Structure of The Treelets and Shrub Vegetation in Tropical Sub-Mountain Forest of Mount Salak Bogor, West Jawa, Indonesia

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Abstract. We study the structure, indicator species and diversity of treelets and shrubs vegetation in tropical sub-mountain forests of Mount Salak Bogor, West Java. There were 4 vegetation groups at Bray-Curtis distance 0.6 - 0.8, namely groups 1, 2, 3, and 4, each consist of 13 plots, 17 plots, 8 plots, and 22 plots. One way Permanova test shows that the vegetation group is different in terms of structure and composition of vegetation. Dicranopteris dichotoma (Thunb.) Bernh., Athyrium sorzogonense (Presl.) Milde., and Cinchona officinalis L., are the species with the highest Important Value Index in all plots. Indicator species are not found in group 2. There are 8 combined vegetation groups that have indicator species. The one-way Kruskal-Wallis test shows the difference in Shannon-Wiener diversity index (H') (Kruskal-Wallis χ² = 20.541, df = 3, p-value = 0.0001311 ), Simpson's index (D) (Kruskal-Wallis χ² = 23.855 , df = 3, p-value = 2.678e-05), Pielou's evenness index (J') (Kruskal-Wallis χ² = 14.315, df = 3, p-value = 0.002506) and Species Richness (S) (Kruskal-Wallis χ² = 17.868, df = 3, p-value = 0.0004683) among vegetation groups. Post hoc test with Games Howel shows group 2 and 4 have differences in all parameters of diversity. The values of H', D, and S between group 1 and 4 are different. The difference in S values also appears between group 3 and 4.

Keywords: Bray-Curtis distance, indicator species, vegetation group, treelets and shrub vegetation

1. Introduction
The tropical mountain cloud forest (TMCF) is one of the ecosystems in the world that is rarely studied, but on the other side, this ecosystem is important because of its ability to capture and store water that
is important for the community, has many endemic species, and is very susceptible to disturbance [1]. The tropical mountain cloud forest is very important because it provides a variety of habitats for many species but the other side faces a huge threat to its existence [2]. The high mountains in Southeast Asia, especially in Indonesia, Malaysia, and Philippine is the center of TMCF spreading [1]. Like other regions, with the widespread expansion of lowland tropical forests in Southeast Asia and especially Indonesia which are lost due to various pressures, hence the presence of TMCF is becoming increasingly important as an area of protection and resources from a variety of plants and animals, and also the place for genetic diversity protection [3].

Salak Mount is one of the remaining natural ecosystems in Java Island [4], which has high biodiversity [5], and since 2003 is part of the Mount Halimun Salak National Park (MHSNP). As a national park area, Gunung Salak is important because it is a provider of water for the surrounding areas, especially Bogor Regency and Sukabumi Regency. On the other hand, the exploitation of forests on the mountain causes the availability of available water to be disrupted [6]. The Salak Mount area is also a habitat for many animals such as Javan gibbon (Hylobates moloch), Javan Leaf Monkey (Presbytis comata), Ebony Leaf Monkey (Trachypithecus auratus), Macaque (Macaca fascicularis), Asian Palm Civet (Paradoxurus hermaproditus), Wild Boar (Sus scrofa), Javanese Stink Badger (Mydaus javanensis), Pangolin (Manis javanica), Leopard Cat (Prionailurus bengalensis), and Barking Deer (Muntiacus muntjak) [7]. Forest damage that occurred in MHSNP affected habitat availability and wildlife existence [6].

The importance of the tropical mountainous region in Java, especially Mount Salak, makes this area need protection and conservation [5]. One approach that needs to be done for this activity is an understanding of the ecological conditions of vegetation including the treelets and shrub vegetation. According to Tao et al. [8], vegetation research in the tropical mountainous region focused more on vegetation structure with tree life form, while the studies that examined the understory vegetation which included treelets were still very rare.

Plants that grow among the main trees will strengthen the structure of the forest soil. This understory vegetation can function in absorbing and helping withstand the fall of water directly [9]. Understory vegetation can play a role in inhibiting or preventing erosion that occurs quickly. This plant can block the fall of rainwater directly, reduce the speed of surface flow, encourage the development of soil biota that can improve the physical and chemical properties of the soil and play a role in increasing soil organic matter so that soil resistance to erosion increases [10].

One of the main problems faced in managing the wealth of flora, fauna, and ecosystems that exist is the lack of data and information. The purpose of this study was to determine the composition of vegetation, indicator species in the vegetation group and the diversity of treelets and shrubs vegetation in the tropical sub-mountain forest of Mount Salak, Bogor, West Java.

