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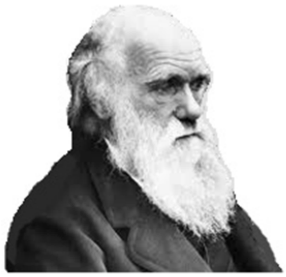

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Success Rate of Mangrove Planting based on Mangrove Morphology at Pramuka Island, Kepulauan Seribu National Park, Indonesia

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ABSTRACT

Planting mangroves on Pramuka Island is done in a monoculture way and usually fails. However, the planting managed by the Kepulauan Seribu National Park has become more successful. The specific objective of the research was to quantify the success rate of mangrove planting in Pramuka Island based on survival, growth and benthos levels in Pramuka Island mangroves. The mangrove planting area that was used as the research sample was an area wherein the planting are 14, 12 and 6 years old. The type of mangrove that planted is *Rhizophora stylosa*. The number of plots was determined based on the area. Data was collected in the form of primary data, namely, the number of living trees, tree heights, number of leaves and leaf dimensions. The success of mangrove planting reached 52%, 66.43% and 57.5% at stations 1, 2 and 3. The highest success rate was at station 2, while stations 1 and 3 are considered failures. This indicates that Pramuka Island has a low success rate of mangrove planting.

***Keywords*:** success rate, mangrove, growth, Pramuka Island, Kepulauan Seribu National Park, *Rhizophora stylosa*

1. INTRODUCTION

Mangrove forests are unique plant biotypes that are restricted to areas with harsh conditions i.e., intertidal areas of lagoons, estuaries and sheltered bays in tropical and sub-tropical areas worldwide.[1] They are capable of growing under extreme environmental conditions such as high and changing salinity, frequent tidal inundation with associated sediment hypoxia, low air humidity and high temperatures, as well as strong variations

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therein[2]. Mangrove forest is one of the world's unique natural ecosystems with high ecological and economic value and high productivity due to decomposition of litter (the so-called detritus). Mangrove forests make a major contribution to organic detritus which is very important as an energy source for biota that lives in the surrounding waters.

The importance of mangrove forest has been recognized, thus mangrove planting activities are carried out. The Kepulauan Seribu National Park Office is often involved in restoring mangrove ecosystems. One that they are rebuilding is on Pramuka Island. The main purpose of planting mangrove is to prevent ablation. Therefore, with climate change, mangrove conservation and restoration has become a priority.[2] Pramuka Island has a coral sand substrate and no mud flow (low nutrient), there is extensive wave and intertidal activity and shallow sea conditions.

In 2003, the Head of the Kepulauan Seribu National Park Office began planting mangroves in a spaced clump system on Pramuka Island. This approach was deemed successful in 2004-2006. The clump system has a spacing of planting clump per one meter, one cluster contains 550 stems with a length of 50 stems and a width of 11 stems. This done as a monoculture, using the species *Rhizophora stylosa* Griff (Photo 1).

Photo 1. *Rhizophora stylosa* Griff

The rhizophora inhabits the intermediate beach zone that encounters sedimentation. The genus Rhizophora is the most common mangrove genus worldwide.[3] Unfortunately, planting on Pramuka Island was often found to be a failure. Based on the evaluation and results of planting mangroves in Pramuka Island, a follow-up should be carried out in the form of research on the success rate of planting mangroves quantitatively with the percentage of survival, mangrove growth and benthos associated with mangroves. This research is expected to be an important note for the Ministry of Maritime Affairs and Fisheries so as to develop a more strategically integrated management approach.

