Journal of Coastal and Ocean Sciences *e-issn: 2746-4512*
Volume 7 No. 1, January 2026: 23-28 *p-issn: 2745-4355*

Abundance and Diversity of Mushroom Coral of the Fungiidae Family in the Waters of Pagang Island, West Sumatra

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Received: 15 December 2025; Accepted: 31 January 2026

ABSTRACT

Mushroom corals (Fungiidae) are one of the families of hard corals (scleractinians) that live free from substrates (free-living), and most mushroom coral habitats are found on reef slopes with fractured coral substrates. The objective of this study was to analyze the abundance and diversity of mushroom corals and to determine differences in abundance across stations. The study was conducted in March 2025 in the waters around Pagang Island, West Sumatra. The study employed survey and belt transect methods. The sampling locations were divided into three stations, each consisting of three sampling points. Station I was located in a coral reef area near the ship traffic between the island and the mainland, Station II was located in a coral reef area near a recreational area, and Station III was located in a coral reef area free from human activity. The results showed that the highest abundance was found at Station III, with 1,416.64 ind/Ha, and the lowest abundance was found at Station II, with 333.32 ind/Ha. The ANOVA test yielded a p-value of 0.023 (< 0.05), indicating that the abundance of mushroom corals differed significantly among stations. The diversity index ranged from 1.039 to 1.823, indicating that the diversity of mushroom corals in the waters around Pagang Island is moderate.

Keywords: Fungal Corals, Diversity, Abundance, Fungiidae, Pagang Island

1. INTRODUCTION

Coral reef ecosystems are among the coastal ecosystems that play an important role as places rich in genetic resources and are reported to host more than 1 million species (COREMAP, 2017). Coral reefs are a group of animals belonging to the phylum Coelenterata (hollow-bodied), most of which are descendants of the phylum Cnidaria (stinging), capable of producing an external skeleton made of calcium carbonate ($CaCO_3$) (Moira & Luthfi, 2020). Coral reef ecosystems dominated by hard corals are found in almost all tropical marine waters. They are vital to the survival of organisms living within and associated with them. Among the families of hard corals, the Fungiidae is among the most common, found in almost all Indonesian waters (Suharsono, 2010).

Fungiidae corals are one of the families of hard corals (scleractinians) that live freely from the substrate (free-living) and are found in the Indo-Pacific waters. Most Fungiidae coral habitats are found on reef slopes with fractured coral substrates (Souhoka, 2016). These mushroom corals are hermatypic corals, where zooxanthellae are found in their endodermal tissue. Mushroom corals are a coral species with unique characteristics. This species can avoid interactions with competing organisms that could threaten its survival (Hoeksema & De Voogd, 2012). Fungal corals serve as habitats for marine organisms, including zooxanthellae, fish, shrimp, crabs, barnacles, bivalves, and worms (Hoeksema, 2012). In addition, one of the roles of mushroom corals (Fungiidae) is to expand the coral reef area. These corals can expand their territory by moving from the reef slope to soft substrates (Saputra et al., 2021).

Geographically and administratively, Pagang Island is part of the Sungai Pinang Nagari, Koto XI Tarusan Subdistrict, South Pesisir Regency (Iqbal, 2023). Pagang Island is one of the tourist destinations in South Pesisir Regency, West Sumatra Province, facing the Indian Ocean. Pagang Island features white-sand beaches and rocky shores, a slightly hilly topography, and a variety of vegetation.

Research on mushroom corals in Indonesia has been conducted, including by Hermanto (2014) in the waters around Gangga Island, North Sulawesi; Hoeksema (2012) in the Spermonde Islands, South Sulawesi; and Pratama et al. (2025) in the waters around Pasumpahan Island, West Sumatra. These

studies generally aim to assess the diversity of mushroom coral species. However, their distribution remains limited compared to the vastness and number of unexplored islands in Indonesia, which are estimated to harbour a wide variety of mushroom coral species.

Previous studies conducted on Pagang Island include research on coral cover (Notiara et al., 2021) and on coral reef cover, as well as a general overview of reef fish (Sirait et al., 2022). However, no research has been conducted on the abundance and diversity of mushroom corals in the waters around Pagang Island, so information on this topic remains limited and largely unknown. Therefore, this study was conducted to determine the abundance and diversity of mushroom corals in Pagang Island, with the hope that the data will complement the database of mushroom coral species in Indonesia and serve as a basis for managing the coral reef ecosystem in the region.

