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PRELIMINARY OBSERVATIONS OF THE DEVELOPMENT OF GONAD PIGMENTATION AS A REPRODUCTIVE PATTERNS OF *FAVIIDAE* IN SPERMONDE ARCHIPHELAGO, INDONESIA

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ABSTRACT

Coral spawning occurs throughout the year in Indonesia due to tropical climate conditions that influence coral development and spawning. As representative data on coral gonad development in the Spermonde Archipelago, observations on the development of the Faviidae gonads were conducted on Barrang Lompo, Kodingareng Keke, Samalona, and Bonetambung Island. Environmental elements are measured in the form of surface water temperature and rainfall. Based on the abundance of this type of gigantic coral at the study site, coral tissue sampling was concentrated on the Faviidae. The pigmentation of the gonads of Faviidae has been studied visually in nature. The samples were carved on the coral before being photographed. To make it easier to detect the level of pigmentation in each species, coral gonadal tissue was imaged. If there is an orange, yellow, or blue tint, it indicates that the coral has colored gonads and is mature gonads, indicating that coral spawning will occur soon. A water lever logger was used to measure the temperature of the water. The results of water temperature measurements vary and can be linked to the development of coral pigmentation as well as observations from November to March when the third phase (pigmented) process in Faviidae was considered to have happened in large numbers. It is possible that Faviidae can breed during this sensitive period. Rainfall data was gathered from Makassar City's Paotere Maritime Meteorological Station.

Keywords: *Faviidae*, Gonad Pigmentation, Spermonde.

INTRODUCTION

Both sexual and asexual reproduction are vital for rebuilding damaged reef regions in coral reefs. Sexual reproduction requires the gametogenesis process, which can take several weeks for sperm and more than ten months for eggs. Spawning and subsequent fertilization of the egg by sperm results in the formation of small dispersive propagules (potentially genetically distinct planula larvae) that can deposit, metamorphosis, and mature into primary polyps (Richmond and Hunter, 1990).

Acropora reproductive success is frequently observed in many reproductive research studies, particularly in high-latitude coral reefs such as those in Australia and Japan (Yusuf, 2012). The reproduction records of 185 coral species spawning at the same time in the Great Barrier Reef are significant (Willis et al., 1985). Not only in Australia, but many Acropora species have been observed to spawn at the same time in Indonesia (Yusuf, 2012; Munasik, 2002). The spawning times of numerous *Acropora* have been widely researched in diverse coral reef regions. Other coral species known to reproduce in the Spermonde Archipelago include *Heliofungia*, *Galaxea*, and *Euphyllia* (Mustafa, 2011; Patiung, 2011). However, little is known about the seasons and reproduction times of the Faviidae tribe's giant corals in Indonesia, particularly in the Spermonde.

Faviidae is a coral taxonomic group that includes several species from 16 genera. After *Acropora*, they have the second biggest number of species and occupy the niche space of coral reef environment, from reef flat to reef crest to reef slope. Several genera, often in large or spherical shapes, are quite easy to find on the reef flat. Due to coastal abrasion on some islands in the Spermonde Archipelago, the huge corals on the flats and tops of the reefs are now beginning to decline. Haerul (2014) studied the genetics of six Faviidae species from the Spermonde, demonstrating that knowledge on their reproductive is still scarce in the literature. As a result, study on the reproductive time of Faviidae is critical for providing information and support for passive restoration in the process of coral reef resiliency in the Spermonde Archipelago.

The results of coral sexual reproduction provide opportunities for improving the status of natural coral reefs, which are feasible to rebuilding coral reefs. Given that enormous coral vegetative proliferation still faces numerous challenges in nature and in the laboratory. To understand the process of generative reproduction in large corals, particularly Faviidae, an initial study effort involving the creation of gonad cells is required.

The purpose of this study is to determine the phases of gonad pigmentation and predict the season and time of

coral reproduction by examining pigmentation indications in several species of Faviidae from March 2020 to February 2021 in the Spermonde Archipelago, as well as environmental factors that influence coral gonad development.

The objective of the research is to offer scientific data on the development of pigmentation, seasonality, and peak reproductive period in Faviidae in the Spermonde Archipelago.

