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Ecophysiology Identification and Flower Morphology of *Rafflesia arnoldii* at Forest Ecosystem of Bengkulu Province

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Abstract. *Rafflesia* flower, especially *Rafflesia arnoldii*, is a rare flower that is the pride and icon of Bengkulu Province. The population is decreasing over time and recently it is found that the size of the flower crown is relatively narrow. Conservation efforts begin with an inventory and identification of ecophysiological conditions and morphological characters, especially in several forest ecosystems in the Bengkulu Province. The target of this research is, in the end, a future conservation model based on cultivation technology. The survey method was used in this study. Data obtained through direct observation of the Bengkulu forest ecosystem habitat and interviews with representatives of the presence of *Rafflesia* flowers. The data obtained were analyzed descriptively-analytic. The results showed that 9 (nine) *R. arnoldii* flowers were found in various phases with the conditions attached to their host plant, namely *Tetrastigma* sp. This flower is found at the coordinate point of 4 ° 26'55 "S, 103 ° 15'14" E in Bungin Tambun III Village, Padang Guci Hulu District, Kaur Regency, Bengkulu Province, and this location is only 12 meters from the water source. Several flower phases were found, namely Copula (6-9 months), Brakta (3-5 months), and Perigon blooming (1-2 weeks) One of the phases of this orange flower has reached the blooming phase with 5 crowns, 53 cm in diameter, the diaphragm is 31 cm wide and 50 cm high. Environmental conditions at the time of flowering include temperatures ranging from 24-25 °C, with humidity (RH) 80-85%.

Key words: blooming, character, ecophysiology, *Rafflesia*, *Tetrastigma* sp.

1. Introduction

R. arnoldii or giant padma is an obligate parasitic plant that grows on lianas (vines) of the genus *Tetrastigma*. Other *Rafflesia* species also share the same host. *R. arnoldii* was first discovered in 1818 in the tropical forests of Sumatra by a guide who worked for Dr. Joseph Arnold, who was following the Thomas Stanford Raffles expedition so that this plant was named according to the history of its discoverer, namely the combination of Raffles and Arnold [1]. *R. arnoldii* has no leaves so it is unable to carry out photosynthesis on its own and take nutrients from its host tree. The visible shape of the *Rafflesia* flower is only the flowers that develop within a certain period of time. Its existence seems hidden for months in its host's body until it finally grows a flower that only blooms for a week. *Rafflesia* flower is the identity of Bengkulu province and as one of the rare



puspa of the three national flowers of Indonesia to accompany the nation's puspa (white jasmine or *Jasminum sambac*) and puspa charm (the moon orchid or *Phalaenopsis amabilis*) based on Presidential Decree No. 4 of 1993 on National Animals and Flowers [2,3]. However, preserving the Rafflesia flower is not easy to do, given the holoparasitic nature of its life, so it is necessary to find alternative preservation efforts from the methods that have been done so far.

The distribution and habitat of rafflesia are scattered in the lower mountain forests of West Java, lowland forests along the southern coast of West Java and Central Java lowland forests of the Meru Betiri National Park, and tropical forests on the island of Sumatra. Some locations that are often found growing *R. arnoldii* flowers include Kerinci Seblat National Park, Bukit Barisan Selatan National Park, Seblat Elephant Training Center in North Bengkulu district, and Padang Guci, Kaur Regency, Bengkulu. Bukit Barisan Selatan National Park itself has been designated as the center for the conservation of this plant. Until now, Rafflesia flowers have not been successfully bred outside their natural habitat.

The results of the research by Ramadhani et al. [4] stated that the population of Rafflesia in the Rhino Camp TNBBS was found as many as 49 individuals (67% alive and 33% dead). Rhino geophysical environmental conditions with a temperature of 25-29 °C, 90% humidity, acidic pH (pH = 5.5), slightly steep (30-45%), medium canopy density (32-68%), and elevation in the range of 490 - 558 m above sea level and within 7 m from the nearest water source can ensure the growth of Rafflesia. Meanwhile, the biotic environmental conditions found included *T. lanceolarium* as the host for Rafflesia and the animal suspected of being a pollinator respectively, namely Diptera: a type of greenfly (*Lucilia* sp.), gray fly (*Sarcophaga* sp.), fruit fly (*Drosophila* spp.) and blue flies (*Calliphora vomitoria*), *Hymenoptera*: black ants (*Lasius fuliginosus*), and *Coleoptera*: seedling ants (*Staphilinidae* sp.). Another study conducted by Suwartini et al. [5] on the existence of *Rafflesia padma* concluded that the population of *R. padma* in CA Leuweung Sancang tended to decline. This requires special attention so that the existence of these rare plants is sustainable. The results of research conducted by Suwartini et al. [5] and Ramadhani et al. [4] have not shown the distribution of Rafflesia and its correlation with geophysical conditions, nor have they shown the morphological character of Rafflesia flowers. As stated by Hayati and Walck [6] that a long study is needed on the life of Rafflesia, the correlation between environmental parameters and the life of Rafflesia.

