Interdisciplinary International Journal of Conservation and Culture
Volume 1, Issue 1, April 2023, (Page 1-10)
DOI: https://doi.org/10.25157/iijcc.v1i1.3050
ISSN 2988-2923

Vegetation structure and floristic composition at habitat *Rafflesia patma* blume in Pananjung Pangandaran Nature Reserve, West Java, Indonesia

Bahana Aditya Adnan[1], Purnomo[2], Suwarno Hadisusanto[2]
[1]Department of Biology Education, Universitas Galuh, Indonesia
[2]Department of Tropical Biology, Universitas Gadjah Mada, Indonesia

Abstract

Rafflesia patma Blume is an endemic plant to Pangandaran, West Java, which is protected because of its rare status. This study aims to study the composition of the floristic vegetation that supports the life of *R. patma* in the Pananjung Pangandaran Nature Reserve, West Java. The research was conducted using a survey method with a purposive sampling technique and quadrat. The data obtained were then analyzed using the Importance Value Index (IVI), Shannon-Wiener index, and Evenness index. The results showed that *R. patma* in the Pananjung Pangandaran Nature Reserve lived as a parasite on the roots and stems of *Tetrastigma leucostaphylum*. The floristic composition of the habitat of *R. patma* in the Pananjung Pangandaran Nature Reserve, West Java, consisted of 251 individuals divided into 28 species. The plant species with the highest Importance Value Index (IVI) were *Syzygium antisepticum*, *Stephania capitata*, *Casearia* sp., and *Buchanania arborescens* for the sapling category, as well as *Syzygium antisepticum* and *Vitex pubescens* for the tree categories. The vegetation around *R. patma's habitat* is quite dense, with the obtained diversity index values indicating a moderate level of diversity. The highest diversity index at the sapling level was found at Cilegon with an H' value of 2.14 and the highest diversity index at the tree level was found at Gua Parat with an H' value of 1.5.

Keywords: Habitat; Nature Reserve; Pangandaran; *Rafflesia patma*; Vegetation

Corresponding author:
Bahana Aditya Adnan
Department of Biology Education
Universitas Galuh
Jl. R. E. Martadinata No.150, Ciamis, West Java
bahanaaditya@unigal.ac.id

Article history
Received: February 2, 2023
Revised: March 1, 2023
Accepted: March 8, 2023
Published Online: April 3, 2023

Cite this article:
Adnan, B. A., Purnomo, & Hadisusanto, S. (2023). Vegetation structure and floristic composition at habitat rafflesia patma blume in Pananjung Pangandaran nature reserve, West Java, Indonesia. *Interdisciplinary International Journal of Conservation and Culture*, *1*(1), 1-10.

INTRODUCTION

The *Rafflesia* plant is made up of several species belong to the Rafflesiaceae family. The *Rafflesia* genus is widespread in Southeast Asia, namely Indonesia, Malaysia, and Philippines (Wicaksono et al., 2016). *Rafflesia* is a holoparasitic plant whose existence depends on its host plant, namely *Tetrastigma* (Barcelona et al., 2011). *Rafflesia* lives on *Tetrastigma* roots with vegetation composed of associations of primary tropical rainforest vegetation with high diversity and distinctive horizontal and vertical vegetation structures (Zuhud, 1998).

All species of *Rafflesia* are classified as rare and protected plants (Susatya, 2011). *Rafflesia* is a rare plant due to its small population in nature, an endemic species, has an annual life cycle and dependent on its host, and is sensitive to habitat disturbances (Priatna et al., 1989). *Rafflesia* conservation status based on IUCN and WCMC criteria is included in the Endangered (EN) category (Lestari et al., 2014). This status is given to species that have a very high risk of extinction and is feared to become extinct in the near future. The population is typically small and the habitat is limited (Adnan et al., 2021).

Rafflesia patma is one of the *Rafflesia* species found in Java Island. Its distribution includes tropical rainforests namely Pangandaran, Nusakambangan, Leuweung Sancang, and Bojonglarang (Zuhud, 1998). The population of *R. patma* in Pangandaran has decreased every year. Although efforts to conserve *R. patma* in *ex situ* locations (Bogor Botanical Gardens) have has been successful, it has

declined in its natural habitat. Therefore, the research on the carrying capacity of the environment on the life potential of *R. patma* in Pangandaran is required.

