Species composition and Vegetation Structure of Mangrove Forest in Pulau Rambut Wildlife Reserve, Kepulauan Seribu, DKI Jakarta

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Abstract. Mangrove forest in Pulau Rambut Wildlife Reserve has high biodiversity, so research is needed on species composition and vegetation structure. This study aims to examine the species composition and structure of mangrove forest vegetation in the Pulau Rambut Wildlife Reserve. Vegetation analysis was carried out using the strip and line method with a sample plot area of 8000 m² and a total of 8 lanes each with a size of 10 m x 100 m. The results showed the mangrove forest of Pulau Rambut Wildlife Reserve has 9 species from 5 families and dominated by the Rhizophoraceae family. The Rhizophora mucronata species dominates the growth rate of trees and seedlings, while Ceriops tagal species dominated the sapling growth rate. The value of diversity, richness, and dominance in the mangrove forest of Pulau Rambut Wildlife Reserve at various growth rates is low, but the value of species evenness is high. The proportions of the number of trees and regeneration form an inverted “J” curve. The canopy stratification in mangrove forest of Pulau Rambut Wildlife Reserve only reached stratum C (4-20 m). The mangrove forest needs a planting and enrichment of plant species to increase the species diversity level.

1. Introduction

1.1. Background
Indonesia has a very large mangrove forest in the world. The area of mangroves in Indonesia is very diverse, the area of mangroves in Indonesia is 3,244,018,460 ha [1]. Mangrove forest is a forest that mainly grows on alluvial mud soil in seaboard areas and river estuaries that are affected by tides and consists of tree species Sonneratia, Avicennia, Bruguiera, Rhizophora, Ceriops, Excoecaria, Scyphyphora, Aegiceras, Xylocarpus, Nypa, and Lumnitzera [2].

Mangrove forest is a unique type of ecosystem that is located between marine ecosystems and land ecosystems with a combination of physical elements, marine biology and land. Mangrove forest ecosystems have various functions, these functions include physical, chemical, ecological, and economic functions that are very influential for coastal ecosystems and surrounding [3]. Mangroves have been widely used by coastal communities in various areas. Mangroves are also able to expand their territory towards the sea so that they can expand the land area[4]. To maintain the sustainability of natural resource productivity in coastal and marine areas, the existence of extensive mangroves must be maintained and protected from damage [5].
DKI Jakarta is one area that has a coastal area. One area that has a mangrove forest ecosystem in DKI Jakarta is the Pulau Rambut Wildlife Reserve. Pulau Rambut Wildlife Reserve has an area of about 90 ha consisting of 45 ha of land and 45 ha of water. The mangrove forest ecosystem in the Pulau Rambut Wildlife Reserve has a fairly high biodiversity and important as water bird habitat. The mangrove forest in Pulau Rambut wildlife Reserve has been affected by oil spills several times so that it can affect the ecosystem [6], so proper management is needed. The study was conducted to examine the species composition and stand structure in mangrove forests and to make this research a source of information for sustainable management.

1.2. Research Goals
This study aims to examine the species composition and structure of the mangrove forest ecosystem vegetation in the Pulau Rambut Wildlife Reserve, Kepulauan Seribu, DKI Jakarta.

1.3. Research Benefits
The results of this study are expected to be one of the important considerations in managing the Pulau Rambut Wildlife Reserve area sustainably.

2. Method

2.1. Time and Place
This research was aimed in February-March 2021 in the mangrove forest of Pulau Rambut Wildlife Reserve, Kepulauan Seribu, DKI Jakarta. The areas of mangrove forest can be seen on figure 1.

![Figure 1. The mangrove area in Pulau Rambut Wildlife Reserve.](image-url)
2.2. Tools and Materials
The tools that are used in this study consisted of a tape meter, measuring tape (phiband), Haga hypsometer, rope, compass, machete, tally sheet, camera, field book, stationery, and a laptop that has the Sexi-FS software, Microsoft Word and Microsoft Excel.

2.3. Research Procedure
2.3.1. Types of Data Collected. The data collected is divided into primary data and secondary data. Primary data are collected in the field using the vegetation analysis method. Vegetation analysis methods aim to determine the species composition and structure of vegetation by taking vegetation data at the level of seedlings, saplings, trees and other forms of life (underplants, epiphytes, lianas, and palms). The data taken in the form of species name, number of individuals, trunk diameter, total height, branch-free height, and canopy cover. Secondary data taken is the condition of the Pulau Rambut Wildlife Reserve.