The ecophysiology and morphological characters of the Rafflesia flower were studied in this research, specifically for *R. arnoldii* in forest habitats at Bengkulu Province. This research will be used as the basis for the preservation of the *R. arnoldii* in the future.

2. Materials and Methods

The research method used is the survey method. Based on this method, the unit of analysis is the Rafflesia flower with its growing environment and related parties to the studied habitat [7,8]. The research sample area was selected by purposive sampling (purposive sampling) with the category of forest ecosystem [9]. The choice of location (habitat) was made deliberately based on the presence of the *R. arnoldii* flower which was found and can still be observed. The location is limited only to Bengkulu Province. The observation location is measured by GPS for altitude and their coordinates (Figure 1). To assess the suitability of the growing environment for *R. arnoldii*, it is necessary to calculate the annual average temperature in the area or area of growth habitat. Calculation of the annual average temperature was performed using following formula:

$$\text{Annual average temperature (}^{\circ}\text{C)} = (26.3 - 0.61h)$$

Where h was referred to elevation (hm). Temperature and humidity were measured by a thermohygrometer, while the degree of soil acidity was measured by a pH meter.

3. Result and Discussion

Observations were made by looking directly at the area where the *R. arnoldii* flower was found, and including primary and secondary data obtained by interviewing the managers of KPPL (Rare Puspa Care Community) Padang Guci, and POKDARWIS Padang Guci.

3.1. Growth Location

Based on observations, the *R. arnoldii* was found at coordinates 4°26'55 "S, 103°15'14" E, Cawang Kidau Dam Forest Area, Bungin Tambun III Village, Padang Guci Hulu District, Kaur Regency, Bengkulu Province. The only selected location that can be observed (the Covid-19 outbreak).

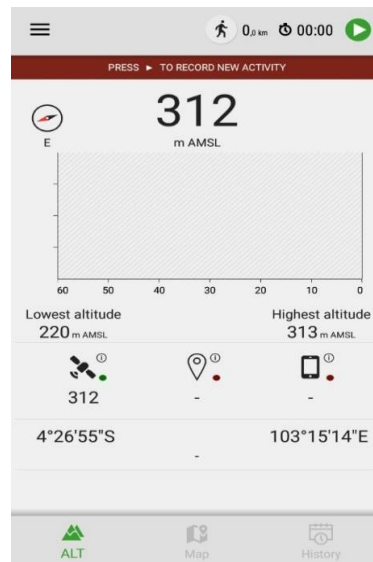


Figure 1. Growth location of *R. arnoldii*

Based on the above observations, it can be determined the annual average temperature in the area with the Brack formula, so the location/habitat of the *R. arnoldii* flower is around 24.4°C. Such high-temperature conditions constitute the range of growing conditions needed by *R. arnoldii* to grow and develop normally and well. This result is in line with the statement of Ramadhani et al. [4] mentioning that *Rafflesia* can grow well in a temperature range of 25-29°C.

3.2. Development of Flower

The observations found the presence of 9 flowers of *R. arnoldii*, one individual is experiencing the blooming phase, six individuals were in the bracta phase, and two individuals were in copula phases.



Figure 2. Development phase of *R. arnoldii*

3.3. Flower Morphology

3.3.1. Flower condition. The *R. arnoldii* flower found in a condition attached to the roots of the *Tetrastigma* tree has 5 petals. *R. arnoldii* attached to the roots of *Tetrastigma* indicating that this flower is holoparasite. There are also those some stick to the stem [3], but they are rare, and in this study, they were not found.

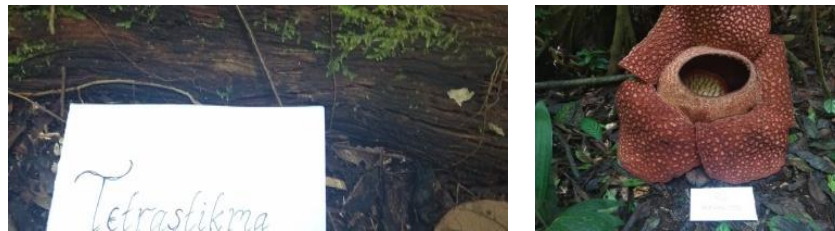


Figure 3. *Tetrastigma* and *R. arnoldii* flower

3.3.2. *Petal colour.* This flower has an orange to dark orange color on the perigon. The spots on the surface of the perigon have two sizes and are lighter in color than the base color of the perigon. Small pock found among the large ones. The spots on the diaphragm are white or light orange, surrounded by a dark orange circle.



