkalan was dominated by sandy mud substrates. Meanwhile, the species with the lowest IVI value were *Anadara rhomboidaliss*, *Amarilladesma* sp., *Semele cordiformis*, and *Placuna placenta* with an IVI value of 0.25 %. This showed that these species have little role in the community.

Ecological characteristics of bivalve

The habitat profile on the southern beaches of Bangkalan in each station has different values. Based on the results of substrate composition analysis, the southern beaches of Bangkalan were dominated by sandy mud substrate, while Rongkang Beach had a rocky substrate at upper intertidal area (Table 2).

The analysis of Bartlett's test of sphericity, KMO, MSA, and communal-

Table 2. Habitat profile of bivalve at the southern beach of Bangkalan.

Station	Zone	Substrate pH	Water pH	Salinity (ppt)	Temperature (°C)	Gravel of substrate (%)	The sand of substrate (%)	Clay of substrate (%)
Rongkang Beach	Upper	rocks	rocks	rocks	rocks	rocks	rocks	rocks
	Middle	6.4	7.9	30	29	1.38	9.88	88.74
	Lower	6.4	7.9	30	30	1.05	10.52	88.43
Kwanyar Beach	Upper	5.2	7.9	30	29	8.50	21.81	69.68
	Middle	4.6	7.3	29	24	7.10	23.85	69.05
	Lower	5.2	7.4	29	24	6	25.10	68.89
Modung Beach	Upper	6	7.9	30	28	2.81	19.18	79.01
	Middle	6.2	7.9	30	28	3.01	17.56	79.43
	Lower	6.2	7.9	30	29	2.10	18.20	79.70

ities analysis of environmental factors of bivalve habitats showed significant results. The communalities value of each variable of feasible environmental factors including substrate pH, water pH, salinity, temperature, sand, and clay were > 0.5. This showed that each variable could explain more than 50 % of the variance of the factors formed. The variable with the highest communalities of 0.891 was temperature, showing the potential to explain the variance or diversity by 89.1 %. In this case, the temperature variable had the highest closeness to the factors formed. Meanwhile, the variable with the lowest communalities of 0.796 was sand of substrate. This showed that the sand of substrate variable was able to explain the variance or diversity of the factors formed by 79.6 %. In this case, the sand of the substrate variable had the lowest closeness. To determine the number of factors formed, the eigenvalue reference > 1 was used as in Figure 5.

Based on Figure 5 there is a very significant decrease in eigenvalue from components 1 to 2. Meanwhile, the decrease in the line on components 2, 3, 4, 5, and 6 is not significant. Component 1 is the only factor with an eigenvalue > 1, showing the potential to explain all variables optimally without including other factors.

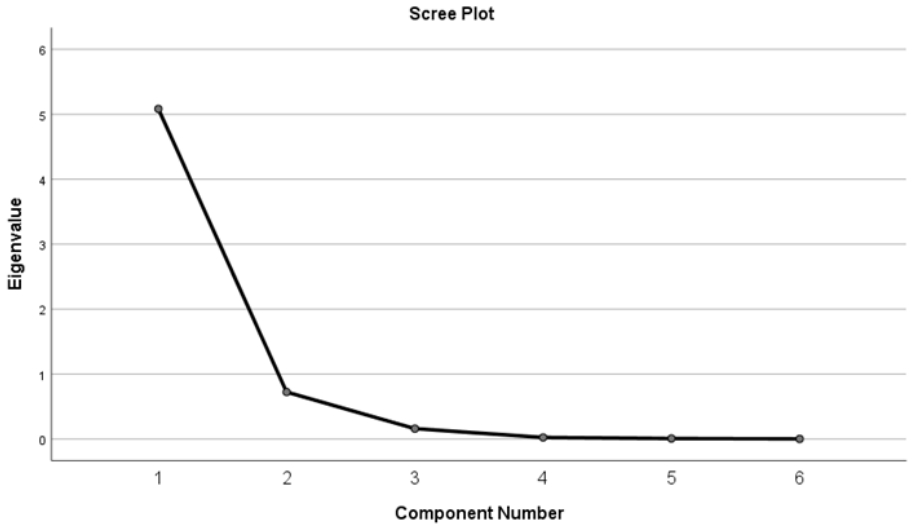

Figure 5. Scree plot of feasible environmental factors of bivalve habitat.

Based on Table 3, the eigenvalue of component 1 was 5.083 > 1, while other factors had eigenvalues < 1. Component 1 was able to explain the variance or diversity of all variables which was very high at 84.714 %. Therefore, six variables including substrate pH, water pH, salinity, temperature, sand, and clay could be summarised into 1 component. This showed that environmental characteristics affecting bivalve community with a total variance could be explained by 84.714 %. The results also showed the habitat characteristics importance for intertidal community (Dame 2012; de Fouw et al. 2020).

Table 3. Total variance explained by environmental factors of bivalve habitat.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.083	84.714	84.714	5.083	84.714	84.714
2	0.723	12.053	96.767			
3	0.160	2.666	99.433			
4	0.024	0.408	99.841			
5	0.008	0.134	99.975			
6	0.001	0.025	100.000			

The composition of substrate types serving as a place to stick, crawl, or dig, plays a significant effect in the development of fauna in coastal environments (Setyono 2006). Mud substrates with a very small grain composition contain food and organic matter, which support water in the sediment, and remain intact as beach recedes (Cappenberg 2016; Atlanta et al. 2022).

The quality of the coastal area plays an important role for benthic animals including bivalve due to high tolerance, which serves as a bio-indicator of environmental changes (Kharisma et al. 2012). In this study, the difference in the pH value of each beach was due to the activities of community in fishing and the presence or absence of residential settlements. This is because community activity can generate waste along the shore, particularly from domestic waste causing significant changes in water pH (Hasibuan 2016). Ivanina et al. (2020) stated that an optimum pH optimally supported bivalve metabolic process. Salinity is a supporting factor for bivalve and the values can be affected by the entry of freshwater into seawater (Lindawaty et al. 2016). Therefore, some bivalve species are found in estuarine areas where salinity fluctuates.

CONCLUSION

In conclusion, 19 bivalve species from seven orders and 10 families were found on the southern beaches of Bangkalan Madura Regency, namely Arcidae, Solenidae, Veneridae, Mactridae, Mesodesmatidae, Tellinidae, Semelidae, Placunidae, Mytilidae, and Ostreidae. Bivalve species found were in the medium category with a diversity index of 2.16, where the IVI of species was *Solen* sp. by 30.00 %. This beach had a favourable habitat profile for bivalve. The substrate pH, water pH, salinity, temperature, sand, and clay affected bivalve community. Therefore, the southern beaches of Bangkalan Madura had the potential for bivalve diversity.

AUTHORS CONTRIBUTION

N.N.R.W. designed the study, conducted sampling, and wrote manuscript. R.A. designed the study, identification, wrote manuscript and review.

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CONFLICT OF INTEREST

There is no conflict of interest.

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