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Research article

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# CORAL BIODIVERSITY IN PULAU MIANG, EAST KALIMANTAN, INDONESIA

# 印度尼西亞東加里曼丹省妙島的珊瑚生物多樣性

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**Abstract**

This study aims to discover the potential of resources and diversity of hard corals of Pulau Miang island (118°0'20"E, 0°44’0"N) located in Sangkulirang District, East Kutai Regency, East Kalimantan. This island is also called Pulau Miang Besar by locals to distinguish it from an uninhabited island to the northeast from this island. The coral reef in Pulau Miang has formed a fringing natural barrier protecting the island from erosion. Pulau Miang is part of the world’s coral triangle region, with very high coral diversity. Since this island is a remote area, very little literature related to its coral biodiversity, and this study became the first article that revealed this coral reef ecosystem. Quadrat transects were used to calculate the percentage of coral life covering this island. Transects lay down 100 times at two different depths and were photographed to measure the coral area within transects. An ImageJ software was used to count and mark coral colonies. The result showed that the average percentage of coral cover area in Pulau Miang was 21.39%, categorized as poor condition, while the coral biodiversity index was 1.98 or in an intermediate state. Two genera dominated coral taxa – Acropora and Porites. Based on the number of colonies and coral cover area, Acropora and Porites are the dominant coral genera in Pulau Miang among coral taxa.

**Keywords:** Pulau Miang, Coral Cover, Biodiversity Index, Acropora, Porites

**摘要** 本研究旨在發掘位於東加里曼丹東庫台縣桑古里朗區的綿島島（118°0'20"E，0°44'0"N）的硬珊瑚資源和多樣性潛力。該島也被當地人稱為大綿島，以區別於該島東北方向的無人島。綿島的珊瑚礁形成了一道天然屏障，保護島嶼免受侵蝕。綿島是世界珊瑚三角區的一部分，珊瑚的多樣性非常高。由於這個島是一個偏遠地區，很少有文獻與它的珊瑚生物多樣性相關，這項研究成為第一篇揭示這個珊瑚礁生態系統的文章。樣方樣帶用於計算覆蓋該島的珊瑚生命的百分比。橫

斷面在兩個不同的深度放置 100 次，並拍照以測量橫斷面內的珊瑚面積。圖像 J 軟件用於計數和標記珊瑚群落。結果顯示，綿島珊瑚覆蓋面積平均百分比為 21.39%，屬於較差狀態，而珊瑚生物多樣性指數為 1.98 或處於中等狀態。兩個屬占主導地位的珊瑚類群—鹿角珊瑚和珊瑚。根據群落數量和珊瑚覆蓋面積，鹿角珊瑚和門廊是綿島珊瑚類群中的主要珊瑚屬。

**关键词:** 綿島, 珊瑚蓋, 生物多樣性指數, 鹿角珊瑚, 門廊

# I. INTRODUCTION

Diversity is defined as "as diverse as biological resources," which naturally means the number of different species in a location. In addition, biodiversity also includes differences in genetics, populations, and ecosystems that will continuously change and evolve due to the adaptation process [1]. In other words, there are species variations, genetics, and ecosystem diversity in an area; there are times when abiotic components also include landscape features, drainage systems, and climate. Biodiversity assessment can be done with genetic differences or Linnean classification [2]. However, many studies suggest determining classifications using higher taxes such as genus, family, and others, or it can be called the taxonomic surrogacy method since it saves more time and resources in identifying species [3].

Coral reef biodiversity in the Coral Triangle (CT) is recorded as the highest on earth where 605 species out of 798 species of coral in the world. Biogeographers have highlighted the waters of the Philippine and Indonesian islands as centers of marine biodiversity for decades. Coral Triangle, founded in September 2007, has 16 regions (coral ecoregions). The CT region is on four continental plates, where all of the plates were unstable during the Eocene period (55-38 million years ago), resulting in various tectonic events that affected the formation of reefs. During the Miocene period (24-5.3 million years ago), the Ryukyus islands in Japan to the Indonesian archipelago saw reef changes resulting from time to time. Based on fossil records, coral reefs in CT are the youngest because, in the Pleistocene period (2.5 million-11.7 thousand years ago), the sea level of the CT was -130 m [4, 5].

