Tree Species Diversity in Momiwaren Forest Reserve in Indonesia

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Abstract. The Momiwaren lowland forest reserve has hot springs surrounded by a variety of forest vegetation. The diversity of tree species around the source of hot springs is poorly documented. This study was conducted to assess the tree structure and species composition around the hot springs in the Momiwaren lowland forest. A vegetation survey was carried out using the nesting line method and the data were descriptively analyzed. This study revealed that the total number of tree species was 106 consisting of seedlings (52 species, 110 individuals), saplings (69 species, 138 individuals), poles (38 species, 98 individuals) and trees (44 species, 120 individuals). The most abundant tree species in the area was Vatica rassak (Dipterocarpaceae).

1. Introduction
West Papua Province (Indonesia) has massive forests and unique biodiversity. In addition, it has several natural hot springs. One of the hot springs is located in Momiwaren lowland forest in Southern Manokwari District, West Papua Province, Indonesia. Geographically, the area is located between 01º58'26'' S and 133º56'33'' E, with a total forest reserve area of approximately 1,200 ha. The hot springs in Momiwaren have been an object of tourists’ attraction, both domestic and international.

The spring’s water is heated by geothermal heat in the earth’s interior due to the formation of cracks in the rock layers of the earth. The hot water was released through cracks or crevices of the earth’s crust to form the hot springs [1].

The hot springs site covers ±200 ha of forest area. The aquatic area includes a 30 m creek from the hot spring to a waterfall with a depth of 20 cm and a pool with a depth of 40 cm. The average water temperature can reach 42 to 45.2 °C.

The area of hot springs is surrounded by protected forest to prevent the trees from illegal logging. Therefore, this study was aimed to determine the stand structure and species composition of the trees and to create vegetation profiles near the hot springs in Momiwaren lowland forest.
2. Material and Methods

2.1 Study Area
The research was conducted around hot springs in Momiwaren lowland rain forest located in Southern Manokwari District, West Papua Province, Indonesia. Geographical location of the study area was at 133°59'8.1276" E - 134°9'19.7712" E and 1°32'34.098" S - 1°49'21.9792" S. Topography of Momiwaren forest reserve is plain to steep area.

2.2. Data Collection
To determine the point locations, the nesting line method (focused line method) was applied. For the purpose of establishing the plot, the line was designed perpendicular to the hot springs with azimuth 0° and 180° of the North-South direction and azimuth of 270° and 90° of the East-West direction with a path length of 100 m.

Data were collected by conducting sampling at the hot springs with a circular plot having a radius of ±100 m which was divided into four quadrats i.e. quadrant 1 (west), quadrant 2 (north), quadrant 3 (east) and quadrant 4 (south). Each quadrant consisted of five observation plots. The number of seedlings, saplings and poles were identified and counted in subplots having size of 2 x 2 m, 5 x 5 m, and 10 x 10 m, respectively.

Trees species were sampled in plots and every individual was identified to species level. Species identification was performed by two vegetation identifiers from Manokwariens herbarium technician. Unidentified samples were sent to the Herbarium of Balai Penelitian Kehutanan Manokwari and Herbarium Manokwariense for further identification. All trees species were divided into 4 size categories based on DBH (diameter at breast height): seedlings (starting from germination phase to DBH < 150 cm), saplings (DBH < 10 cm or height between 150 - 300 cm), poles (DBH 10 - 20 cm) and adult trees (DBH > 20 cm).

2.3. Data Analysis
2.3.1 Density
Density analysis was used to determine number of each species per hectare (ind/ha) and was carried out for all trees species of all ages and sizes. The density data per stage were transferred to be analyzed with SPSS 16 to obtain boxplot.

2.3.2 Basal Area (BA)
Basal area was only performed for trees category, the basal area is used to measure the diameter of the bark/stem which is generally conducted at an altitude of 1.30 m from the ground surface (diameter at breast height/DBH). Basal area is used to describe how dominant the trees species are in a location [2]. Basal area (BA) is calculated using the formula as follows:

\[ BA_i = \sum D_i^2 \times 0.7854 \]

where:
- \( BA_i \) = basal area (m\(^2\)) of tree species i
- \( D_i \) = diameter (m) of tree species i,
- 0.7854 = \( \phi \) divided by 4.

