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The abundance of zooxanthellae on massive and branching coral reefs at Bama Beach, Baluran National Park, Situbondo, East Java

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ABSTRACT

Zooxanthellae are single-celled microalgae that live symbiotically in coral tissue. The porpose of this study was to determine the abundance of zooxanthellae in massive and branching corals. The research method used was descriptive analysis. The sampling technique used direct field sampling by chisels, both on massive coral reefs or branching coral reefs. Observation of zooxanthellae was conducted in the laboratory using a microscope. The results obtained from the research indicate that massive corals have a relatively higher abundance of zooxanthellae with values of 109 x 10^5 cells/cm² than branching corals with values of 73 x 10^5 cells/cm². In addition, massive corals are more resistant to bleaching than branching corals due to their large reserves of zooxanthellae and their ability to adapt to environmental stress.

Introduction

Coral reef ecosystems are ecosystems that are mostly found in tropical waters. This ecosystem is known for its high productivity and has various benefits, both ecological and economic. The potential and benefits of coral reefs are closely linked to the role of zooxanthellae.

Zooxanthellae are single-celled microalgae that live symbiotically in coral tissue. Zooxanthellae have an important role in coral reef ecosystems as primary provides for corals and contributing to corals ability to build complex calcium carbonate skeletons. Zooxanthellae play a role in energy production from photosynthesis, coral skeleton formation, and environmental resilience. According to Narfa *et al.* (2024), zooxanthellae are algae that live in various coral tissues and have a mutualistic symbiosis. The more zooxanthellae, the faster coral growth.

The growth form of coral reefs is a morphological adaptation of coral colonies to the environment, such as light intensity, currents, depth, and substrate conditions. Some of the main forms of coral reef growth, massive which are solid and round with a very strong skeletal structure; branching, often called branching corals, resembling trees or bushes; encrusting, which are flat and creeping, covering the surface of the substrate-like a carpet; foliose, which are shaped like sheets resembling leaves or bowls; and fungal, which as the name implies, have a growth form resembling mushrooms. These forms are influenced by several natural factors, especially light intensity and wave. The dominant form of coral growth in a habitat depends on the environmental conditions or habitat where the coral reef lives (Barus *et al.,* 2018).

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Bama Beach is located in Baluran National Park which has a unique diversity of ecosystems, especially its aquatic ecosystems. The coral reefs at Bama Beach are very diverse because Bama Beach is part of a conservation area (Widhi and Paluphi, 2024). The important role of the Baluran National Park conservation area especially Bama Beach, is to support the cycle of life, in this case the coral reef ecosystem. Coral reefs are directly used as habitats to support the life cycle of flora and fauna in the Bama Beach ecosystem area. If water conditions experience problems that will disrupt the life of marine organisms, zooxanthellae will leave the coral and the mutualistic symbiosis will be disrupted. This study was conducted to determine the abundance of zooxanthellae in massive and branching corals.

Materials And Methods

This research was conducted at Bama Beach, Baluran National Park, Situbondo Regency, East Java Province, in February-March 2024. Zooxanthellae abundance was obtained by taking coral tissue samples and isolating zooxanthellae from the coral samples. The research method used was descriptive analysis. Coral sampling techniques were carried out carefully to minimize impacts on the ecosystem. Massive coral sampling was done using a chisel and a small hammer to slowly break the coral skeleton about 2-3 cm while ensuring the polyp tissue remains intact during collection. After the coral sample was obtained, the coral skeleton was stored in a bottle filled with sterile seawater, which was then placed in a cooler until processed in the laboratory.

Sampling of branching corals using a cutter to cut branches 2-3 cm long, then the cut branches are put into a bottle filled with sterile seawater and do not come into direct contact with air so that the tissue remains alive. In the sampling process, there are several things that need to be considered, such as not taking the main branches, because this is to reduce the risk of damage to the colony.

The release of zooxanthellae samples from coral polyps was carried out through a decalcification process in 10% formalin plus 10% acetic acid in a sample bottle. After the sample softened and the coral tissue separated from its skeleton, the sample was washed with fresh water for 24 hours and then crushed. The method used to count zooxanthellae is by using a haemocytometer. The procedure carried out before counting zooxanthellae is to grind the sample tissue until smooth, then separate the zooxanthellae using a centrifuge for 10 minutes at a speed of 1500-3000 rpm. The sample is put into a measuring cup and 15 ml of water is added, then shaken or stirred until evenly distributed. Then taken with a pipette and dripped into the haemocytometer, covered with a cover glass, and counted under a microscope (Rauf *et al.,* 2015).

