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ZOOXANTHELLAE DENSITY IN DIFFERENT ZONE AND LIFE FORM IN INNER AND OUTER ZONE OF SPERMONDE ISLANDS

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ABSTRACT

The Spermonde Islands are part of the mega diversity area in the world's coral triangle area, crossed by the Wallace line. The Spermonde Archipelago consists of 120 islands spread over four zones: the inner zone, middle inner zone, middle outer zone, and outer zone. Samalona Island is located in an inner zone with a high level of eutrophication, and Langkai Island is located in an outer zone with a high brightness level. This study aims to determine whether there are differences in zooxanthellae density in various life forms and coral reef zones in the inner and outer zones of the Spermonde Islands. Coral sampling was done at coral reef ecosystems on Samalona Island and Langkai Island using SCUBA tools, cutting tools, and plastic samples. The zooxanthellae were separated from their hosts using a modified airbrush sprayer with an air pressure of 3000 psi. The zooxanthellae density was calculated using the formula of Eaton et al. Water qualities were measured in-situ using the water quality checker. The data were analyzed using factorial analysis with two factors. This study indicates that the zooxanthellae density in the folios life form is higher than in the encrusting and branching life forms. This study indicates that: (1) the zooxanthellae density in the same life form is not significantly different between the inner zone and outer zone; (2) the comparison of the zooxanthellae density in the same coral reef zone was not significantly different between the inner and outer zones; (3) the comparison of zooxanthellae density in the same coral reef zone was significantly different between life forms in the inner zone (Samalona Island); (4) the comparison of the zooxanthellae density in the same coral reef zone was significantly different between the life forms in the outer zone (Langkai Island).

Keywords: Zooxanthellae density, life form, coral reef zone, Wallace line, Spermonde Islands

INTRODUCTION

The coral reef ecosystem is a tropical marine ecosystem that has a high diversity and is very productive (Tuwo and Tresnati, 2020) so that it can support the life of heterotrophic organisms such as fish (Tresnati *et al.*, 2019a; Tresnati *et al.*, 2019b; Yanti *et al.*, 2019; Yasir *et al.*, 2019; Tresnati *et al.*, 2020a; Tresnati *et al.*, 2020b; Tresnati *et al.*, 2020c; Tuwo *et al.*, 2020a; Tuwo *et al.*, 2020b; Ulfah *et al.*, 2020; Tresnati *et al.*, 2021; Tuwo *et al.*, 2021) and other organisms (Yanti *et al.*, 2020; Kaisar *et al.*, 2021). Hard corals of the order Scleractinia have a mutualistic symbiosis with single-celled algae zooxanthellae. Zooxanthellae live in the endodermis layer of coral polyps (Tuwo, 2011). In this symbiosis, corals benefit in the form of organic matter from the photosynthetic results of zooxanthellae. Zooxanthellae can produce organic matter up to 95% of the total coral requirement, while zooxanthellae benefits from nutrients and CO_2 from coral metabolism processes (Sorokin, 2013). The photosynthesis process in zooxanthellae requires sunlight so that the brightness and depth of the waters are essential for corals. The deeper the water, the less light that enters the water. This difference in light intensity can affect photosynthetic activity. This difference in photosynthetic activity is estimated to cause differences in the number of zooxanthellae cells at each level of water depth (Supriharyono *et al.*, 2015; Asmiati *et al.*, 2017) because, as autotrophic organisms, zooxanthellae need sunlight for the photosynthesis process (Salim *et al.*, 2020).

Each depth has a different dominance of coral growth forms. At a depth of 5 m on the reef flat, the coral growth forms are dominated by *Acropora tabulate*, branching corals, coral foliose; at a depth of 10 m on the reef slope dominated by encrusting coral growth forms; while at a depth of 15 m at the reef base is dominated by massive coral, encrusting coral, and coral branching (Tombokan et al., 2017).

Oceanographic factors influence differences in the dominance of the distribution of coral growth forms. In areas directly facing the open sea, the movement of water masses and currents affects the ability of coral larvae to attach to the substrate (Nybakken, 2001).

The study results on the zooxanthellae density indicated that the zooxanthellae density was significantly different in each coral reef zone (reef flat, reef crest, reef slope). The results of previous studies also indicated that the densest zooxanthellae density was found in life form folios, followed by life form branching, and the lowest density was found in the encrusting life form (Ihsan, 2016). The results of another study showed that the highest zooxanthellae density in life form folios was found in the depth zone of the reef flat, and the lowest density at a depth of the reef slope (Salim *et al.*, 2020).

