The success of coral rehabilitation through transplantation using spider modules (case study: Botutonuo marine area, Bone Bolango Regency)

by Sri Nuryatin Hamzah

The success of coral rehabilitation through transplantation using spider modules (case study: Botutonuo marine area, Bone Bolango Regency)

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Abstract. Botutonuo Waters, Bone Bolango Regency, is an area that has coral reef potential for marine tourism practices. However, high human activity such as destructive fishing practices and increasing population in coastal area causes the coral reef ecosystem to be stressed and damaged. One of the alternatives that can be implemented to protect and conserve coral reefs is through coral transplantation. This study was conducted to provide information about the success of transplantation using the spider module. The experiment was conducted for two months by placing ten spider modules in the water. A total of 60 coral fragments were used where six coral fragments were tied to each module. Coral growth monitoring was carried out every two weeks for four times. The results revealed that the absolute growth of corals for two months of observation showed positive results, namely 1.52 cm. The growth rate of the transplanted corals was 0.19 cm/week or 0.03 cm/day. The survival rate of transplanted corals was 100% and is included in the category of high transplant success rate.
Key Words: Botutonuo waters, coral reef, growth, spider, survival rate.

Introduction. Coral reefs are one of the ecosystems that are crucial for the sustainability of existing resources in coastal areas and oceans. The existence of this ecosystem provides many benefits not only for the biota association but also for humans. Rusandi et al (2016) stated that ecologically, coral reefs function as a habitat for various reef fish caught by fishermen, as a coast protector from waves, a source of germplasm, and economically as a source of income through marine tourism and ornamental coral trades. Currently, the rate of exploitation of coral reefs is not as fast as the rate of regeneration, so that has an impact on damage to coral reefs in coastal areas. Giyanto et al (2017) reported that the current condition of coral reefs in Indonesia was 36.18% in the bad category, 34.3% in the moderate category, 22.96% in the good category, and only 6.56% in the very good category. In general, the trend of the condition of live coral cover is decreasing, which deserves serious attention due to the huge role of coral reefs in the coastal environment. Even some research results indicate that coastal areas with damaged coral reefs have the potential to receive bigger waves and are threatened with coastal abrasion.

Botutonuo waters are one of the waters in the Tomini Bay area of Gorontalo. Currently, the Botutonuo water area is used for various activities such as fishing and marine tourism. Information obtained from the coastal community of Botutonuo shows that in 1980-1990 fishing activities were carried out by destructive methods in this area. The amount of rubble was found to be an indicator of destructive fishing in the past. If no measures are taken to restore this condition, the damage to coral reefs can get worse. Restoration of coral reef ecosystems can occur naturally. However, the time required is quite long, so interventions are needed to restore the condition of coral reefs in numerous locations in a short time.

Several methods have been implemented to restore coral reef conditions in a shorter time, including artificial reef methods, mineral accretion (bio rock), and coral transplantation (Suharsono et al 2013). Coral transplantation is a method of coral cultivation by cutting a portion of a particular coral colony to be planted in a new place (Prameliasari et al 2012). Transplantation through asexual fragmentation is essential as an effort to reproduce corals for recovery, trade, and marine tourism (Nedimyer et al 2011; Suharsono et al 2013). Transplantation using spider modules has never been tested in Gorontalo Province since this method is the newest and not widely used in Indonesia. It was identified that transplanting with the spider module was only found in South Sulawesi and Bali (Williams et al 2019; Subhan 2019). Therefore, there is a lack of information about coral growth using the spider module.

This study aims to provide information about coral growth and survival rates using the spider module as well as a reference in selecting a transplant model that is cheap and easy to apply in the field.

Material and Method

Study site. This research was conducted in May-July 2020 at Botutonuo waters, Bone Bolango Regency. The research location is depicted in Figure 1.

Figure 1. Location of coral transplantation using spider modules.

Preparation and module construction. The placement of the spider module was determined in the initial observation, namely through the manta tow survey, to see the condition of the coral reefs around the Botutonuo waters. The spider module was placed on the bottom of the water where damaged coral reef conditions were observed. The spider construction can be seen in Figure 2.

