Impact Test Size and Type of *Echinometra mathaei* as Agent of Bioerosion on Reef Flat

Cristiana Manullang*[1], Makoto Tshuciya[2], Ambariyanto[3,4], and Diah Permata[3]

[1]*Marine Science Master Degree Program, Faculty of Fisheries and Marine Science, Diponegoro University Jl. Prof. Soedarto, S.H. Tembalang, Semarang, Indonesia 50275*

[2]*Faculty of , University of the Ryukyus, Nishihara, Okinawa, Japan 903-0213*

[3]*Faculty of and Marine Science, Diponegoro University, Semarang, Indonesia. 50275*

[4]*Central Laboratory of Research and Services (UPT-Lab Terpadu), Diponegoro University Jl. Prof. Soedarto, S.H. Tembalang, Semarang, Indonesia 50275*
Email: cris.manullang@yahoo.com

Abstrak

Pengaruh Ukuran dan Tipe Echinometra mathaei pada Bioerosi Karang

Bioerosi adalah aktivitas berbagai organisme yang menyebabkan terjadinya erosi dan kerusakan misalnya pada kalsium karbonat karang. Aktivitas ini merupakan faktor utama yang mempengaruhi morfologi terumbu karang. Bioerosi dipengaruhi oleh tiga variabel yakni jenis spesies, ukuran dan kelimpahan spesies tersebut. Tujuh puluh lima persen dari bioerosi disebabkan oleh landak laut. Perbedaan pada ukuran dan jenis landak laut memberikan dampak signifikan terhadap daerah yang terjadi bioerosi. Penelitian ini bertujuan untuk menguji pengaruh ukuran dan jenis landak laut E. mathaei (tipe A dan B) pada komposisi $CaCO_3$ dalam isi usus dan tinja organisme tersebut sebagai agen bioersi. Landak laut yang digunakan diperoleh dari ekosistem karang di pantai Minatogawa, Okinawa-Jepang. Masing-masing tipe landak laut dibedakan berdasarkan ukuran ≥30 mm dan <30mm. Penelitian dilakukan dengan tiga ulangan. Pemeliharaan ini dilakukan di laboratorium dengan analisis komposisi $CaCO_3$ pada tinja dan konten usus. Hasil penelitian membuktikan bahwa komposisi $CaCO_3$ disebabkan karena aktivitas bioerosi harian dari E. mathaei. Landak laut dengan ukuran diameter ≥30 mm terbukti lebih aktif dibandingkan dengan diameter <30mm. Disamping itu landak laut tipe B lebih aktif dibandingkan tipe A dengan ukuran yang sama. Persentase $CaCO_3$ dalam usus selama pemeliharaan di laboratorium adalah 73% dan sisa 27% berupa bahan organik dan anorganik. Bierosion harian E. mathaei tipe A ≥ 30 mm 166,70 $mg.hari^{-1}$, tipe A <30 mm 77.78 $mg.hari^{-1}$, tipe B ≥ 30 mm 126,30 $mg.hari^{-1}$, tipe B <30 mm 116,17 $mg.hari^{-1}$. Tingkat bioerosion harian E. mathaei dipengaruhi oleh jenis, spesies, kecepatan menggiling, dan ukuran landak laut.

Kata kunci: *ukuran; Echinometra mathaei; bioerosi; karang*

Abstract

Bioerosion is an activity of various organisms such as erosion and destruction of coral calcium carbonate and become a major factor influencing coral reefs morphology. Bioerosion is influenced by three variables: type of species, size of species and abundance. Seventyfive percent of bioerosion caused by sea urchin. Differences on size and type of sea urchin gave a significant impact to the bioerosion area. This study aimed to examine the influence of the size and the type of sea urchin E. mathaei (type A and type B) on the composition of $CaCO_3$ in the gut content and feces as bioersion agent on the reef flat in Minatogawa Coast, Okinawa-Japan. The organisms used were E. mathaei type A and type B with each type distinguished by size ≥ 30 mm and < 30 mm with three replications. The maintenance was carried out at laboratory for 3 days by observing analysis of the composition of $CaCO_3$ on feces and gut content. It indicates that the composition of $CaCO_3$ as daily bioerosion was caused by E. mathaei. The results showed E. mathaei with diameter ≥ 30 mm was more active than those with diameter of < 30mm and type B was more active than type A in each of the same size. Percentage of $CaCO_3$ in the gut during maintenance in the laboratory was 73% and the other 27% consist of organic and inorganic materials. Daily bierosion E. mathaei type A ≥ 30 mm 166.70 $mg.day^{-1}$, type A < 30 mm 77.78 $mg.day^{-1}$, type B ≥ 30 mm 126.30 $mg.day^{-1}$, type B < 30 mm 116.17 $mg.day^{-1}$. Daily bioerosion rate E. mathaei was influenced by the type, species, speed of grind, and the size of the sea urchin.