2. RESEARCH METHOD

Time and Place

Station I was located in the coral reef area near the ship entrance and exit to Pagang Island, Station II was located in the coral reef area near the recreation area, and Station III was located in the coral reef area free from activity (Figure 1).

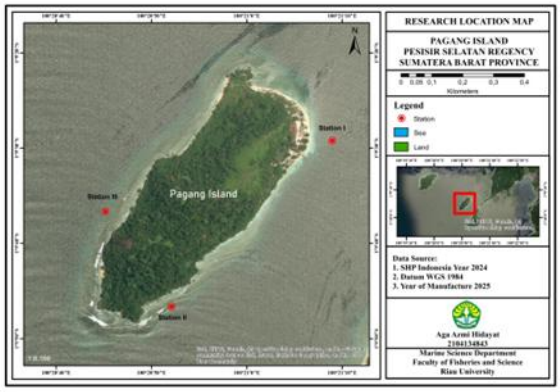

Figure 1. Location of research

Procedures

Coral Data Collection Procedure

Coral data were collected using the Belt Transect method (Hill & Wilkinson, 2004). This method involves stretching a tape measure 70 meters along the depth contour. Observations are made every 20 m, with a width of 1 meter on each side, and each Station is repeated three times, with a 5-m spacing between repetitions. The first repetition covers the distance 0–20 m, the second repetition covers 25–45 m, and the third repetition covers 50–70 m. Data collection involved counting the number of mushroom corals and recording their types. An underwater camera was used to help analyze the types of corals identified in the field.

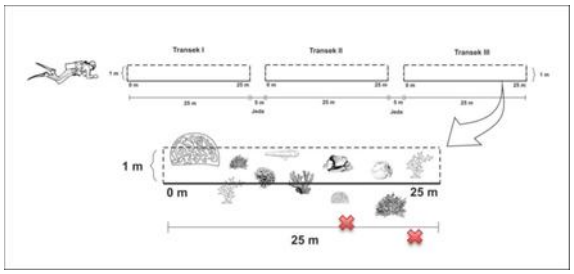

Figure 2. Coral data collection scheme (Fisheries, KKD 2016)

Abundance of Mushroom Coral

Abundance is the number of individuals per unit area. The abundance of each species at each Station was calculated using the following formula (Odum, 1996):

$$Di = \frac{ni}{A} \times 10{,}000$$

Description:

Di : Species abundance (ind/Ha)
ni : Number of individuals of species i (ind)
A : Observation area (Ha)

Diversity Index

This index is used to determine the diversity of mushroom coral species. The equation used to calculate diversity is the Shannon-Wiener equation (Krebs, 1999).

$$H' = -\sum_{i=1}^{n} p_i \log_2 p_i$$

Description:

H' : Diversity Index
p_i : ni/N (Proportion of species i)
ni : Number of individuals of species i
N : Total number of individuals of all species

The criteria for diversity indices are categorized and presented in Table 1.

Table 1. Diversity index criteria

Diversity index (H')	Criteria
H' > 3	Tall
1 ≤ H' ≤ 3	Currently
H' < 1	Low

Water Quality Parameters

The water quality parameters observed in

this study were oceanographic parameters, including temperature, current velocity, salinity, brightness, and pH. Observations were conducted according to natural conditions in the field at the time of mushroom coral data collection at each Station. Water quality parameters were measured three times.

Data Analysis

The data obtained were presented in tables and graphs. To compare abundance across Stations, an ANOVA was used. ANOVA, or Analysis of Variance, is a method used to test the equality of three or more population means by analyzing variance. One-way ANOVA was used to compare mushroom coral abundance. Subsequently, the LSD (Least Significant Difference) test was conducted if the ANOVA results showed significant differences. Both tests were analyzed using SPSS (Statistical Package for the Social Sciences).

3. RESULT AND DISCUSSION

Water Quality

The water quality parameters measured include temperature, turbidity, current speed, salinity, and pH. The water-quality parameter measurements on Pagang Island are shown in Table 2.