2. MATERIALS AND METHODS

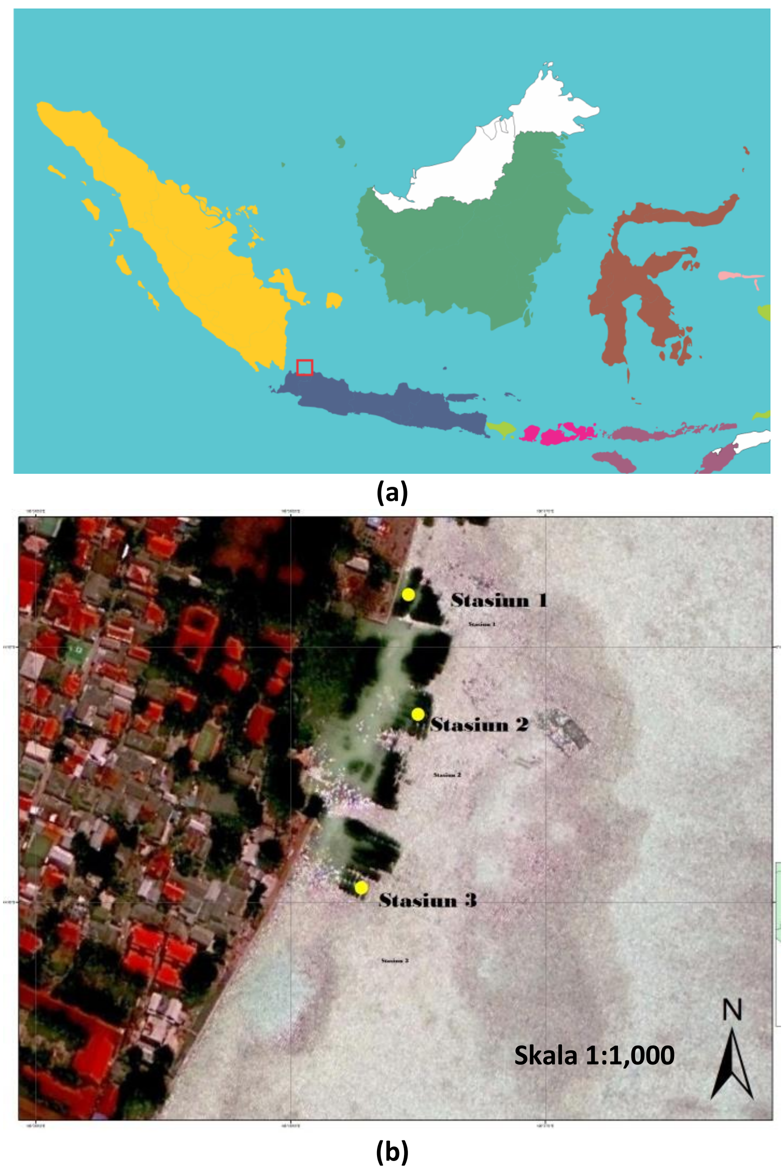

Figure 1. (a) Indonesian Map, (b) Research Map

Research was conducted from January to March 2019, on Pramuka Island, Kepulauan Seribu, Jakarta (Figure 1). Seribu Islands National Park has an area of 107,489 hectares, and is a marine conservation area to the highest tide limit, at, geographically, between 5° 24'-5° 45

'LS and 106° 25'-106° 40' BT. It includes the region of land called West Penjaliran Island and East Penjaliran Island. These cover an area of 39.50 hectares. Pramuka Island is an administrative island located in the Kepulauan Seribu and is within the Panggang Island District, District South Thousand Islands, Thousand Islands Administrative District, Province DKI Jakarta. The time needed to get to Pramuka Island is approximately 4 hours by wooden boat or 90 minutes by using a speed boat from Muara Angke.

Pramuka Island is the center of government of the Administrative District of Kepulauan Seribu and is included in the Taman Nasional Kepulauan Seribu (TNKpS). Based on the Director General's Decree on Forest Protection and Nature Conservation Department of Forestry Number SK.05 / IV-KK / 2004 dated January 27, 2004 concerning Zoning of the Management of Taman Nasional Kepulauan Seribu, Pramuka Island is in the National Park Zone (17.121 Hectares), which is located geographically 5° 38'00 "-5° 45'00" LS and 106° 33'00"-106° 40'00" BT. Benthos sampling, benthos identification, measurement of mangrove size, sediment sampling and water quality measurements were conducted at Pramuka Island, Kepulauan Seribu. Laboratory analysis was carried out at the Laboratory of Soil Fertility and Plant Nutrition of the Faculty of Agriculture, Padjadjaran University, to determine the content of 3 fractions and levels of Organic Carbon, Nitrogen and Phosphate, while benthic identification was carried out at the Padjadjaran University Natural Resources Research and Development Laboratory (PPSDAL).

