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The Benthic Foraminiferal Assemblages in the Seagrass Bed of Tanjung Berakit Waters, Bintan Island

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ABSTRACT

Seagrass is the most common ecosystem in Tanjung Berakit waters. Therefore, Tanjung Berakit waters have a very important role as a benthic foraminiferal habitat. This study was conducted to describe the distribution of benthic foraminifera relating to the environmental condition of the waters. The samples were collected from eight stations by handling garb in November 2017. This study collected 18 species of shallow water benthic foraminifera dominated by *Amphistegina* and *Heterostegina*. This study recorded a correlation between the sediment texture and foraminiferal assemblages. The most common foraminifera were inhabiting fine-textured sediments, especially very fine sand and silt. Only a few foraminifers are collected from extremely fine sediments such as clay sediments, or extremely coarse including pebbles.

1. Introduction

Tanjung Berakit is located in the eastern of Bintan Island as a part of the Riau Islands Province. Several areas of the eastern Bintan coastal have been designated as Regional Marine Conservation Areas based on the Decree of the Regent of Bintan No.36/VIII/2007. The utilization of the Regional Marine Conservation Areas in the East Coastal Sea Areas, Gunung Kijang District and East Bintan District is prioritized for marine tourism and sustainable fisheries activities and. One of the villages in Bintan Regency which is included in the Regional Marine Conservation Areas area is Berakit Village, which is dominated by seagrass and there are several mangroves growing around the coast.

Indonesia has about 13 species of seagrass among about 60 species of seagrass known in the world (Kuo 2007). Seagrass is a flowering plant that has adapted to live in shallow seawater. Seagrass beds have a very important role as a feeding ground and protection for various types of animals, contributors to primary production in coastal waters, catching and recycling nutrients as well as stabilizing sediments and shorelines. In addition, seagrass beds are also very important as nursery grounds and habitats for several types of fish and invertebrates as well as epiphytic animals such as algae and foraminifera. The previous study by Natsir and Subkhan (2011) on the western coastal area of Bintan Island shows that the seagrass bed was dominated by *Elphidium*, *Heterostegian*, *Quinqueloculina* and *Spirolina* as opportunistic foraminifera.

Foraminifera generally live and grow in all saline waters from swamps to open seas such as seas and swamps (Boltovskoy and Wright 1976). Foraminiferal life is influenced by environmental factors including sediment type, salinity, depth, nutrients, currents, and others so that they potentially can be used as an environmental indicator. Some types of foraminifera life as benthic, and some others are planktic organisms. The Benthic foraminifera is meiobenthic components of bottom water communities which also have a role as producers of calcium carbonate ($CaCO_3$) in sediments in almost all sea beds in the world (Rositasari 2010). Calcium carbonate is one of the elements that form coral reefs. Therefore, currently, benthic foraminifera can be used as bioindicators in coral reef waters.

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Currently, information on the distribution of foraminifera on Bintan Island is little present, therefore research on the diversity and distribution of foraminifera on Bintan Island is very important. In addition, this information is useful for experts who need foraminiferal data to interpret the depositional environment, paleooseanography, paleoecology, paleoclimatology, and others. This study was conducted to recognize the benthic foraminiferal distribution in the bottom sediments of Tanjung Berakit waters, Bintan Island.

2. Materials and Methods

2.1. Field Work

Seabed sediment were collected using handling grab from the east coast of Bintan Island, around Tanjung Berakit Harbor in November 2017 (Figure 1). Samples were collected from eight predetermined stations, then put into plastic bags for the laboratory analysis in the Laboratory of Marine Geology, Research Center for Oceanography, National Research and Innovation Agency.

Several sampling locations (stations TB-1, TB-2, and TB-3) are relatively close to Tanjung Berakit Port which is not fully operated. While in the northern part (stations TB-4, TB-5, TB-6, TB-7 and TB-8) the sampling location is more closed and protected by mangrove vegetation. Thus, the sedimentation process can occur easily so that the sediment in these stations is relatively finer. The types of sediment in these waters are coarse sand sediment mixed with silt and clay.