2.3.2. Vegetation Analysis. The vegetation analysis method used in this study is a combination method between the path method and the checkered line method which is placed perpendicular to the shoreline. The number of observation lines is 8 lines with a distance between lines of 30 meters according to field conditions. The location of the sample unit (sampling design) used is systematic sampling with random start. The sub-plots measure 2 meters x 2 meters for seedling growth rates, 5 meters x 5 meters for growth rates and palms, and 10 meters x 10 meters for tree growth rates. Method of retrieval of data performed for the analysis of vegetation is presented in figure 2.

![Measurement plot in the line (transect).](image)

2.3.3. Canopy Stratification. Observation of canopy stratification was carried out to determine the vertical structure of the observed mangrove forest. Required data collection is the name of the tree species, tree position, total tree height, free height of tree branches, trunk diameter, canopy shape, and the projection area of the canopy to the ground surface. Canopy stratification is described in the form of a canopy profile diagram with a pole measuring 60 meters (X-axis) x 10 meters (Y-axis) to determine diameter class and stratum layers.

2.4. Data Analysis
2.4.1. Importance Value Index (IVI). Important value index (INP) of a species is a value that describes the role or influence of a species of mangrove vegetation in an observed community. INP is the result of the sum of the values of relative density (Kr), relative dominance (Dr), relative frequency (Fr) [7]. Therefore, the Important Value Index can obtain from data on relative density, relative frequency, and relative dominance. IVI calculation using the formula:

- Tree and pole level:
  \[
  \text{IVI} = \text{RDen} + \text{RF} + \text{RD}
  \]
- Sapling and seedling level:
  \[
  \text{INP} = \text{RDen} + \text{RF}
  \]
  a) Density of a species (Den) (ind/ha)
\[ \text{Den} = \frac{\sum \text{Individuals of a species}}{\text{Sample plot area}} \]

b) Relative density (R.Den) (%)
\[ R.\text{Den} = \frac{\text{Density of a species}}{\text{Density of all species}} \times 100\% \]

c) Frequency of a species (F) (ind/ha)
\[ F = \frac{\sum \text{Subplot found a type}}{\sum \text{The entire sample subplot}} \]

d) Relative frequency (RF) (%)
\[ RF = \frac{\text{Frequency of occurrence of species}}{\text{Total frequency of occurrence of species}} \times 100\% \]

e) Dominance of a species (D) (m²/ha) for tree level
\[ D = \frac{\text{Basal area of a species}}{\text{Sample plot area}} \]
Basal area of a species (m²) for tree level can be found by the formula:
\[ \text{Basal Area} = \pi R^2 = \frac{1}{4} \pi D^2 \]

f) Relative dominance (RD)
\[ RD = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100\% \]

2.4.2. Species Diversity Index (\(H'\)). The diversity of plant species is obtained from the formula for the Shannon Index of General Diversity [8] as follows:
\[ H' = -\sum_{i=1}^{n} \left( \frac{n_i}{N} \right) \ln \left( \frac{n_i}{N} \right) \]

Information:
H’ = Shannon Species Diversity Index
\(n_i\) = Species density value of \(-\)
N = Total density of all species

The value of \(H' < 2\) indicates that the diversity of species is low. If \(H' = 2-3\) the diversity of species is classified as moderate, whereas if the value of \(H' > 3\) indicates that the diversity of species in that location is abundant.

2.4.3. Species Dominance Index (C). The species dominance index is calculated by the formula [9] as follows:
\[ C = \sum_{i=1}^{n} \left( \frac{n_i}{N} \right)^2 \]

Information:
C = Species dominance index
\(n_i\) = Species density value of \(-\)
N = Total density of all species

The value of the dominance index for species ranges from \(0 \leq C \leq 1\). If the value is \(0.75 \leq C \leq 1\), the dominance is classified as high. If the value is \(0.5 \leq C \leq 0.75\), the dominance is classified as moderate. If the value is \(0 \leq C \leq 0.5\), the dominance is low.
2.4.4. Species Richness Index (R). Species richness index is obtained from the formula of Margallef [8] as follows:

\[ R = \frac{S - 1}{\ln(N)} \]

Information:
- \( R \) = Species richness index
- \( S \) = Total of species found
- \( N \) = Total of individual

Species Richness Index is divided into three categories, low if \( R < 3.5 \), medium if \( 3.5 < R < 5.0 \) and high if \( R > 5.0 \) [8].