MATERIALS AND METHODS

This research was conducted from March 2020 to February 2021 on Kodingareng Keke, Bonetambung, Samalona, and Barrang Lompo Islands, Spermonde Archipelago, Indonesia (Fig. 1)

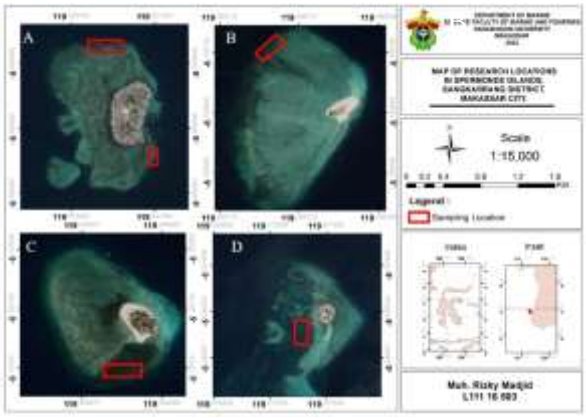

Figure 1. Research site of, A. Barrang Lompo Island, B. Kodingareng keke Island, C. Samaiona Island, D. Bonetambung Island.

Environmental Factor Measurement

A temperature logger deployed in the waters of Barrang Lompo Island provided information on seawater temperature around Spermonde. During the study period (March 2020-February 2021) the temperature data logger is calibrated on a scale every hour.

Rainfall data is obtained from trend data per year from the Paotere Maritime Meteorological Station, Makassar City, to see the level of rainfall around a selected research location.

Coral Sampling

Collected coral sample was undertaken out every month from March 2020 to February 2021. Due to the availability of huge corals at the study site, Faviidae were chosen as specimens. Every month, at least four colonies of various species are chosen. The specimen was photographed to aid with identification. There are indications of the appearance of eggs on pieces of coral specimens where the gonads are white or yellow/orange in color on the soft tissue, and there are also colonies/specimens that do not contain gonads (see table 1 Gonad analysis), it could be indicated that these corals can spawn within close proximity, therefore is necessary to photograph small eggs on corals as evidence of changes in gonadal pigmentation in corals.

Visual Assessment of Coral Gonad Pigmentation

Acropora spp. was subjected to visual pigmentating of coral gonads. This is accomplished by checking in-situ in nature (Yusuf et al., 2013).

The colour of gonads that had appeared on the mesentery of the corals was used to visually observe pigmentation on Faviidae. Table 1 shows a visual classification of gonadal pigmentation levels (Bonilla 2021), as well as an overview of gonadal pigmentation levels in Faviidae corals (Figure 2).

Table 1. Visual classification of gonad pigmentation level

Level	Gonad Condition	Description
I	None	There is no coral gonad
II	Unpigmented	Coral gonad exist,without color
III	Pigmented	Coral gonad orange/blue color

Data Analysis

Seasons and Peaks of Reproduction

The season and peak of reproduction are explained descriptively through considering trend data on the number of colonies with pigmentation in the gonads according to their level of development in each lunar cycle and predicting the occurrence of mass spawning in Faviidae tribe corals in the Spermonde Archipelago.

Environmental Factors on the Development of Gonad Pigmentation

This section descriptively explains with environmental data such as oceanographic factors (rainfall and water temperature) to examining the effect of those environmental factors on the development of coral gonadal pigmentation and the estimation of Faviidae spawning period.

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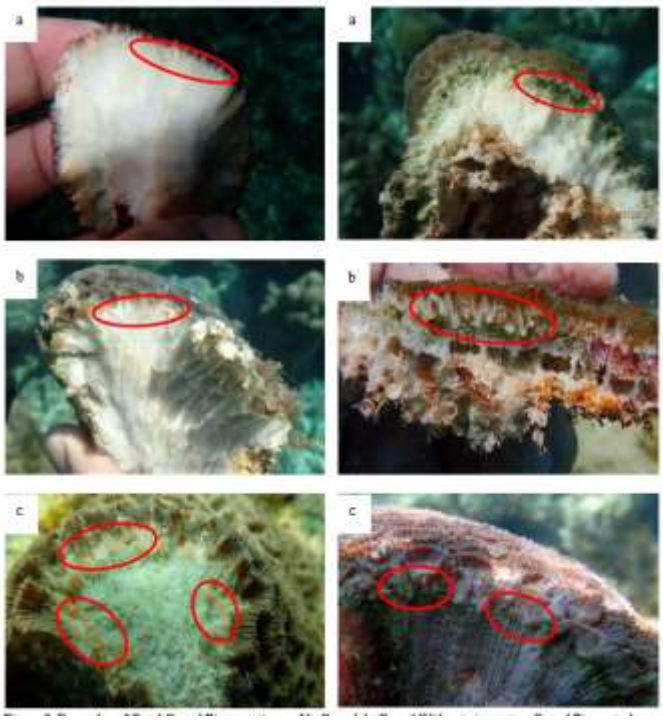

