

Vegetation analysis and plant diversity in Pinus Jantho Forest (PJF) nature reserve, Aceh Besar

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Abstract. Pinus Jantho Forest (PJF) Nature Reserve has unique characteristics and a distinctive ecosystem that plays an important role in the preservation of germplasm and the protection of natural resources. The sustainability of PJF Nature Reserve is strongly determined by vegetative species. Therefore, strategies are needed to correctly support its management. One such strategy is characterizing the diversity of plants that make up the community in PJF Nature Reserve. This research analyzes the vegetation and diversity of plant species in PJF Nature Reserve. Data collection and sampling were done using multiple squares, in which plots were laid out by systematic sampling. PJF Nature Reserve is composed of 111 species from 46 families. Seedling and understorey levels have the highest number of individuals (1028 in total). There are 240 individuals at the sapling level, 108 individuals at the pole level, and 72 individuals at the tree level. The Euphorbiaceae family has the largest number of species (11 species). The highest Important Value Index (IVI) for seedlings and understorey, saplings and poles, and trees respectively were *Chloranthus elatior* (11.09%), *Piper aduncum* (21.90% and 19.32%), and *Pinus merkusii* (25.52%). The diversity index indicates a high level of plant species diversity (3.25-3.63).

Keywords: PJF, Important Value Index (IVI), nature reserve, *Pinus merkusii*, species diversity

INTRODUCTION

Sumatran forests have a greater wealth of plant communities than other regions in the world [1]. Of five major islands in Indonesia, Sumatra is the third largest island based on endemic species [2]. This rich environment is evidenced by various types of lowland and mountainous ecosystems [3]. However, Sumatra has been categorized as one of 200 critical-status ecoregions, making it a global conservation priority [4][5]. In the northern part of Sumatra is the province of Aceh. Aceh has many forest areas that need to be protected and conserved for their biodiversity. One such forest is Pinus Jantho Forest (PJF) Nature Reserve.

Pinus Jantho Forest Nature Reserve is a tropical rain forest conservation region designated by the Decree of the Minister of Forestry No. 186/Kpts-II/1984 on October 4th. While it

initially covered an area of 8000 ha, the area has expanded to 15.356,49 ha based on Decree of the Minister of Environment and Forestry No. 103/MenLHK-II/2015 April 2nd, 2015. Pinus Jantho Forest Nature Reserve has both typical and unique characteristics of a tropical rainforest ecosystem [6]. This region has become the natural habitat of Aceh-specific *Pinus merkusii* trees, as well as other plants and animals endemic to the region. Thus it plays an important role in the preservation of germplasm and protections of natural resources and catchment areas [7].

The function of PJF Nature Reserve as a conservation area for biodiversity is highly determined by its vegetative community. At present, the PJF Nature Reserve is under threat, since many forest areas have been disturbed due to illegal human activity, such as logging, forest burning, and land conversion for various purposes. In this regard, the sustainability of the forest ecosystem requires proper management systems. One such management strategy is characterizing plant diversity in the PJF Nature Reserve Area.

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METHODOLOGY

This research was conducted from December 2018 to December 2019 in Pinus Jantho Forest Nature Reserve, Aceh Besar. It is located at 5°6' - 5°16.2' North latitude and 95°37.2' - 95°45' East longitude. Data and samples were collected by exploratory survey using multiple plots. Pathway and sample observation plots were determined perpendicularly from the edge to the inside. The observation sample plots were placed by systematic sampling on each path. Four lines were made with a distance of ± 400 m. Each path was divided into 5 observation sample plots with a 50 m distance between each sample plot. The observation sample plots were 20 x 20 m, and sub-plots were made in each plot of 10 x 10 m, 5 x 5 m and 2 x 2 m, respectively. Vegetation measured and observed included understorey, seedlings, saplings, poles and trees.

The understorey and seedlings (< 1.5 m) were observed in 2 x 2 m plots, saplings (> 1.5 m height with <10cm diameter) were observed in 5 x 5 m plots, poles (saplings with 10-20 cm in diameter) were observed in 10 x 10 m plots, and trees (mature trees with > 20 cm in diameter) were measured in 20 x 20 m plots. Each plant species was observed at various growth levels (understorey, seedlings, saplings, poles and trees). All samples were then made into herbarium specimens for further identification.