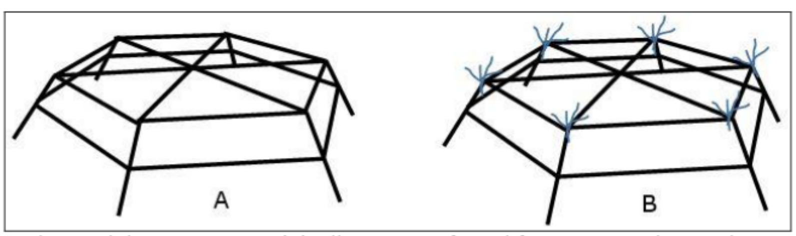

Figure 2. Spider module construction (A); illustration of coral fragments tied to spider modules (B).

The spider construction was made of steel with a diameter of 12 mm, which was shaped to resemble a spider's web and legs (Figure 2). The frame height is ± 50 cm, with the bottom diameter of ± 120 cm, and the distance among the legs is ± 60 cm. Each spider frame was coated with sand, which is glued using resin and serves to prevent rust from the iron when the module was lowered into the water.

Seed procurement, fragmentation, and fragment binding. Coral seedlings were obtained from broodstock nearby the transplant site. The seedlings were taken by cutting the parent corals from the site using pliers and scissors into small colonies (fragments) with a size range of 3–12 cm for branching corals (Rani et al 2017; Suharsono et al 2013). The coral fragments were then put in baskets and soaked with seawater to keep the coral fragments from stress. The coral taken was fragments of *Acropora* sp. as the species generally grows faster. The coral fragments collected were then tied using cable ties to the spider frame, as many as 6 fragments for each module, so that a total of 60 fragments were tied to 10 spider modules.

Measurement of growth and survival rates of coral fragments. Coral fragment growth measurements were carried out every two weeks for two months. At the start of rearing, transplanted corals were measured as initial length using a caliper. Furthermore, every two weeks, the increase in branch length in the waters was measured manually. Also, the number of dead or missing fragments in each experimental unit was counted to determine the survival rate. During the measurement of coral growth, cleaning of the module area, which was overgrown with algae, was also carried out to prevent the death of coral fragments due to algal dominance.

Measurement of water quality parameters. Water quality parameters measured in this study were temperature, salinity, and dissolved oxygen (DO) using a Lutron DO-5510, pH using pH Meter AS-218, current using Flowatch Meter FL-03, and transparency using Secchi Disk. Measurement of the parameters was performed in situ along with the measurements of coral growth.

Data analysis. The results of coral reef measurements were tabulated and analyzed. Some of the analysis parameters are the following:

1. Absolute growth

Coral growth over a period was calculated using Effendie (1979) formula:

$$\beta = Lt - Lo$$

where: β = absolute growth (cm); Lt = the average branch length after the t^{th} observation; Lo = average branch length at the beginning of research.

2. Coral growth rate

Coral Growth Rate was calculated using Effendie (1979) formula:

$$P = \frac{Lt - L0}{t}$$

where: P = increase in length/height of transplanted coral fragments; Li+1 = the mean length/height of the fragments after the t^{th} observation; L0 = the mean length/height of the initial fragments; t = observation time.

3. Survival rate

The formula (Effendi 1979) used for the coral survival rate is:

$$S = \frac{Nt}{N_0} \times 100\%$$

where: S = survival rate (%); Nt = Number of coral fragments at the end of the observation; and No = Number of coral pieces at the beginning of observation.

Results and Discussion

The range of coral lengths at the beginning of the study was 8.67–10.08 cm, with an average of 9.36 cm. The measurement results showed that there was coral growth during the two months of observation (Figure 3).