Table 1. Water quality

Station	Temperature (ºC)	Brightness (%)	Current speed (m/sec)	Salinity (ppt)	pH
I	31	100	0.26	31	8.25
II	28	100	0.43	28	8.23
III	31	100	0.13	30	8.27

Based on Table 1, the results of water-quality parameter measurements indicate no significant differences between stations. Temperature measurements in the waters around Pagang Island ranged from 28-31℃; water clarity was 100% at all stations; current speed was 0.13-0.43 m/s; salinity ranged from 28-31 ppt; and pH ranged from 8.23-8.27.

The water temperature is 28-31℃, and within this range, mushroom corals generally remain within their thermal tolerance limits. According to Ministerial Decree No. 52 of 2004, the optimal temperature for coral reef growth is between 20-30℃. A temperature of 31℃ approaches the upper limit of tropical coral thermal tolerance. If this temperature persists for an extended period (more than a few days to weeks), it can trigger thermal stress, leading to physiological disturbances, including the release of zooxanthellae from coral tissues, a phenomenon known as bleaching (Hughes et al., 2017).

However, mushroom corals have unique adaptations, such as a solitary body shape and limited mobility, which allow them to move to more conducive locations, such as sandy areas or those sheltered from direct sunlight. This provides an advantage in coping with higher temperatures. Some studies report that mushroom coral species can survive even in marginal conditions, with reduced competition from other hard corals (Hoeksema, 2012). The measured light intensity was 100%. A light intensity of 100% reflects maximum lighting conditions. A light intensity of 100% reflects maximum lighting conditions. Coral growth is well-suited to water areas with high light intensity, given their symbiotic relationship with Zooxanthellae. The light intensity was very high because the water was very calm during the observation, with no wave agitation.

The current speed ranges from 0.13 to 0.43 m/s. According to Yuliana et al. (2021), in areas with current speeds between 0.2 and 0.4 m/s, the abundance of mushroom corals is relatively higher compared to areas with currents that are too calm (<0.1 m/s) or too strong (>0.5 m/s). This reinforces the finding that moderate currents play a positive role in supporting the abundance and health of mushroom corals. Current speeds of 0.13–0.43 m/s are conducive to mushroom coral abundance, as they aid in nutrient circulation and keep the surface clean of sediment. Salinity 28–31 ppt. According to Ministerial Decree No. 51 of 2004, optimal salinity for coral reef ecosystems ranges between 33–34%. Research by Putra et al. (2022) in Nusa Penida waters shows that mushroom coral abundance remains stable at salinities of 29–31 ppt, with low stress when other parameters (such as temperature and current) are also favorable. pH measurements ranged from 8.23 to 8.27. According to the 2004 Ministerial Decision on Environmental Quality

Standards, the optimal pH range for coral reefs is 7-8.5. Thus, water quality parameters provide a supportive environment for mushroom coral abundance (Fungiidae).

Types of Fungi Corals on Pagang Island

Based on observations, seven coral-fungus species were found in the waters around Pagang Island, belonging to two genera: Ctenactis and Fungia. The types and classifications of fungi found are shown in Table 3.

The results of the abundance calculations for mushroom coral at each Station on Pagang Island can be seen in Table 4.

Table 3. Types and classification of mushroom coral on Pagang Island

Phylum	Class	Order	Family	Genus	Species
Cnidaria	Hexacorallia Anthozoa	Scleractonia	Fungiidae	Ctenactis Fungia	*Ctenactis crossa* *Fungia horida* *F. concinnna* *F. fungites* *F. paumotensis* *F. scabra* *F. granulasa*

Table 4. Abundance of mushroom coral at each station on Pagang Island

Station	Repeat 1	Repeat 2	Repeat 3	Average
I	83.33	83.33	166.66	333.32
II	416.66	666.66	333.33	1,416.65
III	166.66	333.33	250	749.99

The abundance of mushroom corals in the waters of Pagang Island, West Sumatra, varied significantly between the three observation stations, influenced by environmental and habitat factors that differed across the stations. Based on the research results, Station I had the lowest mushroom coral abundance, with 333.32 ind/Ha. Several factors, such as environmental conditions, may cause this. Station I is an area with high vessel traffic and human activity. Vessel activity can increase turbidity through sediment resuspension, which in turn can hinder light penetration and disrupt photosynthesis by zooxanthellae within coral tissue (Fabricius, 2005).