Data Analysis

1. Important Value Index (IVI)

Vegetative composition to determine the dominant species was calculated by the Importance Value Index (IVI). The Importance Value Index for tree and pole growth rates is obtained by the formula $IVI = RD + RF + RD$, while for saplings, seedlings, and understorey, it is obtained using formula $IVI = RD + RF$ [8].

a. Relative Density

$$RD = \frac{\text{Density of a species A}}{\text{Total density of all species}} \times 100$$

b. Relative Frequency

$$RF = \frac{\text{Frequency of a species A}}{\text{Total frequency of all species}} \times 100$$

c. Relative Dominance

$$RD = \frac{\text{Basal area of species A}}{\text{Total basal area of all species}} \times 100$$

2. Species Diversity Index (H')

The diversity of plants was calculated using Shannon-Wiener Diversity Index (H'). Notes: H': Shannon-Wiener species diversity index, p_i : total proportion of plant abundance of species i , n_i : number of species i , N : total number of all species, \ln : natural logarithm.

$$H' = - \sum p_i \ln p_i, p_i = (n_i/N)$$

The Shannon-Wiener Diversity Index is interpreted as follows:

- $H' > 3$ shows that the species diversity in a place is high.
- $1 \leq H' \leq 3$ shows that the species diversity in a place is medium.
- $H' < 1$ shows that the species diversity in a place is low [9].

RESULTS AND DISCUSSION

Vegetation in PJF Nature Reserve, Aceh Besar is composed of 111 species of plants belonging to 46 families (Supplement 1). This composition is more diverse than other areas such as Dungus Iwul Nature Reserve, West Java; Manggis Gadung Nature Reserve, East Java; and Lho Fat Pun Fi Nature Reserve, West Kalimantan [10] [11] [12]. The high plant composition indicates an environment that supports plant growth fairly well. PJF Nature Reserve is in an ideal environmental range for many plants (Table 1). Such plants can grow optimally from 22-33 °C, 70-90% humidity, and 5.6-6.0 pH [13] [14]. There are differences in the number of species in each region due to variations in environmental conditions. Different environmental characteristics will create different compositions of vegetation [15].

Table 1. Environmental factors in PJF Nature Reserve Aceh Besar

No	Environmental Factors	
1	Temperature	27-34.3 °C
2	Humidity	65-98%
3	Soil humidity	74-100%
4	Soil pH	4.5-6.5
5	Light intensity	31.75%

The seedlings and understorey have the greatest number which are 1028 in total, while trees had the lowest, with only 72 individuals (Figure 1). The abundance of seedlings, understorey, saplings, poles, and trees in PJF Nature Reserve indicates balanced forest conditions. This is due to sufficient numbers of individuals in regeneration. This balanced condition is generally found in tropical forests, such as Wain River, East Kalimantan, Sesaot, West Nusa Tenggara [16][17][18].

There are 1448 types of vegetation growing in PJF Nature Reserve that spread over four growth levels. According to the identified 46 families of plants in PJF Nature Reserve, Euphorbiaceae, Asteraceae, Moraceae and Fabaceae have larger species compared to other families (Figure 2). The high abundance of

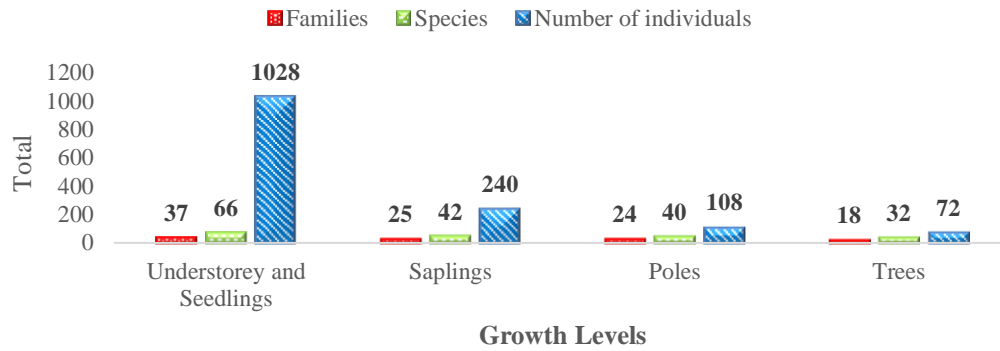


Figure 1. Number of families, species and individuals at each growth level in PJF Nature Reserve Area, Aceh Besar

