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Determination of Dominant Mangrove Species and Comparison of Tree and Sapling Composition in The Mangrove Area of Sonsilo Village, West Likupang District, North Minahasa Regency

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ABSTRACT. Mangrove forests are key ecosystems in tropical coastal areas that function as environmental stability guards through physical roles (preventing erosion and tsunamis), chemical (absorbing pollutants and storing carbon), and biological (marine biota habitat and source of biodiversity). This study aims to identify the species and determine the dominant species of mangroves and the comparison of tree and sapling composition in the mangrove area of Sonsilo Village, West Likupang District, North Minahasa Regency. The research was conducted over three months (September–November 2024) using a *purposive sampling* method to collect data on density, canopy cover, and species frequency. The results revealed seven mangrove species: *A. marina, B. gymnorrhiza, C. tagal, R. apiculata, R. mucronata, S. alba*, and *X. granatum*. Among these, three species (*B. gymnorrhiza*, *R. apiculata*, and *R. mucronata*) were dominant at both tree and sapling levels, exhibiting the highest Importance Value Index (IVI). Mangrove species diversity in the area is categorized as low to moderate, as indicated by the Shannon-Wiener Diversity Index (H'), reflecting that species richness is not yet fully optimal. Analysis of the Dominance Index (D) and Evenness Index (J') suggests a relatively even distribution of individuals among species. The study recommends regular monitoring and evaluation, as well as conservation efforts, to maintain the stability of the mangrove ecosystem and support its sustainable use. These findings highlight the importance of biodiversity management in preserving the ecological balance of mangrove habitats.
Keywords: Sonsilo Village, mangroves, mangroves composition

INTRODUCTION

Mangrove forests are key ecosystems in tropical coastal areas that function as environmental stability guards through physical roles (preventing erosion and tsunamis), chemical (absorbing pollutants and storing carbon), and biological (marine biota habitat and source of biodiversity) (Rumondang *et al*., 2023; Suyantri *et al*., 2023). Globally, the world's mangrove area reaches 16.5 million hectares, 23% of which are in Indonesia, making this country the owner of the largest mangrove ecosystem in the world (Sirait *et al*., 2021). However, the rate of mangrove degradation in Indonesia reaches 52,000 ha per year, mainly due to land conversion for ponds, infrastructure, and tourism (KLHK, 2022). In North Sulawesi, similar pressures occur along with the determination of the Likupang coastal area as a National Tourism Super Priority Destination (DSP), which has the potential to threaten the sustainability of the mangrove ecosystem if not managed based on ecological data (Kemenparekraf, 2021).

Sonsilo Village, North Minahasa Regency, is one of the strategic locations for developing mangrove ecotourism, with an area of ± 50ha (Kemenparekraf, 2021). Despite its status as a buffer for the Likupang

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DSP, comprehensive studies on the structure of mangrove vegetation in this village are still limited. Information on the dominance of species, tree composition, and saplings (mangrove seedlings) is crucial for assessing ecosystem health and developing conservation strategies that align with tourism development (Aslan *et al*., 2020). For example, the dominance of particular species, such as Rhizophora apiculata, can reduce biodiversity. At the same time, an imbalance in the composition of trees and saplings indicates a disruption of natural regeneration (Valentino *et al*., 2023). Previous research in Sonsilo Village by Wijarnako & Rompah (2024) has identified the potential for Mirda Sonsilo mangrove ecotourism but has not touched on the structural aspects of vegetation.

Meanwhile, the study by Kepel *et al*. (2019) in North Sulawesi showed high mangrove carbon stocks (average 450 MgC/ha) but did not discuss its relationship with species composition. This creates a knowledge gap, especially regarding how tourism activities can affect vegetation structure and the ecological carrying capacity of the area. Based on this urgency, this study aims to determine the number of species, species dominance index, species evenness index, diversity index, and important value index. The study results are expected to be a scientific database for the government and tourism managers in formulating sustainable ecotourism development policies while maintaining the ecological function of mangroves as carbon absorbers and coastal protectors.

MATERIALS AND METHODS

Study Location

This research activity was carried out on the coast of Sonsilo Village, West Likupang District, North Minahasa Regency, North Sulawesi Province. The research location is divided into three stations, namely Station 1 (submerged all day) with a geographical position of 1°43'29.6"N 124°59'08.5"E, 1°43'29.3"N 124°59'08.9"E, 1°43'29.2"N 124°59'09.4"E, Station 2 (medium submerged) with a geographical position of 1°43'20.4"N 124°59'15.6"E, 1°43'19.6"N 124°59'16.0" E, 1°43'19.5"N 124°59'16.8"E, and Station 3 (rarely submerged) with a geographical position of 1°43'10.0"N 124°59'22.0"E, 1°43'10.0"N 124°59'22.0"E, 1°43'09.0"N 124°59'25.0"E (Figure 1). The area of mangroves in Sonsilo Village is 1,200 ha. The location of this study is in a bay area, which has muddy substrate characteristics and stable tidal conditions. The research period lasted for 3 months, namely from September - November 2024.