2.4.5. Species Evenness Index (E). Species evenness index is obtained by the formula as follows:

\[ E = \frac{H'}{\ln(S)} \]

Information:
- \( E \) = Species Evenness Index
- \( S \) = Total of species found
- \( H' \) = Species Diversity Index

Value of species evenness index \( E < 0.3 \) indicates low species evenness, \( E \) values range from 0.3-0.6, indicating moderate species evenness, and \( E > 0.6 \) indicates high species evenness [8].

2.4.6. Vegetation Structure. The vegetation structure is generally characterized by tree density, cover or base area on the stand, the distribution of diameter classes, and the distribution of species in space [10]. Vegetation structure is divided into horizontal stand structure and vertical stand structure. The horizontal structure was obtained by quantitative descriptive analysis of the relationship between tree density and diameter class.

3. Result and Discussion

3.1. Species Composition

The mangrove forest of Pulau Rambut Wildlife Reserve consists of 9 species from 5 families. The major mangroves found are 6 and the minor mangroves are 3. The components of the mangrove forest of the Pulau Rambut Wildlife Reserve are presented in table 1. Based on table 1, the plants that make up the mangrove forest of the Rambut Wildlife Reserve consist of 9 species and 5 families. The 9 species consist of 6 major mangroves and 3 minor mangroves, but all of these species are true mangroves.

The major mangrove able to make pure stands and excrete salt water so it can grow in stagnant water, while mangrove minor incapable of forming pure stands and grows on the edge of the mangrove habitat [11]. Based on observations, the Rhizophoraceae family dominates the mangrove forest in the Pulau Rambut Wildlife Reserve. Mangrove forests dominated by the Rhizophoraceae family are also found in Hidayatullah and Pujiono's research in Golo Sepang [12] and Heriyanto and Subiandono in Alas Purwo National Park [13], where the Rhizophoraceae family is the common family that dominates mangrove forests in Indonesia.

The dominant species found in the mangrove forest of the Pulau Rambut Wildlife Reserve are Rhizophora mucronata and Ceriops tagal. Important value index (IVI) data are presented in table 2. The dominant species at the tree growth rate was R. mucronata with an IVI of 130.33%, and the codominant species was C. tagal with an IVI of 49.85%. This makes Rhizophora mucronata the most dominant species and plays a role in the community. The Rhizophora mucronate species has a higher relative density, relative dominance, and relative frequency than other species, this is because this species is able to utilize environmental conditions efficiently.
The Rhizophoraceae families, *Rhizophora mucronata* and *Bruguiera cylindrica* are able to utilize sunlight, minerals and nutrients, water, and competitive characteristics so that they can dominate other species. In addition, *R. mucronata* is one of the most important and widespread species, so it can be found dominating in various places [4]. A species in the ecosystem can be seen with the Important Value Index (IVI). IVI has various values in each species and each level of growth (table 2).

**Table 1.** Plant species in the Pulau Rambut Wildlife Reserve mangrove forest.

| Common Name       | Scientific Name              | Family           | Information       |
|-------------------|-------------------------------|------------------|-------------------|
| Bakau hitam       | *Rhizophora mucronata*        | Rhizophoraceae   | Mangrove mayor    |
| Bangko            | *Rhizophora stylosa*          | Rhizophoraceae   | Mangrove mayor    |
| Jangkar           | *Rhizophora apiculata*        | Rhizophoraceae   | Mangrove mayor    |
| Tengar            | *Ceriops tagal*               | Rhizophoraceae   | Mangrove mayor    |
| Tanjung merah     | *Bruguiera gymnorrhiza*       | Rhizophoraceae   | Mangrove mayor    |
| Buta-buta         | *Excoecaria agallocha*        | Euphorbiaceae    | Mangrove minor    |
| Bola granat       | *Xylocarpus granatum*         | Meliaceae        | Mangrove minor    |
| Api-api           | *Avicennia officinalis*       | Avicenniaceae    | Mangrove mayor    |
| Sentigi           | *Phempis acidula*             | Lythraceae       | Mangrove minor    |

