Enhancing Mangrove Resilience: Assessing *Rhizophora sp.* Survival in Davao Occidental's Conservation and Rehabilitation Zones, Philippines

ABSTRACT

Three distinct sampling locations within Davao Occidental, namely Brgy. Sto. Rosario in Sta. Maria municipality, Sitio Tawang in Brgy. Buhangin, and Sitio Agdao in Brgy. Tubalan in Malita municipality were investigated to evaluate the survival of planted mangroves (*Rhizophora sp.).* The study revealed a notable discrepancy in survival rates among the sites, with Sitio Agdao exhibiting the highest survival with 97.58%, followed by Sto. Rosario (91.84%), and Sitio Tawang registering 70.46% survival rate. No significant variance was observed between survival rates in Sta. Maria and Malita. Findings indicated diverse causes of mangrove mortality, including strong waves during northeasterly winds impacting Sto. Rosario, flashfloods affecting Sitio Tawang, and the presence of epiphytes (specifically barnacles) in Sitio Agdao. Among the sites, Sitio Tawang exhibited significantly lowest survival rates compared to Sto. Rosario and Sitio Agdao. Substrate analysis revealed clay loam in Sto. Rosario, sandy loam in Sitio Agdao, and sandy clay in Sitio Tawang. The study recommends extending mangrove survival rate monitoring to other conservation and rehabilitation areas, continuing mangrove rehabilitation efforts, and manually removing epiphytes to enhance survival rates.

Keywords: Mangrove Resilience, Rehabilitation and Conservation Areas, Survival Rate

1. INTRODUCTION

Mangrove ecosystems offer a diverse array of resources, including timber, fuelwood, charcoal, construction materials, and serve as vital nursery habitats for numerous aquatic species such as shrimps, mudcrabs, fish, and molluscs (Calumpong& Menez, 1997) and a host to some epiphytic plants (Pacyao *et. al.,* 2022; Pacyao and Marquez, 2022). Pacyao and Macadog (2018) documented the presence of 15 aquatic species exhibiting secondary productivity within mangrove rehabilitation sites, with the majority falling under the phyla Arthropoda, Mollusca, Echinodermata, and Chordata. The provisioning of such resources underscores the significance of mangroves in sustaining human livelihoods, ranging from the collection of fuelwood to support fisheries activities. Indeed, the continued existence of coastal areas inhabited by mangroves relies heavily on the varied goods and services provided by these ecosystems (Walton *et al.,* 2007).

Despite efforts to mitigate its decline, alarming recorded data from the Philippines illustrates ongoing depletion of the mangrove ecosystem due to various human anthropogenic activities (Pacyao&Llameg, 2018; Pacyao&Barail, 2020). By the early 1990s, Philippine mangroves had diminished to just over 120,000 hectares from an initial estimate of nearly

500,000 hectares (Calumpong& Menez, 1997). Contributing negative anthropogenic factors include the grazing of astray animals, improper waste disposal, and the conversion of mangrove areas into fish ponds or reclaimed land (Pacyao&Barail, 2020; Pacyao&Llameg, 2018).

Given the ecological and economic significance of mangroves, as well as the challenges they pose to humanity, numerous public and private organizations and institutions are directing funds and resources towards mangrove rehabilitation efforts in coastal regions. The Southern Philippines Agri-Business and Marine and Aquatic School of Technology (SPAMAST) has established collaborative partnerships with Local Government Units (LGUs) and People's Organizations (POs) to sustain prior initiatives led by the Bureau of Fisheries and Aquatic Resources (BFAR), Department of Environment and Natural Resources (DENR), and other relevant agencies for mangrove rehabilitation and conservation. In 2022, despite limited resources, SPAMAST successfully planted nearly 5,000 mangroves across two municipalities, Malita and Sta. Maria. The chosen species for these endeavors was *Rhizophora sp.*, selected for its local abundance and endemic nature.

With this, this research aimed to evaluate the survival rate of *Rhizophora sp.* mangroves planted within the conservation and rehabilitation zones of Sta. Maria and Malita, Davao Occidental. Specifically, the objectives were to: (1) Identify the project site with the highest survival rate; (2) Investigate potential factors contributing to mangrove mortality; (3) Characterize the substrate types in the study areas; and (4) Document the planting techniques utilized by the project partners.