Figure 2. Examples of Coral Gonad Pigmentation; a. No Gonad, b. Gonad Without pigment, c. Gonad Pigmented

RESULTS AND DISCUSSION

Gonad Pigmentation Faviidae specimens

The table below shows data on the distribution of gonadal maturity for Faviidae observed throughout 10 month cycles in 2020, which are March, June, July, August, September, October, November, and December. It will be carried out in January and February of 2021. During 10-month cycles, up to 80 Faviidae colonies were recorded (Table 1).

Table 1. The incidence of coral pigmentation and the number of coral specimens of the Faviidae every month from 2020 to 2021

Date	Observation time	Moonphase	Pigmentation Coral	Number of Colonies
2020 Year				
11 March 2020	6 Rajab 1441 H	+2 BP	3	7
15 June2020	23 Syawal 1441 H	+2 BM	1	6
23 July 2020	2 Dzulhijjah 1441 H	+3 BM	1 . 2	5
15 Agusts 2020	25 Dzulhijjah 1441 H	-2 BM	1	5
28 September 2020	10 Safar 1442 H	-4 BP	1 . 3	16
27 October 2020	10 Rabiul awal 1442 H	-5 BP	1 . 2 . 3	4
22 November 2020	7 Rabiul akhir 1442 H	-9 BP	1 . 2 . 3	8
31 December 2020	16 Jumadil awal 1442 H	+1 BP	2 . 3	9
2021 Year				
23 January 2021	10 Jumadil akhir 1442 H	-6 BP	1 . 2 . 3	9
22 February 2021	11 Rajab 1442 H	-6 BP	1 . 3	9
Total				78

Proportion of Faviidae Colony Pigmentation Levels

Figure 3 depicts the trend data on the proportion of gonadal pigmentation during each lunar cycle. According to these findings, phase one (empty) is a coral colony that lacks of gonads. In phase one, the proportion of colonies is always high in June-August, reaching 21%, 14%, and 17%, respectively. The share then fell by 10% in September before rising by 17% in October. In November and January 2021, phase one decreased by 3%, 0%, and 3%, respectively. In February 2021, phase one climbed by 14%, and in specific month phases, particularly December and March 2021, there was no phase one in any sample.

A coral colony in phase two (without pigment) has gonads in the mesentery but no color (without pigment) in the gonads. This phase emerges in August, December, January, and February, with varying proportions in each month. And there is no phase two (without pigment) in any coral sampling from September to November. In August, the proportion of the second phase is 6%, but there is no such thing as a 0% proportion in the following months, namely September-November. There was a 38% increase in the proportion of phase two (without pigment) in November, and a 31% drop in the following months, for December by 31% and January by 25%.

Phase three is a coral colony with gonads in the mesentery and a color (pigmented), indicating that spawning corals will occur in the near future. There were no phase three (pigmented) gonads in coral sampling from June to August (0%), then a 16% increase in September, and no gonads in October (0%). Furthermore, there is a large increase in each phase of the month from November to March. In November, it was 4%, then 16% in December-January, then a very big increase in February-March, specifically 20% in February and 28% in March.

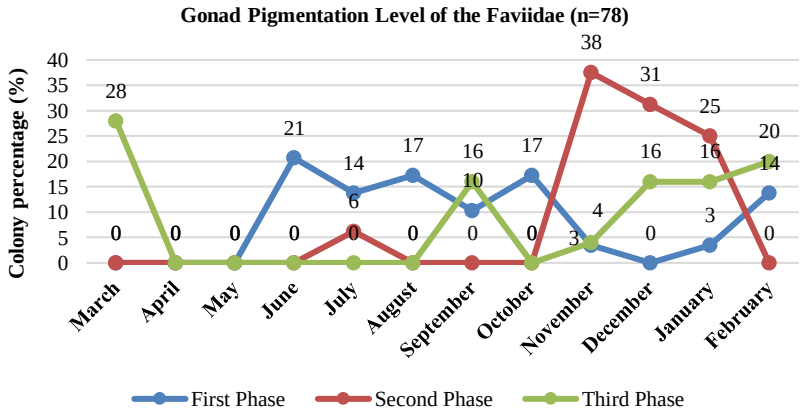

Figure 3. Graph of Gonad Pigmentation Distribution of *Faviidae* every month 2020 – 2021

Third Phase Gonad Pigmentation Levels

Twelve Faviidae species have been identified using visual approaches on macrophotographs. The twelve species were classified into three stages of gonadal maturity: the first, second, and third phases. According to the procedure, the first phase is polyps with no gonads (empty), the second phase is gonads that are visible but not pigmented or white (without pigment), and the third phase is coral gonads that have an orange or yellow color in the photo. (pigmented).