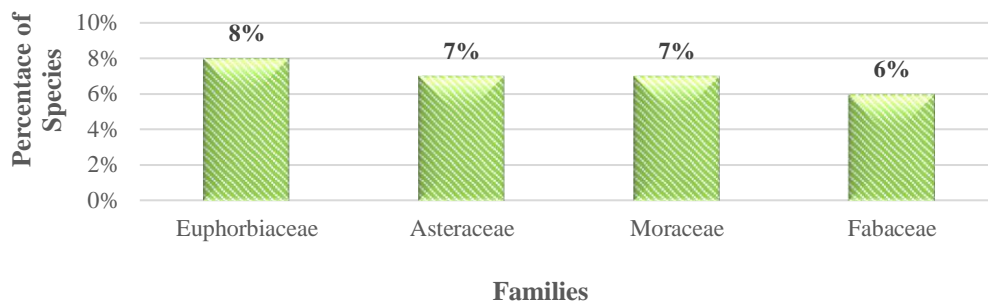


Figure 2. Percentage of Family dominance in PJF Nature Reserve Area, Aceh Besar

Euphorbiaceae found in PJF Nature Reserve indicates that these plants have high durability and wider life tolerance. These results corroborate reports in several other forest regions, such as Dungus Iwul Nature Reserve, Jasinga, Bogor and Tangkoko Bitung Nature Reserve, North Sulawesi [19][20].

The dominance of Euphorbiaceae in several forest areas is closely related to its effective reproductive strategy of spreading fruit and seeds by birds and mammals. As a dominant species in most tropical forests, Euphorbiaceae has a year-round flowering and fruiting period with high adaptability to various environmental conditions [21].

Importance Value Index (IVI) is a quantitative parameter used to express the degree of dominance (level of control) of species in a plant community. That means that the most dominant species has the greatest Importance Value Index [20]. The Importance Value Index (IVI) of plants in the PJF Nature Reserve shows that *Chloranthus elatior* has the highest dominance at the seedling and understorey levels (11.09%). In contrast, the sapling and pole levels are dominated by *Piper aduncum* (21.90% and 19.32%), while the tree level is dominated by *Pinus merkusii* (25.52%) (Table 2).

The dominance of *Chloranthus elatior* in seedling and understorey growth rates is evidenced by its individual density and high frequency in several research plots. The abundance of this species is supported by the ideal environmental conditions for its growth. The PJF Nature Reserve forest area has a temperature of 27-34.3°C, a humidity of 65-98%, and a soil pH of 4.5-6.5 (Table 1). *Chloranthus elatior* can grow well in shaded areas at 21-27°C, 86.8% humidity, and 6.0 pH [22]. Species with higher IVI values have a better survival rate for growth or adaptation compared to other species [11]. Naturally, forests maintain balance by improving diversity and fertility *Piper aduncum* was found to grow predominantly in several observation plots with high light intensity, such as on the edges and in forests with gaps (gap canopy). However, it can also be found in shaded forest areas. Its dominant presence is supported by its excellent physiological and ecological characteristics. *Piper aduncum* has light-loving (photoblastic) seeds, making it able to germinate optimally in an environment with sufficient light. In addition, it has a high sexual and vegetative reproductive capacity since animals help in its dispersion, allowing it to adapt to various environmental conditions [23][24][25].

Table 2. Importance value index (IVI) of dominant species at every growth level in PJF Nature Reserve, Aceh Besar

Growth level	Species	Family	IVI (%)
Tree	<i>Pinus merkusii</i>	Pinaceae	25.52
	<i>Bouea oppositifolia</i>	Anacardiaceae	21.56
	<i>Pterospermum javanicum</i>	Sterculiaceae	20.91
	<i>Gluta reinghas</i>	Anacardiaceae	20.50
	<i>Ficus sumatrana</i>	Moraceae	20.15
	<i>Cryptocarya griffithiana</i>	Lauraceae	19.23
	<i>Nephelium lappaceum</i>	Sapindaceae	17.78
	<i>Shorea lepidota</i>	Dipterocarpaceae	15.82
	<i>Dialium indum</i>	Fabaceae	13.06
	<i>Blumeodendron tokbrai</i>	Euphorbiaceae	11.83
Pole	<i>Piper aduncum</i>	Piperaceae	21.90
	<i>Cryptocarya griffithiana</i>	Lauraceae	20.53
	<i>Pterospermum javanicum</i>	Sterculiaceae	17.52
	<i>Nephelium ramboutanake</i>	Sapindaceae	17.44
	<i>Murraya paniculata</i>	Rubiaceae	16.52
	<i>Aglaia glabriflora</i>	Meliaceae	13.86
	<i>Gluta reinghas</i>	Anacardiaceae	13.53
	<i>Macaranga deniculata</i>	Euphorbiaceae	12.51
	<i>Dendrocnide stimulans</i>	Urticaceae	11.90
	<i>Nephelium lappaceum</i>	Sapindaceae	11.63
Sapling	<i>Piper aduncum</i>	Piperaceae	19.32
	<i>Palaquium rostratum</i>	Sapotaceae	16.66
	<i>Gluta reinghas</i>	Anacardiaceae	12.72
	<i>Cryptocarya griffithiana</i>	Lauraceae	12.54
	<i>Lantana camara</i>	Verbenaceae	8.07
	<i>Rhodamnia trinervia</i>	Myrtaceae	7.65
	<i>Chromolaena odorata</i>	Asteraceae	7.65
	<i>Callamus sp.</i>	Arecaceae	6.51
	<i>Afgekia sericea</i>	Fabaceae	6.10
	<i>Shorea lepidota</i>	Dipterocarpaceae	5.79
Seedling and understorey	<i>Chloranthus elatior</i>	Chloranthaceae	11.09
	<i>Cenotheca lappacea</i>	Poaceae	10.81
	<i>Imperata cylindrica</i>	Poaceae	10.45
	<i>Tetracera indica</i>	Dilleniaceae	10.04
	<i>Palaquium rostratum</i>	Sapotaceae	6.84
	<i>Isachne globosa</i>	Poaceae	6.50
	<i>Elatostema rostratum</i>	Urticaceae	6.35
	<i>Melastoma malabatricum</i>	Melastomataceae	6.31
	<i>Piper aduncum</i>	Piperaceae	6.21
	<i>Digitaria ciliaris</i>	Poaceae	5.57