Methods

Data collection in this study was carried out using the purposive sampling method, namely sampling in research that is intentionally or based on specific considerations (Sugiyono, 2016). Determination of the research location was carried out by direct observation in the field based on the level of immersion at each station, namely Station 1 (seawater submerged all day), Station 2 (medium submerged sea water), and Station 3 (rarely submerged sea water). Furthermore, each

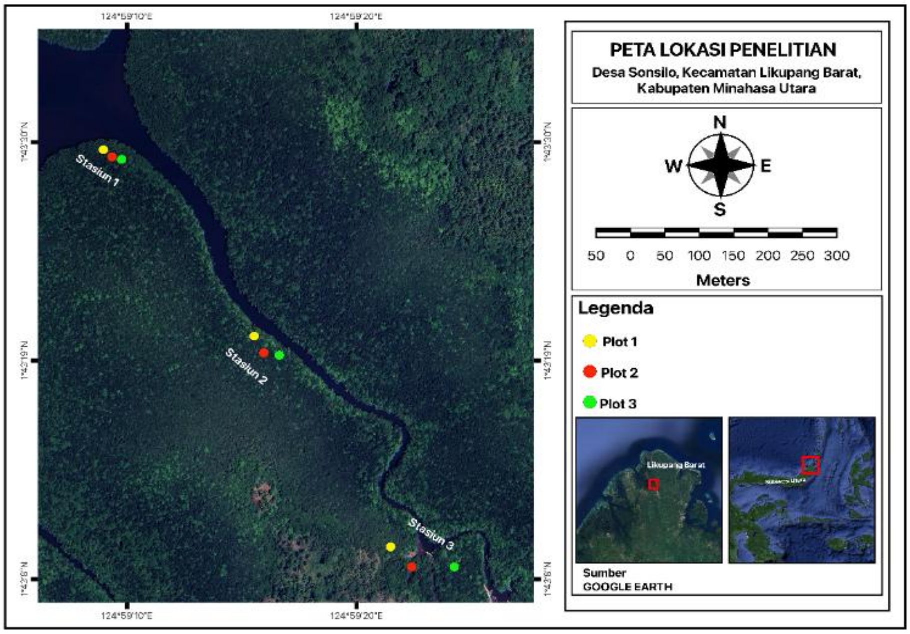

Figure 1. Search location map

station was randomly placed in 3 (three) plots (squares) measuring 10 x 10 m2, and this plot was used to analyze tree-level mangroves. In each plot, a sub-plot measuring 5 x 5 m2 was randomly placed to analyze sapling-level mangroves (saplings). Mangrove classification followed standard ecological criteria**,** where tree-level mangroves were defined as individuals with a diameter at breast height (DBH) ≥ 4 cm, while sapling-level mangroves were defined as individuals with DBH < 4 cm and height ≥ 1.5 m (Sukardjo, 1987; Dharmawan *et al*., 2020). Identification of each type of mangrove is seen from the roots, stems, leaves, and fruits using a guidebook from Noor *et al*. (2006), Djamaluddin (2018), and Sidik *et al*. (2018).

Data Analysis

Mangrove data analysis was conducted by analyzing species density (Di), species relative density (RDi), species frequency (Fi), species relative frequency (RFi), species coverage (Ci), species relative coverage (RCi), important value index (IVI) (Krebs, 1989). The Species Dominance Index, as described by Krebs (1989), measures the degree to which a specific species dominates an ecosystem. The Shannon-Wiener Diversity Index is a commonly used tool in ecology to assess the diversity of species within a community. Meanwhile, the Pielou Evenness Index (1966) evaluates how evenly individuals are spread across the various species in a particular area.

RESULTS AND DISCUSSIONS

Mangrove Species Composition

The composition of the growth categories of mangrove species at Station 1, Station 2, and Station 3 consists of trees and saplings. Table 4.1 shows the composition of the number of trees and saplings for each type of mangrove found at each station. Station 1 shows the total number of trees, 24 trees/m2, and the most dominant is *R. mucronata*; the total number of saplings is 11 trees/m2, and the dominant one is *R. apiculata*. Station 2 shows the total number of trees, 32 trees/m2, and the most dominant is *R. mucronata*; the total number of saplings is 13 trees/m2, and the most dominant is *R. mucronata*. Station 3 shows the total number of trees, 39 trees/m2; the dominant one is *B. gymnorrhiza*; the total number of saplings is 12 trees/m2, and the dominant one is *B. gymnorrhiza*.

