

Colony size variation of Acroporidae Family in Spermonde Island, Makassar, South Sulawesi

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Abstract. The Acroporidae family plays a key role in maintaining the balance of marine ecosystems, particularly in coral reef environments. One important parameter is colony diameter, which reflects growth, colony age, and the overall health of the marine environment. This study aims to assess the potential stock of Acroporid coral populations across 11 stations in the Spermonde Archipelago, Makassar, South Sulawesi. The research employed the underwater photogrammetry method, producing data. Data were analyzed using mean colony diameter, standard deviation, heatmap analysis, and significance testing. The results showed that *Acropora* was the dominant genus at most stations, with the highest dominance at Station 3 (79%). *Anacropora* had the largest colony diameter, while *Montipora* and *Alveopora* tended to be smaller. Station 3 was identified as the site with the best population stock. These findings indicate that Acroporidae coral populations are heterogeneous and influenced by local environmental conditions.

1 Introduction

Coral reefs are among the most complex and productive tropical marine ecosystems in the world. In addition to providing habitat for a wide variety of marine organisms, coral reefs play an essential role in maintaining coastal stability, sequestering carbon, and serving as an economic resource through fisheries, tourism, and the ornamental coral trade [1]. One of the dominant coral families in reef ecosystems is Acroporidae, characterized by its complex branching morphology and rapid growth rate [2]. The ecological role of Acroporidae is highly significant in maintaining the balance of aquatic ecosystems, particularly in coral reef environments. This family is recognized as a primary builder of reef structure, offering habitat and protection for a diverse array of marine species.

The Spermonde Archipelago, located in the southwest of Makassar Strait, is a cluster of islands with exceptionally rich coral reef ecosystems but faces substantial pressures. This area serves as a hub for fishing, maritime transportation, and the collection of ornamental corals. As a megadiverse country, Indonesia hosts more than 500 coral species, including members of the Acroporidae family such as *Acropora*, *Montipora*, *Isopora*, and *Anacropora*. These coral populations continue to experience stress due to climate change, coral bleaching,

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illegal harvesting, and human activities such as reclamation and sedimentation [3]. Effective management based on robust data—particularly through coral stock assessments—is essential for understanding community structure, regeneration potential, and the natural reproductive capacity of coral reefs. The Spermonde Archipelago, located in the southwestern waters of Makassar, is a cluster of islands with exceptionally rich coral reef ecosystems but faces substantial pressures. This area serves as a hub for fishing, maritime transportation, and the collection of ornamental corals.

Assessing coral stock populations, particularly those of the Acroporidae family, is crucial in this region to understand the current community structure and to design long-term management and conservation strategies. In the context of resource management, stock information is highly valuable for setting exploitation quotas, identifying broodstock, and supporting restoration programs focused on priority species. One of the approaches to evaluate stock populations is by measuring variations in coral colony size, particularly colony diameter, which serves as an indicator of growth phase and reproductive maturity. Larger colonies generally have greater reproductive capacity and provide more larvae for ecosystem regeneration [2].

A recent data collection method for obtaining colony size in a non-invasive manner is Underwater Photogrammetry. This technique has proven effective for mapping coral communities with high precision, as it can capture comprehensive information on coral colonies without damaging the natural substrate [5]. It also facilitates documentation, diameter measurements, and coral morphology classification from multiple perspectives. Through dedicated software processing 2D morphometric and community structure analyses can be produced for coral stock data.

2 Methods

2.1 Time and place

This study was conducted in July 2025 in the Spermonde Archipelago, Makassar, South Sulawesi, as shown in Figure 1.

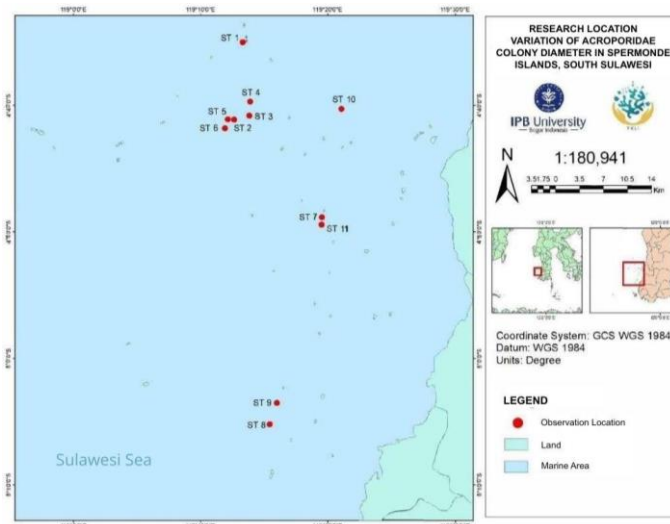


Fig. 1. Map of the study location in the Spermonde Archipelago, Makassar.