This study aims to assess the zooxanthellae density based on life form (branching, encrusting, and folios) and reef zone (reef flat, reef slope, and reef base) in the inner zone (Samalona Island) and outer zone (Langkai Island) of Spermonde Islands. The Spermonde Islands are part of the mega diversity area in the world's coral triangle area, crossed by the Wallace line. The zooxanthellae density can be used as a reference in the assessment of coral reef ecosystems in the Spermonde Islands, Makassar Strait, South Sulawesi.

MATERIALS AND METHOD

The research was carried out in two zones, namely: (1) the inner zone represented by Samalona Island, which has a high level of eutrophication; and (2) the outer zone, which is represented by Langkai Island, which is the outermost island of the Spermonde Archipelago which has a high brightness level (Figure 1).

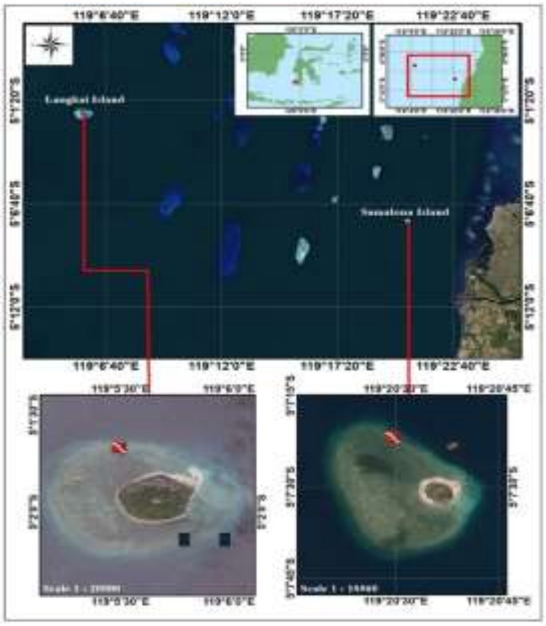

Figure 1. Sampling location at Langkai Island and Samalona Island, Spermonde Islands.

Coral Sampling

Coral samples were taken from three different genera: the genus *Montipora* which represents the sheet growth form (folios); the *Porites* genus, which represents the branching growth form (branching); and the *Pavona* genus, which represents the encrusting growth form. Sampling was carried out in three zones, namely reef flat, reef slope, and reef base.

Each sampling was repeated three times. Samples in the form of pieces of coral measuring 15 x 30 cm were put into sample plastics, then brought to the laboratory to analyze the zooxanthellae density. During transportation from the sea to the coastal area, water changes are carried out every 15 minutes so that corals do not suffer stress which can cause zooxanthellae to come out of their hosts. After arriving at the laboratory, the sample is immediately handled and preserved.

Separation of *zooxanthellae* from their host

The separation of zooxanthellae from their host was grouped according to the depth and form of growth. Zooxanthellae were released from their hosts by spraying an airbrush with a wind pressure of 3000 psi.

Coral was sprayed on the top of the coral. Spraying was carried out in plastic. Spraying was carried out until all areas, measuring 2 x 2 cm, which was sprayed, turned white. After spraying, there was a yellowish or orange-colored liquid in the plastic bag, which indicates that the zooxanthellae have been released from their host. The volume of the liquid in the plastic bag was made up of 100 ml of sterile seawater, then manually centrifuged in a plastic bag, then put into the prepared sample bottle.

The total sample bottles used were 27 bottles separated according to three depth zones, three life forms, and three replications (3 x 3 x 3 = 27).

Sample Observation Preparation

The sample in the form of a liquid containing zooxanthellae was put into a container containing 10 ml of formalin buffer containing an active solution in the form of phosphate-buffered formalin with a composition of 100 ml of 40% formaldehyde, 900 ml of distilled water, 4 g of sodium dihydrogen phosphate monohydrate, 6.5 g disodium hydrogen phosphate anhydrous, and pH of 6.8.