The mangrove species composition across the three stations indicates a clear zonation pattern shaped by environmental gradients, particularly tidal inundation and substrate conditions. Stations 1 and 2 are characterized by assemblages dominated by species typically associated with seaward to middle mangrove zones, such as *Rhizophora mucronata* and *R. Apiculate* (Ismail *et al*. 2019; Raganas & Magcale-Macandog, 2020), which are commonly found in soft, muddy substrates with high inundation frequency. In contrast, the species composition at Station 3 includes taxa more characteristic of middle to landward zones, such as *Bruguiera gymnorrhiza*, suggesting comparatively reduced tidal influence and greater substrate stability. The presence of consistent species assemblages across growth stages further indicates that environmental conditions at each station support the establishment and maintenance of distinct mangrove communities, reflecting natural zonation processes rather than random species distribution.

Table 1. Composition of Trees and Saplings

No	Name	STATION 1 Growth Category		STATION 2 Growth Category		STATION 3 Growth Category	
		Trees (ind/300 m^2)	Saplings (ind/300 m^2)	Trees (ind/300 m^2)	Saplings (ind/300 m^2)	Trees (ind/300 m^2)	Saplings (ind/300 m^2)
1	*R. mucronata*	18	-	15	10	5	-
2	*R. apiculata*	6	11	9	2	4	1
3	*A. marina*	-	-	-	-	8	-
4	*B. gymnorrhiza*	-	-	3	-	10	10
5	*X. granatum*	-	-	1	-	8	1
6	*S. alba*	-	-	-	-	2	-
7	*C. tagal*	-	-	4	1	-	-
	Total	24	11	32	13	39	12

Mangrove Species Identification

The results of the study at 3 (three) stations showed that there were seven species of mangroves, namely *Avicennia marina*, *Bruguiera gymnorrhiza, Ceriops tagal, Rhizopora apiculata, Rhizopora mucronata, Sonneratia alba*, and *Xylocarpus granatum.* Marpaung *et al*. (2024), in their study in Sonsilo Village, found 8 species of mangroves, namely A*. marina, B. gymnorrhiza, C. tagal, N. fruticans, R. apiculata, R. sp., S. alba, and X. granatum*. Marpaung *et al*. (2024) found one type that was not found in this study, this is because the sampling locations in previous studies tended to be closer to residential areas marked by the *N. fruticans* type.

Density and Relative Density

The highest density of mangrove species was at Station 1, namely *R. mucronata* at the tree level of 600 trees/ha and *R. apiculata* at the sapling level of 366.67 trees/ha. The highest density of mangrove species was at Station 2, namely *R. mucronata*, at the tree level of 500 trees/ha and the sapling level of 333.333 trees/ha. The highest density of mangrove species was at Station 3, namely *B. gymnorrhiza*, at the tree level of 333.33 trees/ha and the sapling level of 333.33 trees/ha. Furthermore, the highest relative density of mangrove species was at Station 1, namely *R. mucronata* at the tree level of 75% and *R. apiculata* at the sapling level of 100%. The highest relative density of mangrove species was at Station 2, namely *R. mucronata*, at the tree level of 46.88% and the sapling level of 76.92%. The highest relative density of mangrove species at Station 3, namely *B. gymnorrhiza*, is at the tree level of 27.03% and the sapling level of 83.33% (Figures 2 and 3).

