The association among dominant tree species in mount Halimun Salak National Park

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Abstract. Association is a relationship in an ecosystem between living organisms. Positive associations arise when a plant species is associated with other plant species, and negative associations occur under opposite situations. This study aimed to identify the relationship among dominant tree species of the National Park Mount Halimun Salak by producing a permanent 100 m x 100 m plot divided into 25 sub-plots of 20 m x 20 m to store the trees. Smaller sizes of 5 m x 5 m and 1 m x 1 m were nested on each sub-plot to inventory saplings and seedlings. Vegetation research determined the dominant tree species. In addition to an association coefficient, the Association indexes were determined by a contingency table of 2 x 2. The results showed that the composition of vegetation at the tree levels includes 32 families, 46 genera and 61 species; 28 families, 35 genera and 53 species at sapling stage; 24 families with 19 genera and 43 species at the seedling level. The dominant species on the tree level were *Altingia excelsa*, *Schima walichii*, *Agathis damara*, *Engelhardia spicata* on the sapling level were *Schima walichii*, *Altingia excelsa*, *Litsea* sp., *Macaranga triloba* on the seedling level were *Schima walichii*, *Aporosa frutescens*, *Quercus sundaica*, *Macaranga triloba*. The association analysis showed that *Agathis damara* and *Altingia excelsa* were very significantly associated negatively.

1. Introduction
The Halimun Mountain area is designated a protected forest since 1924 with size of 39,941 ha. Then in 1935, the status is changed into nature reserve which is lasted until 1992. This area is then designated as Mount Halimun National Park with an area of 40,000 ha, following Minister of Forestry Decree No.282/Kpts-II/1992 dated on February 28, 1992. As one among 51 national parks in Indonesia, this forest area contains high biodiversity especially plants.

According to a record from a number of exploration that was done during 1997-2002 in the same place including additional existing literature reviews, 845 plant species from 436 genus and 125 families were recorded. While the number or flowering species has been increasing from time to time [1]. This plant species richness can be categorized into a number of groups and ecologically all of these species from the mountain ecosystem has their own function. Ecological interaction internally and externally occurs among of them. Interaction among species is the foundation of the formation of the ecological community and its evolution. Therefore, associations between species are essential to study population distribution patterns, evolution, and succession [2], [3], [4], [5], [6]. Furthermore, a species' association pattern could be an important aspect of formulating suitable management and conservation actions, both in-situ and ex-situ.

Associations between species occur when two or more species are more often present together in habitat than coincidence. As a result of biotic behaviors such as mutualism, rivalry and predation the
relation takes place. Associations may be positive or negative between two animals. Positive interactions arise when both organisms prefer the same habitat or have equal environmental requirements and create an advantageous relationship between two sides for example, mutualism. Conversely, negative associations occur when two species have different or opposing environmental needs and causes to an adverse interaction, such as competition between species or predation. Association analysis is a good method to determine the distribution patterns.

The pattern of vegetation distribution is influenced by various environmental factors such as temperature, water, soil nutrients, sunlight, disturbance, biotic interactions [7], [8], [9], altitude [10], and rainfall [11]. Each plant species has unique living conditions so that it will only grow well in certain places that meet these requirements. The presence of a species (especially the dominant one) can be used as an indicator of suitable habitat to grow.

This study aims to study the association of only four dominant tree species in the Halimun Salak National Park. In this study, the association analysis is chose as it provides a good method to determine the association patterns of a species.

2. Research Procedure

2.1 Research Location

Mount Halimun Salak National Park area is a wet area. Annual rainfall ranges from 4,000 to 6,000 mm, with dry months occur in between May and September. This climate is classified into A through B types according to the Schmidt and Ferguson rainfall classification. The monthly temperature ranges between 19.7-31.8 °C, and the average humidity is 88%. This area is an important water catchment area in the west part of the West Java. More than 115 rivers and tributaries lay in the National Park area. Three major rivers flow north to the Java Sea, namely Cikaniki and Cidurian and Ciberang, part of the Cijung watershed. Nine important watersheds flow into the Indian Ocean in the south, including Cimandiri, Citepus, Cimaja, and Cisolok. These rivers flow across the regions of Bogor, Tangerang, Rangkasbitung, Bayah and Palabuhanratu.

Administratively, the Gunung Halimun Salak National Park covering three regencies, namely Bogor, Sukabumi (West Java), and Lebak (Banten). The topography of this region is hilly and mountainous, at an altitude range of 500-2,211 m above sea level. The summit includes the mountain of Halimun Utara (1,929 m), Ciawiiti (1,530 m), Kencana (1,831 m), Botol (1,850 m), Sanggabuana (1,920 m), Kendeng South (1,680 m), Halimun Selatan (1,758 m), Endut (east) (1,471 m), Sumbul (1,926 m), and Salak (first peak at 2,211 m, and a second peak at 2,180 m). These mountain ranges are often shrouded in mist (locally called "halimun"), as implies in the name.