Keywords: *size; Echinometra mathaei; bioerosion; reef flat*

*) Corresponding author

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Introduction

Coral reef ecosystem is well known for its biological and genetic diversity. Various activities of the organism as a cause of coral reef structure and constituent coralline algae experiencing bioerosion. Bioerosion is the activity of various organisms that cause calcium carbonate erosion and destruction the building of coral animals (Holmes, 2000). Bioerosion is the process of calcium carbonat removal from reefs or coral colonies by biological processes (Tomascik *et al.*, 1997) and as a major factor that affects the reef building and its morphology.

Organisms that cause frame-building coral reef limestone eroded and broken through the activities were refered to bioeroder (Glynn, 2001). Bioerosion activity on reef structure affects the abundance of carbonate structures from the Precambrian and Cambrian period (Vogel, 1996). This process occurs both mechanically and chemically (Zundelevich *et al.,* 2007; Nava and Carballo, 2008). The rate of bioerosion is also influenced by nutrient concentration related to trophic level (Lescinsky *et al.,* 2002; Pari *et al.,* 2002; Hutchings *et al.,* 2005), substrate density (Schönberg, 2002) and ocean acidification (Wisshak *et al.,* 2012).

Bioerosion on coral reefs is generally caused by the activity of the three groups of organisms, i.e. Parrot fish (Scaridae), sponge (Clionidae), and also sea urchin (Carreiro-Silva and McClanahan, 2001; Brown-Saracino *et al.* 2007). Although other animals like chiton also has similar activity (Barbosa *et al.,* 2008). Peyrot-Clausade *et al.* (2000) reported that fish and sea urchin are the most important grazers both at two reefs of La Saline on La Réunion Island (Indian Ocean) and of Tiahura on Moorea Island (French Polynesia).

In addition, microborers, grazers, and macroborers have been reported to contribute in bioerosion rate (Tribollet *et al.,* 2002; Tribollet and Golubic, 2005). However, seventy five percent of the total bioerosion caused by sea urchin therefore, the major bioeroder on coral reef ecosystems is sea urchin. Bioerosion that caused by sea urchin has many aspects, one of significant aspects is the biological and geological aspect, including abrasion activity that make up the holes and caves in the coral (Bak, 1994).

Bioerosion caused by sea urchin usually ranges from 3-9 kg m^2.$year^{-1}$, it depends on the type of species, the speed of erosion, the size of the sea urchin, and population density of the animals (Mokady *et al,* 1996; Herrera-Escalante *et al.,* 2005). Significant differences in the size and species of sea urchin will give different impact on the bioerosion area. The rate of bioerosion of sea urchin can be calculated by analysiing gut contents and also feces of the animals (Milss, 2007).

Gut of sea urchin consist of various compositions, such as algae, coral particles, fragments of sea urchin spines, and shells of gastropods. While the sea urchin feces containing 73% calcium carbonat that derived from erosion of coral, 20% from organic material and 7% from dissolved organic material (Mills *et al*., 2000). According to Bak (1994), the type of sea urchin as bioeroder include: *Diadema antilarum, D. savignyi, D. setosum, Echinothrix calamaris, Echinometra lucuntur, E. diadema, E. mathei*.

Echinometra mathei is one of bioeroder which are easily found in the Indo West Pacific and live in a way that boring during his life as an adult individuals remain relatively rare in the hole and out of the hole. According to Russo (1980), *E. mathei* is one of the important bioerosion agents that contributed about 2 to 8% of the total product of bioerosion. In Hawaii, an estimated weight about 4000 grams total weight.m^{-2}.$year^{-1}$ bioerosion product. Where *E. mathei* give contribution about 80-325 grams of dry weight.m^{-2}.$year^{-1}$. Daily erosion velocity of each individual sea urchin ranged from 0.1 to 0.2 grams in dry weight.m^{-2}.$year^{-1}$. According to Downing and El Zahr (1987), from gut contents analysis of *E. mathei* obtained velocity erosion.day^{-1} that ranged from 0.9 to 1.4 grams dry weight.day^{-1}.

Sea urchin with a size 30-40 mm has great potential to causing bioerosion 5-10 times higher in populations with half the size*. E. mathei* has a size of about 19.5 to 40.8 mm and has the ability to perform the erosion of approximately 0.11 to 0.7 mm (Bak, 1994). Along the coastline of Okinawa Island can be found various of sea urchin *E. mathaei*. This species is divided into 4 types (type A, type B, type C, and type D) based on differences in morphology, ecology, and the characteristics of the embryo (Uehara, 1990; Setyawan *et al.,* 2013). These four types of differences can also be seen from the formation of bioerosion. Suzuki (2005) reported that bioerosion by *E. mathaei* is an agent that dominates on the island of Okinawa, the difference in size and type affect bioerosion formation, extent, and rate of erosions. *E. mathaei* type A and type B are dominating Minatogawa coast where the second type has bioerosion rate higher than other types.