2. Research Methods

2.1 Study area

Mount Salak is administratively located in Bogor Regency and Sukabumi Regency. Data collection was carried out in Sub-district of Pamijahan, Regency of Bogor in the sub-montane forest of Mount Salak that located in the village of Gunung Bunder Dua (S6°41’484”-E106°42’234”) and the village of Gunung Sari S6°41’786”-E106°42’006”).

2.2 Sampling

We define treelet as woody plant and fern plant with a diameter at breast height (at the height of 130 cm above soil surface) < 10 cm. In our investigation, a shrub is regarded as an all woody plant that has branching exactly above the soil surface and does not have the main stem. Vegetation sampling was carried out in four places on Mount Salak, that was, on the slopes that facing to North, South, East, and West so that ecologically the entire area can be represented. We made a transect with the sized of 1000 x 20 m. In that transect, we made a quadrat with the sized of 10 x 10 m and placed it
alternately at a distance of 10 m. Every individual of shrub and treelets are counted, then identified to the species level. To make it easier in the vegetation study, every 10 quadrants are integrated into a plot. We put 3 transects in every sampling area. Thus there were 12 transects with 60 plots.

2.3 Data analysis
We identify every plant to the level of species. We calculate the Important Value Index (IVI) of each species in each plot, as follows: $\text{IVI} = \text{Relative density} + \text{Relative Dominance}$ [11]. We also calculate on each plot, Shannon-Wiener diversity index: $H' = - \sum pi \ln pi$ [12], where: $H'$ = Shannon-Wiener diversity index, $pi = n/N$; where $n$ is IVI of a species, and $N$ is total IVI. Simpson Index: $D = \sum (\frac{n}{N})^2$, where $D$ = Simpson Index, $n$ is IVI of a species, and $N$ is total IVI. Pielou's evenness index calculated by the formula from Pielou [13]:

$$E = \frac{H'}{\log s}$$

where: $E$ = Pielou's evenness index; $H'$ = Shannon-Wiener diversity index; $s$ = the total of all species in an ecological unit. Species Richness: $S$ = number of species.

We conducted hierarchical clustering with cluster analysis using the Bray-Curtis dissimilarities measure to determine the natural grouping of vegetation plots based on IVI. We used Kruskal–Wallis one-way analysis of variance to test the differences in diversity parameters because data that is often not normally distributed. Post hoc test was applied to significantly different diversity parameters ($P < 0.05$) using the Games-Howel Test. We use the R version 3.51 program with the Vegan [14] and indicspecies packages [15] for data analysis and graphics display.

3. Results and Discussion
3.1 Vegetation Groups
The result of Cluster analysis shows that at Bray-Curtis’s distances 0.6 - 0.8 there are high similarities between clustered plots. Grouping generated 4 vegetation groups namely group 1, 2, 3, and 4, each of which consisted of 13, 17, 8 and 22 plots respectively. Vegetation groups 1 and 2 are composed of plots located in the South, the East, and the West slopes. All plots found in the South slope are found in these two groups. The plot in the West slope in this group was only 1 and was in vegetation group 2. Vegetation group 3 was composed of plots in the East slope with 1 plot and 7 plots in the West Slope. Vegetation group 4 is composed of plots located on the West slope and all plots in the North Slope (Figure 1). The Permanova test showed that vegetation groups differ in terms of structure and composition of vegetation.

**Figure 1.** Dendrogram that shows vegetation groups of treelets and shrubs in the tropical sub-mountain forest of Mount Salak.
Although there were significant differences in the structure and composition of saplings and shrubs based on the Permanova test, a small $R^2$ value of 0.5 indicated that the change was not too drastic between the vegetation groups. This occurs in fern treelet species with the first highest IVI in all vegetation groups. It begins to appear in species with the third highest IVI.

3.2 The structure and composition of vegetation in vegetation groups

In all plots at vegetation group 1, 2, and 4, the vegetation was dominated by the species with the highest IVI which has fern life form, namely *Dicranopteris dichotoma* (Thunb.) Bernh., and *Athyrium sorzogonense* (Presl.) Milde. *Cinchona officinalis* L. is a non-fern life form treelet species which has the highest IVI in plots in vegetation group 1. In vegetation group, 3 only *A. sorzogonense* has the highest IVI. One of the most found plants is *Dicranopteris dichotoma* (Table 1). According to Hoshizaki and Moran [16], this plant is a turn of wild ferns that grow on cliffs or in damp and wet shrubs, at an altitude of 500 m to 2,500 m above sea level.