Table 2 depicts the progression of the third phase of gonadal pigmentation in each species over a 12-month period. Except for April and August, the third phase of pigmentation appears every month. *Favia speciosa*, *Favia pallida*, *Favia veroni*, *Goniastrea australensis*, *Platygyra acuta*, and *Platygyra pini* are among the six species in the third phase of gonad development. In September, the third phase of gonadal pigmentation was observed in two coral species, *Favites abdita* and *Platygyra acuta*. The third phase of pigmentation occurs at least in October and November, with each month having one species in the third phase of gonadal pigmentation development, such as *Favites abdita* in October and *Platygyra sinensis* in November. *Goniastrea edwardi* and *Platygyra sinensis* were the two species that had entered the third phase of gonadal pigmentation

development in December. The third phase of pigmentation then grows month by month in January and February. *Favites abdita*, *Favites halicora*, and *Goniastrea edwardsi* were the three coral species in the third phase of gonad development in January. Then there were four species in February: *Goniastrea pectinata*, *Platygyra sinensis*, *Platygyra pini*, and *Platygyra sinensis*. The third phase of pigmentation then grows month by month in January and February. *Favites abdita*, *Favites halicora*, and *Goniastrea edwardsi* were the three

coral species in the third phase of gonad development in January. Then there were four species in February: *Goniastrea pectinata*, *Platygyra sinensis*, *Platygyra pini*, and *Platygyra sinensis*.

Goniastrea edwardi and *Platygyra sinensis* were the two species that had entered the third phase of gonadal pigmentation development in December. The third phase of pigmentation then grows month by month in January and February. *Favites abdita*, *Favites halicora*, and *Goniastrea edwardsi* were the three coral species in the third phase of gonad development in January. Then there were four species in February: *Goniastrea pectinata*, *Platygyra sinensis*, *Platygyra pini*, and *Platygyra sinensis.*

Species with the third phase of coral gonadal development and that occurred at a specific time were discovered over a 12-month period. The presence of corals in the third phase implies that corals can spawn between November and March since there is a pretty high degree of pigmentation in coral gonads throughout each of these months.

Table. 2 The development of the third phase of gonadal pigmentation every month. The third phase of the pigmentation level is marked in orange

No	Species	Observation Month Phase Three											
		2020										2021	
		Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Des	Jan	Feb
1	*Favia pallida*												
2	*Favia speciosa*												
3	*Favia veroni*												
4	*Favites abdita*												
5	*Favites halicora*												
6	*G. australensis*												
7	*G. edwardsi*												
8	*G. pectinata*												
9	*P. ryukyuensis*												
10	*Platygyra acuta*												
11	*Platygyra pini*												
12	*Platygyra sinensis*												
	Total	6	0	0	0	0	0	2	1	1	2	3	4
	PERCENTAGE (%)	50	-	-	-	-	-	17	8	8	17	25	33

Sea Surface Temperature

Figure 4 depicts the average temperature of the waters at the research locations, particularly the Spermonde Islands. There will be temperature fluctuations in 2020. Every month, the temperature rises and lowers. The average temperature of the waters at the research site was over 30°C in March 2020, and subsequently declined to roughly 29°C the following month, June 2020. Furthermore, the water temperature dropped by 1°C to 28°C in the next month, July-September 2020. The sea temperature rose by 2°C to 30°C the following month, November 2020. In the following month, December 2020 - February 2021, the average water temperature fell by 1°C to 29°C.

According to the average yield data from water temperature and the third (pigmented) phase of pigmentation at the study site, there is significant variation in water temperature during each phase of the moon. The lowest average temperature obtained from water temperature data collecting occurred in August 2020, and the temperature in August 2020 was roughly 28°C.

