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SURVIVAL OF CORAL TRANSPLANTATION USING SPIDER MEDIA ON SAMALONA ISLAND, MAKASSAR

Kelangsungan Hidup Karang Hasil Transplantasi Menggunakan Media Spider di Pulau Samalona, Makassar

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ABSTRACT

Coral reef ecosystems in coastal areas and on small islands, such as Samalona Island, play a vital role in fisheries and tourism. One method of coral reef conservation in Indonesia is the use of spider webs. This study aimed to analyze the survival and growth rate of coral reef transplants using the spider web method on Samalona Island from January to December 2024. Field data were obtained by measuring the length of coral fragments monthly. The results showed that coral seedling mortality was highest in the first quarter (27.05%) and lowest in the fourth quarter (1.44%). The highest growth rate was recorded in the fourth quarter (3.77 cm), with an average monthly growth rate of 0.88 cm.

Keywords: Coral Reef, Transplantation, Spider Web, Samalona Island

ABSTRAK

Ekosistem terumbu karang di wilayah pesisir dan pulau-pulau kecil, seperti di Pulau Samalona, memiliki peran penting dalam sektor perikanan dan pariwisata. Salah satu metode konservasi terumbu karang di Indonesia adalah menggunakan media web spider. Penelitian ini bertujuan menganalisis kelangsungan hidup dan laju pertumbuhan transplantasi terumbu karang dengan metode web spider di Pulau Samalona, dari Januari hingga Desember 2024. Data lapangan diperoleh dengan mengukur panjang fragmen karang setiap bulan. Hasil penelitian menunjukkan kematian bibit karang tertinggi pada triwulan I (27,05%) dan terendah pada triwulan IV (1,44%). Laju pertumbuhan tertinggi tercatat pada triwulan IV (3,77 cm), dengan rata-rata laju pertumbuhan bulanan sebesar 0,88 cm.

Kata Kunci: Terumbu Karang, Transplantasi, Web Spider, Pulau Samalona

INTRODUCTION

Coral reef ecosystems are regarded as major ecosystems in coastal areas and small islands that are classified as productive and have substantial benefits in supporting marine tourism and fisheries sectors. Coral reef ecosystems are inhabited by various biota, particularly reef fishes that constitute fishing targets. In addition, coral reef ecosystems have their own distinctive attraction due to the variation and diversity of their associated biota, especially various fish and coral species. Coral reef ecosystems function as nursery grounds, spawning grounds, and fishing grounds; therefore, these ecosystems become target locations for fishing activities. The benefits and roles of coral reef ecosystems are extensive and diverse; however, at the same time, they constitute ecosystems that are highly vulnerable and fragile. Consequently, coral reefs are highly susceptible to damage or degradation (Tonin, 2018).

Coral reef ecosystems experience a decline in quality along with changes in environmental conditions triggered by both natural processes and human activities. Naturally, coral reef degradation can be influenced by increases in sea surface temperature due to global warming, storms, increased seawater acidity, volcanic eruptions, as well as biological disturbances such as predation and disease outbreaks.

Overall, coral reefs in Indonesia are in poor condition, with 35.15% of coral reefs categorized as being in poor condition. Research involving 1,064 stations across 108 locations in Indonesian waters showed that 6.39% of coral reefs were in very good condition, 23.40% were in good condition, and 35.06% were in fair condition (Giyanto *et al.*, 2017). Coral reefs continue to decline annually, resulting in a significant reduction in their ecological functions. Threats to coral reefs are increasing, including in Indonesia (Ayyub *et al*., 2018), as well as in the waters of Samalona Island, Makassar.

Conservation efforts through coral reef rehabilitation are urgently needed to preserve marine ecosystems, which in turn can increase populations of economically valuable fish and develop marine tourism potential (Saputra *et al*., 2022). Thus, the results of this research are expected to serve as a basis for developing more appropriate, effective, and sustainable coral reef restoration efforts, particularly in Indonesian waters that face high levels of coral reef degradation threats (Malik *et al*., 2023). One of the efforts to restore coral reef ecosystems is coral transplantation, which is a method of propagating coral colonies through asexual reproduction. This process is conducted by cutting portions of live coral and planting them in areas where coral reefs have been damaged.

Ecologically, coral reef areas that have experienced degradation still possess the ability to undergo natural recovery; however, the regeneration process to return to a good condition occurs very slowly and requires a long period of time (Pakaya *et al*., 2022). Several coral species can be transplanted, such as *Acropora* and *Pocilopora*, which exhibit growth rates of 6–8 cm/year, and massive coral types such as *Porites* and *Lobophyllia*, with growth rates of 0.5–1 cm/year (Suharsono, 2008).

