Benthic Foraminifera in Intertidal Sediments Around UNSRAT Marine Station in Likupang, North Minahasa

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ABSTRACT

Despite their biological and ecological importance, research on foraminifera is still very limited. In recent years (from 2018 to present), interest in foraminifera studies has begun to emerge and it was shown by publication of several research articles. The study was aimed to obtain basic information on the presence of foraminifera in intertidal area around UNSRAT Marine Station in Likupang, North Minahasa. Sampling for foraminifera was conducted in five stations in front of the marine station. Sediments were collected from the upper 2 cm of sediments, brought to the laboratory, washed through 63µm sieve, and air-dried. A number of > 300 foraminifera tests were picked for identification and photographed. A total of 16 genera were found and they were grouped into three functional groups: symbiont-bearing, opportunistic, and heterotrophic foraminifera. In symbiont-bearing group, *Calcarina* was found present in all stations and it was followed by *Baculogypsina* and *Amphistegina*. Genus *Elphidium* was found to be dominant in the opportunistic group, while *Quinqueloculina* was the only opportunistic foraminifera that was found in all stations. The study also revealed that most of the foraminifera tests were categorized intact, meaning that their morphological features were still well preserved.

Keywords: benthic foraminifera, sediments, UNSRAT, Likupang

INTRODUCTION

Foraminifera are amoeboid protozoa that mostly live freely in the sea, eukaryotes that have single cells and show animal-like characteristics (Boudagher-Fadel, 2013). These organisms are distributed from intertidal areas to the deepest sea areas in all areas of the world (tropical to polar regions).

These organisms can have complex carbonate skeletons and some of them possess shells (called tests) that are collection of sediment particles. The test is divided into spaces that will increase in number as it grows. Living foraminifera have pseudopodia which functions, among others, as a tool to take food and sediment particles. These organisms are divided into two main groups: benthic foraminifera and planktonic foraminifera (Sen Gupta, 1999).

Foraminifera are significant in both geology and ecology, because they can serve as valuable tools for understanding past climate and environment, as well as play important role in marine ecosystems. From geological point of view, foraminifera are significant contributor of calcareous sand in tropical and shallow coastal areas (Cedhagen, 1996). And, from ecological viewpoint, some foraminifera (with algal-symbionts) and zooxanthellate coral have similar water-quality requirement which make them potential to be used as bioindicator (Hallock *et al*., 2003).

The wide distribution of these organisms illustrates the importance of obtaining information about the presence of certain taxa in certain area. This is because the presence of each taxon will be influenced by the place where they

live. The study of foraminifera in healthy and polluted waters is important not only from a theoretical and academic point of view but also because of its practical importance. Knowledge of the effects of various types and levels of pollution on various foraminifera species can be used to determine certain species as indicators of pollution. Species that exist in a certain environment can provide an indication of a certain type of aquatic contamination (Boltovskoy & Wright, 1976).

The coastal area around Sam Ratulangi University Marine Station is part of the Likupang waters which has been implemented as a Special Economic Zone with the advantage of the tourism sector in terms of resorts and cultural tourism (kek.go.id/kawasan/KEK-Likupang).
Coastal area in general has two functions, namely ecological functions which are a place to live for various marine organisms and economic functions which are closely related to social functions to support human life. By implementing the area as tourist destination, the pressure faced by the waters will increase as it affect the ecological function. Research to obtain data on the biodiversity of foraminifera which can be related to information about the water present status of the area is important. The data will be of crucial important in future management of the area.

MATERIALS AND METHODS

The study was conducted at the intertidal area around Sam Ratulangi University Marine Research Station in Likupang. The area was divided into 5 stations and each station were represented by two sampling area which represented area exposed at lowest tide and submerged area. Station 1 to Station 3 were situated in front of the marine station, while station 4 and 5 were in front of a small outlet (Figure 1).