Data gathered in November 2020 showed that the average water temperature jumped dramatically to roughly 30 °C, and that month also had the highest average water temperature. The relationship between the third (pigmented) phase and water temperature is that corals can still produce well by producing gonads in certain months, such as December-March, and species with gonad maturity in that month continue to increase significantly in terms of the number of species that produce the third (pigmented) phase of gonadal pigmentation.

Every month, the average temperature ranges from the lowest to the highest. In August, the lowest average temperature was 28.50°C, while the highest average temperature was 30.59 °C in November. According to Nontji (1993), coral reefs may grow well if the water temperature is approximately 25-30 °C, therefore with the average temperature acquired, coral gonadal development will be able to develop properly since the temperature obtained is perfect for coral gonad growth.

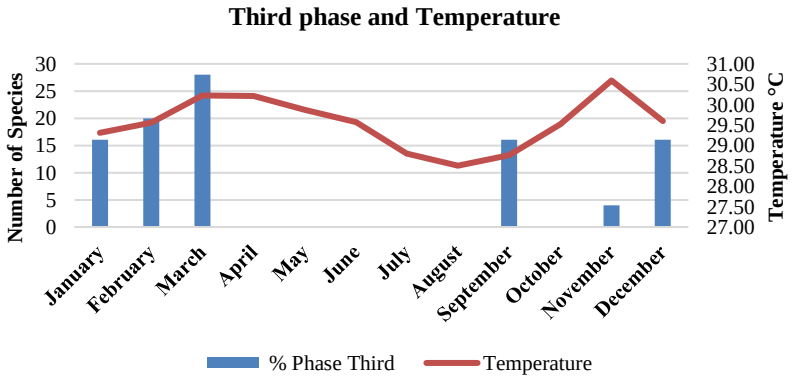

Figure 4. Graph of the relationship between temperature and pigmentation of third phase (pigmented) corals for one year in the Spermonde Islands

Rainfall

Figure 5 indicates the average rainfall in the research sites, particularly the Spermonde Archipelago. There will be monthly changes in rainfall levels in 2020, including high and low rainfall levels. The average rainfall in the waterways at the research area was roughly 22 mm in March 2020, and then dropped to 12 mm the following month, June 2020. The following month, July 2020, rainfall dropped by 8mm. Rainfall climbed to 16 mm the next month, August 2020. The rainfall then decreased by 5 mm in September 2020, and increased by 10mm, 20mm, 29 mm, and 33mm from October 2020 to January 2021. In 2021, rainfall in February dropped by 21mm. According to the average yield data from the rainfall at the study site, the level of rainfall varies significantly during the month. The average rainfall in May 2020 is 4 mm, according to rainfall data gathering. The average rainfall data climbed dramatically in January 2021, to 31 mm, and that month also had the highest average rainfall.

The connection between rainfall and the third (pigmented) phase, namely the rain intensity, which varies by month, is not very influential because rainfall intensity varies by month; for example, December-March has quite high rainfall intensity, but corals can still reproduce on that moon.

Coral can breed all year, but only in certain regions and at specific times. Supriharyono (1986 in Supriharyono, 2000) claims that coral gonads can form shortly before the rainy season, however some species are assumed to exist during the dry season (warm water temperature).

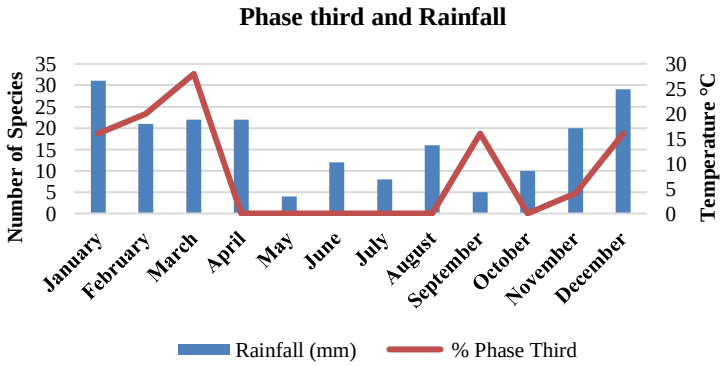

Figure 5. Graph of the association of rainfall and third phase (pigmented) Gonad Pigmentation over a year in the Spermonde Archipelago

CONCLUSION

Except for particular months, such as April-August, the third phase of gonadal pigmentation develops all year. The peak season for reproduction of corals in the Faviidae tribe is thought to be between November and March. Faviidae have been observed reproducing in large numbers during the transitional season II (November) and the rainy season (West Monsoon).

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