Holothuroidea as a Constituent of Benthic Communities in the Seagrass Ecosystems at Bira Island Islands

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Abstract. Seagrass ecosystem has an important ecological role for the life of marine organisms and as one of the suitable habitats for the holothuroidea group, known as sea cucumbers. One of the distribution areas of Holothuroidea in Indonesia is Pulau Bira Kepulauan Seribu. This study was undertaken to investigate the composition, abundance and species diversity of the holothuroidea as constituents of benthic communities, and to determine the quality of waters in the seagrass ecosystem. Descriptive method with survey design was used in this study. Data analysis was carried out descriptively based on the calculation of abundance, composition, and diversity, while the analysis of environmental parameters affecting holothuroidea diversity was carried out by principal component analysis (PCA). The results showed as many as 3 species were identified as Holothuriidae, with the highest to lowest abundance consecutive namely Holothuria atra (1.77 ind/m²), Holothuria leucospilota (0.16 Ind/m²), and Holothuria fuscocinerea (0.10 Ind/m²) with the composition of 86.96%, 7.90% and 5.14% respectively. Species diversity is classified as low criteria, while the environmental parameters that affect species diversity are dissolved oxygen, turbidity, orthophosphate and Biological Oxygen Demand (BOD). Although some environmental parameters were still in the normal condition, analysis of the community structure of Holoturoidea indicates a decline in water quality.

1. Introduction
One of the areas in the Kepulauan Seribu which is relatively large and known as a tourist spot is the Bira Island. This Island region has several important ecosystems, including mangrove, seagrass and coral reef ecosystems [1]. Ecosystem that has an ecologically important role is the Seagrass Ecosystem, because seagrass is a shelter and a place to find food and a breeding ground for several marine organisms [2]. Various organisms lives in this region and formed a benthic community, one of which is benthos, a group of animals that live in the bottom waters or benthic environment and their lives are very dependent on the substrate in their habitat [2,3]

Echinoderms are part of the benthic community which consist of 5 main classes, one of which is holothuroidea that is widely used for consumption by people around Bira Island [4]. Intensive Holothuroidea fishing and accompanied by tourism activities around Bira Island has influenced the existence of ecosystems, potential resources, and the water quality. The changes in physical and chemical parameters of the waters cause disruption of benthic populations. By analyzing the relationship between biotic and abiotic factors, a condition of the water quality will be obtained [2]. The lack of data about holothuroidea as a potential resource on Bira Island encourages the need for up-to-date informations as a basis for management efforts in the region.
2. Methods
This study was carried out at Seagrass ecosystem from January to June 2019. Observation location was divided into 3 sub stations based on seagrass vegetation conditions. A transect line was drawn parallel to the coastal with a distance between transects of 25 meters. For each transect, 5 plots of 1 m\(^2\) each were installed were selected purposively with a distance of 10 meters. Data retrieval was done using underwater photos with some taken directly, then the photos of species were identified by using an identification book. Measurement of the Environmental parameters included temperature, pH, water depth, substrate, turbidity, dissolved oxygen (DO), Biological Oxygen Demand (BOD), Nitrate, Nitrite, and Orthophosphate. The data were calculated based on several formulas and then analyzed descriptively [8].

![Research Sites](image)

Figure 1. Research Sites

2.1. Species Abundance

\[ D_i = \frac{n_i}{A} \]  \hspace{1cm} (1)

- \( D_i \) = Abundance of one individual species
- \( n_i \) = Individual number of one species
- \( A \) = Plot area

2.2. Species Diversity

\[ H' = -\sum P_i \log P_i \]  \hspace{1cm} (2)

- \( H' \) = diversity index
- \( n_i \) = Number of individuals per species
- \( N \) = Number of individuals of all species
- \( P_i = n_i / N \)

The diversity index criteria
- \( H' \leq 3 \): low diversity
- \( 1 < H' \leq 3 \): moderate diversity
- \( H' \geq 3 \): high diversity
2.3. Species Dominance

\[ D = \sum_{i=1}^{n} \frac{ni(ni-1)}{(N)(N-1)} \]

\( ni \) = Individual number of one species
\( N \) = Total number individuals of species

The influence of several environmental factors on holothuroidea diversity was analyzed by multivariable statistics using the Principal Analysis (PCA) Program [9].