The method employed in this study was a quantitative approach using photogrammetry, with one replication conducted at each sampling point. Data collection was carried out at 11 stations located in different areas. The data were collected by a team from the Karang Lestari Indonesia Foundation, which was divided into four groups, each assigned to different sampling locations.

2.2 Tools and materials

Tools and materials used in this study were employed to collect data on colonies of the family *Acroporidae* using the underwater photogrammetry method, as presented in Table 1 below.

Table 1. Tools and materials for stock population *Acroporidae*.

No	Tools and Material	Purpose
1	Scuba SeT	One set
2	<i>Underwater Camera</i>	Olympus TG-5 with waterproof housing
3	<i>Belt Transect</i>	Measurement comparison
4	<i>Roll meter</i>	Measurement comparison
5	<i>Garmin dive com</i>	Measuring depth

2.3 Work procedures

This study consisted of four stages, beginning with in-situ sampling conducted by a team from the Karang Lestari Indonesia Foundation. The next stage involved the analysis of coral data through processing using the PhotoQuad software. The resulting data were then analyzed using the mean diameter variation formula to determine the average size of the coral colonies.

2.4 Underwater photogrammetry

The data collection method used in this study was underwater photogrammetry. This technique involves capturing high-resolution images to create a digital surface model, allowing for detailed analyses of coral structure and growth variation over time (5). Field observations were conducted by a team from the Karang Lestari Indonesia Foundation in the waters of Makassar, South Sulawesi [6]. Data were collected using an Olympus TG-5 underwater camera to record images beneath the surface, along a 50-meter belt transect positioned horizontally by divers, with the camera directed downward. The diver's field of view extended approximately one meter to the right and left of the belt transect to ensure even coverage of the observed area. An illustration of the data collection process is presented in Figure 2 below.

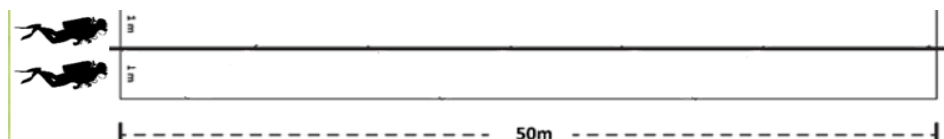


Fig. 2. Illustration of photogrammetry data collection.

2.5 Average variation in coral colony diameter

The data analysis in this study aimed to determine the mean variation in the diameter of the family *Acroporidae*. The resulting data were then subjected to statistical testing to assess differences in diameter among stations.

2.5.1 Combined Mean Size of Coral Diameter Variation

The mean size of corals in this study was calculated using the formula proposed by [7] as follows:

$$X = \frac{\sum x}{n} \tag{1}$$

Description:

n = Number of stations

$\sum x$ = Number of colony diameter measurements

X = Mean Variation in Coral Diameter

2.5.2 Standar Deviation

$$f = \sqrt{\frac{\sum (xi - \bar{x})^2}{n-1}} \tag{2}$$

Description :

f = Standar deviation

xi = The value of α for the i -th substrate at the n -th station

\bar{x} = Average

3 Result and Discussion

3.1 Result of colony occurrence coral

Table 2. shows the dominance of coral colonies by genus at each station. *Acropora* was most abundant at Station 5, with 78 colonies, while *Anacropora* dominated Station 1 with eight colonies. *Alveopora* reached its highest abundance at Station 7 with 56 colonies, and *Isopora* was most numerous at Stations 6 and 9, each with 13 colonies. *Montipora* recorded its greatest number at Station 5, with 72 colonies.

Table 2. The presence of coral genus colonies in the research stations.

Lokasi	<i>Acropora</i>	<i>Anacropora</i>	<i>Alveopora</i>	<i>Isopora</i>	<i>Montipora</i>
Station 1	40	8	-	-	10
Station 2	4	-	1	-	2
Station 3	8	-	-	1	20
Station 4	10	-	-	-	11
Station 5	78	-	-	-	72
Station 6	29	2	-	13	32
Station 7	1	-	56	-	-

Lokasi	<i>Acropora</i>	<i>Anacropora</i>	<i>Alveopora</i>	<i>Isopora</i>	<i>Montipora</i>
Station 8	21	-	-	-	9
Station 9	23	1	5	13	38
Station 10	19	4	-	1	6
Station 11	9	-	-	-	3
Total	242	15	62	28	203

Acropora occurred at every station due to its faster growth compared with other genera. Haerul [6] reported that Indonesia is the center of *Acropora* diversity, with more than 90 species, many of which remain unnamed. *Montipora* was found at 10 stations; like *Acropora*, it is a key reef-building genus in tropical regions such as Indonesia and has high regenerative capacity, allowing it to occupy available substrate more rapidly than other genera.