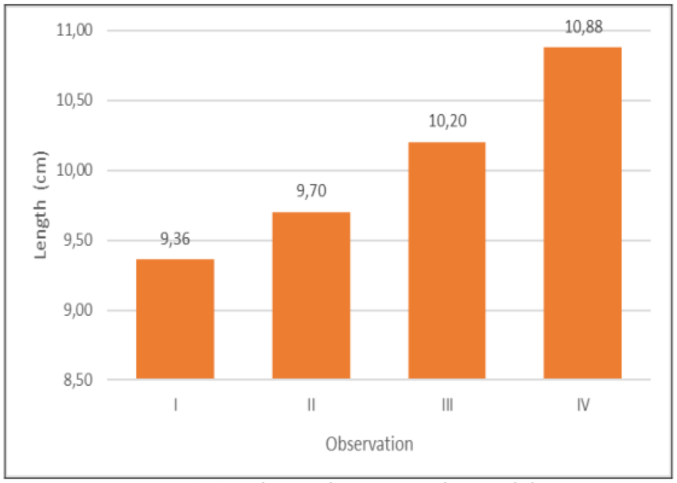

Figure 3. Coral growth using spider modules

Figure 3 shows that there was an increase in coral growth at the research location every two weeks of measurement for two months of field observation. The average size of the initial coral fragments was 9.36 cm and at the end of the study, in the fourth observation, the length was 10.88 cm. The results designated that the absolute growth of the transplanted corals was 1.52 cm. The absolute growth of *Acropora* sp., which was transplanted using this spider, was higher than that of Subhan (2019) and Rani et al (2017), which were 0.59 cm and 0.1-0.2 cm, respectively. The results showed that the coral growth observation experiment in the Botutonuo waters shows better performance than previous studies using the same transplant module. Furthermore, absolute growth in this study is better than the results obtained by Alim (2019) in the same research location with the concrete beam transplant module. Alim (2019) reported that the absolute growth of coral during two months of observation was 0.6 cm. Based on visual observation, the transplanted coral began to stick to the spider module, and some coral fragments had started to wrap the ties (Figure 4).

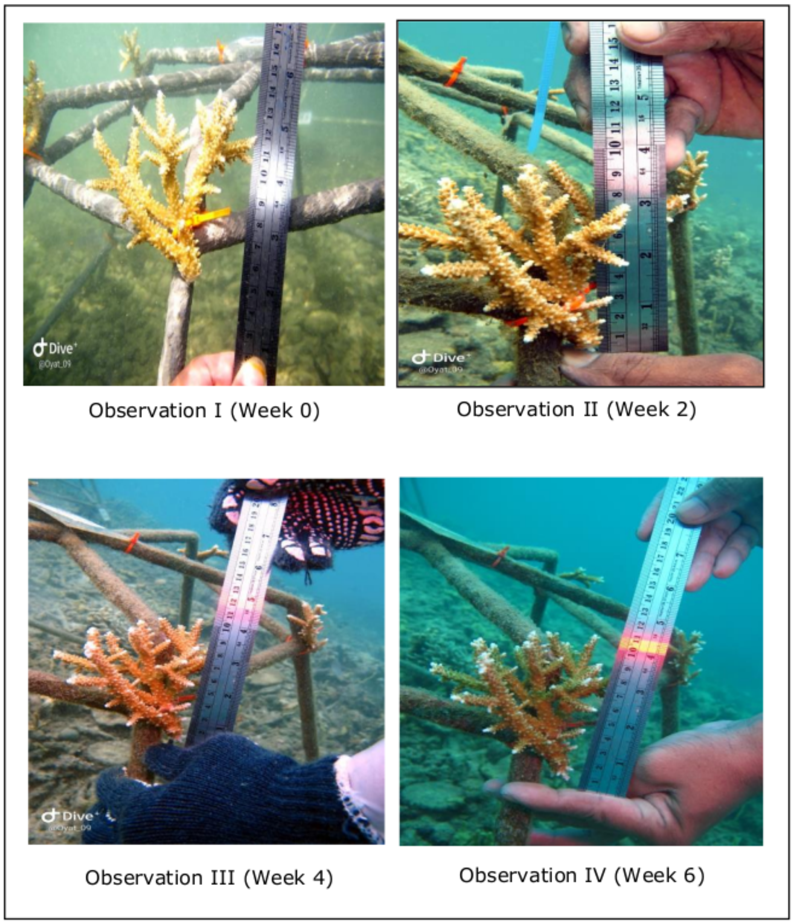

Figure 4. Observation of growth and morphological changes in transplanted corals using spider modules.