The method that was used in this research is the *purposive sampling method*. Stations are determined based on the distribution of mangrove plantations and their location. The measurement of mangrove samples was carried out at 3 stations with the same type of mangrove, *Rhizophora stylosa*. Sampling intensity for mangrove characteristics is 10% of total planting area[4]: station 1 - 1 plot, station 2 - 4 plots and station 3 - 1 plot.

Number of Plot at station 1:

$$\frac{area\ x\ sampling\ intensity}{plot\ area} = \frac{294{,}18\ m^2\ x\ 10\%}{10\ x\ 10} = \mathbf{0{,}29\ plot}$$

Number of Plot at station 2:

$$\frac{area\ x\ sampling\ intensity}{plot\ area} = \frac{1034{,}64\ m^2\ x\ 10\%}{5\ x\ 5} = \mathbf{4{,}1\ plot}$$

Number of Plot at astation 3:

$$\frac{area\ x\ sampling\ intensity}{plot\ area} = \frac{262{,}81\ m^2\ x\ 10\%}{5\ x\ 5} = \mathbf{1{,}05\ plot}$$

3. THE RESULTS

3. 1. Water Quality

The measurement results of physical and chemical parameters indicate that the condition of the waters in each station is relatively the same. The waters of the mangrove ecosystem in

Pramuka Island have temperatures ranging from 27.3 to 32.7 °C, DO ranges from 6.1 to 8.1 mg/l, salinity ranges from 30-31 ppt, pH ranges from 6.62 to 8.86 and flow is between 0.1-0.3 m/s (Table 1).

Table 1. Water Quality Data.

Parameter	Station 1	Station 2	Station 3	Optimum	Referensi
Temperature (°C)	27,3 - 30,8	29,2 - 31,9	29,6 - 32,7	26-28	[6]
DO (mg/L)	6,9 - 8,1	6,3 - 7,3	6,1 - 7,3	4,5-9	[6]
Salinity (ppt)	30	30	30-31	10-30	[7]
pH	6,62 - 8,54	6,67 - 8,67	6,97 - 8,86	6,5-8,5	[7]
Flow (m/s)	0,1	0,1 - 0,2	0,2 - 0,3	<0,1	[8]

Temperature

Affandi and Tang (2002) state that the optimum temperature for the growth of *R. stylosa* is 26-28 °C, while high temperatures will cause disruption of growth in mangroves (such as disruption of plant metabolism) and eventually lead to low productivity or growth rates.[9]

Based on the results of measurements, the value of water temperature in each station is not optimal to support mangrove growth. The most optimal temperature value is at station 1 which is 27.3-30.8 °C (Table 1). The temperature at stations 2 and 3 is higher than station 1. This is probably because mangrove cover at stations 2 and 3 is not as wide and thick as at station 1. Station 1 is also surrounded by other trees so it affects the intensity of the light entering the waters. However, the water temperature in the mangrove ecosystem on Pramuka Island is still relatively natural, although it is not in an ideal condition for mangrove growth. Our results approximate those of Reynhard et al. (2014), in which the water temperature for mangrove growth, especially *Rhizopora*, ranged from 27.5- 28.5 °C [6] .

Dissolved Oxygen

The DO value measured at each station is the optimum value for mangrove growth. The dissolved oxygen value under normal conditions is 4.5-9 mg / l.[6] However, there is a difference in DO values at each station, the highest DO value is at station 1 which is in the range of 6.9-1.11 mg / L and the lowest DO value is at station 3 which is in the range 6.1-7.3 mg / L (Table 1). The high DO value is caused by station 1 having the lowest temperature. A decreased temperature will affect the increase in DO values. In addition, the high value of DO at station 1 can also be because station 1 is surrounded by other mangrove trees so more oxygen is put into the water. The low DO value at station 3 is due to it having the highest temperature. High temperatures will produce low DO values.