The basal area data per stage were transferred to be analyzed with SPSS 16 to obtain boxplot.

2.3.3 Diversity Index
Shannon-Wiener diversity index is calculated using formula as follows:

\[ H = - \sum pi \ln (pi) \]

where:
H = Shannon-Wiener diversity index
pi = number of sample in which species i is present

2.3.4 Frequency
All species of plant life-forms are described using frequency. Furthermore, number of plots where tree species i is present are divided by total number of sample plots. Hence, the frequency is calculated as follows:

\[ F_{ri} = \frac{n_i}{N} \]

where:
\( F_{ri} \) = frequency of species i,
n = number of plots in which species i is found,
N = total number of sample plots.

2.3.5 Importance value Index (IVI)
The importance value index is performed only for trees and is calculated to figure out distribution of each tree species in terms of dominance [3]. The index is determined by adding relative frequency, relative density and relative dominance:

\[ IV_i = RF_{ri} + RD_{ei} + RD_{oi} \]

where:
\( IV_i \) = Importance value index of tree species i,
\( RF_{ri} \) = Relative Frequency of tree species i,
\( RD_{ei} \) = Relative Density of tree species i,
\( RD_{oi} \) = Relative Dominance of tree species i.

3. Result And Discussion
3.1 Species Richness
The study revealed that the total number of species found in study site was 106 tree species for all size categories. For seedling, the species number found was 52 species with 110 individuals. Saplings had 69 species with 138 individuals, poles had 38 species with 98 individuals and trees categories had 44 species with 120 individuals.

![Figure 1](image-url) Comparison of number of species and number of individuals among the four size categories

Retracted
Furthermore, the greatest number of species was found in the category of saplings, followed by seedlings, trees and poles, respectively. The saplings vegetations were mostly contributed to the abundance of species (69 species) and individuals (138 individuals). In comparison to the types of seedlings, the number of species found in the field was fewer than the saplings. This was because there were the seedlings types which were intolerant, and thus, suffered and were not able to survive until reaching the poles level [4]. The trees species abundance was lower than the previous two categories because of logging activities happened at the site. The most dominant family in Momiwaren Protected Forest area was Dipterocarpaceae, while the most dominant species was Vatica rassak.

3.2 Density and Basal Area
Results of data analysis on trees density for 4 size categories in Momiwaren Forest reserve are presented in Figure 2.

![Figure 2: Boxplot of trees density for 4 size categories in Momiwaren Forest](image)

Densities at seedlings and saplings levels appear to be more evenly spread than those at poles and trees levels because the amount of trees in seedlings and saplings levels was greater than that in poles and trees levels. The relationship between the amount of trees with tree diameter indicated that the larger the tree diameter, the less the amount of trees. [5] said that trees having small diameter is more abundant in amount and the amount will be reduced with the increase of tree diameter.

Besides density, basal area is one of important values to determine the dominant trees size categories at a location. The range of basal area in quadrant 1 was narrower than that in other quadrants (Figure 2).

3.3 Diversity index
Diversity index is an index describing the level of diversity at a location. Shannon Wiener diversity index for the overall observation area was 1.743. Diversity index for seedlings was 1.58; for saplings was 1.728; for poles was 1.406 and for trees was 1.348. The higher the diversity of the species, the higher the productive ecosystem, as well as the pressure and stability of the ecosystem [6][7].
Based on the species diversity index, Momiwaren forest reserve had a fairly stable species diversity and did not have many damages, whether naturally or as a result of human activity. The species diversity values of these plants in Momiwaren forest reserve are not much different from the species diversity value of the plants in Gunung Dempo Protected Forest in South Sumatera (1.93) [8]. Tree distribution in the research locations was majorly influenced by topography, land fertility level and plant ability to regenerate and adapt to the environment. [9] stated that the growing area is mainly affected by level of plant growth in all levels, starting from seedlings to trees level.

