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Benthic foraminiferal assemblages in Tambelan Archipelago, Indonesia

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Abstract. Coral reefs ecosystem is one of favorable sites as habitat of most of marine organisms including benthic foraminifera. Foraminiferal assemblages are regularly used as bio-indicators of environmental feasibility for reefs. Hence, the objective of the present study was to recognize the foraminiferal assemblages in the Tambelan Archipelago as a baseline data for monitoring of environmental changes and to plan conservation strategies. The survey was conducted on November 2010 at 12 sampling sites around Tambelan Archipelago. A total of 5582 specimens of benthic foraminifera belonging to Order Astrorhizida, Textulariida, Miliolida, and Rotaliida were recorded. Most of collected species were recognized as symbiotic-bearing foraminifera; the most common of them where *Amphistegina sp.* and *Calcarina sp.* that counted more than 1000 specimens.
Key Words: coral reef, foraminifera, box core, Riau.

Introduction. Tambelan Archipelago is situated in South China Sea waters at coordinates 00°59'40"N and 107°33'46"E. This archipelago consisted of some small islands such as Benua, Uwi, Selentang, Sedua Large, Ibul, Mundaga and many other smaller islands. Waters in the islands is covered by various ecosystems including mangrove, seagrass and coral reefs. It provides a favorable habitat for various marine organisms, including foraminifera.

Foraminifera are single-celled organisms belonging to the phylum Protozoa and started to develop since the Cambrian to present. The majority members of foraminifera are living in the marine environment and they had sizes ranging from 3µm to 3mm (Haq & Boersma 1998). Generally, the habitat of foraminifera is wide spread and covers all types of marine waters. The abundance of foraminifera is affected by various ecological factors and the ability of this organism to adapt to environment conditions. Some species of benthic foraminifera are often found in sandy and muddy sediments (Boltovskoy & Wright 1976; Dewi et al 2010; Renema 2008). Furthermore, Yamano et al (2000) stated that approximately 30% of the total sediments in Green Island, Great Barrier Reef, Australia are benthic foraminifera and they are one of the important contributors for coral reefs formation in this location. Thus, foraminiferal assemblages were regularly utilized as bio-indicators of environmental feasibility for reefs growth (Hallock et al 2003). In addition, these organisms are also used in the petroleum and mining lines, and micropaleontology and palaeoecology studies. Therefore, the data on foraminifera assemblages are very important for better conservation planning and environmental changes monitoring. However, unfortunately, no information on the foraminifera assemblages in the Tambelan Archipelago was available. Hence, the objective of the present study was to recognize the benthic foraminiferal assemblages in various sediment types in Tambelan Archipelago.

Materials and Methods

Samples collection and preparation. Samples of foraminifera were obtained from 12 stations covering the area around the Tambelan Archipelago (Figure 1). Sampling was conducted on November 2010 using a box core sampler of Research Vessel of Baruna Jaya VIII. Sediment samples from each station were put into a plastic bag for further analysis in the laboratory. Preparation on the collected samples was through several stages, i.e. washing, picking, and the identification and description of sticking and documentation. Previously, approximately 100 grams of sediment from each sample was added with 10% formaldehyde, left for 24 hours and filtered. The filtered samples were soaked with 50% rose bengal for 24 hours, and then washed by tap water. Washing was done by running water over sieves with mesh sizes 1.0, 0.5, 0.25, 0.125 and 0.063 mm, and then dried in the furnace at 30°C for 24 hours. Then, the dried samples were soaked in methylene blue solution to prevent contamination among the samples, and then washed. The next stage was picking by evenly spreading the dried sample on extraction tray under a microscope. Foraminifera from these samples were taken and stored on foraminiferal slides.