One method of coral reef conservation in Indonesia involves the use of web spider media. This medium consists of a hexagonal iron frame with spider-like legs, using sand substrate as the transplantation medium. Sand also helps prevent corrosion of the frame and bonds the sand using adhesive. This method is inexpensive, stable against water currents, and resistant to wave action (Rani *et al*., 2017).

According to Williams *et al*. (2019), the web spider method demonstrated an increase in coral cover from 10% to 60% when implemented on Badi Island. Based on the study by Rani *et al*. (2017), coral reef rehabilitation using the spider frame method is considered effective for rehabilitating coral reefs at depths of 3–5 m and is regarded as easier to implement. Firihu *et al*. (2022) also reported in their study that the advantages of using the web spider method include the ability to rehabilitate severely damaged coral reefs located in anthropogenic areas, as well as the use of inexpensive materials for frame construction.

The objective of this study was to analyze the survival rate and growth rate of coral reef transplants using the web spider frame method in the waters of Samalona Island, Makassar City. The benefit of this study is to provide preliminary information regarding the survival of coral reef transplantation results using the web spider frame method on Samalona Island in the future.

METHODS

Research Time and Location

Data collection was conducted from January to December 2024 on Samalona Island, Makassar City, South Sulawesi.

Figure 1. Research Location Map

Tools and materials

The following are the tools and materials used in the research:

Table 1. Tools and Materials Used

No	Description	Unit	Functions
1.	Ship/Boat	Unit	Transportation to Research Locations
2.	Underwater Camera	Unit	Documenting Research Activities
3.	Underwater Paper	Unit	Recording Research Data
4.	Scuba Set	Unit	Used by Researchers in Data Collection
5.	Ruler	Unit	Used to Measure Coral Growth

Data Collection Method

Field data collection was conducted by measuring the length and height of transplanted coral fragments once a month for one year. Each transplant consisted of 18 coral fragments, with 30 frames of spider web media sampled out of a total of 200 frames. Each sampled frame was assigned a code/name tag to facilitate the researchers' monthly collection of transplanted coral growth data.

Data Analysis

The research data analysis will be processed using Microsoft Office software (Excel). To minimize measurement deviations caused by several factors that are difficult to control, a 90% confidence level was used in the data analysis, meaning a 10% margin of error was allowed. Measuring the success of a coral reef ecosystem rehabilitation program can be seen through two indicators: the survival rate and growth rate of transplanted coral.

Transplanted Coral Survival

To determine the coral survival rate, a formula that aligns with the activities undertaken is required. The survival rate of transplanted corals was calculated using the following formula (Ricker, 1975).

$$\mathbf{SR} = \frac{\mathbf{Nt}}{\mathbf{No}}\ \mathbf{X\ 100\%}$$

Description:
SR : Survival Rate
Nt : Number of Individuals at the End of the Study
No : Number of Individuals at the Beginning of the Study

Growth Rate of Transplanted Coral

Coral growth rate was determined by the change in colony length between the beginning and end of the observation period, then divided by the study period. After the cutting process, new coral begins to grow again after 1-2 weeks of healing (Johan *et al*., 2008). Coral growth rate is strongly influenced by environmental conditions and the level of stress experienced, so a single coral species can exhibit different growth rates in different locations (Luthfi *et al.,* 2018).

Coral growth rate can vary depending on the age of the colony and environmental conditions, including temperature, light intensity, water depth, and sedimentation levels (Faqih *et al.,* 2016; Mompala *et al.,* 2017). Overall, the transplanted coral seedlings/tenders belonged to the Acroporidae family, genus Acropora. In this activity, growth rate measurements were conducted using direct observation.

The growth rate of the transplanted coral was observed by measuring the height of the coral fragments. Coral measurements were taken using a ruler. The growth rate of the transplanted coral can be calculated using the following formula (Effendi, 1997):

$$\mathbf{P} = (\mathbf{Lt} - \mathbf{Lo})/\ (\mathbf{t})$$

Description:
P : Increase in Coral Length/Height
Lt : Average Length/Height after Observation t
Lo : Average Initial Length/Height of the Study
T : Observation Time (months)

RESULTS

Oceanographic Conditions of the Waters of the Research Location

Observations of the coral reef rehabilitation site on Samalona Island reveal differences in water conditions across several parameters. Monitoring results show differences between months and several parameters. From January to June, the average water temperature ranges from 29 to 30°C, with a current velocity of 0.32 m/s, a salinity of 33 0/00, and a transparency of 5 m. Predators that can inhibit coral growth include moss and algae. Furthermore, from July to December, the difference lies in the brightness level, which reaches 7 m, and coral bleaching occurs in October.