Zooxanthellae Density Counting

The zooxanthellae density was counted using the Eaton et al. formula modified by Devayani *et al.* (2019):

$$K = \frac{n \times Cga \times Vt}{Sa \times Vs \times As}$$

where K was zooxanthellae number (cells/cm²), n was the number of zooxanthellae observed (cells), Cga was cover glass area (mm²), Vt was total volume of zooxanthellae sample (100 ml), Sa was the sprayed area of the coral sample (cm²), Vs was the volume of sample used/observed (ml), and As was zooxanthellae in Sedgewick Rafter Counting Chamber (1 ml).

Environmental Parameters

The water quality parameters measured were salinity, temperature, pH, dissolved oxygen, total dissolved solid, conductivity, and turbidity.

Data analysis

Data were analyzed using factorial (two-factor) analysis. Significantly different variances were compared using Tukey's test (post hoc test). Data were analyzed using SPSS 16.0. software.

RESULTS AND DISCUSSION

Samalona Island is in the inner zone of the Spermonde Islands, and Langkai Island is in the outer zone of the Spermonde Islands. The Spermonde Archipelago consists of 98 island groups. The Spermonde Islands also have more patch reefs than the number of islands. The coral reef area in the Spermonde Islands is 61,000 ha (Yusuf *et al.*, 2015) both of the fringing reef type that grows on the shores of the island, as well as patch reefs between islands and which form a barrier on the outside facing the deep seas (Yusuf, 2018). Langkai Island is approximately 66 nautical miles from Makassar City. The area of Langkai Island is about 26.7 ha, with a surrounding reef area of 142.2 ha. Langkai Island is quite densely populated, with a total of 430 people (127 families), 80% of whom come from the Bugis (Maros and Pangkep Regencies) and the remaining 20% is divided equally from the Mandar and Makassar tribes (Takalar, Makassar and Gowa Regencies). The main livelihoods of the residents of Langkai Island are fishing rods (55%), fishermen using trawls or nets (31%), boat craftsmen (5%), and a small part as grocery traders, teachers and civil servants (Nurdin *et al.*, 2013). The eastern waters of Langkai Island are the shipping lanes for ships to and from Soekarno Hatta Port, Makassar. The depth of the waters around Langkai Island is more than 30 m, but in some places the depth is less than 10 m. In the waters to the west, with a distance of less than 2 km from the reef plain, in certain areas there is a drastic change in depth reaching more than 200 m (Nurdin *et al.*, 2013).

Samalona Island has an elliptical triangular shape. The area of this island is about 3 ha, but it can change from time to time due to abrasion. Due to abrasion, the Southside continues to narrow. In this narrow area grows a protective tree as high as 20 m. The stretch of white sand scattered in the North, Northeast, West, and Northwest is a unique attraction for tourism (Yusuf *et al.*, 2010). In addition, coral reefs scattered in the West, North, and South are a marine tourism attraction on Samalona Island. On the Westside, the reef is about 400 m from the coast; in the North, it is about 200 m from the beach, and the East and South sides of the reef are shorter, which is about 50-100 m. The slopes or topography of the reef slopes in the East and South are steep. At the island's south and west sides, the edges are gentler than the lower reef slopes. The coral reef slope at a depth of 1 m ranges from 25˚-30˚, which reaches the limit of the reef slope at a depth of 3 m. In addition, the reef slope becomes 60-70˚ between a depth of 4 to 17 m until it reaches the bottom of the reef. The bottom of the reef is flat and consists of sand (Yusuf, 2018).

The zooxanthellae density based on life form in the inner zone and outer zone

The zooxanthellae density in the outer zone (Langkai Island) of the Spermonde Islands was higher than in the inner zone (Samalona Island). This density can be seen in the zooxanthellae density in coral growth forms (branching, encrusting, and folios), where folios corals have a higher zooxanthellae density in two zones, both the inner and outer zones (Figure 2).

The average zooxanthellae density in the inner zone was 3017778±1002959 cells/cm² in the folios life form, 2462222±735794 cells/cm² in the encrusting life form, and 1600000± 381576 cells/cm² in the branching life form, mainly cylindrical *Porites*.

The average zooxanthellae density in the outer zone was 3791111±1155188 cells/cm² in the folios life form, 2768889 ± 860422 cells/cm² in the encrusting life form, and 1911111±767140 cells/cm² in the branching life form, especially the cylindrical *Porites* species.

The analysis of variance between growth forms showed differences in the zooxanthellae density between coral growth forms—likewise, the zooxanthellae density between the inner and outerzones. However, the zooxanthellae density based on life form was not significantly different ($p>0.05$).