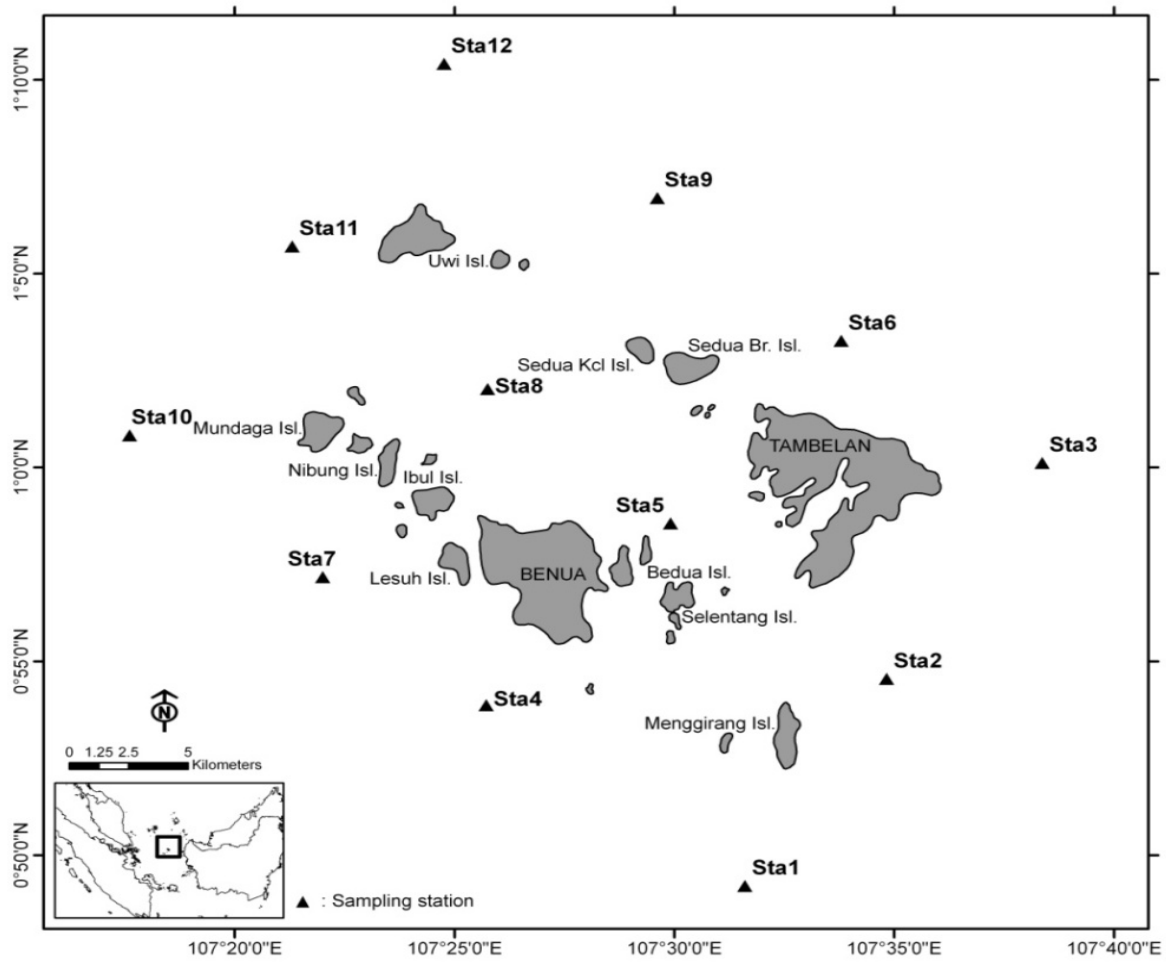

Figure 1. The map of Riau Island showing the sampling sites in Tambelan Islands (Δ= sampling station).

Description and identification of collected specimens. Specimens were identified based on their morphology such as shell shape, chamber shape, chamber formation, number of chamber, shell ornamentation, slope of the apertura, apertura position and additional chambers. The identification was carried out following Graham & Militante (1959), Barker (1960), Cushman (1969), Albani (1979) and Loeblich & Tappan (1992).

Sticking process and the documentation were done by placing specimens on foraminiferal slides elected to the position of the apertural, dorsal, ventral view and side views under a microscope. The quantitative analysis was performed to examine the abundance of foraminifera, and the hierarchical cluster analysis was utilized using SPSS Ver.16 to determine the similarity distributon among sampling sites.

Results and Discussion. There are 5582 specimens which were collected, belonging to 38 species (Table 1). The sampling sites of Tambelan Archipelago consist of various sediment types, including silt, clay and sand. The most populated benthic foraminifera was found in fine sandy sediment at station 2. This site was inhabited by 1160 specimens of benthic foraminifera, where Milioliida and Rotaliida were predominant orders.