The remaining genera (*Anacropora*, *Alveopora*, and *Isopora*) occurred at fewer stations. (7), *Anacropora* and *Alveopora* exhibit slower growth, are more sensitive to environmental change, and have narrower geographic and ecological distributions.

3.2 Percentage colony occurrence acroporidae

Based on the distribution of *Acroporidae* coral genera by station, it is evident that *Acropora* is the most dominant genus at most sites. *Acropora* plays an important role in stock population structure due to its rapid growth and high regenerative capacity [2]. The dominance of *Acropora* at many locations indicates a high potential stock population and strong ecosystem recovery capacity.

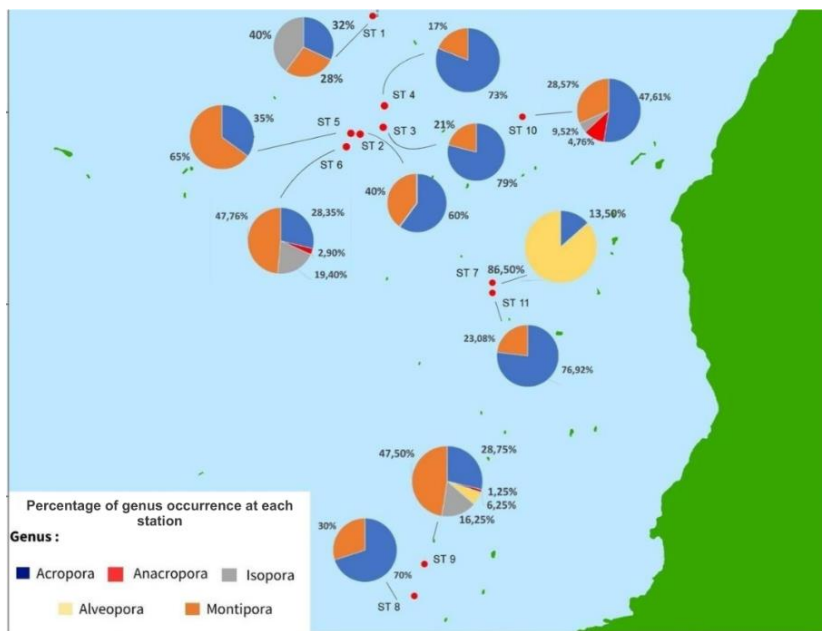


Fig. 3. Distribution of coral genera in the research stations.

Montipora shows a relatively even percentage of occurrence but is not dominant. This genus has a slower growth rate and a stable survival strategy, thus contributing more to

maintaining community continuity rather than serving as a major source of broodstock [8]. *Anacropora* and *Isopora* appear only in limited numbers and at a few sites, indicating that the stock populations of these genera are small and their habitats highly specific. Such genera tend to be vulnerable to disturbance and are not suitable for utilization without a conservative approach.

Overall, this distribution pattern suggests that coral stock populations in the Spermonde Archipelago are heterogeneous: some locations have high potential as seed sources (*Acropora*), while others require protection because they harbor rare genera.

3.3 Variation in the diameter size of acroporidae colonies

Figure 4 shows the diameter distribution of five coral genera in the Spermonde Archipelago, reflecting environmental and human impacts. Large *Acropora* colonies dominate Stations 1, 3, 5, and 10, indicating stable habitats and good regeneration potential. *Montipora* occurs widely but mostly as small colonies, suggesting high recruitment yet slow growth. Station 10, within a conservation zone, hosts sizable *Anacropora* and *Isopora* colonies, highlighting well-protected stocks. In contrast, Station 9, along a shipping route, has small colonies across genera, indicating stress and low recovery potential.