Material and Methods

Sample collection

Sea urchin, *Echinometra mathaei* were collected from tide pool on the coast of Minatogawa, Okinawa Island (N 26^{0}07'10.6'; E127^0 45'21.5") on July 2013. This study use type A and type B of of the animals which are commonly found in the area. The samples were brought to the laboratory of the Faculty of Science, University of the Ryukyus, Okinawa, Japan for further experiment.

Laboratory treatment

Laboratory experiments carried out to see the content of calcium carbonate on the gut and feces. Aquarium were made as natural as possible with a range of 30-33 ‰ of salinity, 28^{0}C of temperature, 250 lux Fluorescent illuminated for 12 hours, and the water in the aquarium were circulated. Observations were conducted for 5 days. Dead coral that has holes were taken from Minatogawa and dead coral habitats such as *E. mathaei* (type A and type B) in aquarium. There are four aquariums (three aquarium contained with *E. mathaei* with different types and sizes), namely: Aquarium A1 (*E. mathaei* type A ≥ 30 mm), aquarium type A2 (*E. mathaei* type B ≥ 30 mm), aquarium B1 (*E. mathaei* type A < 30 mm), and the aquarium B2 (*E. mathaei* type B < 30 mm). According to Uehara and Hiratsuka (2007), Echinometra adult size has a diameter of 30-35 mm and feed demand is higher than the size of < 30 mm, while the size of < 30 mm is a condition in which *E. mathaei* still the Juvenile stage to adulthood and feed consumption is still small.

Gut content analysis of $CaCO_3$ and feces

Analysis of the gut contents and feces $CaCO_3$ compared by type and size. Gut contents and feces were taken and placed in a sample bottle. Then the samples were rinsed with Double Distilled Water (DDW) three times to remove NaOH contained in the sample. Then the samples were dried in oven at 60^{o}C temperature for 24 hours. Once weighed, given a sample of 2N HCl to remove $CaCO_3$ contained in the sample. After that, the sample were rinsed with DDW three times, dried and then weighed again. Initial weight before HCl is treated with dry weight of feces produced by *E. mathaei*. The difference between the weight before the treatment with HCl after being given an estimate of $CaCO_3$ contained in the gut contents.

Results and Discussion

Total dry weight of $CaCO_3$ increased by the large size of the *E. mathaei*. Greatest $CaCO_3$ contained in *E. mathaei* with a diameter ≥ 30 mm. There are significant differences in the content of $CaCO_3$ in *E. mathaei* size ≥ 30 mm in size <30 mm.

$CaCO_3$ content of the hull during maintenance in the laboratory is 73% of the amount of gut contents and 25% are other (organic and other inorganic materials). Total $CaCO_3$ in sea urchin gut area bioerosion predictable levels caused by sea urchin. It is of course also linked to the type, sizes, and sea urchin habitat.

$CaCO_3$ content of the feces was 79% of total dry weight and 21% is organic and the other inorganic materials. $CaCO_3$content of the feces is a daily bioerosion caused by *E. mathaei.*

Table 1. Dry weight ratio of $CaCO_3$ in the gut and feces

Type	Weight of Gut	Weight of Feces
A ≥30 mm	135.7566	52.8073
A <30 mm	139.3342	49.8757
B ≥30 mm	31.2614	24.0353
B <30 mm	31.1566	28.7232

The data showed that the content of $CaCO_3$ in the gut more than in feces. $CaCO_3$ content of gut *E. mathaei* size ≥ 30 mm had a significant difference to the content of $CaCO_3$ on the feces at the same size, while the size <30 mm $CaCO_3$ content in the gut was not significantly different to the $CaCO_3$ content of the feces.

$CaCO_3$ content of gut *E. mathaei* type A and type B ≥ 30 mm in diameter greater than the diameter of < 30 mm. Mills *et al*. (2000) states that the content of the feed on sea urchins increased according to the size of the diameter. In addition, the size and extent Aristotelarn also affects the speed to grind a hole in the reef. This allows for interspecific differences in feeding rate as a limiting factor on the gut of each species variation due to differences in the size and shape of the lanterns are different depending on the species and age of sea urchin (Appana, 2003). Dry weight of $CaCO_3$ on *E. mathaei* type A and type B with a diameter of each ≥ 30 mm and <30 mm during the observation in the laboratory at an average of 73% of the total dry weight of the gut and the other 27% including organic and other inorganic materials. Research by Milss *et al.* (2000) in Tiahura reef (French Polynesia) reported that the percentage found in the gut contents of *E. mathaei* consisting of 73% $CaCO_3$, 20% and 7% of organic material dissolved organic material. Milss *et al.* (2000) found a similar proportion is 73% $CaCO_3$ and 27% organic matter in the gut contents *Echinometra spp*. collected from Rottnest Island, Western Australia.

