Carrying capacity of environment to the life potential of Rafflesia (Rafflesia patma Blume) in Leuweung Sancang Nature Reserve Garut West Java

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Abstract. This research aims to determine the condition of vegetation around the Rafflesia environment, conditions and population of Rafflesia host, condition and population of Rafflesia, and environmental characteristics of abiotic component in Leuweung Sancang Nature Reserve. The method used is a quantitative descriptive method with a purposive sampling technique in which 4 circle plots of 0.1 Ha are made. The results showed that vegetation around Rafflesia's environment was dominated by Ki Kopi (Tarenna polycarpa) on tree vegetation, Ki Barera (Tetrastigma leucostaphylum Dennst) on sapling vegetation, and Pereng (Ficus sp) on seedling vegetation. Species diversity is quite abundant (1.027) with species richness is classified as moderate (3.833) and species evenness is high (1.585). The host of Rafflesia, Ki Barera (Tetrastigma leucostaphylum Dennst) was found as many as 9 trees with an average diameter of 4-15 cm. Rafflesia is overgrown on the roots of the top soil and stems. Found 34 knobs of Rafflesia with a mortality rate of 38.24% which is relatively low. Abiotic environmental conditions are very supportive of Rafflesia's life. Thus the biotic and abiotic environment in Cipalawah block of Leuweung Sancang Nature Reserve supports the life potential of Rafflesia patma Blume.

1. Introduction
Carrying capacity of the environment according to the Law of the Republic of Indonesia Number 32 (2009) concerning Environmental Protection and Management, is the ability of the environment to support the lives of humans, other living things, and the balance between the two [1]. Carrying capacity is not fixed, but develops over time, and can be influenced by management and control techniques. Environmental balance is dynamic, meaning that there can be a decrease or increase in population of each plant and animal species and various biotic components.

Leuweung Sancang Forest was designated as a Nature Reserve based on Minister of Agriculture Decree No. 370/Kpts/Um/6/1978 with an area of 2,157 Ha. Potential flora in the Sancang Forest include the poisonous Warejit (Excoecariaoch), Parahlar (Dipterocarpus sp) which is the only native species of Dipterocarpaceae and grows on Java and Kaboa (Lumnitzea racemose) which is a typical plant. In addition, there are also living flowers Rafflesia patma [2].

Rafflesia patma Blume is one species of 4 genus Rafflesia medium sized of all Rafflesia species ever found [3]. Rafflesia is classified as rare and has been protected based on Minister of Agriculture Decree No. 6/PMP/1961, concerning the prohibition of releasing Rafflesia species. Rafflesia patma is included
in the Endangered status according to the WCMC (World Conservation Monitoring Center). Characteristics of Rafflesia as a rare plant species must get priority for preservation because the population in nature is small (rare) and is an endemic species. Scarcity of this species is caused by Rafflesia having different biological characteristics from other plants, namely having an annual life cycle, being a parasite in certain liana species, and breeding difficult [4]. This leads to the notion that Rafflesia chose certain environmental conditions to support its breeding and growth.

The distribution of Rafflesia patma currently covers the area of tropical rain forests in Java Island, namely in the Nature Reserve: Pananjung Pangandaran, Leuweung Sancang and Nusa Kambangan [4]. The population of Rafflesia patma in Leuweung Sancang decreases from year to year. Although the effort to conserve Rafflesia patma in the ex situ location (Bogor Botanical Garden) has been successful [5], but in its natural habitat it has declined. Therefore it is necessary to conduct research on the environmental carrying capacity of the life potential of Rafflesia patma Blume in Leuweung Sancang.

The purpose of this research is to determine the condition of vegetation around the Rafflesia patma Blume environment, conditions and population of Rafflesia patma Blume host, condition and population Rafflesia patma Blume, and the environmental characteristics of the Rafflesia patma Blume abiotic component in the Leuweung Sancang Nature Reserve.

2. Methods
The method used in this research is quantitative descriptive method. Sampling was carried out in the Cipalawah block of Leuweung Sancang with a research sampling technique using a purposive sampling technique where each encounter with Rafflesia patma Blume was made a plot. The plot consists of a Rafflesia plot and a Tetrastigma (non Rafflesia) plot with a ratio of 1: 1. The plot is made in the shape of a circle of 0.1 Ha. Data collected at each plot was in the 0.1 Ha plot size (radius 17.8 m) data collected at the tree level vegetation (plot 1). At 0.01 Ha plot size (radius of 5.6 m) data collected on the sapling level vegetation (plot 2). Whereas the 0.001 Ha plot size (1.8 m radius) collected seedling vegetation data (plot 3). This research was conducted in December 2019 - January 2020.