2.2. Laboratory Analysis

The preparation stage for the sediment samples consisted of washing including drying, then picking, followed by identification, and documentation by sticking the specimen on the foraminiferal slide. The sediments were washed over a sieve under running water and dried at the 30°C temperature. In order to prevent contamination by subsequent samples, the filter was immersed in the methylene blue and washed. Then, the samples were spread out evenly on the extraction tray on the picking stage under a binocular microscope. The selected specimens were

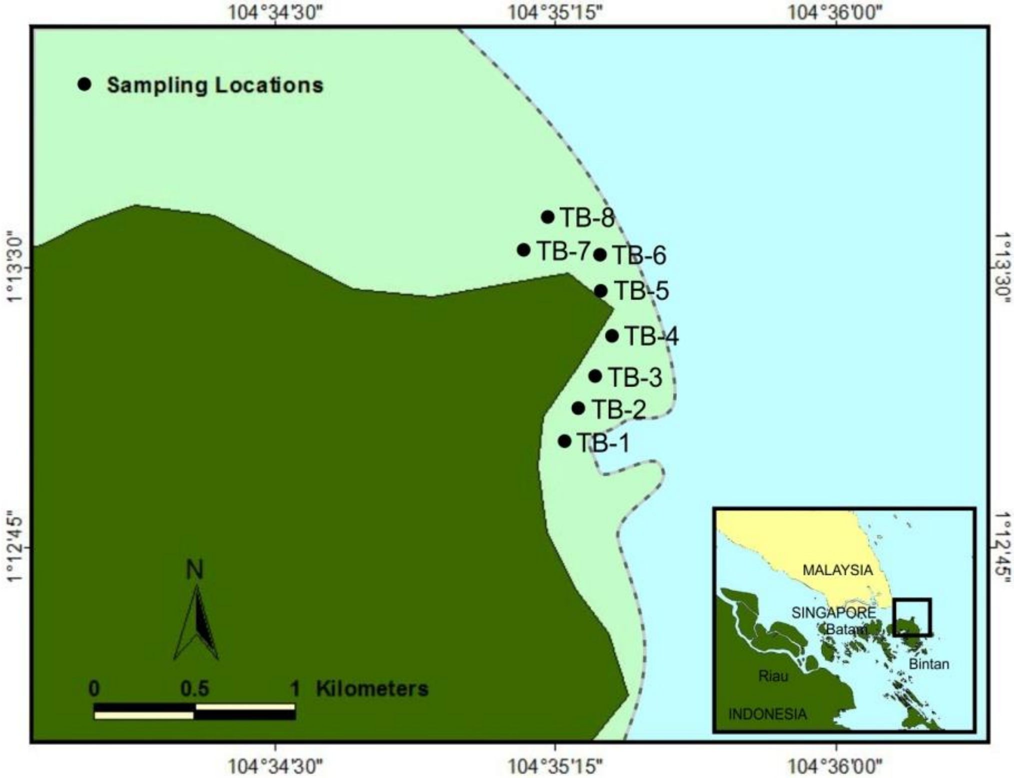

Figure 1. Sampling location in the Tanjung Berakit waters, Bintan Island

stuck on the foraminiferal slide. The grain size of the sediment is divided into seven types according to the size of the filter used, starting from the smallest, namely 0.125; 0.25; 0.5; 1; 2; 4; and 8 mm to analyse the content of foraminifera and other organisms.

Some of the morphological parameters used as the basis for the identification of these specimens include shell shape, number of chambers, chamber shape, chamber formation, aperture position, aperture slope, shell ornamentation, and additional chambers. While the identification process refers to Yassini and Jones (1995) and Loeblich and Tappan (1994). The selected specimens were stuck on the foraminiferal slide in some views such as aperture, dorsal, ventral, and side view, then observed under a binocular microscope and documented.

2.3. Data Analysis

The number of benthic foraminifera of the respective sample sediment was counted so that the abundance of species at each station was recorded. The faunal diversity indices were analyzed by Paleontological Statistics (PAST) version 4.03 software. The indices that were tested included species diversity (Shannon-Wiener, H'), Eveness (e'), species richness (Margalef, d'), equitability index (Pielou, J'), and Berger-Parker index (max pi).

The relationship between species and sediment texture was observed using Canonical Correspondence Analysis (CCA). Then, a Q-mode cluster analysis was applied to have the resemblance of the foraminiferal assemblages around Tanjung Berakit Waters. this analysis was done based on Ward's method to recognize the response of foraminiferal assemblages to the stations. A q-mode hierarchical analysis applied to the relative abundances of the species based on euclidian distance correlation coefficients.

3. Results

3.1. Diversity Indice

The results of the study showed the difference distributions on each station. The number of foraminifera from Tanjung Berakit waters was 18 species. Station TB-7 located near the mainland, and the mangrove ecosystem has the highest number of benthic foraminifera.