Additionally, physical disturbances from ship anchors or artificial waves can cause direct damage to solitary mushroom corals, which are relatively easy to overturn (Hoeksema, 2012). Another factor influencing the abundance of mushroom corals at Station I is that this area faces northeast and is directly exposed to morning sunlight. However, weak currents and waves can also cause sediment accumulation, which can interfere with mushroom coral growth, especially on sandy or muddy substrates. This low abundance aligns with findings by Risk et al. (2001), who reported that unstable substrates, such as fine sand, tend not to support mushroom coral growth.

At Station II, the highest abundance was recorded at 1,416.64 ind/Ha, influenced by moderate currents and waves. Hoeksema (2012) states that mushroom corals prefer areas with moderate currents and stable coarse sand, conditions likely similar to those at this Station. Station III follows with an abundance of 749.98 ind/Ha, which may be influenced by the absence of human activity in the area, thereby providing optimal conditions for mushroom corals. However, the abundance value of mushroom coral at Station III is not higher than that at Station II. This is because Station III faces west, which is often exposed to stronger tidal currents and waves, especially in the afternoon. This can provide good nutrient circulation, but if it is too strong, it can disrupt the stability of individual mushroom corals.

Diversity of Mushroom Coral on Pagang Island

The diversity index can be interpreted as a quantitative measure of the variation or diversity of species in a community or ecosystem, facilitating the analysis of information on the number of organisms. The results of the diversity index calculations for mushroom corals at each Station are presented

in Table 5.

Table 5. Mushroom coral diversity on Pagang Island

Station	Diversity
I	1,039
II	1,823
III	1,522

The coral diversity index in the waters around Pagang Island ranges from 1.039 to 1.823, indicating a moderate level of diversity. The highest coral diversity index was found at Station II, at 1.823, while the lowest index was found at Station I, at 1.039. The diversity index (H') at Station I has a value of 1.039, Station II has a value of 1.823, and Station III has a value of 1.522. The diversity index of each Station falls into the moderate category. The diversity of mushroom corals in the waters around Pagang Island is classified as moderate to low. This is closely related to the general condition of the coral reefs in the area. Research by Notiara & Suparno (2021) noted that the average coral reef coverage in Pagang Island was only 3.40%, which is categorized as poor. The dominant coral type is massive coral, not mushroom coral, which typically lives solitarily on sandy or gravelly substrates.

Suharsono (2008); Hoeksema (2012) explain that mushroom coral is a sensitive indicator of environmental quality, including water clarity, substrate type, and levels of anthropogenic disturbance. Research by Subhan et al. (2016) in the waters around the Thousand Islands recorded a moderate diversity level of 2.1 and documented 15 species from the Fungiidae family. The most commonly found species were Fungia fungites, Herpolitha limax, and Helliofungia actiniformis. Protected locations with muddy sand substrates tend to support higher species numbers than areas under anthropogenic pressure.

Based on research conducted by Pratama et al. (2025) in the waters of Pasumpahan Island, West Sumatra, the diversity index values obtained at each Station at both depths were categorized as moderate. This is consistent with research on Pagang Island, where the diversity index values at each Station were also categorized as moderate. This aligns with Suharsono (2008), who stated that the coral distribution west of Sumatra is of Indian Ocean type, characterized by relatively low to moderate diversity. They are spread from Weh Island at the northern tip of Sumatra to the west coast of Sumatra. The diversity index is influenced by the number of species and the distribution of individuals among them. The higher the species richness, the higher the diversity index. Conversely, the lower the species richness, the lower the diversity index.

4. CONCLUSION

Based on research conducted in the waters of Pagang Island, it can be concluded that seven mushroom coral species belonging to two genera were found: *Ctenactis crossa, F. horida, F. concinna, F. fungites, F. paumotensis, F. scabra,* and *F. granulosa*. The highest abundance of mushroom corals was found at Station II (1,416.98 ind/ha), while the lowest abundance was recorded at Station I (333.32 ind/ha). The abundance of mushroom corals at different stations showed significant differences. The diversity index (H') of mushroom corals in the waters around Pagang Island falls into the moderate category. When collecting data at each Station, it is advisable to sample at different depths to obtain a more diverse dataset on the abundance and diversity of mushroom corals.

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