Vegetation analysis for associated plants was calculated by the Importance Value Index (IVI), community similarity index, diversity index, richness index, and evenness index.

2.1. Importance value index
Importance value index illustrate the important role of vegetation in ecosystems. If the IVI of a type of vegetation is of high value, then that species greatly influences the stability of the ecosystem [6].

Importance Value Index (IVI) = Relative Density + Relative Frequency + Relative Dominance

To find out the IVI at the level seedlings and saplings calculated from the value of relative density and relative frequency [6].

Importance Value Index (IVI) = Relative Density + Relative Frequency

2.2. Community similarity index
To see between vegetation in the Rafflesia plot and the Tetrastigma (non Rafflesia) plot is calculated using the Ludwig and Reynold similarity index [4].

\[ IS = \frac{2W}{a + b} \times 100\% \]

Information:
IS= coefficient of community similarity (index of similarity)
W = the same number of individuals or the lowest value of the species contained in the two sample plots compared
a = number of individuals of all species found in community A (Rafflesia plot)
b = number of individuals of all species found in community B (Tetrastigma plot)
Community similarity index range from 0 - 100%. The closer to the value of 100%, the state of the stands being compared has a high similarity [6].

2.3. Diversity index
Species diversity in the community can be known from the species diversity index of Shannon-Wiener [6].

\[ H' = - \sum \frac{n_i}{N} \log \frac{n_i}{N} \]

Information:
- \( H' \) = Shannon - Wiener diversity index,
- \( n_i \) = number of individuals of a type i,
- \( N \) = total number of individuals of all types

The magnitude index of species diversity according to Shannon-Wiener is defined as follows:
- \( H' > 3 \) indicate that the diversity of species in a transect is abundantly high
- \( 1 \leq H' \leq 3 \) indicates that the diversity of species in a transect is being abundant
- \( H' < 1 \) indicates that species diversity in a transect is little or low

2.4. Richness index
To find out the magnitude of the richness of plant species used the Margalef index [4].

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

Information:
- \( R \) = Margalef richness index,
- \( S \) = number of types,
- \( N \) = total number of individuals

The magnitude of \( R < 3.5 \) shows that the species richness is low, \( R = 3.5 - 5.0 \) shows that the species richness is moderate and \( R > 5.0 \) is high.

2.5. Evenness index
The type of evenness index most widely used in ecology is the Ludwig and Reynold evenness index [4].

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

Information:
- \( E \) = type of evenness index,
- \( H' \) = species diversity index,
- \( S \) = number of types

The magnitude of \( E < 0.3 \) indicates that evenness of species is low, \( E = 0.3 - 0.6 \) evenness of species is classified as moderate and \( E > 0.6 \) then evenness of species is high [6].

Analysis of the conditions and host population of *Rafflesia patma* Blume is done by direct observation, namely by counting the number of individual hosts (*Tetrastigma leucostaphylum*), stem diameter, and location of the growth of *Rafflesia*. Analysis of conditions and population of *Rafflesia patma* Blume is directly in accordance with the metering by measuring the diameter and counting the number individual. While the observation of the *Rafflesia* abiotic environment is measured directly using tools: slink-psychrometer, soil-tester, soil-thermometer, light-meter, anemometer, and GPS.
3. Results and discussion

3.1. Vegetation condition around Rafflesia patma Blume

The research area (Cipalawah Block) consists of coastal forest (mangrove) and lowland forest. Rafflesia interacts with other types of plants around it. As a parasitic plant, Rafflesia desperately needs a host for its residence and source of nutrition (association I). The host for Rafflesia is Liana from the Vitaceae family. This liana plant needs another tree around it as a structural host for vines (association II). Furthermore, the structural host interacts with other trees in the vicinity (association III). Thus it is necessary to analyze the vegetation around the Rafflesia environment by looking at the Importance Value Index to express the level of species dominance in the community [7].

The highest importance index in the Rafflesia plot and the Tetrastigma plot can be seen in Table 1. Based on observations it can be seen that in the Rafflesia plot, the Ki Kopi tree (Tarenna polycarpa) is one of the trees that makes the ecosystem balance in the Rafflesia patma habitat and acts as an association plant. The species that appears most frequently in the Rafflesia habitat is a typical species of that habitat [8]. Whereas in the Tetrastigma plot, the Pereng tree (Ficus sp) dominates. Ficus sp acts as a structural host for Tetrastigma leucostaphylum. Belimbing Wuluh Tree (Averrhoa bilimbi) and Ki Kopi (Tarenna polycarpa) play a role as an associate plant.