Salinity

The water salinity that was measured at the study site has relatively the same value, which ranges from 30-31 ‰ for all stations (Table 1). The salinity value is optimal for mangrove growth. The same salinity value comes about because all three stations are exposed to sea water at the same time. Mangroves grow in the zone of freshwater/salt water boundary and encounter seawater at the time of submerged tides. The salinity also ranges from 10-30 ppt.[7] Our results are similar to those of Aksornkoae (1993) who concluded that mangroves live and grow within a salinity range of 10-30 ppt.[10] At station 3, the salinity value is slightly higher, however, this can be tolerated as, according to Irwanto (2006), *Rhizopora* sp is a type of mangrove (tropical plant) that is *euryhaline* or tolerant of salt.[11].

Degree Acid (pH)

The results of pH measurements indicate that at each station, the optimum value for mangrove growth exists. The highest pH value is found at station 3, which is 6.97-8.86 and the lowest value is at station 1 which is 6.62-8.54 (Table 1). The pH value at station 3 is likely due the substrate at station 3 being of coral fragments. Thus, more carbonate ions are contributed than at the other two stations.[7] Over all, the measured pH value is still fairly normal and productive for mangrove growth.

Flow

The current velocity in the mangrove ecosystem of Pramuka Island ranges between 0.1-0.3 m/s. This current velocity is not an ideal or optimum current for mangrove growth. The current velocity in the range of 0.1-0.3 m/s includes a speed that is not good for the sedimentation process and nutrient deposition because it is can cause scour and carry away suspended particles[8]. The lowest current velocity is at station 1 which is 0.1 m/s, while the highest current velocity is at station 3 which is 0.3 m/s. This is because at station 3, the mangrove ecosystem directly faces the sea, while at station 1 it does not. At station 1, the existing mangrove ecosystem is quite extensive so seawater entrance is not too large. At station 2, the mangrove ecosystem also directly faces the sea, but station 2 is a transition zone and the front of the mangrove is blocked by seagrass species *Enhalus* sp. The current velocity at station 2 and station 3 (especially) is likely to hit the newly planted mangrove and reduce the survival rate and chances to become established.

3. 2. Sediment Quality

Sediment characteristics within Pramuka Island's mangrove ecosystem are listed in the following Table 2.

3. 2. 1. Sediment Characteristic

Based on the analysis using the Sheppard triangle, the type of sediment in the mangrove ecosystem of Pramuka Island is clay sand with soil pH at stations 1, 2 and 3, respectively, at 6.74, 7.32 and 7.45 (Table 2). Soil pH with a range of values between 6-7 is a pH that is suitable for mangrove growth.[12] The sediment at station 1 consists of 83% sand, 13% dust and 4% clay; station 2 consists of 81% sand, 15% dust and 4% clay and station 3 consists of 83.5% sand, 13% dust and 3.5% clay.[13]

Table 2. Sediment Quality of Mangrove in Pramuka Island.

No	Parameter	Station		
		1	2	3
1	pH	6.74	7.32	7.45
2	Sand	83%	81%	83.5%
3	Dust	13%	15%	13%
4	Clay	4%	4%	3.5%
5	Sediment Type	Clay sand	Clay sand	Clay sand
6	C-Organik	0.32%	0.45%	0.22%
7	N-Total	0.04%	0.06%	0.02%
8	C/N Ratio	8	7.5	8
9	P	2.94 ppm	8.69 ppm	7.77 ppm

3. 2. 2. Organic C-Content in Sediments

The value of % organic C at each station does not vary, and is classified as very low (Table 2). Station 1 has a percentage of C-organic value of 0.32%; that for station 2 is 0.45% and that of station 3 is 0.22%. In our research, the highest percentage of organic C was found at station 2 and the lowest, at station 3. The percentage at station 2 is higher because *serasah* (leaves and twigs) contribute to the detritus layer, so decomposition activities are stronger.

3. 2. 3. N-total content in Sediments

Our research indicates that the percentage of total N at each station is very low. Station 1 has a total N-value of 0.04%; station 2 of 0.06% and station 3 of 0.02% (Table 2). The low total N-content in this sediment is due to the influence of the type of sediment, which is clay sand. Station 2 is probably affected by a local discharge channel for domestic waste.

