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Biodiversity of Bivalves in South Bintan Waters, Riau Archipelago, Indonesia

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Abstract. Bivalves is the second most diverse group of molluscs after gastropods, they are also one of the most important members in marine ecosystems. Their taxonomic classifications are based on their morphology which tend to represent adaptation responses to ecology. The samples of bivalves examined in this study were taken in the South Bintan waters by Marine Geological Research and Development Center, Bandung. Identification of the bivalves shell samples was with the aid of a microscope and NIS-Elements software and identified using an identification book. There were 34 species of bivalves found in South Bintan Waters belong to 14 families. The highest abundance was in Station 1 the location close to the overflow of the river and a harbor (1162.5 ind.m-2) and the lowest was in Station 10 the location Station 10 the location close to a small island which is usually used as a tourist spot (62.5 ind.m-2). Their diversity and eveness index were included in the medium category with H' value of 0.58-4.12 and e value of 0.11-0.89 respectively. There was species dominance in Station 3 (*Liralucina lyngei* of Lucinidae) and 10 (*Cardites bicolor* of Carditidae) but not in other stations. Both species was the most frequent species. Bivalves in South Bintan waters showed many different morphologies which represented their adaptation. The bivalve shells found were of different morphology. There are several forms of bivalve shell morphology that have shape round like species *Chama japonica*, triangular like species *Gemma gemma*, fragile like species *Dendostrea rosacea*. The shell decorations found in the bintan Bivalves samples are Spinose, Commarginally, Commarginally and radially ribbed. The hinge teeth are heteroodont, isodont, and schizodont.

1. Introduction

Bintan is the largest 3,200 islands in the Riau Archipelago and is located 10 kilometers (6.2 mil) east of Batam Island. The waters of Bintan Island are potential areas and have high ecosystem diversity in the form of coral reefs, seagrass beds and mangrove ecosystems. The productive marine ecosystem of south Bintan Island is one of conservation areas through rehabilitation [1]. The waters of South Bintan have macrozoobenthos in marine ecosystem, consist of Arthropoda, Cnidaria, Echinoderms and Molluscs groups [2]. Macrozoobenthos organisms could be used as biological indices to determine the quality of an ecosystem which is called biodiversity [3]. Biodiversity is values that are very important to understand the condition of an ecosystem. The higher the value of the biodiversity index, the better the condition of the ecosystem [4].

Bivalves are one of the important organisms that act as deposit feeders and suspension feeders in the food chain [5]. Ecosystem services provided by bivalves during the Cambrian period up to the present in relation to the extraction of nutrients from the coastal environment have received great attention to reduce the detrimental effects of excess heavy metals [4]. This shows that the existence of bivalves is very important for the ecosystem. Several studies that analyzed the biodiversity of bivalves in various areas of Bintan Island had different results [6]. [7] revealed that the biodiversity of macrozoobenthos in the Senggarang river flow, Bintan Regency has a moderate value. [8] examined the relationship between bivalvia and seagrass in the waters of Teluk Bakau Village, Bintan Regency and stated that the higher the seagrass density, the higher the bivalvia abundance value.

The characteristics of the ecosystem and environment in the South Bintan waters are different from the ecosystem characteristics that have been carried out by previous research on biodiversity in other Bintan areas [8]. Anthropogenic activities such as resorts and seafood restaurants in the South Bintan area are thought to affect the aquatic ecosystem of South Bintan [2]. the purpose of this research is to study the diversity, abundance, and composition of Bivalves.