| No. | Vegetation Level | Species in Rafflesia Plot | Highest IVI | Species in Tetrastigma Plot | Highest IVI |
|-----|-----------------|---------------------------|-------------|----------------------------|-------------|
| 1   | Tree            | Ki kopi (Tarenna polycarpa) | 95.91       | Pereng (Ficus sp)           | 47.15       |
|     |                 |                           |             | Belimbing Wuluh (Averrhoa bilimbi) |             |
|     |                 |                           |             | Ki kopi (Tarenna polycarpa)  |             |
| 2   | Sapling         | Ki barera (Tetrastigma leucostaphylum Dennst) | 140.57 | Ki Kopi (Tarenna polycarpa) | 96.98       |
| 3   | Seedling        | Pereng (Ficus sp)         | 60.67       | Bayur (Pterospermum javanicum) | 86.66       |

An index of similarity (IS) is sometimes necessary to determine the level of similarity between several stands, between several sampling units, or between several communities studied and compared to the composition and structure of the community. Based on observations (Table 2), the similarity index on tree vegetation (64%) is lower than the similarity index on seedling vegetation (74.42%) but higher than sapling vegetation (63.16%). The similarity of communities in the Rafflesia plot and the Tetrastigma plot both tree vegetation, saplings and seedlings are high because they are close to 100%.

| No. | Vegetation Level | Similarity Index |
|-----|-----------------|-----------------|
| 1.  | Tree            | 64%             |
| 2.  | Sapling         | 63.16%          |
| 3.  | Seedling        | 74.42%          |

Species diversity can be used to express community structure. Species diversity can also be used to measure community stability, namely the ability of a community to maintain itself stable despite interference with its components [7].
Table 3. Diversity, richness, and evenness index.

| No | Index | Plot of |
|----|-------|---------|
| 1  | Diversity | 1.027 | 1.034 |
| 2  | Richness  | 3.833 | 3.366 |
| 3  | Evenness  | 1.585 | 0.571 |

Based on Table 3 the species diversity index in the *Rafflesia* plot (1.027) is lower than the *Tetrastigma* plot (1.034), although not significantly. However, the species richness index in the *Rafflesia* plot (3.833) is higher than the *Tetrastigma* plot (3.366). This is because the number of individuals representing the species in the community is not evenly distributed so that the species richness in the *Rafflesia* habitat is higher than the species richness in the *Tetrastigma* habitat. This is representing the number of individual species in the community equally.

Evenness states an indicator of the dominance of each species in the community. Evenness index value is in the range of 1 - 0, if the index value is close to 0 then the species in the community are not evenly distributed whereas if the index value is close to 1 species evenly distributed [8]. Evenness of species in the *Rafflesia* plot is spread evenly because it approaches the number 1 (1.585) and is relatively high. While the evenness of species in the *Tetrastigma* plot is moderate (0.571).

3.2. Conditions and population of *Rafflesia patma* Blume Host

Rafflesiaaceae are the most minimalistic plant, having no leaves or roots, grow as an endophyte parasite inside a host, of the genus *Tetrastigma*. Endophyte grows radially towards the center of the stem in the xylem area [9]. The host for *Rafflesia patma* Blume is the Ki Barera tree (*Tetrastigma leucostaphylum* Dennst). Ki Barera has an uneven surface of the bark with the outer shell peeling off. The bark of old liana is grooved and is easy to break and tear, making it easy for *Rafflesia* seeds to inoculate [3].

All Ki Barera trees (*Tetrastigma leucostaphylum* Dennst) were found to have an average trunk diameter of 4-15 cm. In the *Rafflesia* plot, of the 9 Ki Barera trees (*Tetrastigma leucostaphylum* Dennst) there are only 3-4 trees that host *Rafflesia patma* Blume. The observations showed that the *Tetrastigma* which was overgrown with *Rafflesia* had an average stem diameter of 14 cm and grew on the roots of the top soil and the *Tetrastigma* stem (Figure 1).

![Figure 1. Location of Rafflesia growth on Tetrastigma: (a) on the top soil root (b) on the stem.](image)

3.3. Condition and population *Rafflesia patma* Blume

Based on Table 4 it can be seen that no blooming *Rafflesia patma* was found. Whereas the highest number of individuals is 5 - 9.9 cm in diameter with 9 knobs of live *Rafflesia patma* buds.
Table 4. Population of *Rafflesia patma* Blume in the Cipalawah Block of the Leuweung Sancang Nature Reserve.

| Diameter class (cm) | Bud | Bud Rot | Bloom Rot | Bloom |
|---------------------|-----|---------|-----------|-------|
| 1 - 4.9             | 5   | 4       | 1         | 0     |
| 5 - 9.9             | 9   | 5       | 0         | 0     |
| 10 - 14.9           | 1   | 2       | 1         | 0     |
| 15 - 19.9           | 1   | 1       | 1         | 0     |
| 20 - 24.9           | 1   | 1       | 1         | 0     |

The *Rafflesia patma* mortality rate in Leuweung Sancang is 38.24 %, this mortality rate is relatively low. The *Rafflesia* mortality rate in the range of 20 – 37 % is low and high in the range of 80-100 % [3]. Of the 34 individuals found in the observation plot, 69.23 % of individuals decomposed in class diameter 1 - 9.9 cm. The remaining 30.77 % died in diameter classes 10 - 24, 9 cm.