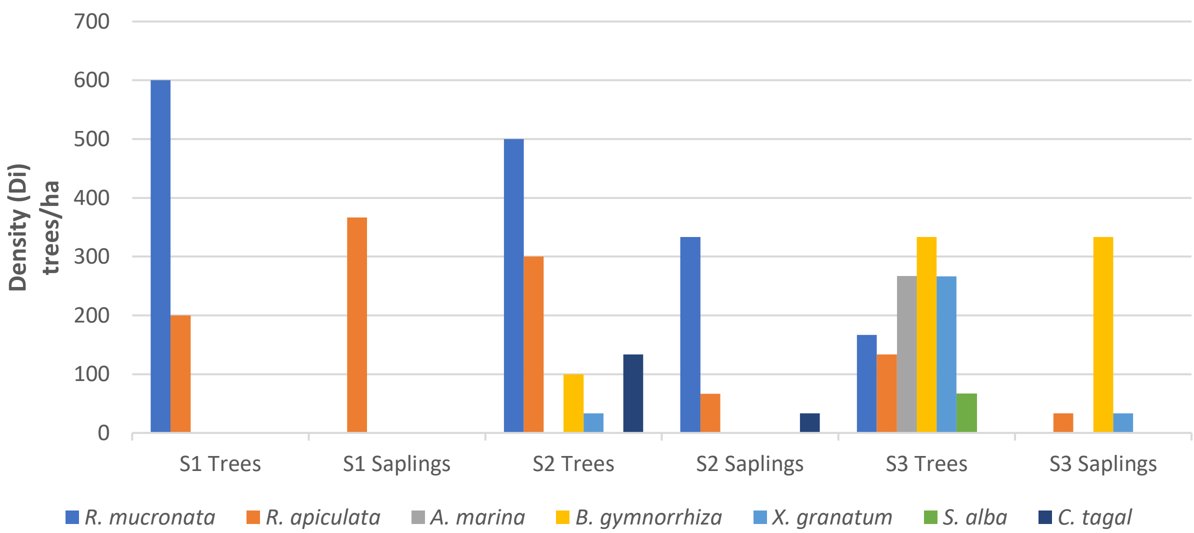

Figure 2. Density

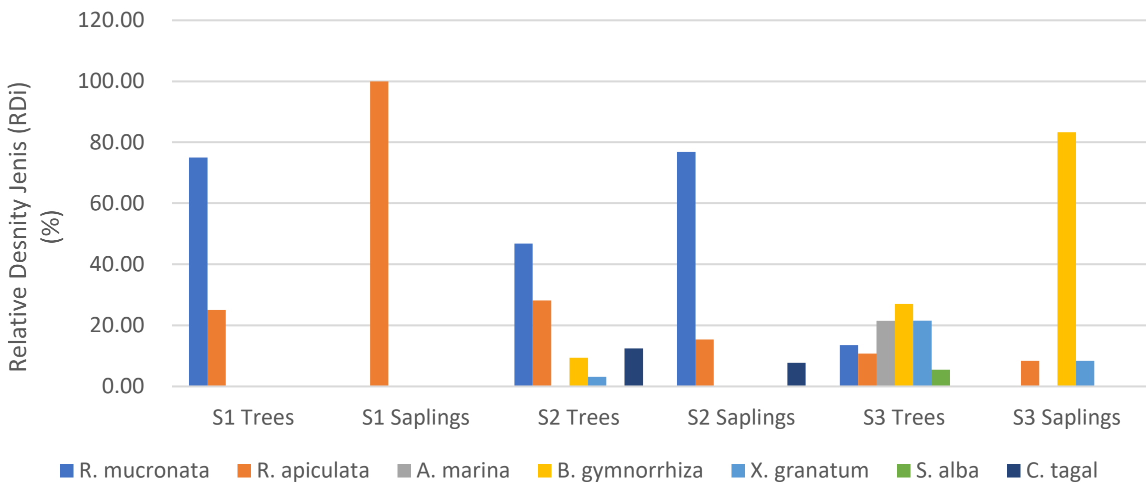

Figure 3. Relative density

Species density reflects the abundance of individuals within a given area, such that higher densities indicate more favorable conditions for establishment and persistence (Paruntu *et al*., 2017). In this study, differences in density and relative density among stations suggest variation in habitat suitability for different mangrove species. The high density and relative density of *Rhizophora mucronata* at the tree level in Stations 1 and 2 indicate that these areas provide environmental conditions conducive to the growth and survival of this species, likely related to muddy substrates and frequent tidal inundation. In contrast, the dominance of *Bruguiera gymnorrhiza* in both tree and sapling stages at Station 3 suggests comparatively more stable conditions with lower inundation frequency, which are more suitable for this species. Differences between this study and previous research likely reflect site-specific factors such as substrate type, tidal regime, salinity, and anthropogenic disturbance, all of which influence mangrove density and community structure (Tidore *et al*., 2021; Marpaung *et al*., 2024).