### Table 1. The species with the highest IVI in each vegetation group

| The 1st Highest IVI | The 2nd Highest IVI | The 3rd Highest IVI |
|---------------------|---------------------|---------------------|
| **Vegetation Group 1** | | |
| Species | J.Plot | Species | J.Plot | Species | J.Plot |
| *Dicranopteris dichotoma* | 1 | *Melastoma malabatricum* | 1 | *Melastoma malabatricum* | 3 |
| *Athyrium sorzogonense* | 9 | *Dicranopteris dichotoma* | 2 | *Symplacos fasciculata* | 1 |
| *Cinchona officinalis* | 3 | *Athyrium dilatatum* | 1 | *Sauraula cauliflora* | 1 |
| | | *Athyrium sorzogonense* | 4 | *Dicranopteris dichotoma* | 3 |
| | | *Pinus merkusii* | 3 | *Athyrium dilatatum* | 2 |
| | | *Cinchona officinalis* | 3 | *Cinchona officinalis* | 3 |
| **Vegetation Group 2** | | |
| Species | J.Plot | Species | J.Plot | Species | J.Plot |
| *Dicranopteris dichotoma* | 6 | *Macaranga rhizinoides* | 10 | *Melastoma malabatricum* | 2 |
| *Athyrium sorzogonense* | 11 | *Athyrium dilatatum* | 1 | *Lithocarpus elegans* | 2 |
| | | *Calamus javanensis* | 6 | *Macaranga rhizinoides* | 4 |
| | | | | *Dicranopteris dichotoma* | 1 |
| | | | | *Athyrium dilatatum* | 7 |
| | | | | *Schima wallichii* | 1 |
| **Vegetation Group 3** | | |
| Species | J.Plot | Species | J.Plot | Species | J.Plot |
| *Athyrium sorzogonense* | 8 | *Dicranopteris dichotoma* | 2 | *Peperomia laevisfolia* | 2 |
| *Athyrium dilatatum* | 4 | *Ficus sinuata* | 1 |
| *Athyrium sorzogonense* | 2 | *Macaranga cf. rhizoides* | 1 |
| *Calamus ciliaris* | Calamus javanensis | Calamus javanensis | 3 |
| **Vegetation Group 4** | | |
| Species | J.Plot | Species | J.Plot | Species | J.Plot |
| *Dicranopteris dichotoma* | 6 | *Dicranopteris dichotoma* | 9 | *Pandanus sp.* | 1 |
| *Athyrium sorzogonense* | 16 | *Athyrium dilatatum* | 8 | *Urophyllum glabrum* | 1 |
| | | *Athyrium sorzogonense* | 4 | *Dicranopteris dichotoma* | 6 |
| | | *Calamus ciliaris* | 1 | *Athyrium sorzogonense* | 11 |
| | | | | *Athyrium dilatatum* | 2 |
| | | | | *Schima wallichii* |

IVI: Important Value Index, J.Plot: Number of the plot where the species has its highest IVI

The species with second highest IVI is also dominated by treelet ferns which are the same sequence of species with the highest IVI in vegetation group 1, and 4. The treelets fern species with the same sequence of IVI found in all vegetation groups is *Athyrium dilatatum*. The genus of Calamus is also
seen in vegetation groups 2, 3 and 4, and in vegetation group 3 and 4 it is dominated by treelets, ferns, and rattan. The most plentiful of non-fern species are in group 1. A clearer difference is seen in the composition of species with the third highest IVI among vegetation groups. Beside to fern species, the non-fern species appear in all vegetation groups where the most number of species are in vegetation groups 1 and 2. In vegetation group 1, 2, and 3, the non-fern species are dominant in most of the plots (Table 1).

Ferns, which are the most dominant plants in trees and bush level in the Gunung Salak sub-tropical forest, are thought to be due to relatively high rainfall in this region. According to Hoshizaki and Moran [16] ferns that grow in the tropics generally, require a temperature range of 21-27°C for growth. With the appropriate temperature conditions cause the spread of many types of ferns in tropical forest areas. This is in line with the research of Pitma et al. [17] that the high diversity of understorey vegetation in Yasuni National Park in eastern Ecuador is thought to be due to high rainfall so that water is available throughout the year to support vegetation growth.

The difference in fern structure in terms of the structure in Marambaia paleo-island, which is located in the southern state of Rio de Janeiro, is closely related to differences in humidity and the incidence of light. The difference between these two abiotic factors is due to the unequal tilt direction [18]. The existence of tropical mountain forests depends on environmental conditions observed from variations in altitude to temperature, water, light, and soil [19].