The Shannon Diversity Index of the samples ranges about 2,119 and 2,748. Station TB-6, adjacent to the mangrove ecosystem recognized as having the lowest diversity, while the highest diversity was recorded in station TB-4. It tends to be the same as the evenness and equitability which respectively range from 0.832 to 0.920 and 0.934 to 0.968 (Table 1).

3.2. Species-Enviroment Relationship

Analyses through the CCA recognized the significant correlation of the foraminiferal distribution to sediment texture as their dwelling place. Foraminiferal assemblages tend to inhabit more fine-textured sediments, especially very fine sand and silt. Then followed by the number of species that inhabit coarser sediments such as medium sand to very coarse sand. Only a few foraminifers were collected from clay sediments, which are very fine-textured sediments, or the coarsest texture of pebbles (Figure 2).

Based on the Q-mode cluster analysis, the major group of benthic foraminiferal distribution was divided into three (Group A, B, and C) (Figure 3). (Figure 3). There are four stations included in Group A such as stations TB-8, TB-4, and TB-7. Meanwhile, group B consists of stations TB-2, TB-1, and TB-5. Group C consists of two stations close to the mangrove ecosystem, namely stations TB-3 and TB-6.

Table 1. Benthic foraminiferal diversity indices in Tanjung Berakit waters

Samples	Number of species	Individuals	Diversity (H')	Evenness (e')	Richness (d')	Equatability index (J')	Berger-Parker (Max, pi)
TB-1	13	799	2.459	0.900	1.796	1.796	0.118
TB-2	13	795	2.417	0.863	1.797	1.797	0.123
TB-3	15	812	2.528	0.835	2.090	2.090	0.120
TB-4	18	903	2.748	0.867	2.498	2.498	0.107
TB-5	13	781	2.482	0.920	1.802	1.802	0.114
TB-6	9	617	2.119	0.924	1.245	1.245	0.161
TB-7	18	926	2.706	0.832	2.489	2.489	0.106
TB-8	17	873	2.670	0.849	2.363	2.363	0.101