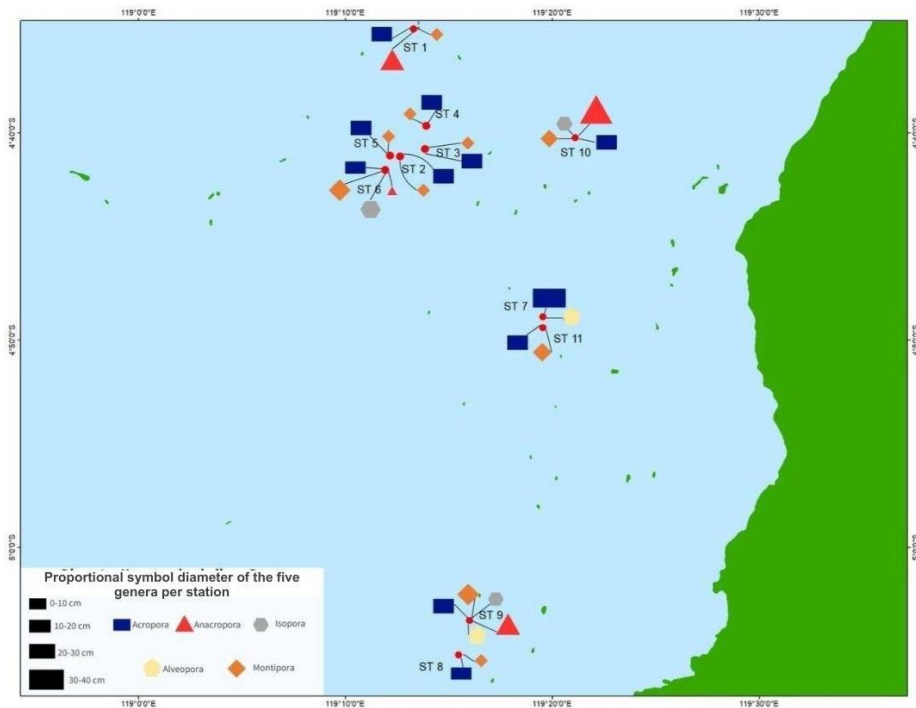


Fig. 4. Map of the percentage distribution of *Acroporidae* colony diameters in the Spermonde Archipelago.

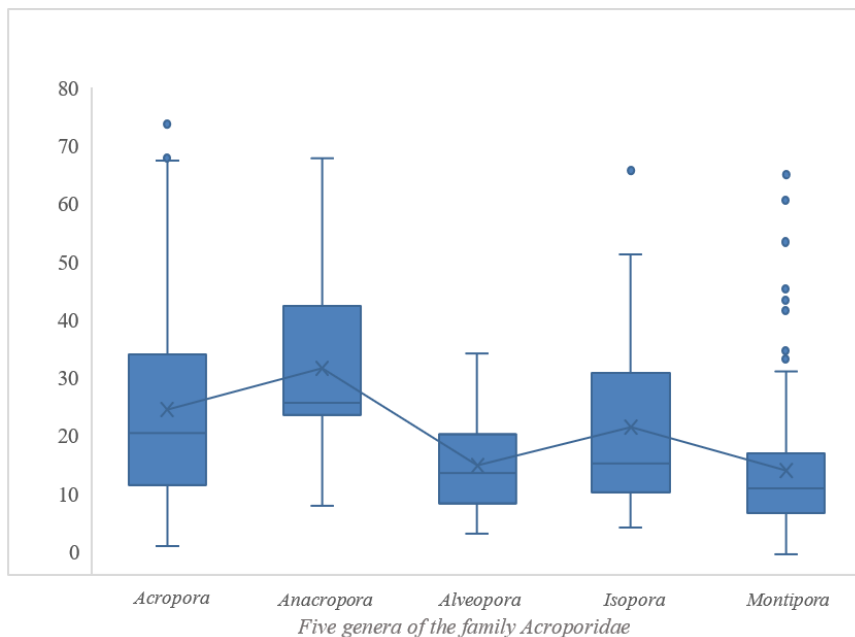


Fig. 5. Boxplot of colony diameter for five genera of the Family *Acroporidae* across 11 stations.

Figure 5 shows variation in the colony diameter of the family *Acroporidae*. Large colonies of *Anacropora* and *Acropora* indicate advanced growth stages and high broodstock potential. Larger colonies generally have greater reproductive capacity, both asexual (fragmentation) and sexual (gamete release), and are therefore essential for maintaining natural community regeneration [9]. The wide size distribution of *Acropora* suggests a healthy population spanning juvenile to adult stages.

Montipora and *Alveopora* tend to have small colonies with low median values, indicating populations dominated by young or suboptimally developed individuals. This may reflect their inherently slow growth strategies or environmental pressures such as sedimentation and anthropogenic disturbance, which limit colony development [10]. Despite their size, smaller genera such as *Montipora* play an important role in maintaining community structure and genetic diversity, particularly under fluctuating environmental conditions.

Isopora exhibits a broad but uneven size distribution with many outliers, suggesting that although some colonies grow large, most remain medium-sized, possibly due to irregular regeneration or growth disturbances across sites.