The number of zooxanthellae is calculated based on the area. According to Effendi and Aunurohim (2012), the abundance of zooxanthellae is obtained based on the following calculation:

$$D = \frac{QxPx10000}{L}$$

Explanation:
D : Density of zooxanthellae
Q : Total Count
P : Dilution
L : Coral Fragment Area
10000 : Convert 1.1 mm^3 to 1 cm^3

Results And Discussion

The average calculation of zooxanthellae abundance on the massive coral reef showed the highest value at station 3, which was 109 x 10^5 cells/cm^2 (Figure 1). At that station, it is located in a conservation area and has minimal human activity. The factor that affects the abundance of zooxanthellae in the massive growth form of corals is light intensity. Zooxanthellae need light for photosynthesis. Massive corals living in shallow waters with high light intensity have a higher abundance due to their high adaptability. Massive corals have a higher tolerance to environmental changes, allowing them to retain zooxanthellae longer under stress conditions. This is in accordance with Asmiati *et al.* (2017), that coral reefs with massive growth forms are capable of adapting to stressful environmental conditions.

Zooxanthellae and coral have a close relationship in the abundance of zooxanthellae in coral growth. The abundance of zooxanthellae has an influence on growth, as zooxanthellae produce energy that is used by corals for metabolism and the growth of coral tissue. Corals with high zooxanthellae abundance tend to have faster tissue growth rates. Massive coral reefs have a stronger tolerance for growth forms compared to other growth forms. According to Abdullah *et al.* (2023), the growth of massive coral reefs is influenced by quite extreme water factors, allowing coral reefs to adapt to certain water bodies. Water factors such as waves, currents, and high turbidity can significantly affect coral morphology (Barus *et al.,* 2018). Waters dominated by massive coral can be interpreted as having conditions with quite extreme levels of pressure, such as strong currents and high sedimentation (Luthfi *et al.,* 018).

Based on the results obtained from calculating the abundance of zooxanthellae in branching corals, as presented in Figure 2.