Sediment samples were obtained by filling up plastic bags with the upper 2 cm of sediments. An amount of 100 gr of sediments were collected from each area. All samples were then brought to the

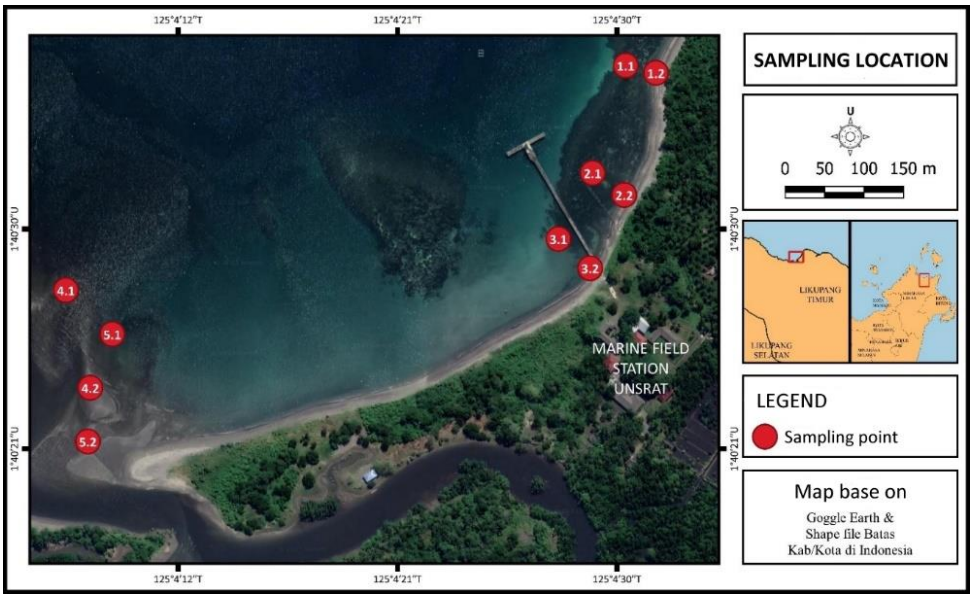

Figure 1. Area of research

laboratory and washed with freshwater through 63µm sieve and air-dried. A small amount of dried sediment sample was then put into a picking tray for further separation. A number of > 300 specimens of benthic foraminifera were picked among the sediments and identified to genera level. Further identification to species level were also conducted when it was possible. All works was conducter under dissecting microscope. The identification was based on Loeblich & Tappan (1994), Forderer & Langer (2018), and Yassini & Jones (2023) and crosschecked through World Register of Marine Species (WORMS) and Foraminifera EU databases. All the genera and species representation were photographed using a Bresser MikrOkular Full HD mounted Olympus stereomicroscope.

RESULTS AND DISCUSSIONS

A total of 16 genera was found during the work and two of them had been identified to the species level. They were then classified into three functional groups: Symbiont-bearing, Opportunistic, and Heterotrophic foraminifera (Table 1). Based on the identified specimens found in both exposed and submerged area, there is not significant difference between the two. Thus, the data in both areas were treated as independent area.

Symbiont-bearing Foraminifera

Calcarina was among symbiont-bearing foraminifera found to be the genera that was found the most in all sampling area in all stations. It is followed by *Baculogypsina* and *Amphistegina*. Both *Calcarina* and *Amphistegina* are known to be genera that are always abundant di coral reef environment (see Paringgi *et al.*, 2018; Kalalo *et al.*, 2020, and Sumale *et al.,* 2022). Symbiont-bearing foraminifera are known to host algal symbiont and these symbionts are important because they have similar water-quality requirement with reef-building corals (Hallock *et al*., 2003; Prazeres *et al*., 2020). This group of foraminifera plays important role in the calculation FoRAM (Foraminifera in Reef Assesment and Monitoring) Index (FI).