Figure 4. Petal colour of *Rafflesia* flower during the blooming phase.

3.3.3. *Diameter.* The flower diameter reaches 53 cm with a diaphragm width of 31 cm and a height of 50 cm. The flower found is much smaller than those found, is 100 cm [10] or 70 – 110 cm. The diameter of the flowers found to be much smaller indicates the occurrence of growth degradation caused by the unfavorable environmental conditions of the growing habitat.

3.4. Flowering Phase

R. arnoldii found in Kaur Forest, South Bengkulu showed various stages of growth. Some flowers were found in copula phase indicated by the appearance of visible buds in the form of skin layer emerged from *Tetrastigma*. This phase took 6-9 months until the bracts were emerged. Several plants showed bracta phase where the top of the bud was covered with complete structure. It could be appeared as ivory white and slowly turned brown or black after 3-5 months. Other plants of *R. arnoldii* were spotted experiencing the perigon phase. This phase was started when the folded perigon slowly bloomed at midnight. This phase took 1-2 weeks where the flower stayed blooming for 5-7 days before decayed after 7 days of blooming.

Interestingly, several phenomena were also found during the observation. Several plants could complete its growth stage (the copula, bract, and perigon blooming), especially in the early phase or the copula phase. This phenomenon was associated with the significant change in forest conditions that diminished the number of host plants. As the climate become highly unpredictable during 2020, it then affected the flower physiology, thus leading to failure in blooming. In addition, duration of copula and bract phases seemed to be influenced by the size of flower bud. The larger the flower buds, the longer its copula and bract phases. In contrast, the duration of perigon phase was assumed to be relatively similar.

3.5. Ecophysiology of *Rafflesia arnoldii*

3.5.1. *Temperature and humidity.* The temperature and humidity are observed when the *R. arnoldii* flower was developing from phase to phase. The results showed that the average temperature at the

location where *R. arnoldii* was found was in the range of 24-25 °C and humidity was 75-77%. The temperature of the growing environment is lower than the growing environment of *R. padma* which ranges from 25 – 29 °C [4], and the relative humidity is also lower, which is 13 – 15% (RH *R. padma* 90%).

Tabel 1. Temperature and humidity recorded during the growth of *R. arnoldii*.

Phase	Temperature (°C)	Humidity (%)
Copula	25	77
Bracta	24	75
Blooming	24	75

3.5.2. *Soil pH.* Soil pH indicates the degree of soil acidity that of the balance of macro and micronutrient absorption. Soil pH during *Rafflesia* flower development was present in Table 2. Table 2 showed that the pH of the soil when the *R. arnoldii* flower blooms are greater, which is 6.5 compared to the Copula and Bracta phases (6.0). The results of observations by Ramadhani et al. [4] on *R. padma* showed lower soil pH. These results indicate that the soil pH desired by *R. arnoldii* tends to be more neutral.

Table 2. Soil pH during the growth of *R. arnoldii*.

Phase	pH
Copula	6.0
Bracta	6.0
Blooming	6.5

3.5.3. *Water Source.* Cawang Kidau Water Source is 12 meters from the location where the *R. arnoldii* grows. Water source can affect the humidity of the growing environment, so it can also affect the growth and flowering phase of *R. arnoldii*. This is by following the statement of Ramadhani et al. [4] that close water sources can affect the growth of *R. arnoldii*.

4. Conclusion

Based on the observations found 9 (nine) *R. arnoldii* flowers in various phases with conditions attached to the host plant, namely *Tetrastigma* sp. This flower was found at coordinates 426'55" S, 103°15'14" E in the Cawang Kidau Water Dam Forest Area, Bungin Tambun III Village, Padang Guci Hulu District, Kaur Regency, Bengkulu Province, and this location is only 12 meters from the water source. One of the stages of this orange flower has reached the blooming phase with 5 crowns, 53 cm in diameter, 31 cm in width and 50 cm in height. The environmental conditions at the time of flowering ranged from 24 – 25 °C, with humidity (RH) 75 – 77%, and soil pH ranging from 6.0 – 6.5.

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