Mean colony diameter was analyzed to determine the average size of each genus at each station. Standard deviation described the degree of variation in colony diameters from their mean, reflecting the heterogeneity of coral growth within stations. The average diameters of *Acroporidae* colonies are presented in Table 3 below.

Table 3. Mean colony diameter (cm) of corals in the Family *Acroporidae*.

Station	<i>Acropora</i>	<i>Anacropora</i>	<i>Alveopora</i>	<i>Isopora</i>	<i>Montipora</i>
1	18,74 ± 3,83	35,16 ± 15,27	-	-	20,7 ± 6,41
2	24,15 ± 2,71	-	22,16	-	17,63 ± 5,28
3	25,61 ± 3,97	-	-	8,5 ± 8,3	11,5 ± 4,33
4	31,87 ± 3,15	-	-	-	21,39 ± 12,1
5	29,87 ± 5,04	-	-	-	13,5 ± 10,33

Station	<i>Acropora</i>	<i>Anacropora</i>	<i>Alveopora</i>	<i>Isopora</i>	<i>Montipora</i>
6	19,72 ± 10,8	13,5 ± 10,33	-	8,5± 8,3	8,5± 8,3
7	45,82 ± 13,2	-	17,63 ± 5,28	-	25,61 ±3,97
8	21,39 ± 12,1	-	-	-	19,72 ± 10,8
9	31,43 ± 9,39	28,1 ± 8,72	21,84 ± 2,97	41,52	24,15 ± 2,71
10	20,7 ± 6,41	42,82 ± 10,3	-	13,7 ± 4,52	20,7 ± 6,41
11	19,75 ± 0,67	-	-	-	24,15 ± 2,71
Average	18,74 - 45,82	13,5 - 42,82	11,5 - 21,84	8,5 - 31,77	12,16-23,55

The analysis above shows that the genus *Acropora* has the largest mean colony diameter, indicating its dominance at each station due to the wide range of colony sizes. *Anacropora* generally has a high standard deviation at all sites, reflecting broad size variation; although less common, this genus can grow large under favorable conditions. *Alveopora* shows the smallest diameters with limited variation, suggesting small colony sizes and restricted distribution due to its specific habitat preferences [11]. *Isopora* presents moderate mean diameters but high standard deviation, indicating significant differences between small and large colonies at some stations. *Montipora* has relatively even mean diameters and lower standard deviation compared to other genera, suggesting more uniform and stable colony sizes and good adaptability to different environmental conditions [1].

To support the heatmap analysis, statistical tests (ANOVA and Kruskal–Wallis) were applied to assess differences in colony diameter among stations. Results were interpreted based on the significance value (P-value): values < 0.05 indicate significant differences, while values > 0.05 suggest no significant diameter differences among genera across stations. The results are presented in the following table.

Table 4. Results of the Statistical Test on Colony Diameter among Genera in the Spermonde Archipelago.

Genus	df	Sig. (P Value)
<i>Acropora</i>	10	0.001
<i>Anacropora</i>	3	0.182
<i>Alveopora</i>	2	0.336
<i>Isopora</i>	3	0.058
<i>Montipora</i>	9	0.002

Table 4 shows differences in colony diameter among genera at each station. The statistical test for *Acropora* yielded an Asymp. Sig. (P-value) of 0.001 (< 0.05), indicating significant differences in colony diameter among stations. For *Anacropora*, the P-value was 0.182 (> 0.05), suggesting no significant differences among stations. *Alveopora* also showed no significant differences (P = 0.366 > 0.05). *Isopora* had a P-value of 0.058 (> 0.05), likewise indicating no significant differences.

By contrast, *Montipora* recorded a P-value of 0.002 (< 0.05), revealing significant diameter differences among stations. The significant variation in *Acropora* and *Montipora* is attributed to their high frequency of occurrence across most stations, resulting in wide diameter ranges between sites.

4 Conclusion

The *Acroporidae* coral community in the Spermonde Archipelago shows population structures that vary among stations. *Acropora* dominates most sites, particularly Station 10, indicating the highest stock potential, supported by large colony sizes and an even distribution of both *Acropora* and *Anacropora*. *Anacropora* also exhibits the largest colonies, highlighting its role as an important broodstock. *Montipora* and *Alveopora* display smaller colonies with limited distribution. Overall, the variation in size and genus composition reflects a heterogeneous stock, with certain locations serving as key sources for natural recruitment. Station 10, which shows the dominance of *Acropora* with large colony sizes, can be designated as a priority conservation zone or a source of natural recruits, given its potential as a coral stock. Similar analyses are needed for other coral families present in the Spermonde Archipelago, Makassar, South Sulawesi..

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