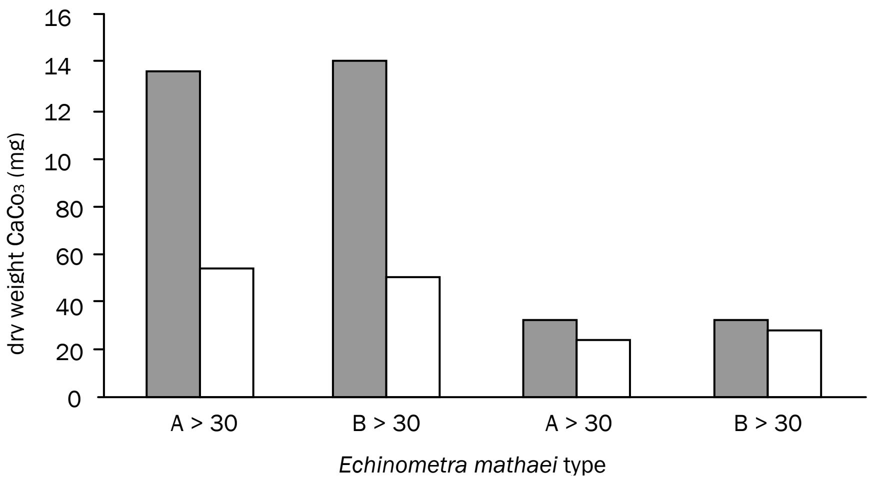

Figure 1. Total and percentage of $CaCO_3$ during observation in the laboratory. Note **:** ▩ **:** gut, □ : feses

The results showed that the rate of daily bioerosion of *E. mathaei* type A ≥ 30 mm 166.70 mg.day^{-1}, type A < 30 mm 77.78 mg.day^{-1}, type B ≥ 30 mm 126.30 mg.day^{-1}, type B <30 mm 116.17 mg.day^{-1}. Differences bioerosion rate is influenced by the type and size. Bioerosion the rate is almost equal to the rate of bioerosion in previous studies. The rate of *E. mathaei* bioerosion in the Arabian Gulf is estimated at 90 to 140 mg $CaCO_3$.day^{-1} (Dowing and El - Zhar, 1987). Bak (1990) found that erosion caused by *E. mathaei* of 140 mg.day^{-1} on Tiahura. Kukubo (1993) estimate the rate of erosion caused by *E. mathaei* Mizugama on Okinawa Island reef flat at 109.3 mg.day^{-1} with an average maximum diameter of 25.3 mm. Meanwhile, Makody *et al.* (1996) mentions bioerosion by *E. mathaei* activity in the Red Sea coral ecosystems by 120 mg.day^{-1}.

The percentage of fecal dry weight content of $CaCO_3$ in type A and type B at an average of 79% of the total dry weight, 21% other materials including organic and inorganic. *E. mathaei* issued feces with high intensity at night, but during the low intensity (Milss *et al.,* 2005). Inorganic compounds in the feces can be water, gas, mineral salts, and acid-base, while the organic compounds in the feces is in the form of proteins, fats, and carbohydrates (Hiratsuka and Uehara, 2007). The content of the dry weight of $CaCO_3$ in daily feces bioerosion illustrate the magnitude of the daily rate. Measurement of the content of $CaCO_3$ in the feces and gastrointestinal tract as an indicator of sea urchin on the reef bioerosion (Mokady *et al.,* 1996).

Conclusion

Observations and discussion can be concluded that *E. mathaei* generally *E. mathaei* size ≥ 30 mm more potential as bioerosion agents compared to the size of < 30 mm. *E. mathaei* type B with a diameter of ≥ 30 mm as an bioerosion agent highest compared with the type A and the same size. This is evident in the content of $CaCO_3$ contained in the gut and feces. Daily Bierosion *E. mathaei* Minatogawa Coast namely: type A ≥ 30 mm 166.70 mg.day^{-1}, type A <30 mm 77.78 mg.day^{-1}, type B ≥ 30 mm 126.30 mg.day^{-1}, type B < 30 mm 116.17 mg.day^{-1}. Bioerosion rate differences is influenced by the type, grind speed, and the size of the sea urchin.

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