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Study of *Acropora* Coral Growth with Various Transplantation Media in Karang Jeruk Waters, Tegal Regency

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ABSTRACT. Coral reefs condition in "Karang Jeruk" waters has suffered a lot of damage. Coral transplantation is one of the efforts to overcome the problem of damage to the coral ecosystem. This study aimed to determine the growth of *Acropora* corals transplanted with three different media (concrete, earthenware, and iron stakes/pegs). The method used in this study is experiment and observation with data collection techniques using primary data and secondary. The results showed that the survival rate of *Acropora* corals transplanted into three different growing media, yielded the same value for all of them, i.e., 66.67%. The most optimal growth of *Acropora* corals was using concrete medium, with an average coral diameter growth of 0.044 mm, and an average coral height growth of 0.025 mm. Concrete medium is also known to be stronger than earthenware and iron stakes media. Treatment on the concrete medium needs to be done every two weeks to clean the algae that cover the transplanted *Acropora* coral seedlings.

Keywords: Coral Reef, *Acropora*, Transplant, Karang Jeruk

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1. Introduction

Indonesia is a country that is dominated by the marine area or environment. Widely known Tropical marine ecosystems include: coral reef ecosystems, seagrass beds, and mangroves. The three ecosystems are very complex, ecologically interrelated, rich in biodiversity, and provide considerable benefits for human life (especially coastal communities). Coral reef ecosystems are a place to live or habitat for almost all marine biota in shallow water, both for foraging, rearing, and hatching or giving birth to offspring (Bangen, 2009). The importance of the existence of coral reefs can be seen from its role in the life of fish (marine biota), i.e., 1) Habitat or shelter and foraging for food, 2) Spawning ground and raising offspring (nursery ground), 3) Center for orientation of peruaya fish (migratory species and occasional visitors), and 4) Sources of growth and development of primary producers and natural feed (Zuhry, Mulyani, & Subroto, 2016). Coral reefs are one of the coastal resources that have enormous potential (in terms of productivity, biota diversity, and aesthetics), but are threatened with extinction due to pressure to use them.

The area of Tegal Regency has a unique marine ecosystem and plays an important role in the sustainability of the life cycle of marine biota and the productivity of capture fisheries. This unique ecosystem is in the form of massive coral reefs shaped like oranges, so the local people call the coral clusters "Karang Jeruk" (lit. Orange Coral). The condition of coral reefs in Karang Jeruk waters has suffered a lot of damage. There has been a decrease in the percentage of coral cover caused by natural and human factors. The most dominant natural factor is high sedimentation caused by eddies of waves and ocean currents. The human factor that triggers coral reef damage is fishing activities by lowering anchors around the coral. This can be seen from the number of dead corals from the genus *Acropora*, *Porites*, *Favites*, and *Favia* which have been covered with algae and also rubble (Zuhry *et al*., 2021). *Acropora* corals are crushed and caught in anchors. Then, corals will break from their colonies and die. *Acropora* corals are a genus of small polyp rocky corals in the phylum *Cnidaria*. Depending on the species and location, *Acropora* species can grow as plates or tables. Table corals are actually a group of hard corals of the *Acropora* type. Like other corals, *Acropora* corals are colonies of individual polyps, 2 mm long touching each other, and sharing tissues including neural tissue. Most *Acropora* species are brown or green, but some are brightly colored. *Acropora* is very susceptible to bleaching (coral bleaching) when there is pressure on their environment (Wisuda, 2016).

Based on the above conditions, it is necessary to make an effort to overcome the damage to the coral ecosystem in Karang Jeruk waters, i.e., through coral transplantation. Coral transplantation is one of the techniques for preserving or rehabilitating coral reefs through grafting or cutting live coral to be planted in other damaged places or create new habitats on vacant land. The purpose of coral transplantation is to restore or establish natural coral reefs. Coral transplantation is able to accelerate the regeneration of new coral reefs that previously did not (Coremap, 2006). The purpose of this study

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was to investigate the growth of transplanted *Acropora* corals and the most appropriate media for their growth (cement/concrete, earthenware, and iron stakes) in Karang Jeruk waters, Tegal Regency.