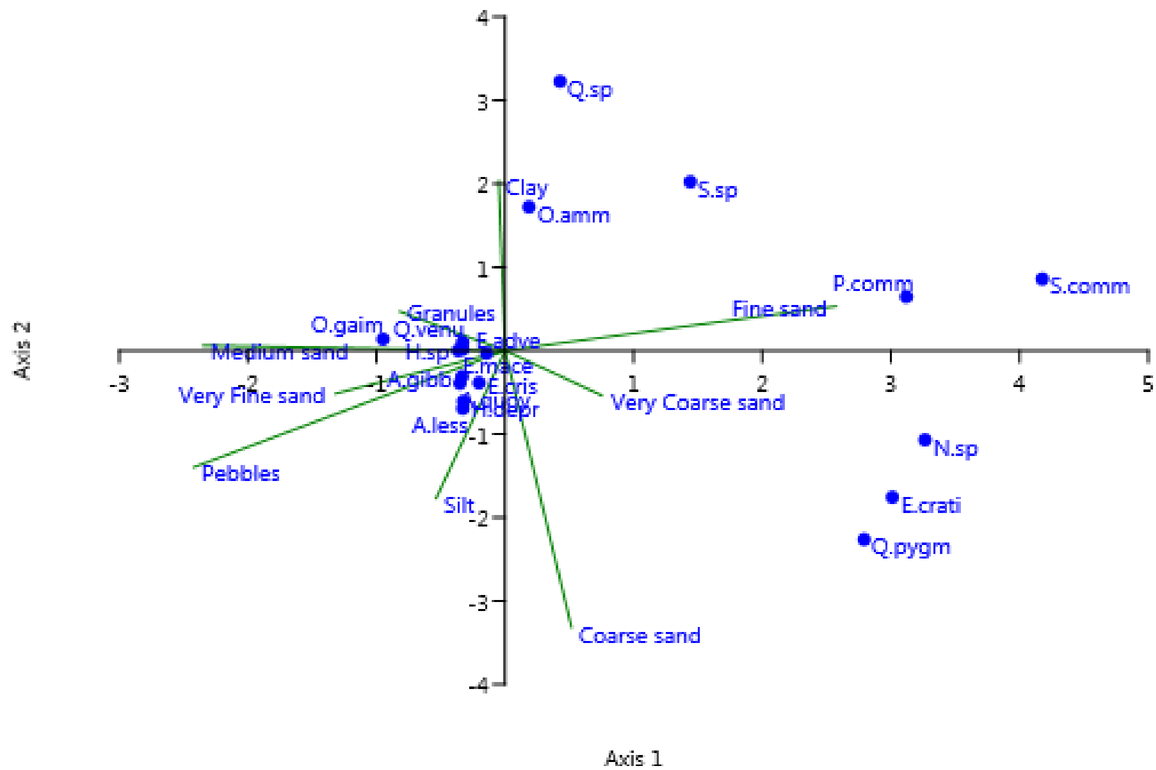

Figure 2. Analysis of CCA between sediment texture and species/samples from Tanjung Berakit waters: (variance of data along axis-1: 53.80% and axis-2: 17.93%). A. gibb = *Amphistegina gibbosa*; A. less = *Amphistegina lessonii*; A. quoy = *Amphistegina quoyii*; E. adve = *Elphidium advenum*; E. crati = *Elphidium craticulatum*; E. cris = *Elphidium crispum*; E. mace = *Elphidium macellum*; H. depr = *Heterostegina depressa*; H. sp. = *Heterostegina* sp.; N. sp. = *Nonion* sp.; O. amm = *Operculina ammonoides*; O. gaim = *Operculina gaimardii*; P. comm = *Planispira communis*; Q. pygm = *Quinqueloculina pygmaea*; Q. sp. = *Quinqueloculina* sp.; Q. venus = *Quinqueloculina venusta*; S. comm = *Spiroloculina communis*; S. sp. = *Spiroloculina* sp.

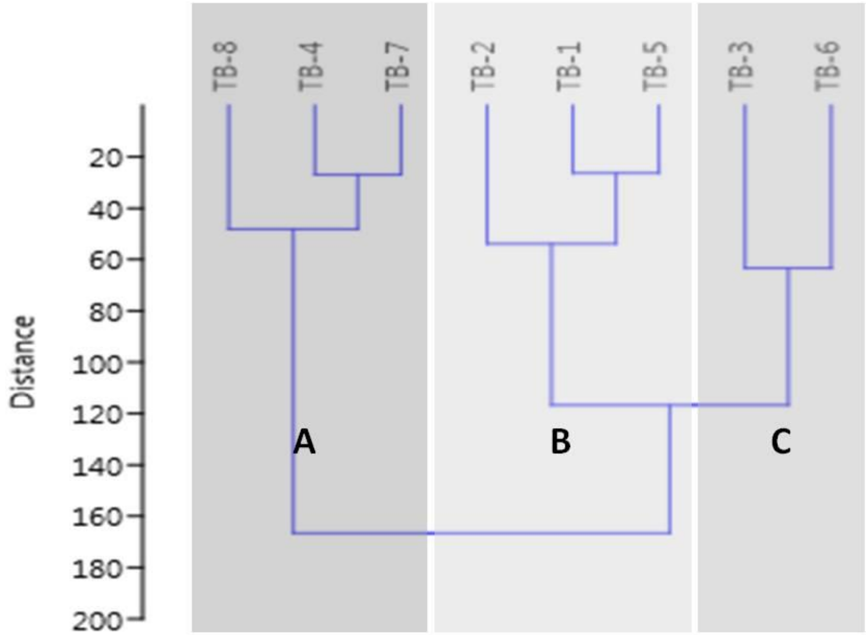

Figure 3. Dendrogram for hierarchical cluster analysis of stations in Tanjung Berakit waters

4. Discussion

Bintan Island waters, especially the eastern coast are dominated by seagrass. Seagrass is a flowering plant in shallow waters, subtidal tropical areas, and the intertidal zone in temperate regions. Seagrass is greatly influenced by the presence of light, so it cannot survive in the depths of water that does not have photosynthesis activity.

Seagrass is a substrate for adherent organisms (epiphytes) including flora and also small attaching fauna such as algae and foraminifera. All large foraminifera live as epiphytes attached to hard substrates such as coral fragments or other substrates, and some species attach to seagrass and algae. In addition to being an attachment substrate, seagrass beds also serve as a barrier for hydrodynamic pressure on the sediment surface so as to minimize the occurrence of displacement and physical disturbances in centhic organisms such as foraminifera. This was inline with the study by Natsir (2022) in the East penjalira Island of Seribu Island that the opportunistic foraminifera were collected abundantly in the coarse sand sediments.