The characteristics of each order were identified based on their shell (test) forming materials. According to Loeblich & Tappan (1992), Astrorhizida is one of the agglutinated foraminifera; their shell is made from mineral particles come from environment. The order Astrorhizida is characterized by agglutinated wall with particles attached to protenaceous or mineralized matrix, single chambered, or irregularly multichambered with incomplete septa. In addition to Astrorhizida, Textulariida also belongs to agglutinated foraminifera with particle cemented by low Mg calcite. The order of Astrorhizida and Textulariida were distinguished from other groups by their ability to secrete calcium carbonate. The Miliolida has a high Mg calcite with porcelaneous surface texture and their chambers become imperforate when they are adult. The Rotaliida has low Mg calcite on their shell with bilamellar wall and perforation, but chamber arrangement on the member of this order is low or rarely high trochospiral, planispiral, annular, or irregular.

Hierarchical cluster analysis of the full data set (12 samples using SPSS Ver.16) produced a dendrogram five high-level clusters (Figure 2). The results revealed the distribution pattern of benthic foraminifera in Tambelan Archipelago is relatively equal among sampling stations, except for station 1, 2 and 8. The most common benthic foraminifera of the study sites are members of order Rotaliida, followed by Milioliida and others in small percentage. Eight of twelve stations are dominated by Rotaliida of more than 50%, probably due to low Mg calcite contains at this station (Figure 3).

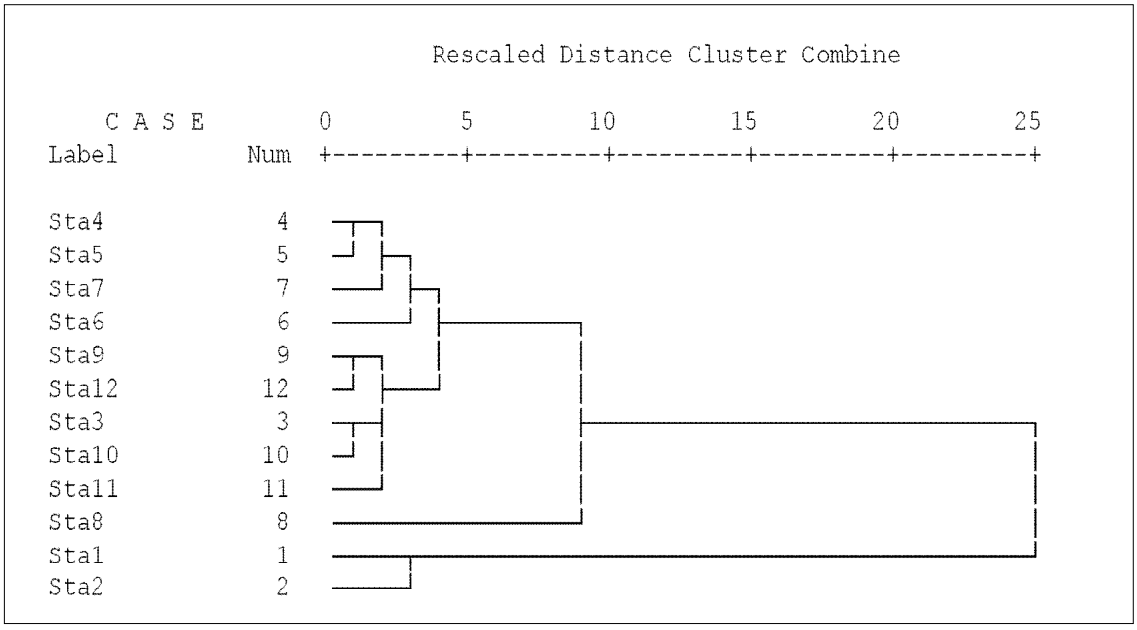

Figure 2. Hierarchical cluster analysis of station based on the benthic foraminiferal assemblages.