2. Materials and Methods

The research material used was *Acropora* coral colonies in Karang Jeruk waters, Tegal Regency. The research method applied in this research is experiment and observation. The experimental method is an observation under artificial conditions to investigate whether there is a causal relationship, and how big the relationship is, by giving treatments to several experimental groups and investigating the control group for comparison purposes. The observation method is a method of collecting data by systematically recording the results of observations of the events investigated during the research process (Marzuki, 2002)

The experimental method intended in this study was to transplant *Acropora* corals on 3 different media, i.e., concrete, earthenware, and iron stakes. Each medium was repeated 3 times for coral transplantation, so that the total number of coral transplants was 9. In the *Acropora* coral transplant activity in Karang Jeruk waters, all transplant media were placed at 1 coordinate point, i.e., S 06^0 48' 55 "and E 109^0 12' 13.9", more precisely under the iron tower that was plugged into the waters. Placement of transplant media in the same place aims to make it easy to identify when data collection and further observations are carried out. In line with this, the observation method in this study aims to collect data and re-observe transplanted *Acropora* corals.

Evaluation of the most appropriate medium for transplanted *Acropora* corals was through the assessment of coral survival rate (equation I), and coral growth rate: diameter, height, and shoots (equation II). All equations/formulas used refer to the Guidelines for Implementing Coral Transplantation, Directorate of Marine National Parks and Conservation (2008).

Equation (I).

$$S = \frac{N1}{N2} \text{ x } 100$$

Note:
S = Survival rate of transplanted corals (%),
N_1 = Number of live corals at the end of observation (colonies),
N_2 = Number of live corals at the beginning of the observation (colonies).

Equation (II).

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

Note:
P = Coral growth rate (mm)
L_t = Average (diameter, height) at the end of the study (mm)
L_o = Average (diameter, height) at the start of the study (mm)
t = Observation time (4 months)

3. Results and Discussion

3.1. Karang Jeruk Waters Conditions of Citrus Coral Waters

The geographical condition of "Karang Jeruk", which is located in the northern waters of Tegal Regency, with an open position to the impact of waves, has a large degradation effect. In addition, the area is one of the fishing locations for fishermen in Tegal Regency and its surroundings. Geographically, Karang Jeruk is located at 109° 11.85' - 109° 12.15' East Longitude and 06° 48.55' - 06° 48.70' South Latitude, with an area of about 3,600 m^2 (Figure 1). If a straight line is drawn parallel to the in Munjungagung Fishermen Village, Tegal Regency, then the coastline is the closest distance, about 3.15 miles. Karang Jeruk Waters has an easily recognizable sign by the presence of a lighted beacon tower (Zuhry *et al*., 2021).

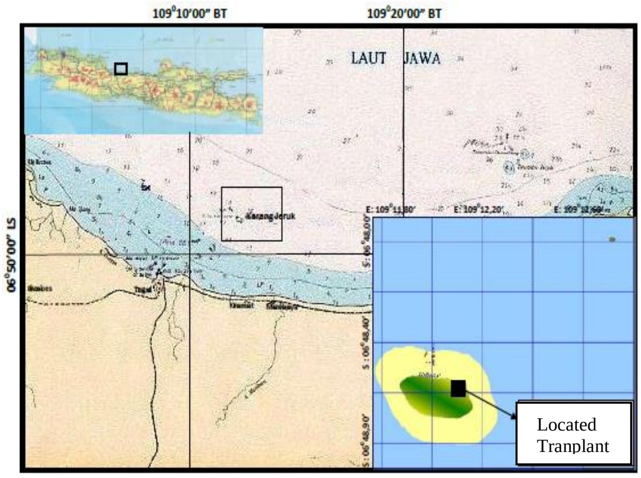

Fig. 1 Location of Karang Jeruk Waters, Kramat District, Tegal Regency

The condition of Karang Jeruk has decreased annually. Several observations resulted in the following data:

Table 1
Coral Cover Condition of Karang Jeruk Waters

Year	Percentage of Coral Cover (%)
2007	31.76 – 75.84
2008	20 – 49.37
2011	24.87 – 53.33
2013	17.83 – 51.5
2015	9.67 – 47.33
2019	1.3 – 69.28

Source: (Zuhry *et al*., 2021).