3. 2. 4. C/N *Ratio*

The obtained C / N ratio are station 1 - 8, station 2 - 7.5, and station 3 - 8 (Table 2). Based on the research of Darmadi (2012), a low C / N ratio can arise due to organic material being completely decomposed,[14] while, a larger C / N ratio indicates that organic material has not been completely decomposed.[15] In addition, a high C / N ratio indicates that the found organic material originates from the mangrove itself, while a low C / N ratio of organic material reveals that the nitrogen is sourced elsewhere, i.e. sewage discharge.[16]

3. 2. 5. P content in sediments

The P-values available at stations 1, 2 and 3, respectively, are 2.94 ppm with very low criteria, 8.69 ppm and 7.77 ppm with low criteria (Table 2). We think that the low P value (P_{2O5} $_{<10}$) is due to the type of sediment present in the mangrove forests of Pramuka Island. Low phosphate values can be the result of excessive organic matter, or because of acidity values. A low P content can inhibit mangrove growth.[17]

3. 3. Mangrove Characteristics

Mangrove survival rate, diameter and height growth are presented in the following Table 3.

Table 3. Growth of Mangrove.

No	Parameter	Station			Optimum	References
		1	2	3		
1	*Survival rate*	52%	66.43%	57.5%	60%	[18]
2	Growth of Stem Diameter	0,063-0,097 cm/month	0,012-0,029 cm/month	0,023-0,032 cm/month	0,075-0,125 cm/month	[19]
3	Growth of length	3,46-4,26 cm/month	2,26-3,01 cm/month	2,01-3,65 cm/month	2,06-2,47 cm/month	[19]

3. 3. 1. The Success Rate of Mangrove

With regard to percentage of survival of *R. stylosa* on Pramuka Island, the highest percentage value is at station 2 and the lowest is at station 1 (Figure 2). Station 1 has 29 living clusters, station 2 has 93 clusters and station 3 has 46 clusters. This is because station 2 has a superior water characteristic value and better optimal nutrient content compared to the other two stations. Mangrove planting can be successful if it reaches a value of 60%.[18] Therefore, it can be concluded that the survival rate of mangroves on Pramuka Island is still relatively low. The most successful mangrove planting effort in Pramuka Island is at station 2, with a percentage of mangrove survival of 66.43%.

The low success rate is due to the salinity, current and pH of local waters. Of these, the currents are the main contributor. Sediment characteristics and available organic ingredients also affect mangrove growth. Rhizophora on land that is not inundated, compared with flooded soil, shows significant difference, this condition indicates that the puddle factor has an impact on the survival of plants.[25] Waterlogged land conditions will push the low availability of oxygen (hypoxia), because the soil pores are filled with water, hence less oxygen is available to the root tissues.[26][27] Still, the aerial system of Rhizophora has good adaptation abilities [28]. This mangrove *aerenchyma* allows entry of O_2 and enables diffusion within the submerged roots.[29] This adaptation facilitates the maintenance of growth of shoots during the period of inundation.[30]