The presence or absence of saplings is critical for evaluating regeneration potential within mangrove stands (Raganas *et al*. 2020). Although *R. mucronata* shows high density at the tree level, its absence at the sapling level at Station 1 indicates limited regeneration, which may pose a risk to the long-term sustainability of this species at that site. Mangrove species differ in their tolerance to inundation and sediment conditions, leading to distinct spatial distributions across coastal gradients. Species of the genus *Rhizophora* generally occupy seaward zones with frequent inundation, whereas *Bruguiera* species are more commonly associated with middle to landward zones where conditions are relatively less dynamic (Srikanth *et al*., 2016; Arfan *et al*., 2024). The successful regeneration of *B. gymnorrhiza* at Station 3 suggests that local environmental conditions support both recruitment and establishment, while the lack of saplings of certain species at other stations highlights the importance of regeneration dynamics in shaping future mangrove community structure (Sreelekshmi *et al*., 2018).

Species Cover and Relative Species Cover

The highest mangrove species cover was at Station 1, namely *R. apiculata*, at a tree level of 426.99 m^2/ha and a sapling level of 124.70 m^2/ha. The highest mangrove species cover was at Station 2, namely *X. granatum* at the tree level of 143.43 m^2/ha and *R. mucronata* at the sapling level of 37.01 m^2/ha. The highest mangrove species cover was at Station 3, namely *B. gymnorrhiza*, at the tree level of 202.99 m^2/ha and the sapling level of 75.02 m^2/ha. The highest relative species cover was at Station 1, namely *R. apiculata,* at the tree level of 51.14% and the sapling level of 100%. The highest relative mangrove species cover was at Station 2, namely *X. granatum* at the tree level of 21.19% and *R. apiculata* at the sapling level of 70.67%. The highest relative cover of mangrove species at Station 3, namely *B. gymnorrhiza*, both at the tree level of 20.10% and the sapling level of 67% (Figures 4 and 5).

Mangrove species cover varied among stations, reflecting differences in stand structure and species growth characteristics rather than abundance alone (Alimbon & Manseguiao, 2021). Station 1 exhibited markedly higher cover values, indicating greater basal area development and biomass accumulation, which suggests environmental conditions favorable for diameter growth, such as fine muddy substrates and sustained tidal influence (Jacobs *et al*. 2019). In contrast, species cover values at Stations 2 and 3 were relatively similar, indicating comparable levels of structural development and overall stand maturity. Despite their comparable total cover, subtle differences in species composition help explain variation in cover patterns between Stations 2 and 3. At Station 2, species with larger stem diameters, particularly *Xylocarpus granatum*, contributed disproportionately to total cover despite lower stem density, reflecting its growth strategy as a large-bodied mangrove species. Conversely, at Station 3, cover was more strongly associated with *Bruguiera gymnorrhiza*, a species characteristic of middle to landward mangrove zones that develops substantial basal area under relatively reduced inundation. These patterns suggest that differences in species cover between Stations 2 and 3 are driven primarily by species-specific growth traits and zonation preferences rather than major environmental contrasts (Sraun *et al*. 2022). Overall, the observed cover distribution highlights the role of functional traits, especially stem diameter and basal area development, in shaping mangrove stand structure across spatial gradients.

Frequency and Relative Frequency

Mangrove species frequency varied among stations and growth stages. At Station 1, *R. mucronata* showed the highest frequency at the tree level (0.67), while *R. apiculata* exhibited the highest frequency at the sapling level (0.67). At Station 2, both *R. mucronata* and *R. apiculata* were recorded in all sampling plots at the tree level (frequency = 1), whereas *R. mucronata* also showed complete occurrence at the sapling level. A similar pattern was observed at Station 3, where *R. mucronata* and *B. gymnorrhiza*