This study focused on surveying vegetation to determine the vegetation structure and floristic composition that support the life of the *R. patma* in the Pananjung Pangandaran Nature Reserve, West Java. So that it can help *in situ* conservation efforts for *R. patma* and *Tetrastigma* sp. around the Pananjung Pangandaran Nature Reserve, West Java. Information about the ecology of these plants is very important because their natural habitat is increasingly being threatened every year. This study is expected to enhance the understanding of these plants, which is critical for conservation.

METHOD

The data collection was carried out in Pananjung Pangandaran Nature Reserve (Figure 1) on February 2020. The Pananjung Pangandaran Nature Reserve is located in Pangandaran Subdistrict, Pangandaran District, West Java Province, Indonesia with an area of ± 419 ha. Geographically, it is located at S 7°42'35" and E 108°39'52" with an average altitude of 100 meters above sea level.

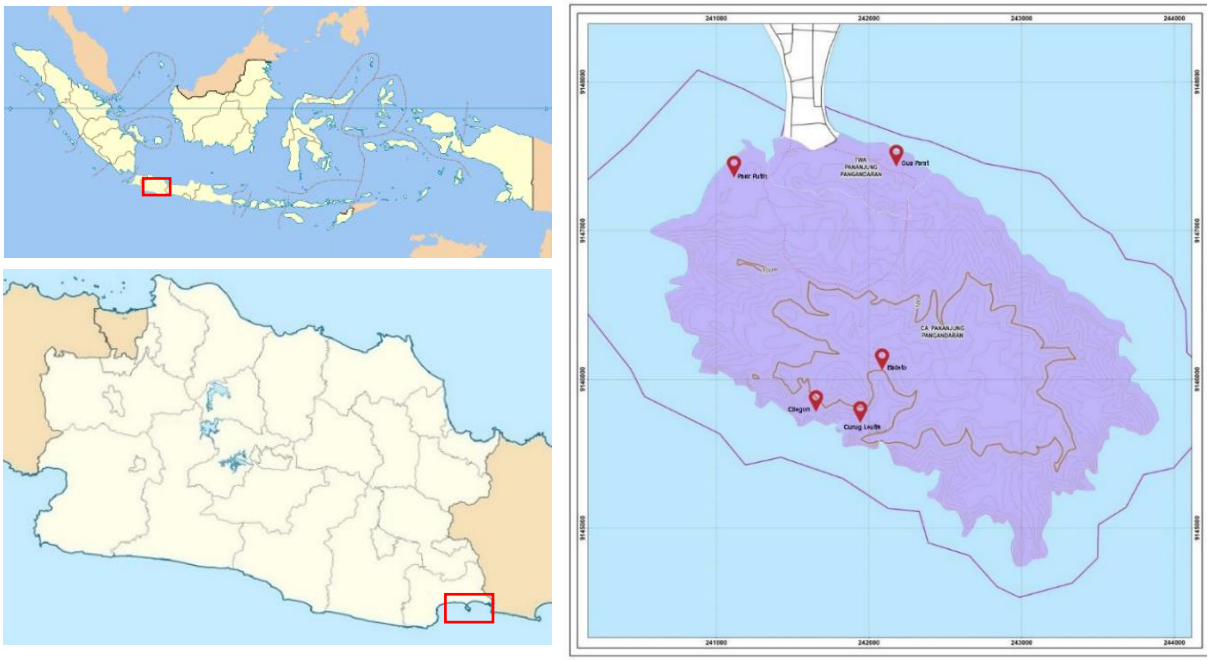

Figure 1. Map of studi site in Pananjung Pangandaran Nature Reserve, West Java, Indonesia.

The observation locations in the Pananjung Pangandaran Nature Reserve were divided into 5 locations namely Gua Parat, Badeto, Cilegon, Curug Leutik, and Pasir Putih (Table 1).

Table 1. Coordinates of the research location in the Pananjung Pangandaran, Nature Reserve, West java, Indonesia.