**Table 2.** IVI growth rates of trees, saplings and seedlings in Pulau Rambut Wildlife Reserve mangrove forest

| Scientific Name              | Density (Ind/ha) | Frequency | Dominance (m²/ha) | IVI (%) |
|------------------------------|------------------|-----------|-------------------|---------|
| **Tree**                     |                  |           |                   |         |
| *Rhizophora mucronata*       | 247,50           | 0,78      | 0,04              | 130,33  |
| *Rhizophora stylosa*         | 13,75            | 0,05      | 0,02              | 15,51   |
| *Rhizophora apiculata*       | 1,25             | 0,01      | 0,03              | 16,10   |
| *Ceriops tagal*              | 102,50           | 0,25      | 0,02              | 49,85   |
| *Bruguiera gymnorrhiza*      | 2,50             | 0,01      | 0,04              | 18,22   |
| *Excoecaria agallocha*       | 23,75            | 0,10      | 0,02              | 21,22   |
| *Xylocarpus granatum*        | 16,25            | 0,10      | 0,05              | 31,70   |
| *Avicennia officinalis*      | 16,25            | 0,06      | 0,02              | 17,07   |
| **Sapling**                  |                  |           |                   |         |
| *Rhizophora mucronata*       | 635              | 0,31      | -                 | 61,22   |
| *Rhizophora stylosa*         | 540              | 0,18      | -                 | 43,71   |
| *Rhizophora apiculata*       | 75               | 0,01      | -                 | 4,99    |
| *Ceriops tagal*              | 550              | 0,44      | -                 | 68,36   |
| *Bruguiera gymnorrhiza*      | 5                | 0,01      | -                 | 1,41    |
| *Excoecaria agallocha*       | 30               | 0,04      | -                 | 4,98    |
| *Xylocarpus granatum*        | 45               | 0,03      | -                 | 4,60    |
| *Avicennia officinalis*      | 30               | 0,05      | -                 | 6,13    |
| *Phempis acidula*            | 45               | 0,03      | -                 | 4,60    |
| **Seedling**                 |                  |           |                   |         |
| *Rhizophora mucronata*       | 15125            | 0,50      | -                 | 113,90  |
| *Rhizophora stylosa*         | 1531,25          | 0,09      | -                 | 15,41   |
| *Rhizophora apiculata*       | 187,5            | 0,01      | -                 | 2,08    |
| *Ceriops tagal*              | 7781,25          | 0,33      | -                 | 65,73   |
Scientific Name | Density (Ind/ha) | Frequency | Dominance (m²/ha) | IVI (%)  
--- | --- | --- | --- | ---  
Excoecaria agallocha | 31.25 | 0.01 | - | 1.44  
Avicennia officinalis | 31.25 | 0.01 | - | 1.44

The species that dominated the Pulau Rambut Wildlife Reserve mangrove forest at the sapling growth rate are Ceriops tagal with an IVI of 68.36%, then Rhizophora mucronata with an IVI of 61.22%. The high IVI of Ceriops tagal indicates that this species is able to adapt well to its environmental conditions. This species is used as a habitat for water birds in Pulau Rambut Wildlife Reserve such as a place to nest, fly, and rest, because it has a fairly wide and dense canopy. Ceriops tagal is a salt tolerant mangrove and is able to grow in conditions of high salinity and poor in nutrients, therefore this species is able to adapt and dominate other species [14].

The species that dominated the Pulau Rambut Wildlife Reserve mangrove forest at the seedling growth rate are R. mucronata with an IVI of 113.90%, then C. tagal of 65.73%. The highest individual density/ha was found in R. mucronata at 15125 ind/ha. R. mucronata and C. tagal have a high degree of adaptability in the form of viviparous propagules, which grow since they are still attached to the parent stem so that when they fall to the ground they can grow well. In addition, the species of R. mucronata has large and long propagules so that it has more food reserves so that it can survive and be spread through sea water currents [15].

Index This diversity of species, the index wealth of species, the index of dominance, and index of evenness is required to determine the quality and stability of the ecosystem of mangrove forests in Pulau Rambut Wildlife Reserve. Diversity index, richness, dominance, and evenness at different levels of growth can be seen on table 3.