2. Materials and Methods

This research was examined the bivalve shell samples collection of Marine Geology Research and Development Center (Pusat Penelitian dan Pengembangan Geologi Kelautan/P3GL) which were taken from Bintan Project of "Efforts to Add Potential Marine Strategic Mineral Reserves in the Phase-1 Granitoid Track in 2020" (Location: South Bintan, Bintan City, Province of Riau islands). This bivalve samples was collected from 10 stations (**Fig. 1**). Station 1 has a location close to the overflow of the river and is located at the port. Station 2 has a location close to the beach and there are anthropogenic activities because it is close to seafood restaurants and resorts. Station 3 is located close to a small island which is an island that used to be a granite quarry. Station 4 has a location with the current flow of Kelon Island. Station 5 has a location close to station 2 with anthropogenic activities. Station 6 has a location quite far from the coast. Station 7 is an area that is suspected to be an area where currents flow from Kelon Island and currents flow from the north. Stations 8 and 9 are locations with a runoff area of the Sei Enam river which is known as a major river in Bintan. Station 10 has a location close to a small island that is commonly used as a tourist spot. The data of water depths and substrate (grain size) was also taken and analysed by P3GL and it was used as secondary data. This research was conducted in December 2020-February 2021 at the Marine Geology Research and Development Center.
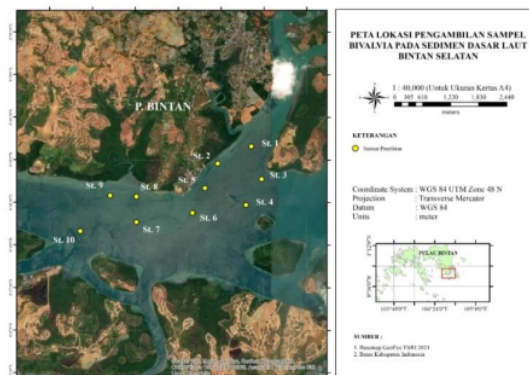

Figure 1. Map showing the ten Sampling Station in South Bintan Waters, Riau Archipelago

Bivalves samples were washed and separated according to the size. Bivalve shells were observed using a microscope and documented using NIS Elements software version D. The identification of bivalves were done based on their shell ornament, such as overall shell shape, pallial line, pallial sinus, socket, hinge plate, muscular adductor scar, cardinal teeth, and hinge teeth. The identification of bivalves based on reference of [8], [9] and [10]. The identified bivalves were calculated for their abundance, then analyzed for their uniformity and diversity index based on the research station.

The abundance of bivalves is calculated using the Shannon-Weaver formula [11].

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

A = Bivalve abundance (ind/m2), Xi = the number of individuals of the 1st pecies, ni = Grab Sampler opening area (0.08 m2).

Diversity index is a species richness and calculated using the Shannon-Weaver diversity index [12].

$$H' = -\sum_{i-l}^{n} pi \log 2\, pi; pi = \frac{ni}{N}$$

H' is Species diversity index, Pi is ni/N (i-th species proportion), ni is Number of individual species, N is Total number of individuals. Diversity index criteria: H < 1 = low diversity; 1 < H < 3 = Medium diversity; H > 3 = High diversity

The Evenness index is the balance among individual composition of each species contained in the community and was calculated using the formula of Evennes index [13].

$$E = \frac{H'}{log_2 S}$$

E is Species uniformity index, H' is Species diversity index, S is Number of species of organisms. Criteria for uniformity index: E < 0.4 = small population uniformity; 0.4 < E < 0.6 = Medium population uniformity; E > 0.6 = High population uniformity.

The Dominance Index is used to determine the dominance of certain species found in a community. The dominance index can be calculated based on the formula of [12] as follows:

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

D is Dominance Index; Ni is Number of individuals of the i-th species; N is Total number of individuals. The criteria for the dominance index are as follows: 0 < C < 0.5 = No dominant species; 0.5 < C 1.0 = There is a dominant species .

3. Result and Discussion

The findings from Bintan Island's waters revealed 34 species of bivalves, including *Arca navicularis, A. noae, A.volucris, Barbatia foliate, B. stearnsii, Cardites bicolor, Cetoconcha hyaline, Chama japonica, C. pulchella, Corbula scaphoides, Glycymeris glycymeris, Isongomon legume, Liralucina lyngei, Cardiolucina macassari, Modiolus barbatus, Saccella tashiensis, S. confusa, Dendostrea folium, Osrea edulis, Dendostrea rosacea* (**Fig. 2**), *Decatopecten radula, Placuna placenta, Jactellina hungerfordi, Tallina diaphana, Tellina gargadia, T. minuta, T. palidula, Tellinangulus aethiopicus, T. edentula, Chamella gallina, Gemma gemma, Irus irus, Placamen retroversum, C. tunicate* (**Fig. 3**), belong to 14 families.