Coral reefs are ecosystems that have high economic value but are vulnerable to damage where corals are the main constituents. Damage to coral reefs that often occurs in Indonesia is caused by water pollution, sedimentation, coral mining, fishing that is not environmentally friendly, rising temperatures due to global warming, strong storms and waves, and increasing populations of *Acanthaster planci* [6]. The cause of bleaching or bleaching on coral reefs is due to the rising temperature of waters where zooxanthellae that symbiosis with corals go or die from coral, soft tissues, namely endodermis [7]. In addition, coral reefs can experience death due to sedimentation if sediment covers the entire surface of the coral and interferes with coral growth because it blocks incoming light [8, 9]. Sedimentation occurs due to deforestation, mining at sea, and activities derived from land brought by rainwater to the sea and land-use changes [10].

Pulau Miang Besar (shortly Pulau Miang) is located northeast of the capital Kutai Timur regency with 7.39 km$^2$ area and 11.73 km coastline length [11]. This island has three important tropical ecosystems: mangrove forests, seagrass meadows, and coral reefs. Coral reefs on Pulau Miang Besar have an area of about 218.8 hectares. The coral reefs around this island form a fringing reef with a sloping bottom profile around the shoreline, forming cliffs on the island's edge [12, 13]. This study aims to discover the potential of resources and diversity of hard corals on Pulau Miang that have never been explored before. The research result can be used as a reference as a carrying capacity for the future development of Pulau Miang.

# II. MATERIALS AND METHODS

## A. Study Site

Pulau Miang is located in East Kalimantan, which has pristine nature due to being located in a remote area. The research was conducted from April 28 to May 3, 2018; 4 stations were chosen because that were represented the northern part (St.1), the western part (St.2), the eastern part (St.3), southern part (St.4) of Pulau Miang. Station 1 (00° 58.816'N, 117°, 58.538'E); station 2 (00°43,839'N, 117°59.551' E); station 3 (00°43.901'N, 118°01.385'E); station 4 (00°43.044'N, 118°01.172' E) (Fig. 1).

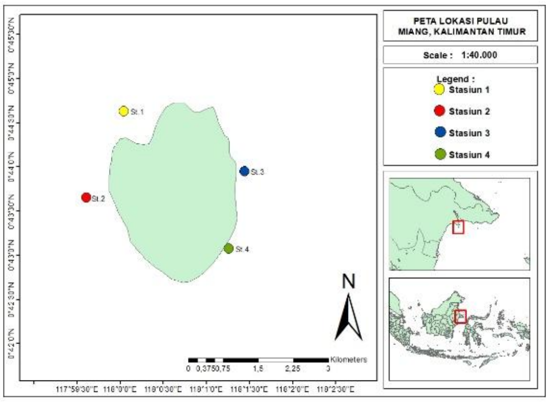


Figure 1. The locality of the study site where data were obtained. Stations 1, 2, 3, and 4 are indicated with yellow, red, blue, and green dots, respectively

## B. Coral Diversity

Coral diversity data has been taken using the combination of 2 methods, namely Underwater Photo Transect and Quadrat Transect. The UPT method is a method that is done by photographing Quadrat Transect placed on coral reefs and done at every meter along 100 m. Quadrat Transect has been made 1x1 m, and in this transect, there are four boxes with a size of 50x50 cm [14, 15]. The photo was then analyzed using ImageJ software. Identification of corals using visual methods regarding [16, 17].

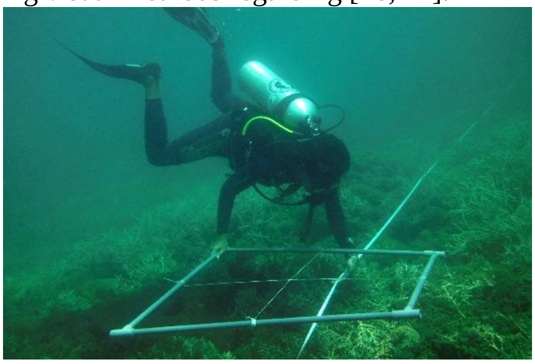

Figure 2. A quadrant transect was used in this research divided into four sections (50 x 50 cm)

## C. Data Analysis

*1) Percentage Live Coral Cover*

The percentage of living coral cover is calculated based on the equations presented [14], with the formula:

$$CC = (LC/\ TC) \times 100\% \quad (1)$$

where CC - percentage of coral cover; LC - live coral area; TC - total covered transect area.

The biodiversity index is calculated by the formula:

$$H' = -\sum Pi \ln Pi \quad (2)$$

where Pi = Ni/N, Ni = frequency of presence of type i, N = total frequency of attendance of all types. The biodiversity index is a composite indicator representing coral richness and evenness in a particular area.