Table 2
Hydro-Oceanographic Conditions of Karang Jeruk Waters

No.	Variable	2012	
		July	October
1	Position	S 06° 48' 55" E 109° 12' 13.9"	S 06° 48' 55" E 109° 12' 13.9"
2	Salinity	33%	33%
3	Oxygen	7.6 mg/L	10 mg/L
4	pH	7	8
5	Water Temperature	30° C	30° C
6	Clarity	4.1 m	4.1 m
7	Depth	5 m	5 m
8	Current Velocity	0.1 m/dt	0.3 m/dt
9	Flow Direction	North	South
10	Substrate	Dead coral	Dead coral

Source: Researcher's Field Survey Results, 2012

The implementation of *Acropora* coral transplantation first begins with measuring the Hydro-Oceanographic parameters of the waters that are suitable as a place for transplanting activities. Tools and equipment to support the success and safety of the *Acropora* coral transplantation process are well prepared and planned. The results of the measurement of the hydro-oceanographic parameters of Karang Jeruk Waters can be seen in table 2.

The salinity value obtained from the results of the study in July through October 2012 did not change or remained at 33%. This value is very supportive in the growth process of transplanted *Acropora* corals. Salinity is known to affect the life of coral animals due to osmotic pressure in living tissue. Optimal salinity for coral life ranges from 30% – 33%. For this reason, corals are rarely found living in the mouths of large rivers with high rainfall or in waters with high salinity (KKP, 2008).

The oxygen content at the beginning of *Acropora* coral transplantation (July) was 7.6 mg/L, then increased to 10 mg/L (October) when re-collecting coral transplant results. The higher the value of the oxygen content of a water, the better for the growth process of *Acropora* corals. The oxygen content is very helpful in the photosynthesis process of *Acropora* corals during the day, while at night the oxygen content is used for the breathing process of *Acropora* corals (KKP, 2008). The pH value during the study period increased, from 7 to 8 (Table 2). The increase in the sea water pH is good for the growth of *Acropora* corals. The optimal seawater pH value for coral growth is 7.5 – 8.5 (KLHK, 2004).

The water temperature in the waters where *Acropora* coral transplant was carried out was 30°C (Table 2). This temperature is very suitable for the ecology of *Acropora* corals. Temperature affects the rate of metabolism, reproduction, and remodeling of the outer shape of corals. It is known that the most optimal temperature for the growth of *Acropora* corals is 23° C – 30° C. At temperatures below 18° C, it will inhibit coral growth, and even cause death. Meanwhile, at temperatures above 33° C, it can cause symptoms of bleaching, i.e., the release of *zooxanthella* from coral polyps and lead to the death of the coral (DKP, 2019).

The water clarity can reach 4.1 meters in the waters where *Acropora* coral transplants are carried out with a depth of 5 meters (Table 2). The water clarity is very important to help the photosynthesis process of marine biota. Sufficient light helps the rate of photosynthesis to produce calcium carbonate and form reefs. If the water turbidity level of Karang Jeruk Waters is high, it will inhibit the growth of transplanted *Acropora* corals. The level of turbidity of the water (due to sedimentation) causes the intensity of sunlight entering the waters to be hampered, thereby disrupting the photosynthesis process of *zooxanthella* whose final product is donated to polyps. High sedimentation can cover and kill coral polyps. Furthermore, the intensity of sunlight is closely related to the depth of the water. The deeper the water, the less intensity of sunlight that enters. Most corals can grow at a maximum depth of 25 meters (Coremap, 2006). In deep waters, with low sunlight intensity, coral reefs will not be found (KKP, 2008).