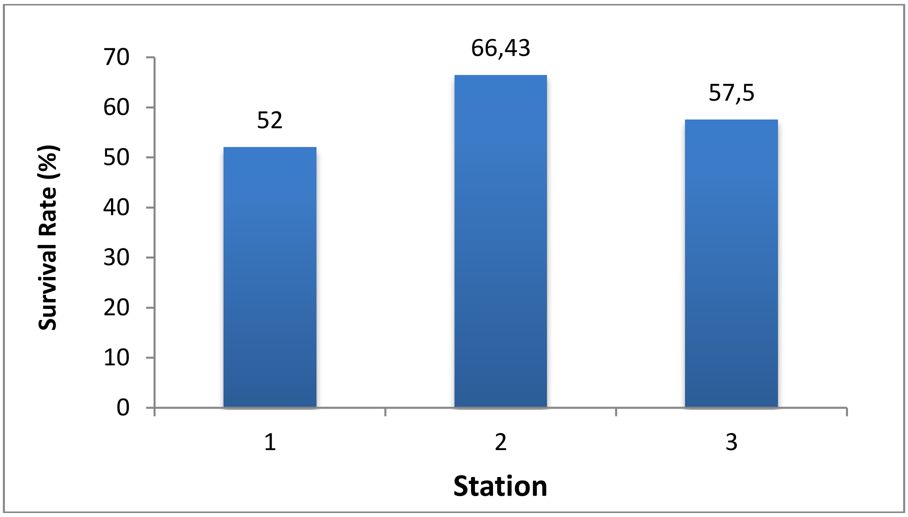

Figure 2. Survival rate of *Rhizophora stylosa*

3. 3. 2. Growth Rate of Mangrove

Length, Stem Diameter and Number of Leaves

The mangrove forests at station 1, 2 and 3 are of different ages. *R. stylosa* at station 1 was 14 years old, station 2 was 12 years old and station 3 was 6 years old. The height of *R. stylosa* at the beginning of planting is 30-40 cm with stem diameters of 0.3-0.5 cm. The number of leaves at the time of planting is 2-4 strands. The measurement results of *R. stylosa* in Pramuka Island show that growth at station 1 was better than that at stations 2 and 3. The biggest factor that influences growth is low sediment nutrient content. In addition, the climate can also affect the growth of *R. stylosa*.[19] Climate factors that become a major role in growth are number of seasons that will limit growth and generate changes in physical factors (substrate and water). The local climate influences mangrove growth through light, rainfall, temperature and wind.[20] According to the measurement results, the growth of *R. stylosa* per month was 2.06-2.47 cm[21] and growth was highest at station 1 and lowest at station 3 (Table 3). This is probably due to differences in the content of organic C, as well as differences in N. At station 1, organic C and N was higher than at station 3.[22]

The stem growth diameter was highest at station 1 and lowest at station 2 (Table 3). According to Gorat (2010), the growth in stem diameter of *R. stylosa* per month in our geographic region is normally 0.075-0.125 cm.[21] The measurements results of stem diameter indicate that station 1 experienced growth in accordance with the Gorat study (2010), while stations 2 and 3 had very slow growth in stem diameter. This is also due to a mismatch of planting conditions, especially the types of sediments and nutrients contained in them. The more fertile the place, the better the growth - as indicated by the size of the tree.[23]

Based on the calculation of the number of leaves, station 2 had the highest number of leaves per clump at 12 years old (9884 - 15875 leaves per clump), and station 3, where the mangroves are 6 years old, had the least number of leaves - 1890 - 3658 pieces per clump. Station 1, where the mangrove is 14 years old and has entered the tree phase, shows 4472 - 6004 leaflets per clump. The small number of leaves at station 1 is probably due to poor nutrient content availability. In nutrient deficient situations, trees produce fewer leaves and will reduce photosynthetic activity.[24]

3. 4. Relation of Nutrient Content and Leaves Number

The correlation between number of leaves and nutrients differs (Table 4). The correlation between number of leaves and organic C-content is 0.98 and shows a positive result. The number of leaves and c-organic has a very strong correlation because the value is with the range $0.8 \leq r \leq 1$. The positive value indicates that the higher the value of organic C, the more the number of leaves. The correlation between number of leaves with N-total also has a strong relationship with a value of 0.97 and shows a positive result. This is because C and N are macro elements that are very necessary for tree growth. These elements play an important role in plant cell development.

The correlation between the number of leaves and P-available has the opposite value and is equal to 0.38. This means that the correlation is low. It can be concluded that the available P-content in sediments does not significantly affect the growth of mangroves on Pramuka Island. The correlation value between the number of leaves and C/N *Ratio* has a very strong but negative value. Increasing the number of leaves will not engender an increase in the C/N *Ratio*.

Table 4. Correlation of Nutrient and Leaves Number.

Parameter	**C**	**N**	**P**	**C/N *Ratio***	**Sediment**
Leaves Number	0,98	0,97	0,38	-0,96	Sand Clay

4. CONCLUSIONS

The results showed that planting *R. stylosa* on Pramuka Island was successful at station 2 with a survival percentage of 66.43%, while that at station 1 and station 3 failed (52% and 57.5%, respectively). On average, at all three stations, *R. stylosa* has a high growth starting from 2.01-4.26 cm per month, growth of stem diameter 0.012-0.097 cm per month, number of leaves per clump as much as 3658-15875 strands, with leaf lengths 2.4-9.7 cm and width leaves from 4.2 to 6.3 cm.

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