It is supposed that is due to this sapling level has higher than the covering observation in sapling level. In addition the species found generally is the type with of having the low dormant level so when carried away by the current of a river and moored around the side of a river, the seeds directly sprout and grow. However, prior to achieve pole and tree level, the types of were not able to survive and then dead. At saplings level, the number of species found was higher than other levels of plants. This may have been caused by larger observation coverage at saplings level compared to that at seedlings level. Also, these species have low dormancy which cause the seeds easily sprout and grow. Unfortunately, these species are most likely dead prior to reaching the pole or tree levels.

3.4 Importance value Index (IVI)
The importance value index is a parameter to show the role of a plant in the plant community. The presence of a single plant species in the area shows the adaptability of that plant with the surrounding habitat and its tolerance to the surrounding environment. The greater the IVI value of a species, the greater the level of adaptability of this species toward its community [10]. Table 1 shows the highest IVI values of 10 dominant species in the Momiwaren Forest Reserve.

| No | Species                  | Families   | Number of individuals | Importance value index (%) | Seedling | Saplings | Poles | Trees |
|----|--------------------------|------------|-----------------------|---------------------------|----------|----------|-------|-------|
| 1  | Aglaia odorata           | Meliaceae  | 16                    |                           | 7.4      | 7.2      | 8.6   | 0     |
| 2  | Decaspernum parviflorum | Myrtaceae  | 12                    |                           | 5.6      | 2.8      | 14.2  | 2.8   |
| 3  | Gnetum gnemon            | Gnetaceae  | 14                    |                           | 6.9      | 2.8      | 19.0  | 0     |
| 4  | Intsia bijuga            | Fabaceae   | 12                    |                           | 3.0      | 0        | 19.6  | 0     |
| 5  | Intsia paradanica        | Fabaceae   | 10                    |                           | 1.7      | 1.6      | 4.0   | 14.3  |
| 6  | Cryptophragnis trichorsis| Apocynaceae | 10                    |                           | 5.6      | 2.5      | 9.4   | 7.3   |
| 7  | Vatica granddendron      | Verbenaceae| 14                    |                           | 0        | 7.2      | 7.7   | 11.5  |
| 8  | Baelodendron             | Euphorbiaceae | 34                  |                           | 7.5      | 8.7      | 28.8  | 18.1  |
| 9  | Syzygium sp.             | Myrtaceae  | 12                    |                           | 12.1     | 4.8      | 4.1   | 7.6   |

Vatica rassak (Dipterocarpaceae) had higher IVI values than the other woodland plant species (Table 1). These plants were found almost in all observation plots, ranged from saplings to trees levels. [9] stated that Dipterocarpaceae is generally capable to survive in the area of the tropical rain forest with precipitation > 1,000 mm per year and/or in dry season less than six months. However, it is difficult to find Dipterocarpaceae in altitude > 1,500 m dpl, because the plant cannot grow in this altitude.
Besides *Vatica rassak* (Dipterocarpaceae), *Pimelodendron amboinicum* (Euphorbiaceae) also had high IVI value (Table 1). [11] stated that *P. amboinicum* are abundant in Papua and New Guinea, because the plant can adapt to the surrounding environment and topography. In addition, the red color of blossoming *P. amboinicum* fruit attracts the hornbill birds in the east of Wallace line to assume its role as dispersal agent.

The variety of IVI values in the Momiwaren forest reserve area shows the existence of environment factors influencing the growth of the plant species in the Momiwaren forest reserve area, such as moisture, temperature, topography, plants competition in obtaining nutrients, sun penetration and growing space. [12] stated that in general, herbs with high IVI value has better adaptation, competitiveness and reproductive ability compared to other plants in the same land area. This might impact the existence of plants in an area.

4 Conclusions
There were 106 total species number for all size categories in Momiwaren lowland rainforest. *Vatica rassak* of the Dipterocarpaceae family was the most dominant species in all tree growing levels.

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