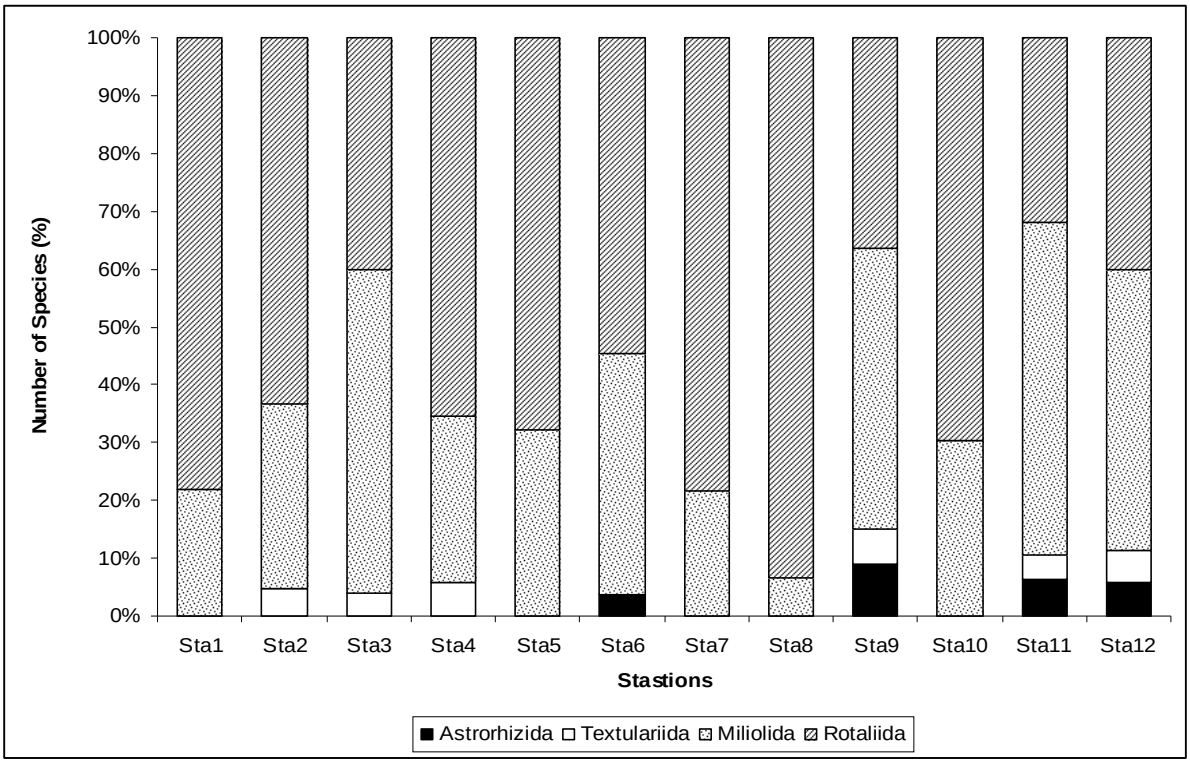

Figure 3. Proportion of collected foraminifea from Tambelan Archipelago according to the order at every sampling site.

A total of 15 species from order Rotaliida with various distribution levels were recorded in this study, where the most abundant species was *Assilina ammonoides* with 1384 specimens. They occured in all stations with most abundance at station 1 and station 2 (Table 1). In addition, *Amphistegina lessonii* (order Miliolida) was also highly distributed, but its abundance was lower compared to *A. ammonoides.* Moreover, we recorded about 16 species of order Milioliida with proportion ranged between 22 and 58%. The most common species of this order were *Spiroloculina communis, Lachlanella parkeri* and *Quinqueloculina* sp. They were predominant species at station 2 with fine sandy sediment at 32.52 m depth. *S. communis* was also recognized by Barker (1960) along with *Quinqueloculina granulocostata* and *Q. parkery* from south part of Papua at 37 m depth. Graham & Militante (1959) reported that these cosmopolitan species were also predominant in Puerto Galera Bay, Philipina. According to Biswas (1976) and Boltovskoy & Wright (1976) most of benthic foraminifera were inhabitant of shallow water (less than 60 m) i.e. *Quinqueloculina, Pseudorotalia, Amphistegina,* and *Elphidium*. Furthermore, Buzas & Sen-Gupta (1982) reported that *Amphistegina lobifera* prosperously lives, grows, and reproduces in shallow water with a high intensity of sunlight, whereas *A. lessonii* would thrive in deeper waters.

The vast majority specimens of benthic foraminifera were found at station 2 which was situated in the southeast part of the Tambelan Archipelago that reaches about 32 m in depth with fine sandy sediment. A total of 1160 specimens belong to 23 species were recorded at this station and most of them are the member of Rotaliida (63%). The benthic foraminifera abundance in other stations was lower relatively, probably due to these locations are facing toward open seas hence may affect to their ability to survive herein. This is in agreement with Murray (2006) and Renema (2002) who reported that benthic foraminifera could not against the hydrodynamic energy, for example sea currents and wave attack, and resulted in lower abundance in this extreme condition. In general there were many symbiotic-bearing foraminifera occurred in the study region such as *Peneroplis, Amphistegina* and *Assilina*. According to Hallock et al (2003) and Langer & Hottinger (2000) stated that these genera are bio-indicator for favorable condition of coral reef.