Table 3. Species diversity index, species evenness index, species richness index, and species dominance index of constituent plant in Pulau Rambut Wildlife Reserve mangrove forest

| Growth Level | H’ | E | R | C  
--- | --- | --- | --- | ---  
Seedling | 0.89 | 0.50 | 0.75 | 0.48  
Sapling | 1.52 | 0.69 | 1.34 | 0.26  
Tree | 1.23 | 0.59 | 1.20 | 0.41

The value of H’ on the growth rate of seedlings, saplings and trees ranged from 0.89-1.52 (low). Low species diversity indicates that the species is not able to maintain its sustainability and species resistance is less stable. Low species diversity is common in mangrove forest types compared to other tropical forests [16]. Evenness index (E) shows the level of evenness of individuals per species. The value of E on the growth rate of seedlings, saplings, and trees ranged from 0.50 to 0.69, this value indicates that the evenness of the species in seedlings and trees level are moderate and the saplings level is high. The evenness index is related to the diversity index, where the higher the E value, the more stable the species diversity and the lower the E value, the lower the species diversity [17].

The R value for the growth rate of seedlings, saplings, and trees ranged from 0.75 -1.34 (low). The low species richness in Pulau Rambut Wildlife Reserve is thought to be due to the small sample plot area of 0.8 Ha. The value of the species richness index is influenced by the size of the sample plot and the level of diversity, the higher the diversity value, the greater the species richness. The species dominance index (C) shows the pattern of dominance of one species over other species in a community. The species dominance index on the growth rate of seedlings, saplings, and trees ranged from 0.26 -0.48 (low). This shows that the pattern of species mastery is increasingly spreading to several dominant species [13]. Some of the dominant species that spread are R. mucronata, C. tagal, and X. granatum.
3.2. **Vegetation Structure**

The forest vegetation structure is a complex arrangement of forms of vegetation and can be used to determine stratification (horizontal and vertical) [18].

**Horizontal Structure.** The individual density per hectare of seedlings was the largest, which was 987.5 individuals/ha. This shows that the regeneration of the Pulau Rambut Wildlife Reserve mangrove forest is sufficient. If the number of young individuals is more than adult individuals, this will ensure forest sustainability because the stock of youth is able to maintain forest regeneration [19]. The horizontal structure is the relationship between diameter class and individual density. Based on the graph in figure 3, the larger the diameter class, the lower the individual density so that the graph forms an inverted “J”. The inverted “J” shape is common in natural forests. The inverted “J” shape was also found in the research of Ghufrona on Sebuku Island, South Kalimantan [18].

3.2.1. **Vertical Structure.** The vertical structure identifies by combining tree density with tree height class. The vertical structure of the mangrove forest of Pulau Rambut Wildlife Reserve is present in figure 4.

![Figure 3](image1.png) **Figure 3.** Horizontal structure in each growth stage.

![Figure 4](image2.png) **Figure 4.** Horizontal structure across different diameter classes

![Figure 5](image3.png) **Figure 5.** Vertical structure in several height class.
Rhizophora mucronata  
Xylocarpus granatum  
Ceriops tagal

The vertical structure is the relationship between individual density and high class (stratum). Based on the graph in figure 4, the mangrove trees on Pulau Rambut Wildlife Reserve only reach the stratum C (4-20 m) and in the dominance of the stratum D (1-4 m).

This shows that it is difficult to achieve growth in stratum A and B because it takes a very long time and high competition compared to stratum C. This shows that the stands in the mangrove forest of Pulau Rambut Wildlife Reserve are relatively young and in the successional stage. The existence of this stratum difference is caused by competition between plants and the nature of species tolerance to sunlight [18].

Figure 6 shows the canopy profile on the observation plot and projected using SexI-FS software version 2.1.0. Based on the canopy profile diagram, the tree canopy in the mangrove forest of Pulau Rambut SM is quite wide and has many branches so that it looks dense.

4. Conclusion
The mangrove forest of Pulau Rambut Wildlife Reserve is composed of 9 species of mangroves from 5 families. The *Rhizophora mucronata* species dominates the growth rate of trees and seedlings. The *Ceriops tagal* species dominated the sapling growth rate. The values of diversity, richness, and species dominance at all growth rates are low, but evenness values are high. The proportion of the number of trees and regeneration forms an inverted “J” curve which indicates a fairly good forest regeneration. The canopy stratification of the Pulau Rambut Wildlife Reserve mangrove forest only reached stratum C. This indicated that the stands in the Pulau Rambut Wildlife Reserve mangrove forest are relatively young and in the successional stage.

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