The number of individuals at stations close to Tanjung Berakit Harbor was relatively small. Apart from *Amphistegina* and *Operculina*, species collected abundantly in the location adjacent to the port are *Operculina ammonoides* and *O. gaimardii.* Other species collected in moderate (between 21-40 individuals) included the Genus *Elhpidium* and *Quinqueloculina*. The high number of benthic foraminifera in a closed area is thought to be influenced by the type of sediment at each station. This is thought to be caused by the influence of land close to the observation station as well as nutrient input brought from the waters of the South China Sea (Meirinawati and Muchtar 2017). The substrate types in stations TB-3, TB-4, TB-7, and TB-8 were coarse sand with coral fragments, coarser than the other two stations. The coarse sand sediment is more favorable for foraminifera to reduce the hydrodynamic energy of these waters. Large sediment grains create cavities that can be used as protection for benthic foraminifera so that they can avoid displacement processes and physical stress on their shells.

Seagrass vegetation may affect sediments with their roots and rhizomes and leaves which can become litter at the bottom of the waters. Station TB-7, which contains many seagrass species, Enhalus acoroides has abundant foraminifera. The number of species in these waters reaches 22 species. The species in the greatest numbers in these waters are of the genus *Heterostegina*. Other species that are also collected in abundance belong to the genera *Amphistegina* and *Operculina*. Also collected these species in the waters of Bali and the Arabian Peninsula, in abundance and associated with seagrass, especially the species *Laurencia papilosa* and *Halodule uninervis*. The high number of foraminifera in these waters is thought due to suitable substrate conditions and rich waters due to the accumulation of decomposing seagrass leaf litter so as to stimulate primary production for the development and foraminiferal growth.

During the study, *Amphistegina* was the most common genus along with *Heterostegina*. The genus *Amphistegina* is represented by *A. gibbosa, A. lessonii,* and *A. quoyii* which were collected from all stations. These species belong to the symbiont-bearing benthic foraminifers (Hallock *et al.* 2003). Renema (2008) and Natsir and Dewi (2015) collected two species of the genus *Amphistegina* on the rubble along with *Calcarina* in Seribu Islands waters. The other, A'ziz *et al.* (2021) also recognized *Amphistegina* abundantly along with *Calcarina, Peneroplis*, and *Operculina* in south part of the South China Sea. The presence of *Operculina* and *Quinqueloculina* which are included in abundance in these waters also shows the influence of the mainland through the tidal and terrestrial currents (Nurdin and Gustiantini 2014).

Meanwhile, *Hetersostegina* was represented by *H. depressa* and *Heterostegina* sp. which are also collected at all stations. These species were also collected in abundance by Renema (2003) in their study in the waters of the Arabian Peninsula, the Red Sea and Bali along with *Operculina*. All of these species were also collected on coral fragments and attached to seagrasses of the Halodule. Based on field observations, *Thalassima hemprichii* was the dominant species of seagrass in these waters than followed by *Halophila ovalis, Halodule uninervis, Enhalus acoroides*, and *Cymodoces serrulata* which were collected in fewer individuals. These species are inhabitants of shallow waters (Gustiantini and Usman 2008). These species was collected abundantly in Pari and Belanda Island of Seribu Islands at a depth of 26-32 m (Natsir 1994, 2010), Graham and Milante (1959) collected these species to be very abundant at several stations in Puerto Galera Bay, Philippines, including cosmopolitan species.

All sampling stations are classified as shallow waters. Sediment sampling at each station was collected from a depth of less than 1 m. The closer station from the port has a lower species abundance than the stations located in the northern part, close to mangrove vegetation. This is thought to be caused by the characteristics of the research location which is relatively open than that in stations TB-4, TB-5, TB-6, and TB-7 which have mangrove vegetation for nutrient retention. Although in more open waters, there are many coral fragments, mollusks, and others as protection, presumably not sufficient to withstand hydrodynamic energy pressure from open water, so only certain species of foraminifers are collected in these locations.

Based on the diversity index, a Q-mode cluster analysis acquired three major groups including Group A, B, and C (Figure 3). A means diversity in Group A was 2.708, characterized by symbiont-bearing foraminifers as predominant such as *Amphistegina gibbosa, Amphistegina lessonii, Amphistegina quoyii, Heterostegina depressa*, and *Heterostegina* sp. The sediment of this group was fine sand as predominant. Then, group B has a slightly lower mean diversity index than group A about 0.453. *Amphistegina gibbosa* was recognze as predominant along with *Operculina gaimardii* and *Operculina ammonoides*, and then followed by *Heterostegina* sp. The substrate type of this group was fine sand as predominant and followed by coarse and medium sand. The last group is Group C has the lowest mean diversity index which reaches 2.453. The sediments were dominated by fine sand with dominant species assemblages slightly similar to group A.

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