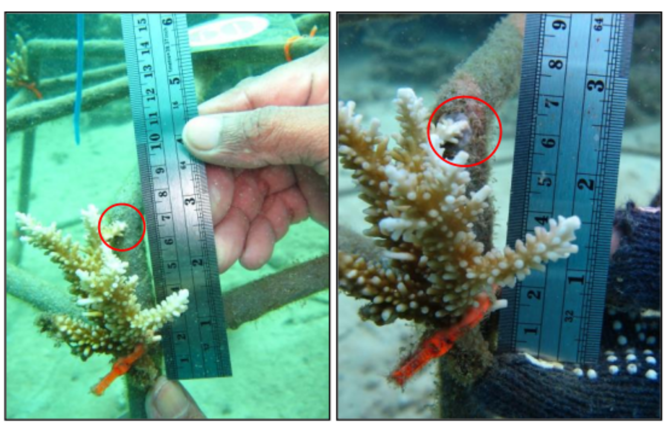

Figure 5. Coral fragments attached to observations II and III (week 2 and week 4).

Figure 4 shows changes in the morphology of the transplanted corals, both changes in the height increase of corals and the adding of new coral branches. The life of coral fragments in the transplant module can be observed through the tie cables and the attachment of elements (Figure 5) to the substrate. Coral fragments are categorized as living on the transplant media when they are attached or when the binding cables have been wrapped by new coral tissue at the end of the transplant. According to Edward and Gomez (2007), corals that have stuck to and covered the substrate are less likely to escape.

Growth rate. In general, the growth rate of corals transplanted using spiders was 0.19 cm/week or 0.03 cm/day. The results of measuring coral growth rate can be seen in Figure 6.

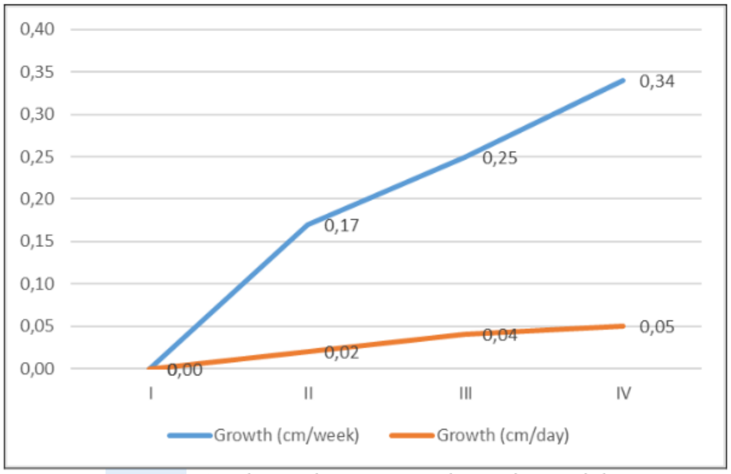

Figure 6. Coral growth rate using the spider module.

Figure 6 shows that the transplanted *Acropora* sp. growth rates were 0.17 cm/week or 0.02 cm/day, 0.25 cm/week or 0.04 cm/day, and 0.34 cm/week or 0.05 cm/day on the second, third, and fourth observations, consecutively. The results showed that the coral growth rate of *Acropora* sp., using the spider method in Botutonuo waters, was faster than Subhan (2019) result in Bali, which also uses the same method, genus, and depth, where the coral growth rate obtained by Subhan (2019) was 0.09 cm/week in observation II and 0.14 cm/week in observations III and IV.

The use of the spider transplant modules in this study also showed a better growth rate performance compared to the use of the concrete block transplant module in Botutonuo waters by Alim (2019), where the growth rates on the blocks were 0.01 cm/day in the second and third week of observation, and 0.03 cm/day at the fourth week of observation. The research informs that applying the spider transplant module is more effective in rehabilitating coral reefs and generates growth faster than the concrete beam transplant. Although to see to what extent its effectiveness and development still needs to be investigated through further observation and continuous monitoring.

Coral survival rate using spider modules. The analysis of coral survival rates using the spider module can be seen in Figure 7.

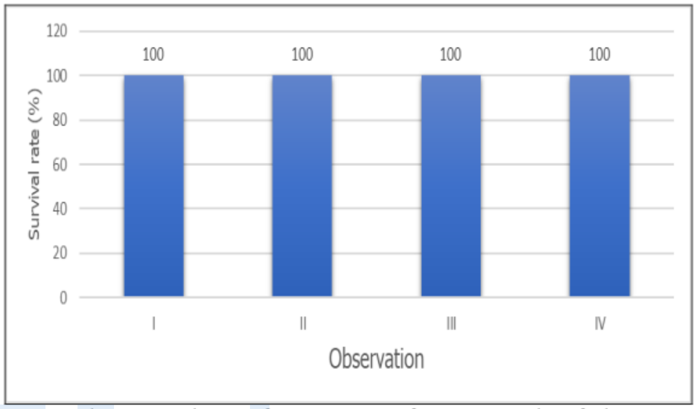

Figure 7. The survival rate of *Acropora* sp. for two months of observation.