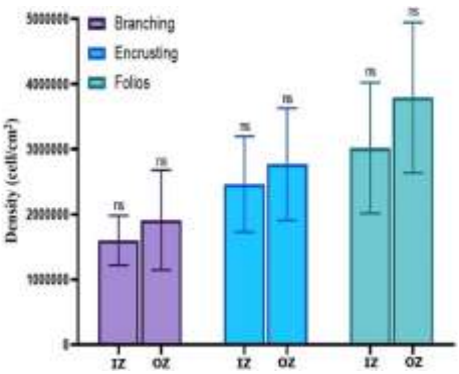

Figure 2. Comparison of zooxanthellae density in the same life form (branching, encrusting and folios) in the inner zone (Samalona Island) and outer zone (Langkai Island). IZ: Inner Zone, OZ: Outer Zone.

A coral colony is a collection of millions of polyps producing lime ($CaCO_3$) with an exoskeleton called corallite. In corallites, there are septums in the form of partitions used as a reference in determining the type of coral. A new coral corallite can be formed from the budding process of the coral. In addition to the different corallites shapes, the sizes of corallites also vary. The difference in shape and size gives predictions about the habitat and how to adapt to the environment, but the dominant factor that causes differences in corallites is the different species of the polyps. Polyps are small, sack-like animals. On the lips of the body have tentacles to attract and catch prey. Polyp food is plankton carried by ocean currents. The polyp absorbs calcium carbonate from seawater and excretes it in the form of a rigid, chalky structure to protect its soft body. The exoskeleton consists of $CaCO_3$ crystals. The epidermis produces the exoskeleton on the lower half of the trunk and soles of the feet. The $CaCO_3$ secretion process produces a chalky skeleton that is shaped like a bowl; the polyp is embedded in it and cannot move. The inside of the coral bowl is filled with glowing limestone partitions, called the scleroseptum. Each species has a unique shape and arrangement of sclerosepta so that it can be used for identification. Coral growth patterns are determined, among other things, by colony growth patterns and the arrangement of polyps within the colony (Zurba, 2019).

Coral polyps have (1) a mouth located at the top, which also functions as an anus; (2) tentacles used to catch prey; and (3) polyp body. The coral polyp body consists of three layers, from outside to inside, namely ectoderm, mesoglea, and endoderm. In the endoderm layer live symbionts of single-celled algae called Zooxanthellae. Zooxanthellae can produce organic substances through photosynthesis, which are then partially secreted into coral polyp tissue as coral nutrients (Tuwo and Tresnati, 2020). Special mesenteric filaments digest incoming food, and the rest is expelled through the mouth (Ihsan, 2016). One individual coral or coral polyp varies in size from very small with a size of millimeters to very large with more than 50 cm. However, in general, coral polyps are small. Large coral polyps are found in solitary corals (Ihsan, 2016).

Corallites vary in size, from the size of a needle head to as big as a shoe. Corallite is propagated through a process called budding. There are two budding processes, namely intra tentacular in which the polyp will divide into two or more; and extra tentacular, where a new polyp is formed from the side of the first polyp. Generally, thousands of polyps are formed interconnected (interconnected) in one colony. In some corals, there is a section that appears like a pillar at the base of the septa called the paliform lobe and in the center of the corallite there is a columella. Corallites are joined horizontally by the coenesteum. The shape of the corallite depends on the growth model; if the corallite forms its short wall, it is called a placoid, while the longer one is called a phaceloid. When corallites form a common wall, it is called a ceroid; when it forms its valley wall, it is called a meandroid, and when it forms a shared valley wall, it is called a flabello-meandroid (Zurba, 2019).

The zooxanthellae density based on coral reef zone in the inner zone and outer zone

The zooxanthellae density between reef flat zones was different from reef slope and reef base zones. The zooxanthellae density of all life form corals in the reef flat zone was higher than in the reef slope zone. Lower zooxanthellae densities were found in the reef base zone (Figure 3).