# III. Result and Discussion

## A. Corals in Pulau Miang

The research results on Pulau Miang have successfully identified 31 coral genera of 10 coral families, namely Acroporidae, Agariciidae, Dendrophylliidae, Diploastreidae, Euphylliidae, Faviidae, Fungiidae, Lobophylliidae, Merulinidae, Pocilloporidae, Poritidae, Helioporidae, Milleporidae.

Table 1.
Number of Pulau Miang corals

| No. | Genus | Colonies |
|---|---|---|
| 1 | Acropora | 1,268 |
| 2 | Anacropora | 1 |
| 3 | Montipora | 6 |
| 4 | Isopora | 50 |
| 5 | Leptoseris | 3 |
| 6 | Pavona | 9 |
| 7 | Pachyseris | 59 |
| 8 | Turbinaria | 7 |
| 9 | Diploastrea | 10 |
| 10 | Galaxea | 4 |
| 11 | Favia | 24 |
| 12 | Fungia | 383 |
| 13 | Herpolitha | 1 |
| 14 | Ctenactis | 1 |
| 15 | Echinophyllia | 13 |
| 16 | Symphyllia | 10 |
| 17 | Oxypora | 40 |
| 18 | Merulina | 34 |
| 19 | Favites | 48 |
| 20 | Platygyra | 11 |
| 21 | Echinopora | 127 |
| 22 | Pectinia | 21 |
| 23 | Goniastrea | 7 |
| 24 | Mycedium | 7 |
| 25 | Pocillopora | 13 |
| 26 | Seriatopora | 241 |
| 27 | Stylophora | 48 |
| 28 | Porites | 427 |
| 29 | Psammocora | 2 |
| 30 | Heliopora | 2 |
| 31 | Millepora | 16 |
| | Total | 2,893 |

The coral colonies dominating Pulau Miang were Acropora, Porites, and Fungia. Acropora is a genus of coral that is abundant in the waters of Pulau Miang because it quickly grows in clear waters but is susceptible to sedimentation and fishing activities [18]. Porites coral is a massive or branch coral commonly found in Indonesian waters. Porites can survive in various environmental conditions that are classified as extreme conditions, such as in waters that have high salinity variations and have high sedimentation rates [19]. Another common coral is Fungia which has a free-living form. This coral was widespread in Indonesia, living in shallow to deep water up to 20 m. Fungiid is known as solitary and group living [20, 21].

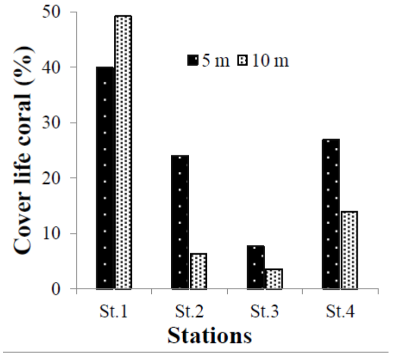


Figure 3. Percentages of live coral cover in Pulau Miang

## B. Percentage of Live Corals

The average percentage of live coral cover in the Pulau Miang was 21.39 %, with the highest percentage of live coral cover found at station 1 at 44.55%, followed by station 4 at 20.34 %. The average percentage of coral cover in the 5th station is 24.59% and at a depth of 10-meters is 18.20 % (Figure 3). In general coral reef in Pulau Miang was in poor condition, which had a percentage of living cover of coral < 25% [22]. This category is not absolute because the coral reef is a complex ecosystem involving thousands of reef biota. So to state coral reef conditions, many variables need to be accessed. The standard variable used by researchers was the size of the coral colony, juvenile coral, competitor type, and various other natural factors. However, the percentage of coral reef cover is widely used to provide basic estimates of coral reef conditions in one region because corals are the main constituents of coral reefs. When corals grow and develop naturally, the population of reef organisms also increases.

In this study, all stations represent Pulau Miang's environmental conditions chosen purposively to represent four different sides of the island following compass points (north, south, east, and west). Another consideration is the depth at which corals grow, and light beams and sedimentation influence health. Previous research has shown that the highest coral cover percentage occurs at station 1 at 44.55 % and falls into the moderate category with a percentage of 25 % - 49.9 %. On the other hand, the lowest percentage of coral cover occurred at station 3 at 5.56 % and fell into the wrong category. In addition, stations 2 and 4 also fall into the wrong category with percentages of 15.13 % and 20.34 %. According to [23], the total coral cover at Sangkulirang Subdistrict was 761.27 ha, and 47.5 % was found in Pulau Miang Besar. The result showed that 3 genera were dominating hard coral in Pulau Miang, i.e., Acropora and Montipora (Acroporidae) and Porites (Poritidae) (Table 1).