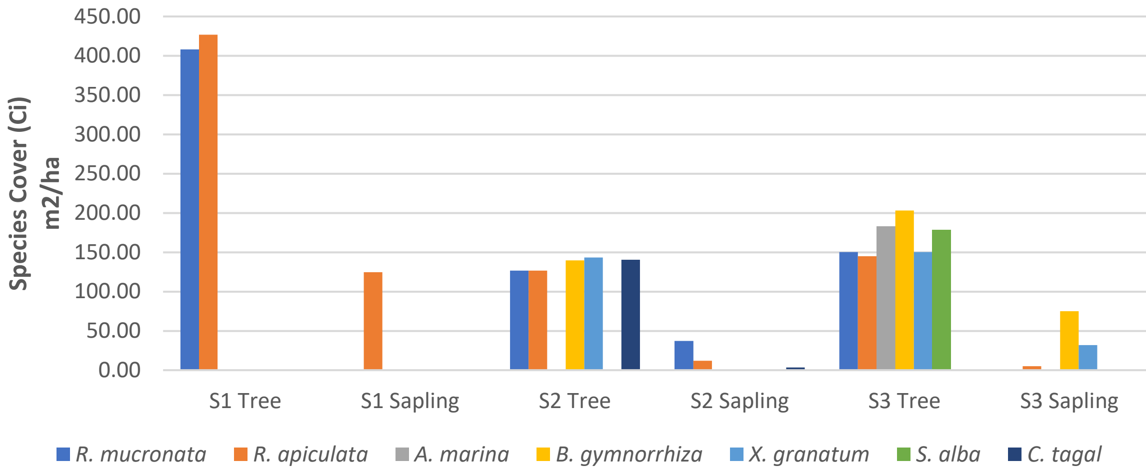

Figure 4. Species cover

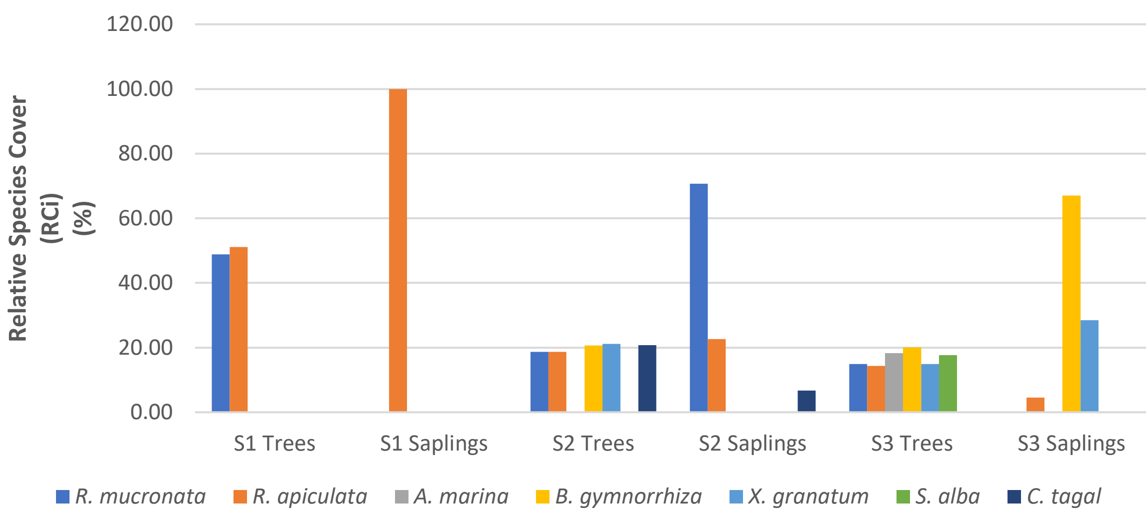

Figure 5. Relative species cover

occurred in all plots at the tree level, while *B. gymnorrhiza* showed the highest frequency at the sapling level. Relative frequency values reflected these patterns, with *R. Mucronata* and *R. apiculata* contributing the largest proportions at Stations 1 and 2, and *B. gymnorrhiza* showing the highest relative frequency at Station 3, particularly at the sapling stage (Figures 6 and 7).

The frequency patterns observed across stations indicate differences in the spatial distribution and habitat preference of mangrove species. The consistent occurrence of *Rhizophora mucronata* across all stations reflects its broad ecological tolerance and adaptability to varying substrate types and tidal conditions (Suwanto *et al*., 2021), which allows this species to be widely distributed within the