Figure 2. (A) *Arca navicularis*, (B) *A. noae*, (C) *A.volucris*, (D) *Barbatia foliate*, (E) *B. stearnsii*, (F) *Cardites bicolor*, (G) *Cetoconcha hyaline*, (H) *Chama japonica*, (I) *C. pulchella*, (J) *Corbula scaphoides*, (K) *Glycymeris glycymeris*, (L) *Isongomon legume*, (M) *Liralucina lyngei*, (N) *Cardiolucina macassari*, (O) *Modiolus barbatus*, (P) *Saccella tashiensis*, (Q) *S. confusa*, (R) *Dendostrea folium*, (S) *Ostrea edulis*, (T) *Dendostrea rosacea*.
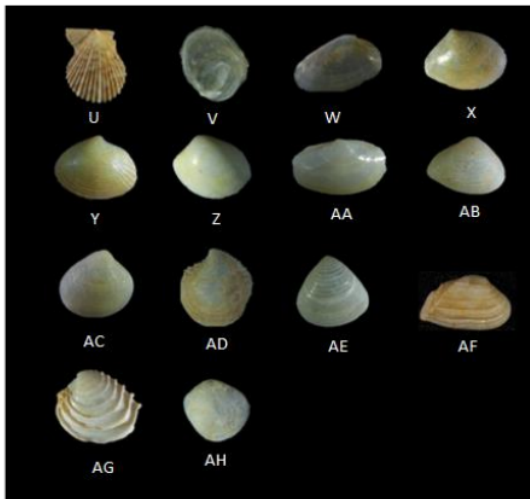

Figure 3. (U) *Decatopecten radula*, (V) *Placuna placenta*, (W) *Jactellina hungerfordi*, (X) *Tallina diaphana*, (Y) *Tellina gargadia*, (Z) *T. minuta*, (AA) *T. palidula*, (AB) *Tellinangulus aethiopicus*, (AC) *T. edentula*, (AD) *Chamella gallina*, (AE) *Gemma gemma*, (AF) *Irus irus*, (AG) *Placamen retroversum*, (AH) *C. tunicate*

Bivalves samples studied were samples taken from seabed sediments in the South Bintan area which had different substrate characteristics. The poor shell condition and lack of knowledge of the taxonomy of the split molluscs meant that some of the species from the samples could not be separated and studied and because the shells were fragmented and difficult to identify and analyse. This causes the values listed are species richness representing the minimum value.

Research on the diversity index of the bivalve community showed 34 species belonging to 13 families. The bivalves found at the study site are dominated by the Tellinidae family, it is suspected that the composition of the bivalves found at the study site is influenced by the ecosystem conditions in which there is a river flow that causes fresh water to enter the waters as well as the influence of rainfall at the study site which causes the substrate to be muddy [14]. Most taxa in this study are mostly sedentary as adults with limited movement for foraging, reproduction, and avoidance of predators. In the juvenile stage, bivalves are more likely to show mobility, which is important for dispersal. Finally, bivalve assemblages can occur in high densities with ecological impacts at large spatial scales [15]. This study have bivalves which are juvenile size. The average species found in this study when in the adult phase is 1-8 cm in size but in this study the average size is 0.1-1 cm, so it is suspected that this affects the wide distribution and high density.