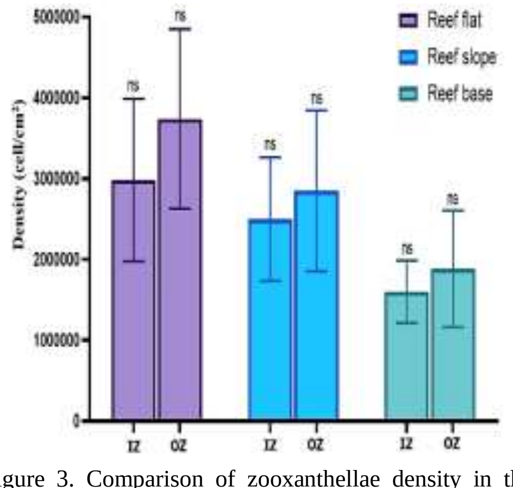

Figure 3. Comparison of zooxanthellae density in the same coral reef zone (reef flat, reef slope, and reef base) in the inner zone (Samalona Island) and the outer zone (Langkai Island).

The calculation results of zooxanthellae density in the inner zone of the flat reef zone were 2982222±1007027 cells/cm², on the reef slope zone, it was 2497778±764354 cells/cm², and the lowest zooxanthellae density was found in the reef base zone, which was 1600000 ± 387356 cells/cm².

The zooxanthellae density in the outer zone, in the reef flat zone, was higher than in the reef slope zone. The lowest zooxanthellae density was found in the reef base zone. The average zooxanthellae density in the flat reef zone was 3737778±1111902 cells/cm²; on the reef slope zone, it was 2848889±994235 cells/cm², and the lowest density was found in the reef base zone, which was 1884444±720041 cells/cm². When compared between zones, the zooxanthellae density in the outer zone was higher than in the inner zone.

The analysis of variance between coral reef zones indicated differences in the zooxanthellae density based on the coral reef zone. The zooxanthellae density was s higher in the reef flat zone than the reef slope and reef base. On the other hand, the zooxanthellae density between the inner zone (Samalona Island) and the outer zone (Langkai Island) was not significantly different ($p>0.05$).

The zooxanthellae density in the inner zone (Samalona Island) in the folios life form was higher than the encrusting and branching life forms. Likewise, the zooxanthellae density in the outer zone (Langkai Island) in the folios life form was higher than the encrusting and branching life forms. The results of previous studies reported a difference in the zooxanthellae density between the reef flat and reef slope zones, but from the two zones, there was no difference in the zooxanthellae density with the reef crest zone. While in the encrusting form growth, there was no significant difference in zooxanthellae density between the three zones (Ihsan, 2016).

The zooxanthellae density in branching, encrusting, and folios growth forms was different in all zones, but the difference in zooxanthellae density was influenced by zones (reef flat, reef slope, and reef base) that had different depths. The reef flat zone has a high zooxanthellae density, while the reef base zone has a low zooxanthellae density. Environmental conditions in each zone cause the low zooxanthellae density in the reef base zone. Changes in environmental conditions can cause the release of zooxanthellae from coral polyp tissue (Rani, 1999).

Differences in zooxanthellae density in the coral reef zone (reef flat, reef slope, and reef base) can be caused by the light factor. The low zooxanthellae density in the reef base zone compared to the reef flat and reef slope zones was suspected to be caused by the penetration of sunlight and higher temperatures at low tide. The water's depth was closely related to the light that penetrates the waters; the greater the depth, the less the intensity of the incoming light. Insufficient light intensity will inhibit zooxanthellae from carrying out photosynthesis (Jones and Yellowless, 1997).

The previous studies indicated that the loss or release of zooxanthellae from polyps was the coral response to environmental stresses. The zooxanthellae density between can be affected by the season (Ismail, 2010).

Damaged coral reef ecosystems can also cause differences in zooxanthellae density. The inner zone tends to have a greater level of damage due to human activities because it is close to the mainland of Sulawesi Island. The condition of the coral reef in the Spermonde Islands has been damaged because the rubble cover is more than 5% (Yusuf *et al.*, 2015).

Coral reef health can be estimated from the symbiotic model between corals and zooxanthellae as the essential elements of coral reef construction. The zooxanthellae density can measure coral polyp health. Zooxanthellae density is strongly influenced by environmental changes such as light, temperature, salinity, or nutrients so that fluctuations in zooxanthellae density can be used as biological indicator (Ismail, 2010). Important biological indicators in coral reef conservation activities.