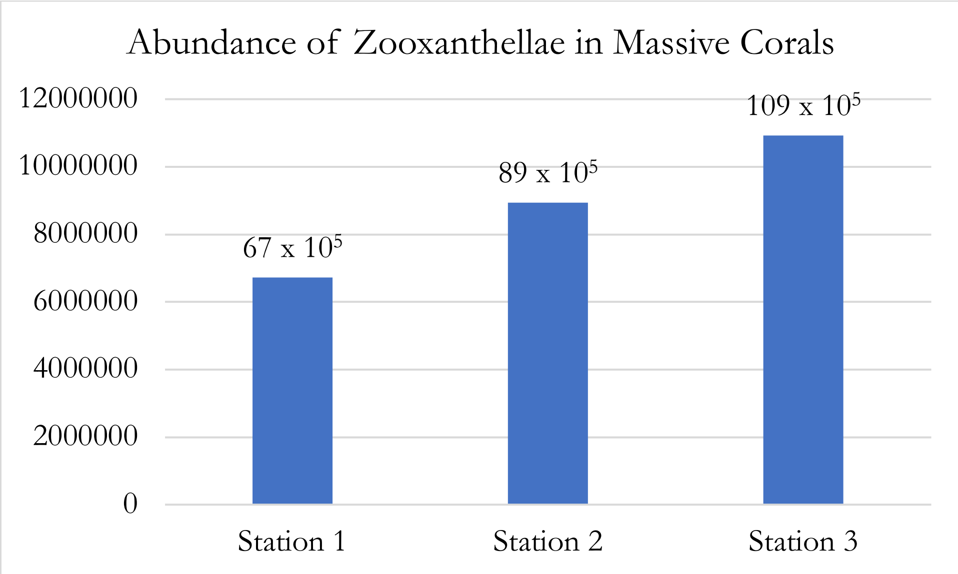

Figure 1. Abundance of zooxanthellae in massive coral reefs

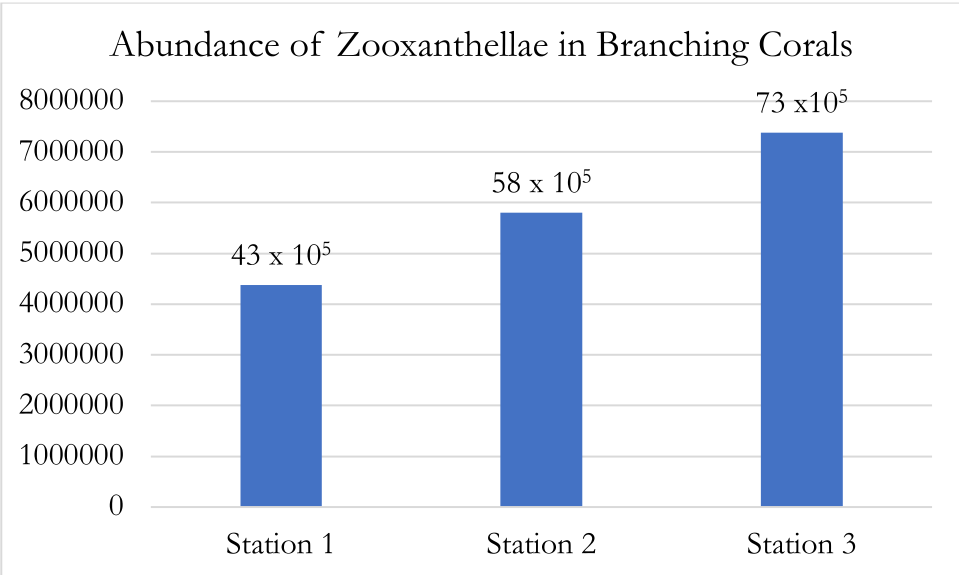

Figure 2. Abundance of zooxanthellae in branching coral reefs

The results of the figure above show that station 3 obtained the highest value, namely 73 x 10^5 cells/cm² because this station is in a conservation area. The symbiotic relationship between corals and zooxanthellae creates complex dynamics, where the abundance of zooxanthellae influences the survival and adaptability of corals to various environmental stresses. According to Sifa *et al.* (2021), zooxanthellae in branching corals can live in hypo-saline and hyper-saline environments, where these environmental conditions can cause coral reefs to become stressed.

The abundance of zooxanthellae provides a strong foundation for branching corals to survive in changing environmental conditions. Environmental changes such as increasing global warming result in coral reefs being unable to keep zooxanthellae attached to the coral. Therefore, the abundance of zooxanthellae will decrease, which will lead to coral bleaching. Therefore, habitat conservation and protection against climate change are needed, because these measures are important for the sustainability of coral reef ecosystems. Coral reefs have different levels of sensitivity to the environment (Suryatini and Rai, 2020). The response of coral reefs to environmental changes and pressures is to strive to survive and show signs of recovery, thereby re-establishing a stable community after experiencing damage (Hidayani and Sariah, 2017).

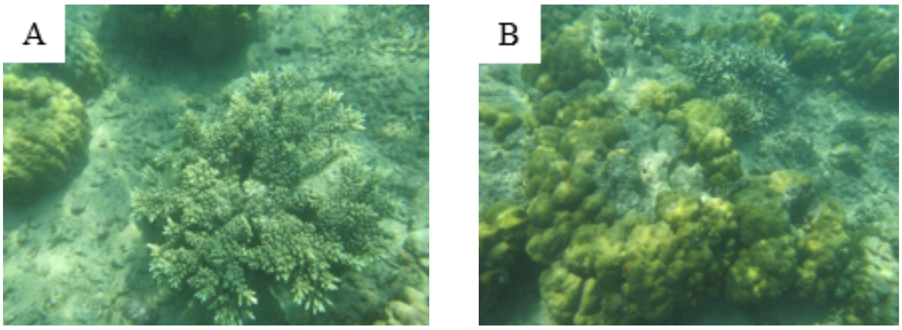

Figure 3. (A) Branching coral reef and (B) Massive coral reef

The Figure 3 shows a large, branching coral reef that has different ecological characteristics. These differences in characteristics affect the adaptability of zooxanthellae in dealing with environmental pressures such as temperature and sedimentation. Comparison of the resistance of massive and branching corals under temperature stress on the adaptation of zooxanthellae, where massive corals tend to be more resistant to temperature stress. This is because massive corals have the ability to store energy within their carbonate framework, thereby reducing the occurrence of bleaching processes in corals. Branching corals are more sensitive to high temperatures. Coral reefs of this type live in the surface waters, where they receive higher sunlight intensity. These conditions can cause the water temperature to rise, leading to coral stress and bleaching. Related research has found that tropical corals are particularly vulnerable to rising sea temperatures. High temperatures can damage the symbiotic relationship between coral and zooxanthellae-forming algae, often resulting in bleaching (Magfirah, 2024).

Large and branching coral reefs have different tolerances to sedimentation. Sedimentation that occurs on coral reefs is the process of deposition of particles on the reef surface, which can interfere with zooxanthellae photosynthesis and trigger stress on coral reefs. Massive corals are more adaptive to high sedimentation because the coral surface can capture sediment particles. The adaptive ability to sedimentation allows massive corals to continue photosynthesizing. Whereas branching corals are unable to adapt quickly to sedimentation. In branching corals during the process of photosynthesis, zooxanthellae require high sunlight intensity. Therefore, when corals face environmental stress such as sedimentation, coral productivity will be disrupted. According to the statement (Barus *et al.,* 2018), coral reefs in the form of branching colonies are classified as fast-growing corals but are very susceptible to sedimentation.

Conclusion

Massive corals have a relatively higher abundance of zooxanthellae with values of 109 x 10^5 cells/cm² than branching corals with values of 73 x 10^5 cells/cm², which depends on the physical structure and environmental conditions. Massive corals are more resistant to bleaching than branching corals due to their large reserves of zooxanthellae and their ability to adapt to environmental stress.

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