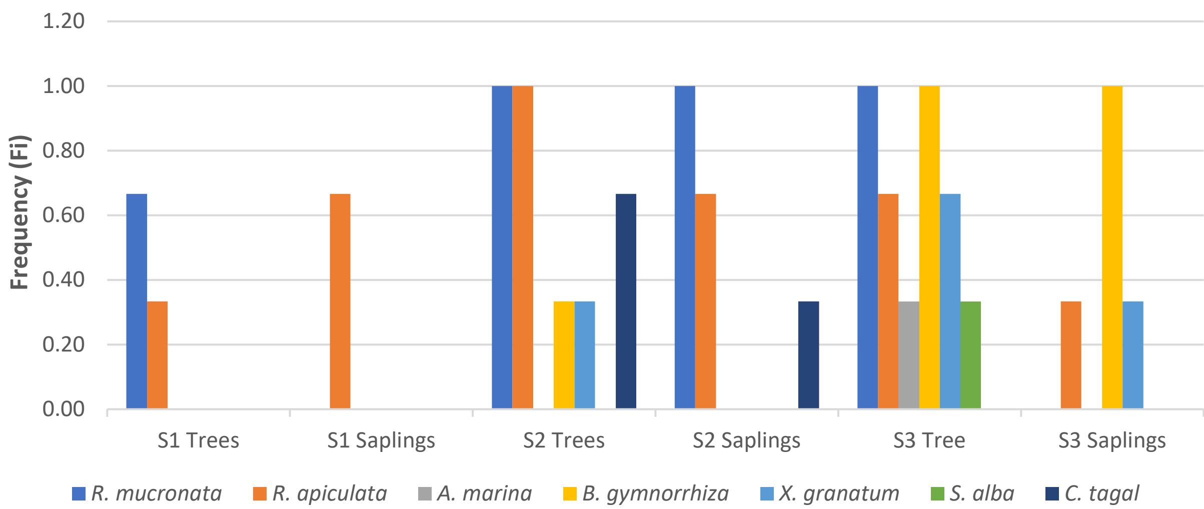

Figure 6. Frequency

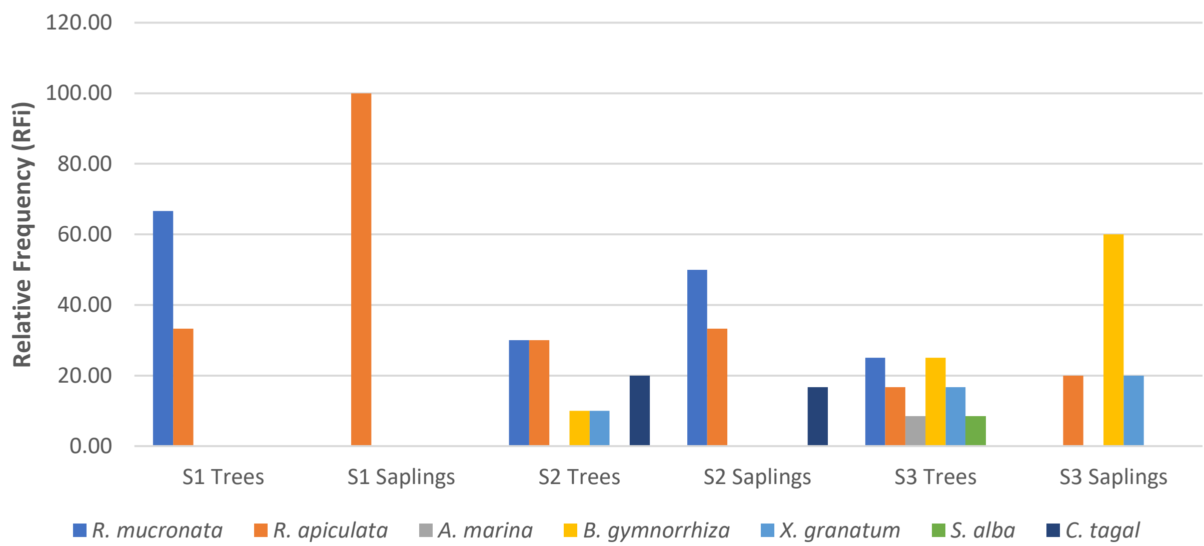

Figure 7. Relative frequency

study area. Similar patterns have been reported by Babo *et al*. (2020), who found *R. mucronata* to be present across multiple substrates condition in mangrove ecosystems. In contrast, species such as *Bruguiera gymnorrhiza* exhibited more localizedv distributions, suggesting a preference for more landward or less frequently inundated environments. Frequency values also provide insight into spatial uniformity, where higher frequencies indicate more even distribution within a station, while lower frequencies suggest patchy or clustered occurrence (Hanafi *et al*., 2018). These patterns highlight the role of environmental gradients in structuring mangrove communities and reinforce the importance of species-specific habitat preferences in shaping mangrove zonation.

Important Value Index

The highest mangrove IVI was at Station 1, namely *R. mucronata* at the tree level of 190.53% and *R. apiculata* at the sapling level with a value of 300%. The highest mangrove IVI was at Station 2, namely *R. mucronata*, at the tree level of 95.60% and sapling level with a value of 198%. The highest mangrove IVI was at Station 3, namely *B. gymnorrhiza*, at a tree level of 72.13% and sapling level with a value of 210.34% (Figure 8).