The zooxanthellae density in the encrusting life form and folios in the outer zone has a high zooxanthellae density compared to the inner zone. The zooxanthellae density was not much different from the results of previous studies where the zooxanthellae density on Lanyukang Island (outer zone) is more significant than Samalona Island and Lae-Lae Island (inner zone) (Ismail, 2010).

The high zooxanthellae density on Lanyukang Island was caused by abundant food sources of dissolved nutrients and zooplankton. The dissolved nutrients and zooplankton are very beneficial for the heterotrophic coral polyps that are very active in preying on zooplankton. The zooxanthellae density in the life form folios in the outer zone was higher than in the encrusting and branching forms, but in the outer zone, the life form branching has a lower density than the inner zone. The zooxanthellae density was thought to be related to the intensity of sunlight, which is the energy source for zooxanthellae photosynthesis. Zooxanthellae are single-celled microscopic algae that require sunlight for photosynthesis. The intensity and quality of light that can penetrate seawater greatly determine the vertical distribution of corals. The deeper the waters, the less intensity of sunlight that can be utilized by zooxanthellae that live in symbiosis on corals.

Water brightness is a physical factor that can affect the intensity of sunlight received by zooxanthellae. The smaller the intensity of sunlight that zooxanthellae can receive, the smaller the coral reef population in the area. Therefore, corals need clean water from suspended particles that can block sunlight into the waters. Suspended material, apart from blocking the penetration of sunlight, can cause coral death if it settles on the surface of the coral cover (Nybakken, 2001).

The movement of water or currents, indirectly, can affect the zooxanthellae density because the movement or flow of water can bring nutrients to zooxanthellae that live in symbiosis with corals. Movement or flow of water can prevent the deposition of mud and other suspended matter on the surface of the coral polyp.

Another factor that can affect coral life is oxygen. During the day, corals can obtain oxygen from zooxanthellae photosynthesis and from the oxygen content in the water mass itself. Meanwhile, at night, corals get oxygen from currents that are rich in oxygen. In the open sea, oxygen supply is always sufficient. Therefore, coral reef growth is better in waters where the water is always stirred by wind, currents, and waves (Santoso and Kardono, 2008).

The differences in zooxanthellae density levels in the reef flat, reef crest, and reef slope zones were also found in the results of previous studies (Supriharyono *et al.*, 2015; Ihsan, 2016). This difference in zooxanthellae density is thought to have something to do with depth (Salim *et al.*, 2020) where the more deep the waters, the lower the intensity of sunlight that corals can receive.

Zooxanthellae density in the inner zone

There were differences in zooxanthellae density in three coral reef zones and three life forms in the inner zone (Samalona Island). In general, there are differences in the zooxanthellae density based on the zone and life form in the inner zone (Samalona Island) (Figure 4). The zooxanthellae density on corals living in the reef flat zone was much higher than on the reef slope and base; the more profound the coral habitat, the lower the zooxanthellae density. The highest zooxanthellae density was found in life form folios, then life form encrusting, and life form branching. The zooxanthellae density in these three life forms was significantly different ($p<0.05$).

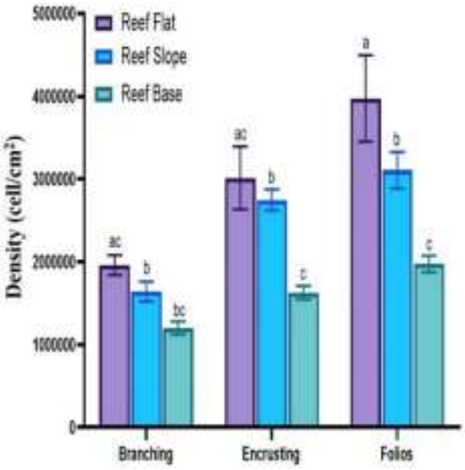

Figure 4. Comparison of zooxanthellae density in the coral reef zone (reef flat, reef slope and reef base) in each life form in the inner zone (Samalona Island).

In the reef flat zone, the highest zooxanthella density was found in life form folios (3973333±522047 cells/cm²), then life form encrusting (3013333±380175 cells/cm²) and life form branching (1960000 ±120000 cells/cm²); in the reef slope zone, the highest zooxanthellae density was found in life form folios (3106667± 220303 cells/cm²), then encrusting life form (2746667±128582 cells/cm²) and branching life form (1640000±120000 cells/cm²); and in the reef base zone, the highest zooxanthella density was found in the life form folios (1973333 ± 100664 cells/cm²), then in the encrusting life form (1626667 ± 83267 cells/cm²) and in the branching life form (1200000 ± 80000 cells/cm²).