Figure 7 shows that no dead coral fragments or coral fragments had escaped from the spider module during the two months of observation. The total number of coral fragments observed at the beginning and the end of the observation amounted to 60 fragments. The results of this study indicate that the use of spider modules for coral transplantation is successful. Harriot and Fisk (1988) in Mompala et al (2017) stated that transplantation of corals was considered successful when the survival rate was in the range of 50–100%. In this study, the survival rate of transplanted corals in Botutonuo waters was 100%, and the results of this study were higher than the results of Subhan's (2019) study, which was only 82%.

Similarly, the results of research conducted by Rani et al (2017) with the same method showed a coral survival rate of 95.56% at the end of the study. The study results indicate that *Acropora* sp. can grow well in Botutonuo waters. Williams et al (2019) reported that transplanting using the spider method succeeded in restoring the condition of coral reefs in the rehabilitation area.

The main factor causing the high survival rate in this study lies in the initial transplantation treatment, starting from finding and tying seedlings to mobilizing spider modules to the research location, being carried out carefully, and trying not to be exposed to open air, thereby minimizing stress levels on corals.

Water quality parameters. Water quality parameters are one of the essential factors that play a role in the survival of aquatic organisms, especially coral reefs. It causes the distribution of coral reefs in water areas to be uneven. The in-situ measurements of water quality parameters can be seen in Table 1.

Table 1

Results of measurement of water quality parameters

Parameters	*Observation*				*Seawater Quality Standards for Coral Reefs (Minister of Environment Decree No. 51/2004)*
	I	*II*	*III*	*IV*	
Temperature (°C)	29	29	29	29.3	28-30
Salinity (‰)	29	29	25.5	27.7	33-34
pH	7.98	8.01	7.89	7.57	7–8.5
DO (mg/l)	2.5	6.09	3.99	5.92	>5
Current (m/s)	0.02	0.015	0.02	0.03	-
Transparency (m)	6	6	6	6	> 5 m

Table 1 shows that the temperature values in Botutonuo waters are in the range of 29–29.3°C. Supriharyono (2000) stated that a suitable temperature for coral growth ranges from 25–29°C. However, coral animals can tolerate temperatures with a minimum of 16°C and a maximum of 36°C (Kinsman 1964). Salinity ranges between 25.5–29 ‰. Low salinity value is thought to be influenced by rainfall due to rain during the research. In addition, low salinity is also predicted to be affected by the supply of fresh water from the rivers around the study site. However, it is a rainfed river, not a continuous stream. The results of pH measurements at the study sites were in the range of 7.89–8.01. This value is in the normal pH range in Indonesian waters and the range of seawater quality standards for coral reefs. Rizki et al (2011) found that the annual pattern of pH in Indonesia varies from 7.7 to 8.2.

The dissolved oxygen (DO) measurements at the research location were in the range 2.5-6.05 mg/L. The range of DO for the first and second observations is below the standard quality for coral reefs based on Minister of Environment Decree No. 51/2004. However, according to Swingle (1968) in Salmin (2005), the minimum DO of 2 mg/L is sufficient to support the life of organisms.

The current velocity obtained at the research location ranging from 0.015 to 0.02 m/s is in a low category when referring to Yusuf et al (2012), which is below 0.5 m/s. The slow movement of the current is due to the morphology of the bay-shaped location so that the current velocity is low. The results of measuring the transparency of Botutonuo waters obtained of 100% or 6 m, as the spider module was placed at a depth of 6 m. Based on the seawater quality standards for coral reefs, the water transparency in Botutonuo is still in the range of quality standard values.

Conclusions. To sum up, absolute coral growth for two months of observation showed a positive result of 1.52 cm. The growth rate of the transplanted corals during the study was 0.19 cm/week or 0.03 cm/day. The 100% survival rate is included in the transplant category with a high success rate. The quality of Botutonuo waters as a transplantation location using spider modules still supports the growth of transplanted corals.

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