Table 2. Water Parameters of Samalona Island

Month	Temperature (°C)	Flow Speed (m/s)	Salinity (‰)	Brightness (m)	Predators
January	30	0,24	34	4	Mosses and Algae
February	29	0,67	33	4,5	Mosses and Algae
March	29	0,49	33	6	Mosses and Algae
April	29	0,28	33	5	Mosses and Algae
May	31	0,30	34	6	Mosses and Algae
June	30	0,32	33	5	Mosses and Algae
July	29	0,30	32	7	Mosses and Algae
August	28	0,32	34	7	Mosses and Algae
September	27	0,34	33	5	Mosses and Algae
October	30,5	0,42	32	7	Mosses and Algae
November	31	0,36	32	7	Coral Bleaching
December	30	0,32	34	8	Mosses and Algae

Source: Processed by Researchers, 2023-2024

This condition has a very strong influence on the survival rate of transplanted corals as well as on their growth rate. Several factors that can affect coral reef growth include:

1. Water temperature plays an important role in the survival of coral reefs, in which coral reefs can survive at water temperatures above 18°C. The ideal temperature for coral growth ranges between 27–29°C.
2. Currents and water circulation play an important role in supplying food and oxygen for coral growth. These processes also include the removal of sand or mud deposits that cover coral polyps. In addition, waters with relatively calm currents and waves constitute more ideal locations to support coral growth.
3. The ideal salinity for coral growth ranges from 30‰ to 36‰. Meanwhile, water conditions with low salinity can cause coral reefs to experience mortality.
4. Water clarity is very important for coral reef growth because corals live in symbiosis with zooxanthellae algae that require sunlight for photosynthesis; therefore, sufficient light intensity allows this process to occur optimally within coral tissues, which ranges from 15% to 20% of surface seawater light intensity.

Survival Rate of Coral Transplantation

Based on the results of monitoring coral reef survival, it is known that the survival rate from the beginning of monitoring until the final monitoring period (January–December 2024) showed that coral seed mortality with the highest percentage occurred in the first quarter, from January to March, amounting to 27.05%, followed by the second quarter from April to June at 8.12%, the third quarter from July to September at 1.38%, and the final quarter from October to December at 1.44%. Mathematically, the percentage of coral reef cover shows a very significant mortality value occurring in the first quarter, in which initially there were 18 coral fragments (100%), decreasing to only 12.97 (72.05) fragments; therefore, in subsequent monitoring, efforts were made to suppress coral seed mortality as observed in the third and fourth quarters.

Coral seed mortality in the first quarter did not constitute a significant problem because one healthy coral fragment, in its growth process, is able to cover a 100% cover percentage using the Underwater Photo Transect (UPT) research method; this can be achieved when the age of the transplanted coral reaches 36 months. The graph of the percentage survival rate of coral transplantation can be seen in Figure 2 below.

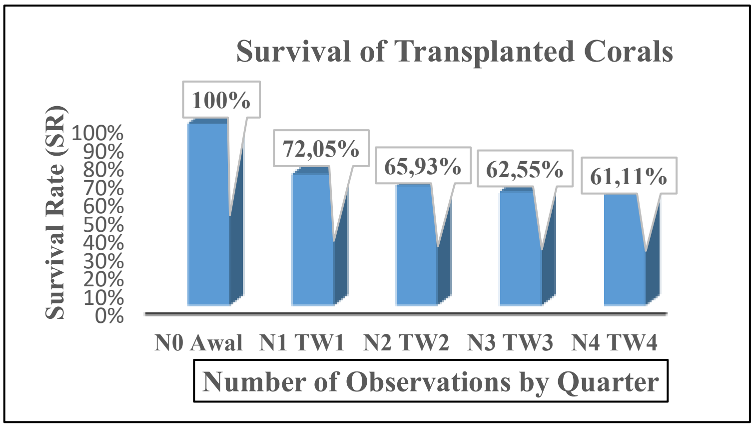

Figure 2. Graph of Percentage of Survival of Transplanted Corals

Transplanted Coral Growth Rate

Coral growth rate is calculated by dividing the difference in coral length from the beginning to the end of the study by the duration of the study. Monitoring of the transplanted coral growth rate begins in the first or second week and is carried out monthly or as needed (Harianti, 2013). After observing the transplanted coral, the growth rate can be seen in Table 2 below.

Based on the growth rate calculations described in the table above, the increase in height in the first quarter was 1.61 cm, in the second quarter 1.80 cm, in the third quarter 3.45 cm, and in the fourth quarter 3.77 cm. This results in an average monthly growth rate of 0.88 cm.