Zooxanthellae density in the outer outer zone

In general, there were differences in zooxanthellae density based on the reef zone and life form in the inner zone (Langkai Island) (Figure 5).

The zooxanthellae density on corals that live in the reef flat zone is much higher than on the reef slope and reef base. The zooxanthellae density indicated that the more profound the coral habitat, the lower the zooxanthellae density. The highest zooxanthellae density was found in life form folios, then life form encrusting, and life form branching. The zooxanthellae density in these three life forms was significantly different ($p<0.05$.In the reef flat zone, the highest zooxanthellae density was found in corals with life form folios (4906667±122202 cells/cm²), then life form encrusting (3613333±333067 cells/cm²) and life form

Branching (2693333±151438 cells/cm²); in the reef slope zone, the highest zooxanthellae density was found in the life form folios (3866667±283784 cells/cm²),

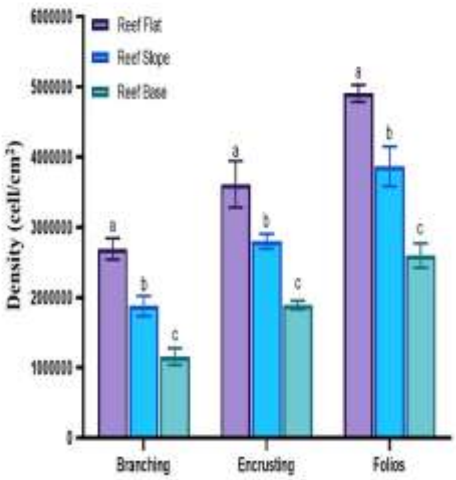

Figure 5. Comparison of zooxanthellae density in the coral reef zone (reef flat, reef slope, and reef base) in each life form in the outer zone (Langkai Island).

then in the encrusting life form (2800000±105830 cells/cm²) and in the branching life form (1880000±144222 cells/cm²); and in the reef base zone, the highest zooxanthellae density was found in life form folios (2600000±174356 cells/cm²), then life form encrusting (1893333±61101 cells/cm²) and life form branching (1160000±1200000 cells/cm²).

Environmental Parameters

Water quality parameters, including salinity, pH, dissolved oxygen, and total dissolved solids, are higher in the outer zone (Langkai Island), while temperature, conductivity, and turbidity are higher in the inner zone (Samalona Island). All water quality parameters are still within the range that was quite suitable for coral life (Table 1). Total dissolved solids consist of dissolved materials (< 10-6 µm diameter), colloids (10-6 to 10-3 µm diameter), and chemical compounds and other materials (organic and inorganic) that can pass through the filter measuring 2 µm (Johan *et al.*, 2017). The turbidity still has not exceeded the maximum turbidity of clean water (25 NTU) (Johan *et al.*, 2017).

Table 1. Environmental parameters in the inner zone (Samalona Island) and inner zone (Samalona Island)

Parameters	Inner Zone (Samalona Island)	Outer Zone (Langkai Island)	Optimum Value	Reference
Salinity (ppt)	30.0	29.5	32 - 35	Tomascik (1997)
Temperature (°C)	29.5	31.3	23 - 25	Tomascik (1997)
pH	7.67	8.11	7.5 - 8.5	Tomascik (1997)
Dissolved Oxygen (ppm)	4.27	7.09	6.46 - 7.03	Tomascik and Sander (1985)
Total Dissolved Solid (mg/L)	45.7	47.4	49.0	Johan et al. (2017)
Conductivity (S/m)	9.20	4.69	5.01 - 5.62	Wibawa et al. (2017)
Turbidity (NTU)	9.2	1.2	<1.0 - 40	Larcombe et al. (1995)

CONCLUSION

This study indicates that: (1) the zooxanthellae density in the same life form was not significantly different between the inner zone and outer zone; (2) the comparison of zooxanthellae density in the same coral reef zone was not significantly different between the inner zone and outer zone; (3) the comparison of the zooxanthellae density in the same coral reef zone was significantly different between the life forms in the inner zone (Samalona Island); (4) the comparison of the zooxanthellae density in the same coral reef zone was significantly different between the life forms in the outer zone (Langkai Island).

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