Epifaunal bivalves generally have several characteristics such as having one muscular adductor scar. The families that are thought to be generally epifaunal are the family ostreidae, carditidae, pectinidae, venerida, mytilidae. Families which are generally infaunal organisms are from families Arcidae, Glycymerididae, Corbulidae, Lucinidae, Tellinidae, Mytilidae, Cetoconchidae, Nuculanida [16]. The shape of the bivalve shell is an adaptation to the environment [17]. The shells of modern infaunal animals are ornate and come in a variety of colors. The shells of clams that live near the surface are thick and radially striped. This adaptation stabilizes the animal in the substrate and can provide protection against predators. Such bivalves are slow infaunals [18]. The shells of deep burrowing species are thinner and much less decorated. They are regularly brightly colored, as withinside the Tellinidae. The carapace is laterally compressed and consequently extra leaf-shaped, however the adductor muscle tissue are the equal size (isomiaric shape). Such structural skills adapt the animal for fast actions thru the sand; lengthy siphons upstairs. The composition of the bivalves found at the research site on Bintan Island can be seen in Table 1. The number of species of bivalves found at the points can be used as a benchmark that the number of species varies between research points.

Table 1. The Presence of Species at Each Site In The Bintan Island Research

No	Family/Species	Site									
		1	2	3	4	5	6	7	8	9	10
1	**Acidae** *Arca navicularis*	-	-	-	-	-	-	-	-	+	+
2	*Arca noae*	+	-	-	-	-	+	-	+	-	-
3	*Arca volucris*	+	-	-	-	+	+	-	-	-	-
4	*Barbatia foliata*	+	-	+	-	-	-	-	-	-	-
5	*Barbatia stearnsii*	+	-	+	-	+	-	+	+	-	-
6	**Carditidae** *Cardites bicolor.*	+	+	+	+	+	+	-	-	+	-
7	***Cetocoonchidae*** *Cetoconcha hyalina*	-	+	+	-	-	-	-	-	-	-
8	***Chamidae*** *Chama japonica*	+	-	+	-	+	-	+	+	-	+
9	*Chama pulchella*	-	-	-	-	-	-	-	+	-	+
10	**Corbulidae** *Corbula cf. scaphoides*	-	-	+	-	-	-	-	-	-	-
11	*Corbula cf tunicata*	+	-	+	+	-	-	-	-	-	-
12	**Glycymeridida** *Glycymeris glyscymeris*	+	-	+	-	+	-	-	+	-	-
13	**Isognomonidae** *Isongomon legumen*	-	-	-	-	-	-	-	+	-	-
14	*Lucinidae* *Liralucina lyngei*	+	+	+	+	+	+	-	-	+	-
15	*Cardiolucina macassari*	+	+	-	+	+	-	-	-	-	-

No	Family/Species	Site									
		1	2	3	4	5	6	7	8	9	10
16	**Mytilidae** *Modiolus barbatus*	+	-	-	-	+	+	+	+	-	-
17	**Nuculanidae** *Saccella tashiensis*	+	+	+	+	+	-	-	-	+	-
18	*Saccella confusa*	-	-	-	-	-	+	-	-	+	-
19	***Ostreidae*** *Dendostrea folium*	+	-	+	-	-	-	-	-	-	-
20	*Osrea edulis*	-	-	-	-	-	+	-	+	-	-
21	*Dendostrea rosacea*	+	-	-	-	+	+	-	-	-	-
22	**Pectinidae** *Decatopecten radula*	+	-	-	-	-	+	-	+	-	-
23	***Placunidae*** *Placuna placenta*	+	-	-	-	-	+	+	-	-	+
24	***Tellinidae*** *Jactellina hungerfordi*	+	+	+	-	-	-	-	-	-	-
25	*Tallina diaphana*	-	-	-	+	+	-	-	-	-	-
26	*Tellina gargadia*	-	+	-	-	-	-	-	-	-	-
27	*Tellina minuta*	+	-	-	+	+	-	-	-	-	-
28	*Tellina palidula*	-	+	-	-	-	-	-	-	-	-
29	*Tellinangulus aethiopicus*	-	+	+	-	-	+	-	-	-	-
30	*Tellinangulus edentula*	+	-	-	-	-	-	-	-	+	-
31	***Veneridae*** *Chamella gallina*	-	+	+	-	+	-	-	-	-	-
32	*Gemma gemma*	+	+	+	+	+	-	-	-	+	-
33	*Irus irus*	+	-	+	-	+	-	-	-	-	-
34	*Placamen retroversum*	+	-	-	-	-	-	-	-	-	-
	Number of Species	22	11	17	8	16	11	4	9	7	4
	Number of Individu	93	63	36	30	60	47	7	11	28	5