The current velocity increased from 0.1 m/s (July) to 0.3 m/s (October), and it greatly affected the transplantation media of iron stakes (pegs). The iron peg media can move from its original position, or it can even be lost if it is exposed to a large current. After re-collection of the data, it turned out that one of the three transplanted *Acropora* coral seedlings was missing. This was because the basic substrate at the transplant site was dead coral, so it was not strong enough to be planted with iron stakes (pegs). Current velocity can affect the growth of corals because currents/waves are important for the transport of nutrients, larvae, sedimentary material, and oxygen. Furthermore, the current can clean coral polyps from adhering dirt. This is why corals that live in areas with waves or strong currents are more developed than in calm and protected areas (KKP, 2008). The current direction in July (the beginning of coral transplantation) was to the north, while the current direction in October (data collection of transplants) was to the south.

3.2. *Acropora* Coral Survival

The survival of *Acropora* corals transplanted in Karang Jeruk Waters is strongly influenced by water conditions. Transplantation of *Acropora* corals was carried out using three media, i.e., concrete, earthenware, and iron stakes/pegs. Each medium was repeated 3 times for coral transplantation, so that the total number of coral transplants was 9. Based on the results of repeated observations made (in October), it turned out that each medium experienced 1 failure in transplantation because the coral died, did not experience growth at all, or was lost (Table 3). The survival of Acropora corals transplanted on each medium is shown in Table 3.

The survival of *Acropora* corals on each transplant medium was the same, i.e., 66.67%. The total number of *Acropora* corals that were able to survive was 6 colonies, while the total number of dead *Acropora* corals were 3 colonies. The cause of death of *Acropora* coral seedlings on concrete media and earthenware media (Table 3) was more because the *Acropora* coral seedlings were unable to compete with algae in the process of obtaining sunlight for photosynthesis. This was proven when re-observation was carried out (in October), the concrete and earthenware media were filled with algae, while the *Acropora* coral seedlings were not visible at all. When transplanting corals, it is necessary to carry out maintenance every 2 weeks. This aims to clean the algae that cover the *Acropora* coral seedlings. Furthermore, the maintenance of seedlings was carried out by cleaning the sediment that had settled, cleaning of organisms, especially algae attached to the seeds and cultivation media, by manually tying and pulling out algae. In the rainy season and certain seasons where algae grow very rapidly, cleaning of the seeds is carried out once a week for all seeds sown because the water conditions are cloudy. Another maintenance activity is to arrange stands if there are seeds that are released from the nursery shelves (Gomez & Edwards, 2007).

Table 3
Acropora Coral Survival

Media	Number of Repeat Sample Transplants	Condition	Cause	Survival
Concrete (A)	A1	Alive	-	66.67%
	A2	Alive	-	
	A3	Dead	Losing competition from algae	
Earthenware (B)	B1	Alive	-	66.67%
	B2	Alive	-	
	B3	Dead	Losing competition from algae	
Iron Stakes/Pegs (C)	C1	Alive	-	66.67%
	C2	Alive	-	
	C3	Missing	The size of the iron stake is not long enough	
			Current velocity, change in current direction	

Source: Researcher's Analysis Results, 2012

The loss of *Acropora* coral seedlings on the iron stake media was due to the fact that the length of the iron stake was only a few centimeters, and the basic substrate was dead coral so that it easily separated from the base substrate. Corals should be transplanted on iron stakes media, at least 30 cm long media with bent ends and plugged into the bottom of the water. The bent part of the iron serves as a barrier to coral fragments that have been tied to the iron using a cable tie with a length of 10 cm (Coremap, 2006). The fluctuating current speed is also a major cause of the loss of transplanted *Acropora* coral seedlings.