3.3 Indicator species in vegetation groups
Determining the indicator species showed that only vegetation group 2 that has no indicator species, this group only has indicator species if it joins other vegetation groups. Vegetation group 1 has the most indicator species that was 5, while vegetation groups 3 and 4 have 4 and 3 respectively (Table 2).

| VG : Vegetation Group; Stat: Statistic; P: Probability; Signif. codes: ‘***’ P < 0.001; ‘**’ P < 0.01; ‘*’ P < 0.05 |

Table 2. Species indicator of treelets and shrubs in each vegetation group and a combination of vegetation groups

| VG | Indicator Species | Stat | P  | VG | Indicator Species | Stat | P  |
|----|------------------|------|----|----|------------------|------|----|
| 1  | Lantana camara  L. | 0.858 | 0.001** | 2 + 3 | Gleichenia sp. | 0.587 | 0.026* |
|    | Pinus merkusii     | 0.853 | 0.001** | 2 + 4 | Litsea cubella (Lour.) Pers. | 0.701 | 0.005** |
|    | Eupatorium inulifolium H.B.K. | 0.838 | 0.001** | 3 + 4 | Pandanus polycephalus Lamk. | 0.893 | 0.001** |
|    | Antidesma tetendung | 0.759 | 0.002** |  | Lasianthus sp. | 0.852 | 0.002** |
|    | Maesa latifolia (Bl.) DC. | 0.734 | 0.001** | 1 + 2 + 3 | Schefflera longifolia (Bl.) Vieg. |  |  |
| 3  | Ficus globosa Bl. | 0.666 | 0.003** | 1 + 2 + 4 | Ficus padana Burm. f. |  |  |
|    | Litsea tomentosa Blume. | 0.615 | 0.005** | 2 + 3 + 4 | Calamus javanensis Bl. |  |  |
|    | Pleomele elliptica (Thunb. & Dalm.) N.E.Br. | 0.477 | 0.039* |  | Dyssoxylum arborescens. |  |  |
|    | Villebrunea rubescens (Bl.) Bl. | 0.441 | 0.046* |  | Pygeum parviflorum T. et B. |  |  |
| 4  | Urophyllum glabrum Jack ex Wall. | 0.867 | 0.001** |  | Medinella sp. |  |  |
|    | Rhodamina cinerea Jack. | 0.603 | 0.004** |  | Manglietia glauca Bl |  |  |
|    | Blumea balsamifera (L.) DC. | 0.533 | 0.034* |  | Cyathea junghuhnianna |  |  |
| 1 + 2 | Cinchona officinalis L. | 0.902 | 0.001** |  | Phoebe grandis (Ness) Merr. |  |  |
| 1 + 3 | Ficus ribes Reinw. Ex. Bl. | 0.713 | 0.001** |  | Polysoma interfolia Blume. |  |  |
There were 8 combined vegetation groups that have indicator species. The combination of vegetation groups showed that vegetation groups 2, 3, and 4 have the most indicator species, as many as 8 species, while the other combination of vegetation groups, only the combination of vegetation groups 3 and 4 that have 2 indicator species and the others have 1 indicator species. Indicator species with fern life forms only found in the combination of vegetation groups 2 and 3, so that was *Gleichenia* sp., and in the combination of vegetation groups 2, 3 and 4 that was *Cyathea junghuhniana*. There were no same indicator species that was found in 1 vegetation group or in the same combination of vegetation group. There are 29 species of indicators (Table 2). The formed Indicator species are species that indicate the structure and composition of vegetation in each vegetation group and a combination of vegetation groups.

### 3.4 Vegetation diversity at vegetation groups.

The one way Kruskal-Wallis test shows that there is a very significant difference in the $H'$ index (Kruskal-Wallis $\chi^2 = 20.541$, df = 3, p-value = 0.0001311), $D$ (Kruskal-Wallis $\chi^2 = 23.855$, df = 3, p-value = 2.678e-05), $E$ (Kruskal-Wallis $\chi^2 = 14.315$, df = 3, p-value = 0.002506) and $S$ (Kruskal-Wallis $\chi^2 = 17.868$, df = 3, p-value = 0.0004683) among vegetation groups.

Post hoc test with Games Howel statistic showed that vegetation groups 2 and 4 have differences ($P < 0.001$) in all parameters of diversity. Parameters of the diversity of $H$, $D$, and $S$ differed significantly between vegetation groups 1 and 4. The significant difference in $S$ value was also seen between vegetation group 3 and 4 (Table 3).