The highest species composition was found in Station 2 which is *J. hungerfordi*. The highest bivalves abundance in the Bintan waters was showed in Station 1 (1162.5 ind/m2) and the lowest is at Station 10 (62.5 ind/m2). The values of the Diversity Index (H'), Uniformity (E), and dominance of bivalves at 10 stations can be seen in Table 2. Overall, the average value of the Diversity Index in the research location is 2.55 which belongs to medium category with a value range of 0.58 – 4.12. The maximum value of the Diversity Index is at Station 1 (3.43) belong to high category and the minimum value is at Station 10 is (0.58) in the low category. The results of the Diversity Index values were varied among station, in which Stations 2, 4, 6, 7, 9, and 10 had a range value of 1.92-27.2 with a medium category. The average eveness index (E) was 0.36 which belongs to the medium category range value of 0.11 - 0.89. The maximum value of the index was at Station 8 (0.8) and Station 10 (0.82) which were in high category. The uniformity value at Stations 2, 4, 6, and 9 is 0.45-0.46. The value of the Dominance index (C) (Table. 2) showed that there were species dominance in Station 3 and 10, i.e. *L. lyngei* and *A. Navicularis*

Table 2. The Values of the Diversity Index (H'), Uniformity (E), and Dominance of Bivalves at 10 Stations

Station	Diversity		Uniformity		Dominance	
	H'	Category	E	Category	C	Category
1	4.12	High	0.63	High	0.3	TAD
2	2,72	Medium	0,45	Medium	0.5	TAD

Station	Diversity		Uniformity		Dominance	
	H'	Category	E	Category	C	Category
3	0.58	Low	0,11	Low	0.8	AD
4	2,70	Medium	0,55	Medium	0.4	TAD
5	3,73	High	0,63	High	0.3	TAD
6	2,58	Medium	0,46	Medium	0.5	TAD
7	1.95	Medium	0,69	High	0.3	TAD
8	3.05	High	0,89	High	0.1	TAD
9	2,23	Medium	0,46	Medium	0.5	TAD
10	1,92	Medium	0,82	High	0.8	AD

Note : AD=There is species dominance; TAD : there is no species dominance

Research on the diversity index of the bivalve community showed 34 species belonging to 13 families. The bivalves found at the study site are dominated by the Tellinidae family this might be influenced by the ecosystem conditions in which there is a river flow that causes fresh water to enter the waters as well as the influence of rainfall at the study site which causes muddy substrate results [19]. Some shellfish species live in groups, and naturally cover most of the surface. High-density mussels have a unique third-dimensional shape and the aggregations are referred to as shell layers. The larvae attach to the substratum by a kind of 'cement' produced by glands in the diet [20]. This form of persistent aggregation - in comparison to the greater cellular aggregation of bivalve species including the biogenic habitat for lots different species. This reasons shellfish beds regularly have incredibly excessive biodiversity values in comparison to surrounding regions and may be visible as biodiversity hotspots [21]. Mussels have a wide global distribution, on rocky shores as well as in sediments, and have not only abundant wild populations, but also cultured stocks. The value of aquaculture is often valued for its ecological impact, it is increasingly being recognized that farmed shellfish stocks can also provide a variety of ecosystem services.

