Biodiversity of macroinvertebrate in artificial substrate from several habitats at Ponelo Island, Gorontalo

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Abstract. Ponelo Island is located at the North Gorontalo District, Province Gorontalo, with a position close to the Wallace line. The impact of the position makes Ponelo Island having high biodiversity, such as macroinvertebrates. This study aimed to compare the biodiversity of macroinvertebrates living in artificial substrates from anthropogenic, seagrass, mangrove, and coral reefs habitat at Ponelo Island, Gorontalo. This study was conducted from August to October 2019 in four different habitats at Ponelo Island. The specimens were identified at the Laboratory of Micro Biology, Department of Aquatic Resources Management, IPB University. The data were analyzed by calculating the diversity index, evenness index, dominance index, similarity analysis among habitats, and ANOVA test. The macroinvertebrate samples from all stations were found in 58 species, consisting of phylum Annelids, Crustaceans, and Molluscs. The diversity value of macroinvertebrate in seagrass and coral reef habitats is higher and vice versa the association level is lower than in other habitats. Acetes sp., Clypeomoror biscaitita, and Sesarma sp. were obtained in all locations. The placement of the artificial substrate had no significant effect on the density of macroinvertebrates in all habitats.

Keywords: anthropogenic; coral reefs; index; mangrove; seagrass

1. Introduction

Macroinvertebrates are invertebrates that generally measure 0.2 to 0.5 mm in size and can reach sizes of 3 to 5 mm at maximum growth. Macroinvertebrate characteristics are very sensitive to environmental changes, slow and limited movement, and can be found in all types of water [1]. Macroinvertebrates can respond differently to threats that can affect their composition and abundance in nature.

Ponelo Island, which is located in Ponelo Islands District, North Gorontalo Regency, Province Gorontalo, has three natural habitats in a coastal area, namely seagrass, mangroves, and coral reefs. These habitats are nursery ground, feeding ground, and spawning ground for many biotas, including macroinvertebrates. The existence of macroinvertebrates in these habitats is greatly influenced by changes in the surrounding environment, because of the sedentary nature of life and their limited movements [2]. Currently, the condition of the habitat on Ponelo Island has begun to decline due to anthropogenic activities. Research on macroinvertebrate biodiversity in seagrass, mangrove, and coral reef habitats has been carried out [3-5], but they are still separated in each habitat or at different locations. The research on macroinvertebrate biodiversity in the three habitats in the same location has never been carried out, and research on macroinvertebrates in anthropogenic areas has also not been carried out until now.
The use of artificial substrates aims to obtain samples with the same chance of being taken from various habitats. Artificial substrate is habitat replication based on natural habitat according to its characteristics. Artificial substrates are made of natural and artificial tools and materials as a living medium for macroinvertebrates [6]. In this study, the use of net with a mesh size of 2 mm on an artificial substrate is intended to have a higher level of selectivity to obtain macroinvertebrate samples. This research uses artificial substrates that are placed in various types of different aquatic habitats. Research using artificial substrates has been carried out by Krisanti in 2012 [7]; Shofirma in 2019 [8]; and Nurshafwan in 2019 [9]. This study aims to compare the biodiversity of macroinvertebrates found on artificial substrates in anthropogenic areas, seagrass habitats, mangrove habitats, and coral reef habitats in the waters of Ponelo Island, Gorontalo.

2. Material and methods

2.1. Time and location of research
Sampling was conducted from August to October 2019. Research location in Ponelo Island, Gorontalo at four area in coastal, namely anthropogenic area, mangrove, seagrass, and coral reef ecosystems. The morphological identification of macroinvertebrate samples was carried out at the Laboratory of Micro Biology 1, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University.

2.2. Data collection
The artificial substrate has a rectangular frame measuring 45 cm x 45 cm and is made of 1-inch diameter paralon pipe. In the frame of the artificial substrate, a net with a mesh size of 2 mm is installed. The installed nets will be overgrown with moss so that macroinvertebrates can live in it. The artificial substrate is placed in four different locations, namely the anthropogenic area, seagrass habitat, mangrove habitat, and coral reef habitat on Ponelo Island, Gorontalo at a depth of 1 meter above the water surface. At the top of the artificial substrate is given a float or buoy and at the bottom, a ballast is installed so that the substrate does not move when there are waves or waves (figure 1). As many as 9 artificial substrates were placed in each research location.

![Figure 1. Illustration of an artificial substrate used in macroinvertebrate sampling.](image-url)
Macroinvertebrate samples were taken every month for three months. In each macroinvertebrate sampling was taken from three artificial substrates for each location. Identification of macroinvertebrate samples using identification references according to Guido T. Poppe (conchology.be), and identification books [10-12].