3. Result and Discussion

3.1. Abundance and composition of Holothuroidea

As much as 3 species of Holothuroidea were identified, with the highest to the lowest abundance represented by Holothuria atra, Holothuria leucospilota, dan Holothuria fuscocinerea.

| Number | Species                  | Station | Total | Ind/m² |
|--------|--------------------------|---------|-------|--------|
| 1      | Holothuria atra          | I 0.41  | II 0.65 | III 0.71 | 1.77   |
| 2      | Holothuria leucospilota  | I 0.07  | II 0.06 | III 0.03 | 0.16   |
| 3      | Holothuria fuscocinerea  | I 0.04  | II 0.05 | III 0.01 | 0.10   |

*Holothuria atra* has the highest composition, while the lowest is indicated by *Holothuria fuscocinerea.*

| Number | Species                  | Total individu | (%)   |
|--------|--------------------------|----------------|-------|
| 1      | Holothuria atra          | 440            | 86.96 |
| 2      | Holothuria leucospilota  | 40             | 7.90  |
| 3      | Holothuria fuscocinerea  | 26             | 5.14  |

During this study, 3 species of sea cucumbers were found, namely *Holothuria atra* (sea cucumber), *Holothuria leucospilota* (cucumber sap) and *Holothuria fuscocinerea* (brown lavender). The number of types of holothuroidea varies at each location of observation. The most abundant species is *Holothuria atra.* Although the density fluctuates, there is no significant difference between time and location. This condition can be caused by differences in reproduction patterns. [10] Holothuria atra might like a protected place under a seagrass stand with sand substrate [11].

Based on its morphology, *Holothuria atra* can be identified based on the body shape of cylindrical and black body color. *Holothuria fuscocinerea* (brown lavender) is characterized by rough skin, the skin of the body is always protected by sand [5].

*Holothuria leucospilota* has cylindrical body features, black in color, on the surface of the skin there are protrusions that will stick if held, the surface of the body is rather slippery, and when there is a threat, it will release white fluid like sap. *H. atra* and *H. leucospilota* are fissiparous sea cucumbers, which can multiply by self-division [12]. This species belongs to the family of Holothuriidae. The morphology of this type of sea cucumber is predominantly white on the whole body, cylindrical shape, and the bottom and back of the sea cucumber are brown [13].

Sea cucumbers are found in seagrass ecosystems belonging to the order Aspidochirotida, generally widespread in tropical regions [14]. Sea cucumbers from the order Aspidochirotida are deposit feeder, generally living in protected waters with lots of organic matter. Seagrass ecosystems in tropical
countries are suitable habitats for sea cucumbers growth from this order, because some ecosystems act as nursery and protection ground for several marine organisms. Coastal areas in tropical countries have several important ecosystems such as mangroves, seagrasses and coral reefs that act as protection of some marine biota from strong currents and waves and also act as organic material traps [3]. Based on previous studies on Bira Besar Island, *H. atra*, *H. leucospilota*, *Synapta maculate* and *H. fuscocinerea* were identified [15]. The existence of these species is thought to be influenced by a substrate dominated by muddy sand, because the muddy sand substrate is quite rich in organic material that can support the life of the sea cucumber [16].

3.2. *Holothuroidea* Diversity and dominance

Diversity criteria of Holothuroidea species at three observation sites show the same conditions, and based on their dominance there are two types.

| Station | *H'* value | Categories | D value | Categories       |
|---------|------------|------------|---------|------------------|
| I       | 0.69       | Low        | 0.76    | dominance species|
| II      | 0.65       | Low        | 0.74    | dominance species|
| III     | 0.41       | Low        | 0.18    | no dominance species|

Based on Simpson's criteria, diversity is included in the low category. This relates to the condition of the substrate which is dominated by sand which lacks of nutritional sources as food for holothuroidea. This is why only a few holothuroides are able to live in the area. Low diversity indicates an imbalance of the ecosystem, which is caused by environment pressure and an indication of pollution [8]. This condition can also be caused by the various activities on Bira Island that affect the Holothuroidea habitat, thereby reducing its diversity [14]. The least number of Holothuroidea species found at each observation station will have an impact on the individual distribution of each species.