The Importance Value Index (IVI) provides critical insight into species that most strongly influence mangrove community structure and are therefore key targets for management and restoration efforts (Purba *et al*. 2025). The high IVI of *Rhizophora mucronata* at both tree and sapling levels in Stations 1 and 2 indicates not only its current ecological dominance but also effective regeneration, suggesting that these areas possess environmental conditions favorable for the long-term persistence of *Rhizophora*-dominated stands. In contrast, the highest IVI recorded for *Bruguiera gymnorrhiza* at Station 3, particularly at the sapling stage, reflects successful recruitment under relatively less inundated and more stable conditions. From a restoration perspective, these patterns suggest that site-specific species selection is essential: *R. mucronata* is more suitable for restoration in frequently inundated, muddy environments, whereas *B. gymnorrhiza* may be more effective in middle to landward zones. Furthermore, high sapling IVI values indicate strong regeneration potential, which is a critical factor for ensuring the sustainability and resilience of restored mangrove ecosystems (Mandiangan *et al.,* 2024).

Diversity, Evenness, and Dominance Index

The results of this study show that the diversity index (H') values at the three stations ranged from 0.69 to 1.57, and based on the criteria, the H' value is included in the low (H' <1) and medium (1≤H' ≤3) categories. The evenness index (J') values at the three stations ranged from 0.73 to 1, the J' value is included in the high category (J'≥ 0.6). The

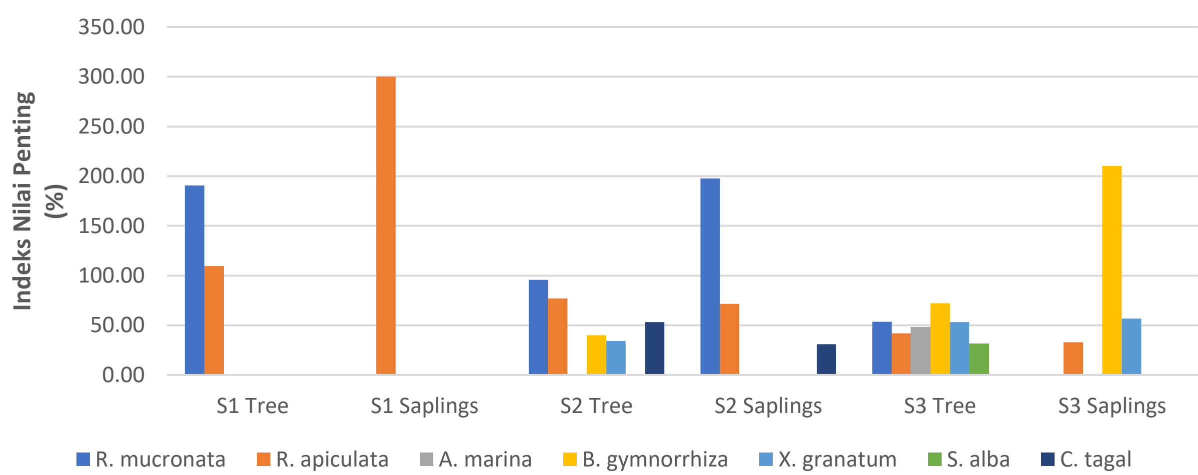

Figure 8. Important value index

Table 2. Diversity, evenness, dominance index

Index	Station 1		Station 2		Station 3	
	Value	Category	Value	Category	Value	Category
H'	0.69	Low	1.18	Medium	1.57	Medium
J'	1	High	0.73	High	0.88	High
D	0.50	Low	0.36	Low	0.25	Low

dominance index (D) values at the three stations ranged from 0.25 to 0.50; the D value is included in the low category (0 <D ≤ 0.50) (Table 1). Based on Table 1, it can be seen that the lowest mangrove species diversity is at Station 1 at 0.69 (low). The low number and variety of mangrove species found at Station 1 cannot be separated from the substrate stability factor and conditions that are less supportive of other mangrove species. The dominance index values at the three stations are included in the low category. Odum (1993) stated that a dominance value approaching zero indicates that there are no dominant species in the research location; this statement reflects that each individual in the observation area has an equal chance of being found in the area. This is by the evenness index value at the three stations which is classified as high. The mangrove vegetation community is evenly distributed, and no dominant species exist at the research location (Akhrianti *et al*., 2021). Previous research by Puzon *et al*. (2022) showed that the ecosystem at their research location had low species diversity (H' = 2.009), high evenness (E = 0.939), and low dominance (D = 0.148). This shows that mangrove species are evenly distributed without any species dominating excessively in the ecosystem. This condition is often found in environments disturbed by anthropogenic factors, such as land conversion and pollution.

CONCLUSION

Seven species of mangroves were found, with three dominant species, namely *B. gymnorrhiza, R. apiculata* and *R. mucronata*. The diversity of mangrove species is classified as low to moderate, with a relatively even distribution of individuals. This study emphasizes the importance of monitoring and periodic conservation efforts to maintain the mangrove ecosystem's stability and support its sustainable use.

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