2.3. Data analysis
Macroinvertebrate samples that have been identified are counted directly per location each month. The number of macroinvertebrates was used to estimate species density, the diversity index (H’) based on the Shannon-Wiener index [13], the evenness index (e) using the Pielou index [14], and the dominance index (D) using the Simpson index [14]. The level of similarity of each study location was analyzed clustering using the Jaccard index [15], which can be calculated based on the Magurran formula [16]. Cluster analysis was performed using the PAST 3 application to obtain dendrogram. Analysis of variance (ANOVA) was used to see the relationship between the effect of artificial substrate placement and macroinvertebrate density.

3. Result
The number of macroinvertebrate samples found during the study at all observation sites were 58 species, consisting of 6 species from the phylum Annelids, 2 species from the phylum Bivalve, 29 species from the phylum Gastropod, and 21 species from the Crustacean phylum. Overall, the three-month average density of macroinvertebrates at each location can be seen in figure 2.

Overall habitat, the average density of macroinvertebrate in the coastal waters of Ponelo Island, from the highest to the lowest, respectively, were mangrove habitat (107 ind./m²), seagrass habitat (93 ind./m²), anthropogenic area (74 ind./m²), and coral reef habitat (61 ind./m²). If we look at the density of macroinvertebrate species in each habitat, then in the anthropogenic area, there are 13 macroinvertebrate species from the phylum Gastropod and Crustaceans, and the highest density was found in Clypeomorus bifasciata (Gastropod) (54 ind./m²). In the seagrass ecosystem, 31 species of macroinvertebrates were found, and the highest density was found in with Nassarius olivaceus (Gastropod) (54 ind./m²). In the mangrove ecosystem, 19 species of macroinvertebrate were found, and the highest density was found in Clypeomorus bifasciata (Gastropod) (195 ind./m²). In the coral reef ecosystem, 28 species of macroinvertebrates were found, and the highest density was found in Sesarma sp. (Crustaceans) (62 ind./m²).

![Figure 2](image-url)  
**Figure 2.** The average density of macroinvertebrates for three months at each research location in the waters of Ponelo Island.
The results of the calculations of the diversity indices of macroinvertebrates found at each research location are briefly presented in Table 1.

**Table 1.** Species diversity index (H'), evenness (e), dominance (D) of macroinvertebrates at each research location in the waters of Ponelo Island.

| Research Location       | H'   | e     | D      |
|-------------------------|------|-------|--------|
| Anthropogenic areas     | 1.3750 | 0.6537 | 0.3334 |
| Seagrass habitat        | 2.2453 | 0.6863 | 0.1443 |
| Mangrove habitat        | 1.5681 | 0.6992 | 0.3391 |
| Coral reef habitat      | 1.9633 | 0.6883 | 0.2175 |

Based on Table 1, it can be seen that the seagrass habitat has a higher diversity of macroinvertebrate species than the other three locations, while the anthropogenic area has low species diversity. The evenness value at each location is relatively constant compared to the dominance index. The evenness value is inversely proportional to the dominance value.

The results of the inter-location macroinvertebrate similarity analysis showed that the anthropogenic area and mangrove habitat had the closest similarity distance (0.3913). Seagrass habitats and coral reef habitats also have a fairly close similarity distance (0.2). Mangrove habitats and anthropogenic areas with seagrass habitats and coral reef habitats show a very solid structure due to the bootstrapping results of 100. The coefficient of the coefficient resulting from the cluster structure is 0.9591 which indicates that the similarity structure is very good. The results of the similarity analysis dendrogram among research locations can be seen in Figure 3.
4. Discussion

Anthropogenic area is a natural area that is influenced by human intervention or activities. There are 13 types of macroinvertebrates found in the anthropogenic area, the least compared to the other three locations. This is because in the anthropogenic area several human activities have the potential to inhibit the attachment of macroinvertebrates to artificial substrates, such as residential activities that contribute household waste to the waters, and also fishing boats. The lack of macroinvertebrates found is a response given to these disturbances [17].

Macroinvertebrate which has the highest density in anthropogenic areas and mangrove habitats is Clypeomorus bifasciata. This species is found in the intertidal zone with rocky substrates, limestone, and soft substrates [18]. This species is generally found in marine waters and even estuaries with high density. This is following the research location, where mangrove habitat is an estuary area that is affected by tides [19]. In the mangrove habitat, this species will live attached to roots and sediments. The high abundance of this species in mangrove habitats compared to other locations is more influenced by the presence of organic matter in sediments than in seawater [20].

Seagrass habitat has the highest abundance compared to the other three locations, where at this location 31 types of macroinvertebrate were found. Gastropod abundance is influenced by the type of substrate and the content of organic matter in the waters [21]. Nassarius olivaceus species have the highest density in seagrass habitats. This is following the research of Litaay [22], where the Nassariidae family is mostly found in seagrass habitats on the island of Sulawesi. Seagrass habitat has ecological functions for macroinvertebrates as a spawning ground and feeding ground, primary producers, sediment traps, and can recycle nutrients and trace elements [23, 24].