#### Table 3. The Games Howel's Post Hoc Test on the parameters of vegetation diversity among each vegetation group

|   | $H'$ |   | $D$ |   |
|---|------|---|-----|---|
| groups | $t$ | df | $p$ | $t$ | df | $p$ |
| 1:2 | 0.587 | 26.002 | 0.935 | 1:2 | 1.197 | 27.738 | 0.634 |
| 1:3 | 1.41 | 18.674 | 0.509 | 1:3 | 1.804 | 18.304 | 0.598 |
| 1:4 | 3.954 | 16.952 | 0.005** | 1:4 | 3.666 | 17.157 | 0.009** |
| 2:3 | 2.144 | 19.543 | 0.174 | 2:3 | 2.468 | 21.178 | 0.095 |
| 2:4 | 5.194 | 24.265 | 0.000*** | 2:4 | 5.042 | 22.113 | 0.000*** |
| 3:4 | 2.511 | 10.96 | 0.113 | 3:4 | 2.237 | 10.638 | 0.175 |

|   | $E$ |   | $S$ |   |
|---|-----|---|-----|---|
| groups | $t$ | df | $p$ | $t$ | df | $p$ |
| 1:2 | 1.953 | 24.169 | 0.233 | 1:2 | 0.158 | 26.205 | 0.999 |
| 1:3 | 0.482 | 17.584 | 0.962 | 1:3 | 1.408 | 18.73 | 0.51 |
| 1:4 | 1.281 | 19.912 | 0.585 | 1:4 | 4.37 | 18.736 | 0.002** |
| 2:3 | 2.479 | 15.306 | 0.104 | 2:3 | 1.329 | 19.953 | 0.556 |
| 2:4 | 4.101 | 31.168 | 0.001** | 2:4 | 4.572 | 26.651 | 0.001** |
| 3:4 | 0.68 | 11.794 | 0.903 | 3:4 | 3.048 | 12.597 | 0.042* |

Signif. codes: ‘***’ $P < 0.001$; ‘**’ $P < 0.01$; ‘*’ $P < 0.05$

The mean values of $H'$, $E$, and $S$ were found to be the highest in vegetation group 4, but we also found in this vegetation group the lowest $D$ value. The vegetation group 2 has the lowest mean values $H'$, and $E$ but with the highest $D$ value. This indicates that the plots found in vegetation group 4 had higher diversity than those in vegetation group 2. The lowest mean value of $S$ was in vegetation group
1 compared to other vegetation groups. The mean value of $S$ in vegetation group 1 is less than those in vegetation group 4 which indicates a low number of species (Table 4).

Our study shows indicator species that show for point 3 based on De Cáceres [20], meaning that there is vegetation diversity in an area. According to Martini et al. [21], one indicator species in the habitat observed after experiencing a fire 5 years ago at Una Biological Reserve, Bahia, Brazil, was the life form of the fern *Pteridium aquilinum*. This type can indicate the environmental conditions.

| Table 4. The mean and standard deviation values of the parameter of vegetation diversity in each vegetation group |
|---------------------------------|--------|--------|--------|--------|--------|--------|
| Diversity Parameter $s$        | 1      | 2      | 3      | 4      |       |
| H'                              | 3.280  | 3.235  | 3.388  | 3.530  | 0.121 |
| D                               | 0.056  | 0.062  | 0.051  | 0.043  | 0.007 |
| S                               | 42.000 | 42.471 | 46.125 | 52.955 | 5.473 |
| E                               | 0.881  | 0.867  | 0.885  | 0.890  | 0.016 |

4. Conclusion
In this study, we found 4 vegetation groups of treelets and shrubs, which were vegetation group 1, vegetation group 2, vegetation group 3, and vegetation group 4. Each vegetation group was different in terms of its structure and composition. Each vegetation group is different in terms of the structure and composition of the constituent species. We found in each vegetation group the species *D. dichotoma*, *A. sorzogonense*, and *C. officinalis*, were species that have the highest IVI. In the vegetation group 2, no indicator species were found. There are 8 combined vegetation groups that have indicator species. The one-way Kruskal-Wallis test shows the difference in Shannon-Wiener diversity index ($H'$), Simpson's index ($D$), Pielou's evenness index ($E$) and Species Richness ($S$) among vegetation groups. The vegetation group 2 and 4 have differences in all parameters of diversity. The values of $H'$, $D$, and $S$ between vegetation group 1 and 4 are different. The difference in $S$ values also appears between vegetation group 3 and 4.

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