The study site is in the Mount Bodas area of the Cirendang village which was previously a production forest of the Perum Perhutani. Currently, however, the area is an extension of the Gunung Koneng Resort, Management Section III of the Mount Halimun Salak National Park. Administratively, the location laid at Cirendang village, Cikakak sub-district, Sukabumi District, West Java.

The research plot geographically located at coordinates of 06°50’49.2" S - 06°50’50.6" S and 106°30’31.4" - 106°30’32.9” E. Topographically, the study site undulated consisting of hills to mountains with altitude ranges from 480-650 meters asl. Average rainfall in the study site ranges from 250-336 mm/yr, with an average temperature of 19° - 27°C. Soil types dominated by andosols and reosols that are fertile enough to be used as agricultural and plantation land [12].

2.2 Research Procedure

At the study site, the plot was 100 m x 100 m straight north. The plot was then broken down into 25 sub-parts of 20 m x 20 m. The four plot corners marked with a 2-inch diameter PVC pipe buried at 50 cm depth so that the remaining 50 cm is visible above the ground. Each subplot divided into observational square plots in the respective sizes as follows:

- 20 x 20 m to inventory vegetation at pole and tree-level
- 5 x 5 m to inventory vegetation at the sapling level,
- 2 x 2 m to inventory seedling-level vegetation
Poles and trees level inside the sub-plot were identified and measured for the diameter at breast height (1.3m) or 10 cm above the buttress (if the tree is buttressed). Sapling and seedling levels were identified and calculated for the number of individuals in each sub-plot. Sub-plots for seedlings and saplings were only taken out of nine out of 25 sub-plots due to homogeneous conditions at the study site as shown in Figure 1.

![Figure 1. Plots of 100 m x 100 m divided into 25 subplots of 20 x 20 m. Nine subplots shaded to an inventory of sapling and seedlings](image)

2.3. Data Analysis

All tree inventory data is processed using the vegetation analysis formula as follows:

- Species density: number of people of a species per plot
- Relative density (Rd) of species (percentage) is the ratio of species number to the total number of species in the plot.
- Species frequency is the number of plots in which a species was found
- The ratio of the species frequency (Rf) to the total frequency of the species (%) of the whole plot.
- The dominance of a population is the overall area of the species base.
- Relative dominance (Rdo) (percent) is the ratio of a species' overall base area to the total base area for all species.
- Basal Area: area of the cross-section of the stem at breast height = \( \frac{1}{4} \pi d^2 \) [13], [14]. Where \( \pi = \text{phi or 3.14} \), and \( d = \text{stem diameter at breast height} \).
- Important Value Index of tree level are Rd+ Rf + RDo, while for sapling and seedling level: Rd + Rf [13], [14].

The dominant species will be revealed from the vegetation analysis, namely species with high importance value index. The biggest four dominant tree species are then selected to study the level of association between these four species. Association analysis is only for tree-level because it is already established. Seedling and sapling level no association analysis is performed. It is necessary to make a Contingency table to calculate the association index (Table 1).

Table 1. Contingency table to calculate the association index
Contingency table

|   | +  | -   | a + b | a + c | b + d | N  |
|---|----|-----|-------|-------|-------|----|
| + | a  | b   | a + b | a + c | b + d | N  |
| - | c  | d   | c + d | a + c | b + d | N  |

Where:
- \( a \) = Number of plots containing A and B species
- \( b \) = Number of plots containing A species only
- \( c \) = Number of plots containing B species only
- \( d \) = Number of plots containing no species A and B
- \( N \) = Number of plots

Furthermore, a direct calculation is performed without calculating the observation value, using the Chi-Square \((X^2)\) calculation formula as follows:

\[
X^2 = \frac{(ad - bc)^2 \times N}{(a + b)(c + d)(a + c)(b + d)}
\]  

The calculated Chi-Square then compared to the Chi-Square table \((X^2)\) table at free degrees (df) of 1 at the level of 1 % (6.63) and 5% (3.84) to determine the association between the species. If the calculated \(X^2\) is greater than or equal to the \(X^2\) table at a 1% level means that the association is very significant. If the calculated \(X^2\) is greater or equal to the \(X^2\) table at the 5% level means significant. Finally, if the calculated \(X^2\) is less than the \(X^2\) table at a 5% level means no association or the association is not significant.

Furthermore, the Coefficient of Association \((C)\) needs to be calculated to identify whether the association is positive or negative using the Coefficient of Association \((C)\) as formulated by Cole [15] as follows:

\[
C = \frac{(ad - bc)}{(a + b)(b + d)}
\]  

Positive or negative values from the calculation results indicate positive or negative associations between the two species. According to Whittaker (1975), positive association means indirectly the two species have good relations or dependency one to another, while negative associations mean indirectly the two species have a tendency to exclude the other or the two species have different influences or reactions to their environment.

3. Result and discussion

3.1 Species composition

Vegetation analysis revealed that from 20 m x 20 m of 25 plots, 388 individual trees were recorded. The dominant species were Rasamala \((Altingia excelsa)\), Puspa \((Schima walichii)\), Damar \((Agathis damara)\), and Kihujan \((Engelhardia spicata)\) with Important Value Index of 61.87%, 27.35%, 19.97%, and 13.62% respectively. At the tree level, species composition consists of 32 families, 46 genera and 61 species. The dominant family is Euphorbiaceae (7 species), Fagaceae (6 species), and Lauraceae (5 species), as shown in appendix 1.