There are 28 macroinvertebrates found in coral reef habitats, consisting of Polychaeta, Crustaceans and Gastropods. The highest density was obtained from crustaceans, Sesarma sp. This is following the research of Manuputy in 2014 [25], where crabs from the Sesarmidae family can be found in coral reef habitats. The ecological functions of coral reef habitats include spawning ground, nursery ground, feeding ground, and rearing areas for macroinvertebrates.

Acetes sp., Clypeomorus bifasciata, and Sesarma sp. are species of macroinvertebrates that can be found in all research locations. Acetes sp. is a planktonic shrimp that has a major contributor to productivity in the oceans and as a major source of protein for populations in coastal areas. Acetes sp. migrating from estuaries to coastal waters at night and migrating to deeper waters during the day [26]. Clypeomorus bifasciata is a gastropod with epifauna habitats. These organisms live on the surface of the rocky substrate in the intertidal zone by moving or attached [27, 28]. This species has the ability to survive in extreme environmental conditions. Sesarma sp. is a type of mangrove fauna with high mobility, so this species has a wide distribution [29].

Seagrass habitats and coral reef habitats have a higher species diversity value compared to anthropogenic areas and mangrove habitats. The diversity and abundance of organisms associated with seagrass vegetation has a higher number compared to other waters [30]. In the food chain system, seagrass leaves are associated with small algae (periphyton and epiphyte) which are a food source for fish and small invertebrates, such as crustaceans, seahorses, bivalves, gastropods, and echinoderms [31]. Epiphytes will thrive attached to seagrass leaves and are very liked by some of these biotas. Seagrass habitat can also be a shelter for small biota from predators. The high diversity of species in coral reef habitats can indicate that the condition of the coral is classified as good or not yet polluted [32]. Meanwhile, anthropogenic areas and mangrove habitats have lower species diversity because they are close to residential areas, which have been affected by human activities. This resulted in the two locations being unable to maximize their ecological function [9].

The evenness of macroinvertebrates species in each location is almost the same. This condition shows that the abundance of individuals among locations is evenly distributed. The constant evenness value shows that the distribution in each species is even and there is no dominance [9]. The evenness of a community can be said to be perfect if each species appears in the same proportion [33]. Uneven community structures are more susceptible to invasion and have low resistance to stress and disturbance. The evenness value which is almost the same also indicates that there is no dominance in the research
location. The dominance value which is close to 0 indicates that the macroinvertebrate habitat is still able to provide its needs, so that there is no competition among species that causes dominance [34].

Macroinvertebrates that found in anthropogenic areas also can be found in mangrove habitats generally. This is illustrated by the cluster formed. The similarity of a community can be caused by the similarity of the physical and chemical parameters of waters. The similarity results that obtained show that the similarity of a community also can be influenced by the same substrate characteristics and environmental quality [35]. Anthropogenic areas and mangrove habitats have almost similar characteristics, because these areas are thought to be influenced by the accumulation of organic and inorganic materials accompanied by tides [36]. Sources of organic material in anthropogenic areas are obtained from residential or household waste, while mangrove habitats do store organic material obtained from litter. The discharge of water bodies that settle on the substrate also can have a major effect on the distribution of macroinvertebrates.

The location of the artificial substrate placing during the study did not significantly affect the density of macroinvertebrates, because the calculated F (F) value obtained was smaller than the F table (F crit) value. Macroinvertebrate density can be influenced by several biotic and abiotic factors. Biotic factors that influence are the predator-prey relationship and interaction. While the abiotic factors that influence are water quality, current velocity, food sources, and seasonal fluctuations [37].

The high value of biodiversity in seagrass and coral reef habitats indicates that these habitats are still capable to support macroinvertebrate life. Macroinvertebrates that are found in seagrass habitats and seagrass habitats such as Acetes sp. and Sesarma sp. have an ecological function such as the main productivity provider that can maintain the balance of the ecosystem. Therefore, the preservation of seagrass and mangrove habitats needs to be preserved, by evaluating and monitoring the habitat regularly and periodically to see whether or not there is a decrease in habitat quality.

5. Conclusions
The value of macroinvertebrate diversity in seagrass and coral reef habitats was higher than in the other two locations. Macroinvertebrate species that can be found in all research locations are Acetes sp., Clypeomorus bifasciata, and Sesarma sp. Macroinvertebrates in anthropogenic areas and mangrove habitats have higher levels of association than other locations. The placement of artificial substrates at the study site did not significantly affect the density of macroinvertebrates found.

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