The value of dominance index is in the range of 0.18 - 0.76. Stations 1 and 2 indicate the presence of species dominance in seagrass ecosystems, because the dominance index value approaches number 1, while station 3 indicates the absence of species that dominate because the value is far from 1. The presence of species dominance is suspected because there is one species that can live better and supported by environmental factors [17] while the absence of dominance is thought to be due to the homogeneous environmental conditions for the life of Holothuroidea. This can occur because of the substrate in the seagrass ecosystem consists of sand and at least a shade of vegetation so that the bottom can still be penetrated by sunlight. Basically, sea cucumbers are nocturnal animals, and generally do not like sunlight, but prefer protected areas or habitats [20].

3.3. *Environmental parameters*

Temperature in seagrass ecosystem is included in the normal criteria for tropical marine waters in the average of 28.7°C (stdev ± 0.1) because the ideal temperature for sea cucumbers is between 28-31°C [17]. Temperature is an important factor in regulating the life processes and spread of organisms [2].

The average dissolved oxygen content was 7.023 mg/L (stdev ± 0.05). Dissolved oxygen in water experiences daily and seasonal fluctuations and is greatly influenced by the temperature and photosynthetic activity of plants to produce oxygen [20]. BOD is low with an average value of 1.19 mg/L (stdev. ± 0.03). This condition indicates the absence of organic pollution. The low BOD indicates the absence of organic matter which is converted into nutrients, so that the availability of nutrients for benthos animals such as Holothuroidea is reduced which has an impact on abundance. Concentration of Orthophosphate, Nitrate, low average (<0.02), as well as the average concentration of Total Organic Matter is <0.05, even though this element is a nutrient needed by aquatic biota, thus affecting the existence of Holothuroidea. Waters are categorized as poor in organic matter if the
phosphate content is $> 0.005 \, \text{mg/L}$ [21]. The average salinity is 30 ppt (stdev $\pm 1.73$) and the pH inside is neutral with an average value of 7.3 (stdev $\pm 0.11$) the pH value is still within the normal range for marine biota.

Based on the analysis of the main factors, dissolved oxygen, temperature, turbidity, biological oxygen demand (BOD) and Orthophosphate are the parameters that give effect to diversity, ie. Environmental factors that are not too influential are wind speed, light, and depth of water.

Temperature in seagrass ecosystem is included in the normal criteria for tropical marine waters in the range of 28.6-29.12 because the ideal temperature for sea cucumbers is between 28 - 31 °C [17]. Temperature is an important factor in regulating the life processes and spread of organisms [2].

Dissolved oxygen in a water experiences daily and seasonal fluctuations that are strongly influenced by the temperature and photosynthetic activity of plants to produce oxygen [20]. BOD values ranged from 1.16-1.22 including the low criteria. This indicates the absence of organic pollution. The low BOD indicates the absence of organic matter which is converted into nutrients, so that the availability of nutrients for benthos animals such as Holothuroidea is reduced which has an impact on abundance. Phosphate in water is in the form of orthophosphate, is one of the nutrients needed by aquatic biota. Orthophosphate concentrations on Bira Island are relatively low, thus affecting the presence of Holothuroidea. The waters are said to be fertile if the phosphate content is $> 0.005 \, \text{mg/L}$ [21].

4. Conclusion

Three species of Holothuroidea were identified on Bira Island, with Holothuria atra as the most abundant and highest in composition, followed by Holothuria leucospilota, and the lowest were Holothuria fuscocinerea. Holothuroidea species is categorized as low diversity and there are dominating species at 2 observation station. Environmental parameters that have major influence on the Holothuroidea abundance are dissolved oxygen, turbidity, orthophosphate, and BOD. Although some environmental parameters are still in the normal range, the analysis of the community structure of Holothuroidea indicates a decline in water quality.
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