Table 4
Acropora Coral Growth

Media	Number of Repeat Transplants	Condition	*Acropora* Coral Growth						
			Diameter (mm)			Height (mm)			Shoots
			Lo	Lt	P	Lo	Lt	P	
Concrete (A)	A1	Alive	0.6	0.75	0.0375	9	9.1	0.025	1
	A2	Alive	0.85	1.05	0.05	9	9.1	0.025	1
	A3	Dead	0.75	0.75	0	9	9	0	4
Average Growth					0.044			0.025	
Earthenware (B)	B1	Alive	0.65	0.75	0.025	9	9.05	0.0125	1
	B2	Alive	0.85	1	0.0375	9	9.1	0.025	4
	B3	Dead	0.85	0.85	0	9	9	0	3
Average Growth					0.031			0.019	
Iron Stakes/Pegs (C)	C1	Alive	0.6	0.75	0.0375	7	7.1	0.025	1
	C2	Alive	0.95	1.05	0.025	10	10.1	0.025	4
	C3	Missing	0.8	0.8	0	7	7	0	3
Average Growth					0.031			0.025	

Note: Lo (diameter and height at the beginning of observation), Lt (diameter and height at the end of observation), P (achievement of coral growth).
Source: Researcher's Analysis Results, 2012

3.3. *Acropora* Coral Growth Achievements

Based on observations for four months, from the beginning of coral transplantation in July to October, the following observations can be seen: the diameter growth of surviving *Acropora* corals, with the largest value, were in the second replicated concrete medium (A2), with a growth value of 0.05mm. Meanwhile, the diameter growth of *Acropora* corals with the smallest values were on the first replicated earthenware media (B1) and on the second replicated iron peg media (C2), with each growth value of 0.025 mm (Table 4). The difference in slow diameter growth was because the first replicated earthenware media (B1) and the second replicated iron stake media (C2) were overgrown with algae so that competition occurred, as stated that branching corals look slow and some experience death due to space competition with turf algae (Burhanuddin, Nessa, & Niartiningsih, 2019).

The results of the height growth observation of *Acropora* corals transplanted on three different media, turned out to have almost the same growth of 0.025 mm, except for the first replicated earthenware medium (B1), the height growth was 0.0125 mm. Corals on the three growing media did not produce additional shoots or the number remained constant, as at the beginning of transplantation (Table 4). This is because the diameter and height of the coral fragments are small, so it takes a long time to produce shoot growth. In addition, the form of growth that points upwards—not sideways—allows these corals not to form new shoots (Syarifuddin, 2011).

The most suitable medium for transplanting *Acropora* corals in Karang Jeruk Waters, Tegal Regency is cement/concrete media. The components of the concrete media are sand, cement, and water. These materials make this medium denser and stronger, so that when exposed to ocean currents it does not experience damage and shift position. The transplant method using cement media can also replace coral fractures that tend to be unstable, because this media can be a solid place for coral larvae to attach (Burhanuddin *et al*., 2019).

4. Conclusion

The survival rate of *Acropora* corals transplanted into three different growing media (concrete, earthenware, iron stakes) all yielded the same value, i.e., 66.67%. The total number of *Acropora* coral seedlings that were able to survive was 6 colonies. The most appropriate medium for transplanting *Acropora* corals at Karang Jeruk Waters, Tegal Regency, is concrete media, because this media is stronger than earthenware media and iron stakes/pegs. The average growth in diameter of transplanted *Acropora* corals on concrete media was 0.044 mm, and the average height growth was 0.025 mm. Meanwhile, the growth of *Acropora* coral shoots did not increase or the number was still constant, as at the beginning of the transplant process. Periodic coral transplantation, especially using concrete media, needs to be developed in order to form new coral colonies. More than that, good cooperation between local governments, academics, and local communities to protect each other's coral reef ecosystems at Karang Jeruk Waters is very much needed in order to achieve sustainability.

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