2. MATERIAL AND METHODS

2.1 Study Areas

The study was conducted in the identified mangrove rehabilitation sites of Davao Occidental, particularly Sto. Rosario in the municipality of Sta. Maria, and in Sitio Tawang, Brgy. Buhangin and Sitio Agdao of Brgy. Tubalan of Malita, Davao Occidental, Philippines.

2.2 Field Sampling Design and Frequency

This study employed one shot sampling on the specified plot that were established in the study area. Samplings were done during low tide. Using a transect tape, a 10m X 10m sampling plot was established in the three sampling sites (Pacyao and Llameg, 2018; Primavera *et. al.,* 2004). There were five quadrats per sampling stations. The 5 quadrats serves as replicates.The duration of the study was conducted last November to December 2023.

2.3 Substrate Characterization

Substrate characterization was done following Feel Method (Thein, 1979). Soil samples were squeezed by hand while noting down the texture of the sample. Soils of the sampling stations were categorized into sandy clay, sandy loam, and clay loam.

2.4Data Gathering Procedure

A structured questionnaire was utilized during interviews conducted to local settlers (those who are directly involved in the mangrove planting) living near the mangrove rehabilitation and conservation areas. Questions include asking them on the planting techniques and practices employed and the possible causes of mangrove mortality. The questionnaire was presented in local dialect to facilitate easy understanding for the respondents

2.5Survival Rate

The survival rate was computed by counting the total numbers of mangroves planted within a 10m X 10m quadrat less the number of mortalities within that quadrat using the formula by (1) (Primaver*et al.,* 2004).

$$\text{Survival Rate (\%)} = \frac{No.of\ Mangroves\ at\ time\ (t)}{Total\ No.of\ Mangrove\ Planted} X\ 100 \quad (1)$$

2.6Statistical Tools and Analysis

To compare differences in survival rates between Sta. Maria and Malita, T-test was used. The Analysis of variance was utilized in comparing survival rates of mangroves planted in Sto. Rosario, Tawang and Agdao. Tukey's test was futher used in ANOVA analysis showing significant difference.

3. RESULTS

3.1 Survival Rates for Mangroves Planted

Table 1 shows the comparison of the survival rates of the different sampling stations, namely: Sto. Rosario for Sta. Maria, Sitio Agdaofor Tubalan, and Sitio Tawang for Brgy. Buhangin.

Table 1. Summary Table for Survival Rates at different Sampling Stations

Sampling Stations	**Station**					**Total**	**Mean**
	1	**2**	**3**	**4**	**5**		
Sto. Rosario, Sta. Maria	98.52	98.50	98.47	96.57	67.14	459.2	91.84
Sitio Agdao, Brgy. Tubalan, Malita	97.29	98.97	98.04	96.45	97.16	487.91	97.58
Sitio Tawang, Brgy. Buhangin, Malita	65.31	55.34	74.07	84.29	73.28	352.29	70.46

Results showed that Sitio Agdao exhibited highest mean survival of 97.58% due to the area is located within the Tubalan cove where minimal waves and current occur. Other contributing factors to its high survival was the practiced of staking method during planting. This finding corroborates with the study of Pacyao and Llameg (2018) that staking prior to mangrove planting contributes is a factor for survivability of mangroves.

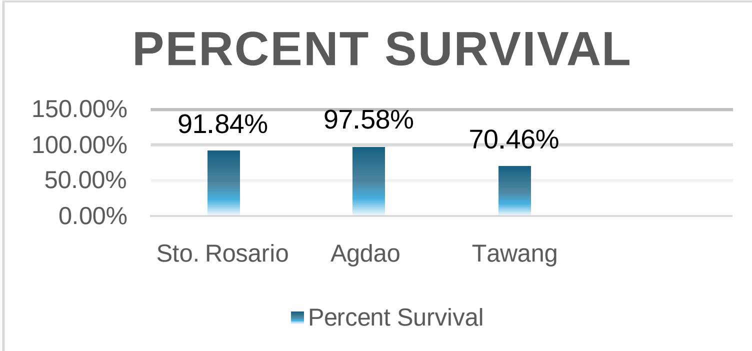

Figure 1. Mean Survival Rate for every area

The lowest survival was with Sitio Tawang with 70.46 because the area is prone to flooding according to the interview conducted to the local settlers (Figure 1). The area is also adjacent to the river that during heavy rains, flash flood can affect the newly planted mangroves. Jimenez and Lugo (1985) mentioned that severe environmental disturbances can inflict larger-scale mortality on mangrove forests. These disturbances include periodic flash floods, monsoon and other storms, which bring heavy sedimentation. Pacyao and Llameg (2018) also supported this finding that when the mangrove area is located in a seaward zone, a 13.71% survival rate is expected to happen due to direct exposure to winds and waves.