The average living coral percentage in 5 m was 24.59% and 18.20% in 10 m depth. High coverage was found in station 1, which has low sediment turbidity, low current, and less wave force. Acropora, Porites, and Echinopora can be seen occupied on reef slopes with various life forms. This environment condition was similar in stations 2 and 4, but the current on these stations was stronger, resulting in some branching Acroporid being broken and leaving rubble surrounding these colonies. Sand and rubble were the primary substrates of this location. Once a strong current comes, the substrate will be mixed and felt down on the coral surface. This natural condition may influence the number of coral colonies less than station number 1.

Sedimentation dramatically affects the health of corals because the high sedimentation in water can reduce the rate of coral recruitment and can reduce coral biodiversity [24]. Unstable substrates also affect coral growth. At the beginning of juvenile growth, corals need a stable substrate, and if at this phase they live on an unstable substrate, then the coral will cement the substrate until it is stable. In this condition, the coral will do horizontal rather than vertical growth. Horizontal growth is hazardous for coral colonies because the more comprehensive the surface of the coral colony, the more likely sediment accumulates on the colony's surface [25].

## C. Biodiversity Index

There are 31 genera found in the waters of Pulau Miang with a coral biodiversity index of 1.98. The value of coral biodiversity at stations 1, 2, 3, and 4 were 1.95, 1.85, 0.88, and 1.52, respectively. The value of coral biodiversity index (*H'*) obtained at a 5 m depth was 0.86-1.81, while at a 10 m depth of 10 m, it was 0.71-2.01 (Figure 4).

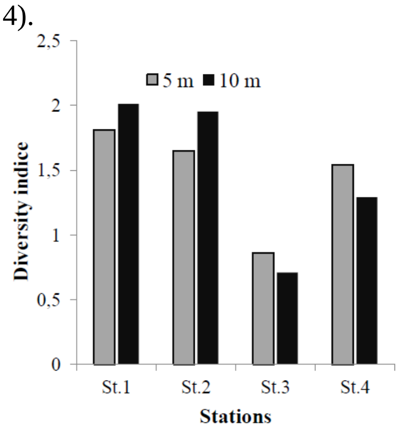


Figure 4. Index of biodiversity genus coral in Pulau Miang in all depths

The coral diversity index in Pulau Miang falls into the moderate category with a value of 1 < H' ≤ 3. The richness of a species or species is the most appropriate way to measure the index of diversity in a region. In this study, the level approach was only carried out until the taxa genus, and it was simultaneously a limitation in translating the biodiversity index. A high-level taxonomist was needed to identify coral until species level, which became the main problem for most coral ecologists [26]. Species richness is a keystone for coral biodiversity, where the higher species richness in a region will increase the ability of resistance and resilience through genetic variation [27]. For example, the genus Acropora has 149 described species [28], and the genus Porites with 60 species of coral in it. Although in this study, the index of diversity used using the genus approach can still provide an overview of the biodiversity of corals that live on Pulau Miang. Moreover, of course, the diversity index will have less value by using the genus approach.

In addition, natural factors such as the high dominance of Acropora and Porites corals, both genera, can be found at all research stations. The high dominance of both coral genera is due to the high adaptation of both to the environment. For example, these two genera have a form of coral growth that branches so that it is more resistant to sediment than corals that have folious or massive growths [24]. Sedimentation can interfere with the recruitment process, leading to low coral diversity and uneven coral genus [9].

Acropora is a coral with high opportunism; when a colony breaks apart by nature or human process, fragments of the coral will soon become a new colony and become the dominant species in the place [29]. Acropora is also known as fast-growing coral with an average growth rate of 5.23 $cm^2$/ month [30]. Fossils found in Acropora corals have also dominated a region since the Paleocene epoch (65-54 mya) [29].

The second dominated coral was Porites. This coral was a significant coral building in the Indo-Pacific area since easily found in shallow to depth areas [31]. The massive Porites coral produce mucus sheets to cover their colonies from sedimentation so that they can live in turbid water [32]. Besides, poritiids corals also have resistance to increasing sea surface temperature [33] and have a successful life-history strategy for winning the competition among benthic organisms. These reasons make Porites dominant on a regional and global scale [34].

## IV. CONCLUSION

This research provides general information on the coral reef status in Pulau Miang, which is categorized as a poor condition. However, local view station 1 showed high live coverage and diversity of corals, which means that the environment supports coral life history and development. Further research suggests that more research stations are needed to accomplish blank spots of coral information in this area, and the researcher should have excellent skills in underwater photography to maximize the quality of digital photography. Future research should engage coral taxonomists for research collaboration for obtaining data on coral species.

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