The dominance of *Pinus merkusii* at the tree level is supported by environmental conditions in the PJF Nature Reserve. *Pinus merkusii* can grow optimally between 19 to 28°C and 400-1500 m above sea level, but it can also grow well in low lands (\pm 90 above sea level) and mountains (\pm 2000 m above sea level). It competes well against other species due to

allelopathy compounds that can inhibit the growth of nearby individuals of other species. Such compounds can inhibit the growth of other species that grow close together. Its ability to produce allelopathic compounds helps them fight competitors for nutrients, allowing *pinus merkusii* to survive longer and develop more effectively [11].

It is endemic to the PJF Nature Reserve and must be conserved and protected. Based on the results of IVI, pine poles, saplings and seedlings are less healthy. There is a possibility that pine regeneration will be hampered in the future. They may be replaced by other plants, particularly *P. aduncum*, which is found predominantly at the pole and sapling level. This study finds that *P. aduncum* has the highest IVI in the pole and sapling classes. As the most invasive plant species in the world, *Piper aduncum* in PJF Nature Reserve could pose a serious threat to the protected plant community in PJF Nature Reserve. Thus, *Piper aduncum* might become the most dominant species in the PJF Nature Reserve Area, Aceh Besar in a few years.

The Shannon-Wiener species diversity index (H') shows that the level of plant diversity in the PJF Nature Reserve is high. This can be seen from the index value which is greater than three ($H' > 3$) for each growth rate (Table 3). A high diversity index indicates a stable forest community. The higher the diversity index value, the higher the species diversity, ecosystem productivity, pressure on the ecosystem, and ecosystem stability [26]. High diversity index also indicates the PJF Nature Reserve is in the succession stage. Forests that are nearing the climax succession stage tend to have a higher diversity of species than forests in the early succession stage. In climax succession, there are high levels of species interaction and complexity, whereas in the early succession stage, interactions between species are few [14][27][28]. The number of old trees found in the PJF Nature Reserve Area is also an indicator that the forest has almost reached climax succession. Old trees have a diameter (DBH) of more than 60 cm, such as *P. merkusii* (DBH = 89.1 cm), *Bouea oppositifolia* (DBH = 115.9 cm), *Shorea lepidota* (DBH = 87.8 cm), *Dipterocarpus grandiflorus* (DBH = 74.2 cm) and several other species. The existence of the Dipterocarpaceae family also indicates a forest near the climax stage, since the species from this group have a large trunk and canopy size [14].

Table 3. Diversity index (H') of all growth rates in PJF Nature Reserve Area, Aceh Besar

No	Growth rate	Diversity Index (H')
1	Seedling and understorey	3.63
2	Sapling	3.33
3	Pole	3.42
4	Tree	3.25

CONCLUSION

The vegetation in PJF Nature Reserve is composed of 111 species of plants from 46 families. The family with the highest number of species is Euphorbiaceae. The species with highest level of dominance at the seedling and understorey levels is *Chloranthus elatior*, sapling and pole levels is *Piper aduncum*, and at tree level is *Pinus merkusii*. *Pinus merkusii* is endemic to PJF and must be conserved and protected. However, based on the results of IVI, pines are less abundant at the pole, sapling, and seedling levels. This suggests that future pine regeneration will be inhibited and the species will be replaced with other plants, particularly by *Piper aduncum*. This species is the most abundant species found at the pole and sapling level. The dominance of *Piper aduncum* in PJF Nature Reserve could pose a serious threat to the preservation of plant diversity, indicating the need for special attention to the current PJF Nature Reserve area. The diversity index is high and indicates stable forest conditions.

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