Plate 1. *Rhizophora sp.*

Choice of species of mangroves to be planted affects survival rate (Primavera and Esteban, 2008, as cited by Pacyao and Llameg, 2018). Result of this study revealed that *Rhizophora* species favoured clay loam soil type in the case of Sto. Rosario. Pacyao and Llameg (2018) recommended clay loam as an area for mangrove planting especially when using *Rhizophora* species.

3.2Substrate Characterization

Table 2 shows the different substrate types of the three sampling stations. Sto. Rosario has clay loam, Agdao with sandy loam, and Tawang with sandy clay. Altamirano *et al.,* (1980) stated that growth of mangrove is most extensive in the sandy loam and clay loam of deltas, lagoons, bays and estuaries, but they also survive in sandy, coralline (calcareous) and peat substrates.Pacyao and Llameg (2018) reported that sandy clay soil type is common in a tidal/mudflat area, as the case of Sitio Tawang. This substrate type is ideal for *Sonneratia or Avicceniaspecies* of mangrove.

Table 2. Substrate type per sampling station

Sampling Stations	Substrate Type
Sto. Rosario, Sta. Maria	Clay Loam
Sitio Agdao, Brgy. Tubalan, Malita	Sandy Loam
Sitio Tawang, Brgy. Buhangin, Malita	Sandy Clay

3.3Causes of Mangrove Mortality after Planting

The research interviews yielded unanimous responses from participants in Sto. Rosario, with 100% identifying significant wave activity and strong currents as predominant factors leading to heightened mortality rates. Conversely, in Sitios Agdao and Tawang, the majority of respondents, constituting 80%, emphasized the potential role of river flooding and the infestation of pests and diseases on mangrove propagules as plausible causes of mortality within their respective ecosystems.

These distinct findings underscore the localized variations in perceived threats to mangrove survival across different coastal communities (Pacyao and Barail, 2020). While Sto. Rosario residents pinpointed the formidable force of natural elements, such as waves and currents, as the primary concern, participants from Sitios Agdao and Tawang highlighted the multifaceted impact of environmental factors, including flooding and biotic stressors, on mangrove health and longevity. Such nuanced insights emphasize the importance of tailored conservation strategies that address specific challenges faced by individual mangrove habitats.

3.4Planting Techniques and Practices

The vast majority (84%) of respondents indicated that they primarily collected ripened mangrove propagules, particularly those that had fallen to the ground. Additionally, a smaller proportion (16%) mentioned climbing mangrove trees to gather propagules. This is a similar findings of Pacyao and Llameg (2018) that mangrove propagules can be picked and harvested by climbing the mangrove trees. Regarding planting locations, 79% of respondents stated that in mid-land areas unaffected by tidal fluctuations, staking methods were deemed unnecessary. However, in open areas such as intertidal zones, 21% emphasized the importance of employing staking methods during mangrove planting to enhance protection and prevent easy uprooting. Furthermore, all respondents unanimously agreed (100%) that if mangrove propagules were to be stored in a nursery, they should be stocked within a week or less to mitigate potential infestations of pests and diseases.

Concerning planting techniques, the predominant strategy employed by 84% of respondents involved digging a hole at least one-third of the height of the mangrove propagules, a recommendation also made by Pacyao and Llameg (2018) and Pacyao and Gencianeo (2018). In terms of mangrove monitoring, all respondents (100%) advocated for regular visitation and cleaning intervals ranging from one week to two months.

4. CONCLUSION

In conclusion, our investigation across three distinct sampling locations within Davao Occidental sheds light on the variability in mangrove survival rates and the factors influencing them. Sitio Agdao demonstrated the highest survival rate, Sto. Rosario followed closely behind, while Sitio Tawang exhibited notably lower survival rates. These differences underscore the importance of considering local environmental conditions and anthropogenic pressures when implementing mangrove conservation efforts. Furthermore, our findings highlight the need for continued monitoring and targeted interventions, such as manual removal of epiphytes, to enhance mangrove survival rates and promote ecosystem resilience in coastal areas.

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