The death of *Rafflesia* flowers is caused by two things, namely the disruption of the distribution of nutrients from the host to the *Rafflesia* knob and the disturbance of wildlife or humans. Low *Rafflesia* deaths occur under conditions of high humidity, low temperatures, and conditions of relatively constant microclimate in drought conditions or raindrop [3]. During the research was the rainy season, it caused *Rafflesia* knobs to rot even before blooming (Figure 2).

![Figure 2](image.png)

**Figure 2.** Condition of *Rafflesia patma* population: (a) and (b) live bud knob (c) bud rot knob (d) bloom rot flowers.

3.4. Environmental factor

Temperature has a direct role in almost every function of the plant by controlling the rate of chemical processes in the plant, while the indirect role is by influencing other factors, especially water supply. Temperature can cause the rate of water loss from living organisms [10]. Based on observations of air temperature in the *Rafflesia* plot is 28.75º C while in the *Tetrastigma* plot is 26.25º C. The temperature in the *Rafflesia* plot is higher than the *Tetrastigma* plot. This happens because in the *Tetrastigma* plot the shade of the vegetation is very lush and dense compared to the *Rafflesia* plot, so more sunlight enters the *Rafflesia* plot. The average relative humidity is 85 %.

Based on observations, the temperature of the soil in both the *Rafflesia* plot and the *Tetrastigma* plot is 20.5º C. Soil temperature plays an important role in controlling the activity of microorganisms. Also affects the growth of plants and the body's maturation process. Soil pH in *Rafflesia* plot is 6.1 and in *Tetrastigma* plot is 5.75. The *Rafflesia* plot has a less acidic soil pH because it is in the 6.1 - 6.5 class
range while the *Tetrastigma* plot has a slightly acidic soil pH because it is in the range of 5.6 - 6.0. Plants can generally grow at a pH of 5.0 - 8.0. This pH has a direct or indirect effect on plants. In Indonesia, soil pH generally ranges from 3 - 9. In general, the ideal pH for plant growth is near neutral (6.5-7) [10].

Based on observations of light intensity at noon in the *Rafflesia* plot which is 728 Lux while in the *Tetrastigma* plot is 162 Lux. The intensity of the light in the *Rafflesia* plot is much higher than the *Tetrastigma* plot because the canopy in the *Tetrastigma* plot is very high and lush. The amount of sunlight entering the *Tetrastigma* plot is less than that of the *Rafflesia* plot. As a result, Ki Barera (*Tetrastigma leucostaphylum Dennst*) which grows on the *Tetrastigma* plot has a small stem diameter.

In general, the wind will affect weather elements such as the optimum temperature at which plants grow and reproduce as well as possible, the humidity of the air which affects the evaporation of the surface of the land and the evaporation of leaves, as well as the movement of clouds. The height of the area in the *Rafflesia* plot is 4.5 m above sea level while in the *Tetrastigma* plot that is 5 m above sea level. The plot distance from the shoreline is approximately 100 - 500 meters with a slope in the *Rafflesia* plot of 6.6º and in the *Tetrastigma* plot of 5.25º. The texture of soil is generally sandy loam. Thus the abiotic environmental conditions support the life of *Rafflesia*.

4. Conclusion
Based on the results of research and analysis of data that has been done, it can be concluded that the vegetation around the *Rafflesia patma* Blume environment is dominated by Ki Kopi (*Tarenna polycarpa*) on tree vegetation, Ki Barera (*Tetrastigma leucostaphylum Dennst*) in sapling vegetation, and Pereng (*Ficus* sp) on seedling vegetation. Species diversity is quite abundant (1.027) with species richness is classified as moderate (3.833) and species evenness is high (1.585). Host of *Rafflesia patma* Blume is *Tetrastigma leucostaphylum Dennst*, found as many as 9 trees with an average diameter of 4 – 15 cm. *Rafflesia patma* is overgrown on the roots of the top soil and stems. Found 34 knobs of *Rafflesia patma* Blume with a mortality rate of 38.24 % which is relatively low. The biotic and abiotic environment in the Cipalawah block of the Leuweung Sancang Nature Reserve supports the life potential of *Rafflesia patma* Blume.

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