The abundance of a bivalves is closely related to the food limitation which appears contradiction with organic-rich fluvial input. The estuary area is an area where most of the organic matter is refractory and the primary production is limited due to the high turbidity of the water [4]. This is especially in the case of waters in Stations 7, 8, 9 where most of the organic matter from peat were dissolved. Most of the sediment consists of fine terrigenous material and re-fractory organics. Areas with such conditions, shellfish organisms that managed to emerge into several protobranchs such as *Arca noae, Barbatia stearnsii, Cardites bicolor*. These results indicate that the abundance of bivalves is influenced by the type of substrate at a location. [22] stated that the distribution of bivalves can be correlated with the type of sediment. The abundance and composition of mollusc species is influenced by a clear pattern substrate type at each location. Thus, the density of bivalves in the waters of South Bintan is moderate when compared to the results of the literature above [23]. Differences in bivalve density can be influenced by several aquatic environmental factors and different ecosystem conditions for each location.

The index of bivalves diversity in the waters of South Bintan generally is in the medium category with a value range (H') of 4.12 - 0.58. A high H value represent a more diverse community and if species are evenly distributed, the H value will be high. This correlation with the value of H makes it possible to know not only the number of species but also how the abundance of species is distributed among all species in the community. Overall, the diversity index value in this study area has an average diversity index value of 2.55 in the medium category. The research of [8] revealed that the diversity index at 3 stations of the seagrass ecosystem in Bakau Bay, East Bintan Waters, had an average diversity index value of 1.37 belong to the medium category. [8] analyzed that the diversity index at 4 stations in the intertidal area of Bakau Bay had an average value of 2.45. This is presumably because the research by [8] only calculated the biodiversity of seagrass ecosystems, while in the [23] only analyzed intertidal areas. This study analyzed the value of biodiversity at 10 stations with different ecosystem characteristics with different depths and substrates. The location in this study

covers ecosystems such as coral reefs, seagrasses, and mangroves so that the composition of the community is different and the value of diversity is higher. According to [22] this uniformity index describes the ecological balance in a community, where the higher the uniformity value, the better the environmental quality and suitable for certain species.

The dominance index values obtained among the stations are different. This value indicated that there is dominance of a species in an ecosystem at two stations and there is no dominance species in others. The existence of a dominant species indicates that there are differences in species adaptation to the environment. It is suspected that at each point there are species that are often found, which means that the distribution of bivalvia species individually is not the same at each point of the study location. The uniformity index measures the regularity of the distribution of species abundance and inequality in the functional space. Functional divergence measures the proportion of total abundance supported by a species with a trait value. This supported by the presence of *C. bicolor* and *J. hungerfodi*. in 7 stations. Several factors that influence the dominance value are currents, waves, geomorphology, and rainfall factors that affect the distribution of bivalves which tend to be sessile.

4. Conclusion

The composition of the bivalve in the waters of South Bintan consists of 14 families, with 34 species, namely *Arca navicularis, A. noae, A. volucris, Barbatia foliate, B. stearnsii, Cardites bicolor, Cetoconcha hyaline, Chama japonica, C. pulchella, Corbula cf. scaphoides, C. cf tunicate, Glycymeris glycymeris, Isongomon legume, Liralucina lyngei, Cardiolucina macassari, Modiolus barbatus, Saccella tashiensis, S. confus, Dendostrea folium, Osrea edulis, Dendostrea rosacearadula, Decatolinacutenna hungeri, Jactostrea dina hungeri Tellina gargadia, T. minuta, T. palidula, Tellinangulus aethiopicus, T. edentula, Chamella gallina, Gemma gemma, Irus irus, Placamen retroversum*. The highest–abundance of soft-bottom bivalves at Station 1 (1162.5 ind/m^2) and the lowest was at Station 10 (62.5 ind/m^2). The diversity index (H') was included in the medium category with the range of 0.58 – 4.12 and the eveness index (e) was belonged to the medium category (0.11 - 0.89) and there was species dominance in Station 3 (*J. hungerfrodi*) and 10 (*L. lyngei*). The shells of bivalves found were of different morphology. Bivalves that have habitats in shallow seas tended to have thick shell and many decorations.

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