At the level of saplings, 137 stems were recorded from 9 plots of 5 m x 5 m \((225 \text{ m}^2)\). The dominant species were Puspa \((Schima walichii)\), Rasamala \((Altingia excelsa)\), Huru \((Litsea sp.)\), and Mara \((Macaranga triloba)\) with important value index of 16.18%, 10.09%, 9.79%, and 9.65% respectively. Vegetation composition consists of 28 families, 35 genera, and 53 species, as shown in appendix 2.
For seedling levels, 9 plots of 2 m x 2 m (36 m²) covered 110 seedlings. The dominant species were Puspa (Schima walichii), Kiuht (Aporosa frutescens), Pasang (Quercus sundaiaca), and Mara (Macaranga triloba) with important value index of 16.82%, 12.15%, 12.15%, and 9.35% respectively. Seedling vegetation composition consists of 24 families, 19 genera and 43 species, as shown in Appendix 3.

3.2. Association of the dominant species

Calculation of the vegetation analysis revealed the four most dominant species, namely Rasamala (Altingia excelsa), Puspa (Schima walichii), Damar (Agathis damara), and Kihujan (Engelhardia spicata). The four dominant species were studied further for the association. Chi-Square Calculation result is presented in Table 2.

| Table 2. Result of the calculated Chi-Square of the dominant species pairs |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| **Altingia excelsa** | **Schima walichii** | **Agathis damara** | **Engelhardia spicata** |
|---------------------|-----------------|-----------------|-----------------|
| Altingia excelsa    | 1,23            | 15,028**        | 1,19            |
| Schima walichii     |                 | 1,5             | 0,05            |
| Agathis damara      |                 |                 | 6,79**          |
| Engelhardia spicata |                 |                 |                 |

Remark:
- **Significant association at a 1% level**

The Coefficient of Association (C) needs to be calculated to determine the positive or negative association. The calculation results of the Coefficient of Associations (C) is presented in Table 3.

| Table 3. Association Coefficient Values (C) of the dominant species. |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| **Association Coefficient**                      | **Altingia excelsa** | **Schima walichii** | **Agathis damara** | **Engelhardia spicata** |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Altingia excelsa                                |                 | -0,03           | -0,133          | 0,006           |
| Schima walichii                                 | -0,03           |                 | 0,008           | 0,089           |
| Agathis damara                                  | -0,133          | 0,008           |                 | -0,214          |
| Engelhardia spicata                             |                 |                 |                 |                 |

The dominant tree species pairs associated negatively and significantly were damar (Agathis damara) and Rasamala (Altingia excelsa), as well as damar (Agathis damara) and Kihujan (Engelhardia spicata). Another negative association was shown by Puspa (Shima malichii) and Rasamala (Altingia excelsa) though the association is not significant. Negative associations are species pair with the opposite condition, which have different habitats and needs. Negative associations are common in established or stable forests. The more stable a forest, the more negative associations occur [16]. Species interactions affect ecological processes such as growth, regeneration, and mortality that ultimately affect the distribution or dispersion [17], [18]. The results of the study concluded that species distribution is influenced by competition between species [19]. Other results concluded that species pairs with positive associations have the same needs so that the ecological niche overlaps [20], [16]. In this study, a positive association yet not significant was showed by Rasamala (Altingia excelsa) and Kihujan (Engelhardia spicata); Puspa (Schima walichii) and Damar (Agathis damara) as well as Puspa (Schima walichii) and Kihujan (Engelhardia spicata). Those three pairs species tend to have similar requirements to grow and hold mutual symbiosis.
4. Conclusion
The species are composed of 32 families at the level of the flower, of 46 typically 61 species, of 28 families, 35 generations and 53 species at the level of the sapling, of 24 families, 19 genera and 43 species at the level of the seedling. The dominant species at the tree level were Rasamala (Altingia excelsa), Puspa (Schima walichii), Damar (Agathis damara), and Kihujan (Engelhardia spicata). At the sapling, the dominant species were Puspa (Schima walichii), Rasamala (Altingia excelsa), Huru (Litsea sp.), and Mara (Macaranga triloba). At the seedling level, the dominant species were Puspa (Schima walichii), Kiuhat (Aporosa frutescens), Pasang (Quercus surdaisca) and Mara (Macaranga triloba). Significant negative associations occur between Damar (Agathis damara) and Rasamala (Altingia excelsa), as well as damar (Agathis damara) and Kihujan (Engelhardia spicata).

Considering the importance of the presence of native plants species at all level of their life growth cycle to represent the uniqueness of the mountain floras and to maintain the balance and health of the mountain ecosystem, well designed monitoring system would be of benefit to determine possible changes due to various possible disturbance. In addition, a comprehensive data record on vegetation composition is highly valuable as references for restoration purposes. It is recommended to conduct periodic monitoring to enable observation of floristic changes dynamic in this mountain ecosystem and to determine the impact of their changes to the environment.

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