Genus *Calcarina.* Genus *Calcarina* was found in all sites, from area with substrates that contain coral reef and coral rubble (station 1 and 2), coral rubble and macroalga (station 3) to the areas with sand and dominated by sediment from land (station 3 and 4).

In his dissertation, Renema (2002) stated that due their very variable species, the taxonomy of the genus Calcarina still need to be resolved. The habitat of Calcarina can also determine the morphological feature of the specimen. *Calcarina hispida* is generally found in inner flat area with the density that get reach 3.8 cm^{-2}, and mostly found between thalli of macroalga near sediment substrate. Other species such as

Figure 2. Several forms of *Calcarina* sp.

Tabel 1. Benthic foraminifera in intertidal area around UNSRAT Marine Station

No	Genera / Species	Station									
		1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2
	Symbiont-bearing group										
1	*Calcarina* sp.	√	√	√	√	√	√	√	√	√	√
2	*Amphistegina* sp.	√			√	√		√		√	√
3	*Heterostegina depressa*	√	√	√	√	√					√
4	*Baculogypsina sphaerulata*	√	√	√	√	√	√		√	√	√
5	*Operculina ammonoides*							√	√		
6	*Peneroplis* sp.	√		√		√					
7	*Sorites*	√		√							√
	Opportunistic functional group										
8	*Elphidium crispum*	√							√		√
9	*Elphidium craticulatum*	√	√	√		√	√	√			√
10	*Elphidium* sp					√					
11	*Ammonia* sp.			√		√				√	√
	Heterotophic group										
12	*Pyrgo denticulata*	√									
13	*Quinqueloculina* sp	√							√	√	√
14	*Q. philippinensis*	√		√		√			√	√	√
15	*Vetebralina striata*			√							
16	*Planorbulinella* sp.								√		
17	*Eponides* sp.			√		√					
18	*Spiroloculina* sp.								√		
19	*Trochamminella* sp.			√		√					

Calcarina mayori live on reef slope and mostly found on pieces of coral rubble (Renema, 2002).

In this study, the test collected were empty tests and it is assumed that all the specimen come from area around the marine station and they were being transported to the area of sampling. Most of the spines of the specimen collected were still intact and this indicate that physical factors (water energy) and other environmental conditions that affect the *Calcarina* were minuscule. Attrition of test is known to indicate long deposition of the specimen and this is caused by interaction between physical factors in the water and between sediments (see for instance Yordanova & Hohenegger, 2002).

Sumale *et al*. (2022), in their study on foraminifera of coral reef area in Manado, found Genus Calcarina to be the most abundant in 3 of 4 stations. This contributed to the high FoRAM Index of the studied area.

Genus *Baculogypsina.* There is only one form of Genus *Baculogypsina* found in this study and the specimen was identified as *Baculogypsina sphaerulata*. Figure 3 show four different morphology forms of the specimen found in different locations.

Figure 3. Several forms of *Baculogypsina sphaerulata*

Figure 4. Several form of *Heterostegina depressa*

Baculogypsina sphaerulata is known to have endosimbiont diatom, similar to other large benthic foraminifera. Yamanouchi (1998) found this species, together with Genus *Calcarina*, to be abundant in the Ryukyu Island Arc, and he used this species to model sediment transport at several islands of the area based on attrition grade of the tests. In our study we found one particular specimen with forked spines which categorized rare. Based on Yamanouchi (1998), all the specimen found fit the all three grades of attrition (grade-A for fresh spines, grade-B for partly broken spines, and grade-C without spines).

This species is usually found living in algal thalli which grow on coral reef at the depth of 1 to 2 m (Debenay, 2012). It prefers intertidal and subtidal zones facing the open ocean of coral reef. Life span of the species is around 17 months and the peak of reproduction in temperate area is spring to summer. The growth pattern of the species in tropical environment has been studied in laboratory by Hosono *et al.* (2013).