Table 3. Transplanted Coral Growth Rate

Growth Rate of Transplanted Coral					
Average Initial Height (L0)	Average Height (L3-T1)	Average Height (L6-T2)	Average Height (L9-T3)	Average Height (L12-T4)	Absolute Growth (βL)
7,09 cm	8,70 cm	10,50 cm	13,95 cm	17,72 cm	10,63 cm

The graph below shows a significant increase in coral fragment height in the third and fourth quarters, from the usual 0.4–0.6 cm per month to 1–1.3 cm per month. This is due to the coral fragments adapting to their new environment. If this surge continues in the following months, it is possible that transplanted corals could achieve 100% coverage using the Underwater Phototransect method.

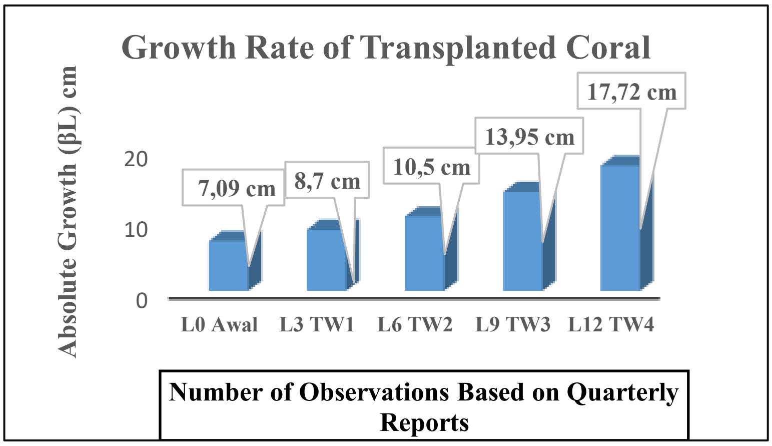

Figure 3. Graph of Transplanted Coral Growth Rate

DISCUSSION

Causes of Coral Reef Degradation

The survival of coral reefs is influenced by surrounding environmental conditions, patterns of changes in ocean water circulation, increases in sea surface temperature, or significant changes in aquatic parameters that can inhibit coral growth and even damage reef structures. Natural factors or oceanographic conditions of the waters as causes of coral damage include an increase in global temperature as a response to Pacific El Niño, which can lead to coral bleaching (Sagala *et al*., 2024). Coral reef degradation is also largely caused by human activities, such as the risk and severity of sedimentation in waters, as well as impacts resulting from ship collisions (Sagala *et al*., 2024).

Geographically, Indonesia is located between the Indian Ocean and the Pacific Ocean, which forms a circulation of water masses. Warm water masses from the Pacific Ocean move toward the cooler Indian Ocean through Indonesian waters, influencing climate and weather patterns in this region. This condition can affect the survival rate of coral reefs; based on monitoring results, the highest mortality rate ranged from 1.44% to 27.05% during the west monsoon season (October–March), resulting in coral bleaching. According to M. Muhaemin *et al*. (2022), the ocean water mass circulation system, known as the Indonesian Throughflow (ITF), occurs because sea level in the Pacific Ocean is higher than in the Indian Ocean. This creates a pressure gradient that causes the ITF to flow from the Pacific to the Indian Ocean through Indonesian waters, including the Makassar Strait. This process can result in vertical and horizontal variations in oceanographic parameters in the Makassar Strait.

Restoration Efforts

Coral reef restoration efforts are carried out as a form of concern in response to various potential sources of damage to coral reef ecosystems. Several coral reef restoration methods have different levels of difficulty and success. Restoration techniques are implemented according to the characteristics of the target area as well as the main problems or causes of degradation encountered (Bostrom-Einarson *et al*., 2020). Diverse coral reef restoration activities based on their objectives, techniques, and methods can be grouped into two categories, namely physical restoration and biological restoration (Sagala *et al*., 2024). Biological restoration efforts are carried out as an attempt to restore coral reef ecosystems through transplantation methods (spider media) and monitoring aimed at enhancing coral reef functions in improving ecosystem services, which can be beneficial on a socio-ecological scale. Based on research by Hein et al. (2020), it is stated that coral reef restoration processes, in addition to attempting to restore ecosystem conditions, can also increase the social value of communities and have impacts on community economies as well.