Table 1

Total individual of collected benthic Foraminifera at every sampling station from Tambelan Archipelago

Order	Species	Sampling stations											
		1	2	3	4	5	6	7	8	9	10	11	12
Astrorhizida	*Ammobaculites agglutinans*	-	-	-	-	-	24	-	-	24	-	24	-
	A. pseudogram	-	-	-	-	-	-	-	-	-	-	-	16
Textulariida	*Textularia agglutinans*	-	16	8	-	-	-	-	-	16	-	-	-
	T. conica	-	16	-	-	-	-	-	-	-	-	-	-
	T. pseudogramen	-	16	-	16	-	-	-	-	-	-	16	-
	Textularia sp.	-	8	-	8	-	-	-	-	-	-	-	-
	Clavulina alveoliniformis	-	-	-	-	-	-	-	-	-	-	-	16
Miliolida	*Edentostomina cultrata*	-	-	64	-	-	16	-	-	-	-	16	16
	Spiroloculina communis	48	96	24	-	32	46	-	16	24	40	64	16
	Schlumbergerina alveoliniformis	-	16	-	-	-	8	16	-	8	-	16	-
	Lachlanella parkeri	64	96	24	32	40	48	16	-	24	-	48	32
	Quinqueloculina bradyana	-	-	-	16	-	-	-	8	16	-	-	24
	Q. philippinensis	-	32	-	-	-	-	-	-	-	-	-	-
	Quinqueloculina sp.	-	40	-	56	56	88	48	-	48	-	56	24
	Milliolinella sublineata	32	16	-	-	-	-	-	-	-	-	-	-
	Pseudomassilina macilenta	-	-	-	-	-	-	-	-	-	-	-	8
	Triloculina tricarinata	-	16	-	-	-	24	-	-	-	16	-	8
	T. vespertilio	32	24	-	-	-	-	-	-	-	-	-	-
	Flintina bradyana	-	8	-	-	-	16	-	-	-	-	16	-
	Peneroplis carinatus	-	-	-	-	-	16	-	-	-	-	-	-
	P. pertusus	-	16	-	-	-	-	-	-	-	-	-	-
	Spirolina sp.	-	8	-	-	-	-	-	8		-	-	8
	Young miliolidae	-	-	-	16	8	-	-	-	8	-	-	-
Rotaliida	*Pileolina patteliformis*	-	-	-	-	-	8	-	-	-	-	-	-
	Discorbinella biconcava	-	-	-	-	-	-	-	-	-	-	8	-
	Marginipora vertebralis	-	-	8	16	16	-	-	-	-	-	-	-
	Planulina floridana	-	8	-	-	-	-	-	-	-	-	-	-
	Cibicides sp.	-	-	-	-	-	-	-	-	-	8	-	-
	Amphistegina lessonii	-	64	48	80	80	64	160	240	24	80	80	-
	A. quoyii	-	-	-	-	32	-	32	112	-	-	-	-
	Hansenisca soldanii	-	-	-	-	-	8	-	-	-	-	16	8
	Ammonia beccarii	64	48	-	16	16		-	-	48	-	-	8
	Asterorotalia trispinosa	24	24	-	-	-	8	-	-	-	-	-	48
	A. subtrispinosa	8	-	-	-	-	-	-	-	-	-	-	-
	Pseudorotalia schroeteriana	96	80	-	32	16	32	-	-	-	8	16	-
	Cellanthus craticulatus	-	80	-	-	-	-	-	-	-	-	-	-
	Elphidium crispum	32	32	8	48	48	72	16	16	-	8	-	-
	Assilina ammonoides	400	400	16	80	80	152	80	80	24	24	-	48
	Total	800	1160	200	416	424	630	368	480	264	184	376	280

Conclusions. A total of 5582 benthic Foraminifera corresponding to 38 species and four orders were recorded in this study. Most of the benthic Foraminifera were collected from station 2, which is situated on the southeast part of Tambelan Archipelago where the sediment is dominated by fine sand. Generally, hierarchical cluster analysis revealed the distribution pattern of benthic foraminiferal assemblages in Tambelan Archipelago is relatively equal among stations, except for station 1, 2 and 8, where the most common benthic foraminifera are members of order Rotaliida, followed by Milioliida. In addition, the most common species from all stations is symbiont-bearing foraminifera i.e. *Assilina ammonoides* and *Amphistegina lessonii* with abundance of 1384 and 1096 specimens, respectively. Approximately more than 30% of specimens were identified as shallow waters foraminifera such as *Quinqueloculina, Pseudorotalia, Amphistegina* and *Elphidium*.

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