Heterostegina depressa. In his study on large benthic foraminifera of coral reef in Bali, Renema (2003) found *Heterostegina depressa* to be one of the most common species (found in 118 of 132 samples collected). The highest was found on reef slope with coral rubble which is covered by coralline algae. It is also found in the highest density among alga covered substrate but least found on macroalgae or seagrass thalli. This specimen is commonly found in various microhabitats in the area of West Indo-Pacific.

In our study, *Heterostegina depressa* was found in almost all the area in station 1 to station 3, and was only found in one area in two locations which were situated in front of River mouth. Test preservation can be categorized as intact (based on Forderer & Langer, 2018 category).

Figure 5. Morphological form of Genus *Amphistegina* tests

Figure 6. The most common forms of Opportunistic Foraminifera (*Elphidium*)

Genus *Amphistegina.* Genus *Amphistegina* is one of the common genus found in tropical area. In their study on foraminifera in coral reef area of Bunaken Island, Paringgi *et al*. (2018) found this genus to be the most abundant. The same study two years later by Kalalo *et al*. (2020) found that > 50% of tests were from *Amphistegina*.

Similar to *Calcarina*, several species from the Genus *Amphistegina* are needed to clarify. For instance, *Amphistegina lessonii* is sometimes difficult to be distinguished from *Amphistegina lobifera*. This is especially true for the small specimens. *Amphistegina* has several simbionts such as diatom *Nitzschia frutulum* var. *symbiotica* (Lee & Anderson, 1991). According to Debenay (2012), *Amphistegina* is one of genera that found to be associated with sands (*Amphistegina lessonii*). Other species such as *Amphistegina bicirculata* prefer muddy sand. Depth preference also varied among the species (Debenay, 2012).

In our study, Genus *Amphistegina* was absent in several points of sampling, but found in all five stations. Although it is too early to say, it is believed that there is a competition between *Calcarina* and *Amphistegina* in one area. When one flourish, the other will come next. However, this need to be investigated further.

Opportunistic Foraminifera

Foraminifera that are categorized as opportunistic functional group are foraminifera that dominate high-stress environment (Hallock *et al.*, 2003). Our study found two genera of the group, *Elphidium* and *Ammonia*. While *Elphidium* was found in almost all areas (except for two), *Ammonia* was only found in four area (represent 3 stations). These taxa represent foraminifera that can thrive in unstable or disturbed environment (especially those affected by pollution or eutrophication). They can adapt to rapidly changing condition or increasing food sources.

Figur 7. Several of Heterotrophic Foraminifera

Heterothropic foraminifera

Heterotrophic foraminifera or also known small heterotrophic foraminifera are usually small in size. We found 7 genera in our study, and the most abundant specimen was from Genus *Quinqueloculina*. One species that can successfully be identified is *Quinqueloculina philippinensis*, this specimen is widely found in area around Likupang and other area in Minahasa (personal observation).

CONCLUSIONS

A total of 16 genera was identified and most of them appear to have more than one species. Most of the specimens are categorized as intact, and this status indicate the water energy and other environmental conditions that affect the tests. A more detailed study on the effect of physical condition of the area and the status of the tests is needed. It is also found from the study that Symbiont-bearing foraminifera are represented by 7 genera, Opportunistic group by 2 genera, and Heterotrophic by 7 genera. Foraminifera with algal symbionts is closely related with zooxanthellate corals because they have similar water-quality requirement. Based on the data found, there is a possibility to study the water quality of the area in the future to find out if the area is conducive for reef growth.

ACKNOWLEDGEMENTS

We acknowledge funding by Sam Ratulangi University through PNBP-RDUU_K2 (Riset Dasar Unggulan Unsrat Klaster 2, No. SP DIPA – 023.17.2.677519/2023. We would like to express our thanks the Rector of Sam Ratulangi University and the LPPM UNSRAT for that. Our gratitude also goes to the Dean of Faculty of Fisheries and Marine Science for the support.

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