The coral transplantation process in ecosystem restoration efforts is carried out by considering benefits, recovery speed, and visual perspectives. In addition, restoration through transplantation must consider the source of coral seedlings to be used. Furthermore, to ensure the survival of transplanted corals, routine and continuous monitoring is required so that the success rate can be high. Monitoring activities are important to control the condition of coral fragments and planting media. To ensure success, ecological restoration monitoring uses two appropriate monitoring program stages, namely (1) the initial establishment phase after transplantation related to the biological response of transplants (early post-transplant growth, fragment attachment to substrate), and (2) the long-term development phase when transplants grow in size and provide environmental and socio-economic benefits with potentially broad impacts (Lagarense B *et al*., 2024).

Coral Transplantation

The coral transplantation process is conducted by considering the condition of surrounding coral reef ecosystems, particularly in selecting coral seedlings or juveniles. Based on identification results, the coral seedlings used for transplantation originated from the family Acroporidae, genus *Acropora*. Based on measurements of coral growth rates, a significant increase was observed, ranging from 0.4–0.6 cm/month to 1–1.3 cm/month. This illustrates the adaptation process of coral fragments to their environment, thereby allowing transplanted corals to exhibit 100% coral cover. Coral species that are ideal for transplantation are fast-growing reefs, stress-resistant, and have low mortality rates, namely Acropora spp. These coral types show higher growth rates and mortality compared to other massive corals. However, various variations in characteristics are used to analyze growth and mortality data, which are important to assess whether certain species are suitable for transplantation at specific locations (Afandi Saputra et al., 2021).

In addition, coral growth rates can also be influenced by water parameters, including sedimentation rates that impact coral seedlings by causing energy loss used solely for survival. According to Nurcahyani et al. (2018), coral growth can be influenced by environmental factors such as water clarity, depth, temperature, currents, salinity, and pH. Meanwhile, results from other studies conclude that many factors cause fluctuations in coral transplant growth rates; however, in some cases, the influence is shown to be due to changes in temperature and currents in the waters (Afandi Saputra *et al*., 2021).

Growth Rate of Coral Transplantation

Coral growth rates can be observed from monitoring and measurement results, revealing several conditions that can influence the growth rate of transplanted corals, including coral age, environmental conditions, sedimentation, temperature, water clarity, and depth. This is consistent with the explanation by S. M. Runtuwene (2020) that the growth of coral juveniles can be influenced by various environmental factors such as temperature, salinity, pH, clarity, and depth. Coral transplantation activities are considered successful when coral fragments experience significant growth. Water temperature (31°C) can influence the rate of coral metabolism and reproduction; constant temperatures can support growth, whereas temperature increases can threaten coral life. Sudden temperature changes in the range of 4–6°C can halt coral growth and reduce coral development (Kusumua et al., 2023).

Several factors influencing coral growth rates as described above include changes in water temperature patterns. However, aquatic environmental conditions and differences among coral species affect growth rates. Acropora sp., with a porous calcareous skeletal structure, has the ability to grow faster compared to other coral species (Haryanto et al., 2023).

Variations in coral transplant growth observed during each quarterly monitoring period indicate differences or increases in growth rates. This is due to the influence of weather conditions that hinder coral growth, such as turbidity that blocks the light required for the photosynthesis process of zooxanthellae present in corals (Rudiansyah et al., 2024).

Based on the results of several studies cited in Rudiansyah et al. (2024), it is explained that the growth rate of transplanted *Acropora* sp. corals falls within the range of 6.9 mm/month to 12.8 mm/month (Hamid *et al*., 2023). This is consistent with the monitoring results of this study, namely an average growth rate ranging from 1 to 1.3 cm/month. Differences in coral growth rates may occur due to differences in water characteristics and water quality parameters at transplantation sites. Each location has distinct habitat characteristics that influence coral growth, such as coral predators and water quality (Nurcahyani *et al*., 2018).

CONCLUSION

Based on the results of the study conducted on coral reef transplantation at Samalona Island, the survival of transplanted corals from the initial monitoring to the final monitoring period (January–December 2024) showed that coral seed mortality with the highest percentage occurred in the first quarter (January–March) at 27.05%, followed by the second quarter (April–June) at 8.12%, the third quarter (July–September) at 1.38%, and the fourth quarter (October–December) at 1.44%. Meanwhile, regarding growth rates, height increments were recorded in the first quarter at 1.61 cm, the second quarter at 1.80 cm, the third quarter at 3.45 cm, and the fourth quarter at 3.77 cm. Thus, the average monthly growth rate obtained was 0.88 cm. The results showed a very significant increase occurring in the third and fourth quarters, with a sharp increase in coral fragment height from the usual range of 0.4–0.6 cm/month to 1–1.3 cm/month, which was attributed to coral fragments that had adapted to their new environment.

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