Locations	Coordinates	
	Lattitude	Longitude
Gua Parat	07°42’23.2”S	108°39’42.5”E
Badeto	07°43’10.1”S	108°39’42.6”E
Cilegon	07°43’17.8”S	108°39’28.2”E
Curug Leutik	07°43’13.4”S	108°39’45.0”E
Pasir Putih	07°42’27.0”S	108°39’11.1”E

a survey method was used to support a purposive and the quadrat plot sampling. The quadrat used was 20 x 20 m. Vegetation composition was observed at the sapling and tree levels. Vegetation data collected in each plot are the number of species, the number of individuals of each species, and

DBH (Diameter at Breast Height). Data were analyzed quantitatively using the Importance Value Index (IVI), Shannon-Wiener index, and Evenness index.

Data analysis

Importance Value Index

The importance Value Index (IVI) is a quantitative parameter to express the level of species dominance in a plant community (Susilowati et al., 2020). The value of the IVI could be calculated using the formula:

For tree species, $\mathrm{IVI} = \mathrm{RD} + \mathrm{RF} + \mathrm{RBA}$
For sapling species, $\mathrm{IVI} = \mathrm{RD} + \mathrm{RF}$

Where:
IVI : importance Value Index
RD : Relative Density
RF : Relative Frequency
RBA : Relative Basal Area

Shannon-Wiener index

The Shannon-Wiener index (H') was used to measure the abundance and diversity of species found in a community. The Shannon-Wiener index was analyzed based on the formula used by Magurran (1988) with the following formula:

$$\mathrm{H}' = -\Sigma \mathrm{pi} \ln \mathrm{pi}$$

Where:
H’ : Shannon-Wiener index
pi : ni/N
ni : Number of individuals of a species
N : Number of individuals of all species

The Shannon-Weiner diversity index value criteria could be categorized as low (H '<1), moderate (H' 1-3) and high (H '> 3).

Evenness index

The spread/distribution of individuals was determined using the Evenness Index used by Pielou (1966) and was calculated as follows:

$$\mathrm{E} = \mathrm{H}' / \ln \mathrm{S}$$

Information:
E : Evenness index
H’ : Diversity index
S : Number of species

The dispersion of a species was categorized as low uniformity (0 <E <0.4), moderate uniformity (0.4 – 0.6), and high uniformity (>0.6).

RESULTS AND DISCUSSION

Condition of host plant *Rafflesia patma*

Based on the results of observations, the host plant species *Rafflesia patma* in the Pananjung Pangandaran Nature Reserve consists of one species, namely *Tetrastigma leucostaphylum* which comes from the Vitaceae family (Table 2).

Table 2. Number of *T. leucostaphylum* at *R. patma* habitat in Pananjung Pangandaran Nature Reserve.

Locations	Total *T. leucostaphylum*	Location of growing *R. patma* on the host	
		Root	Stem
Gua Parat	6	3	0
Badeto	8	9	4
Cilegon	6	41	7
Curug Leutik	5	32	6
Pasir Putih	5	10	2

T. leucostaphylum is a liana plant, which is a woody plant whose life climbs on tall tree species. *Tetrastigma* is a seed plant (spermatophyta) that reproduces generatively using seeds (Zuhud, 1998). The total number of *T. leucostaphylum* individuals found was 30 individuals spread over 5 observation areas, namely Gua Parat (6 individuals), Cilegon (8 individuals), Badeto (6 individuals), Curug Leutik (5 individuals), and Pasir Putih (5 individuals) with an average of 5-6 individuals per site (Table 2). The results obtained were in accordance with the research of Ali et al. (2015) in the Bojonglarang Jayanti Cianjur Nature Reserve, West Java, and Priatna et al. (1989) in the Leuweung Sancang Nature Reserve, West Java. Meanwhile, compared to the research by Suwartini et al. (2008) the results obtained were different, in Leuweung Sancang, West Java, *R. patma* was found growing on two host plant species, namely *T. leucostaphylum* and *T. papilosum*.

The habitus part of *T. leucostaphylum* which *R. patma* grows is on the roots and stems. This is in accordance with Mukmin & Hikmat (2009) discovery that *Rafflesia* flowers grow on the stems and roots of *Tetrastigma*. The rough skin of the roots and stems of *T. leucostaphylum* where *R. patma* grows makes it easier for the seeds to stick and grow in that area. According to Zuhud et al. (1999), the stems and roots of *T. leucostaphylum* are flat with an uneven or grooved surface (rough and cracked), and the wood tissue is soft and has large pores, allowing *R. patma* to easily infect the roots and stems of *T. leucostaphylum* are easily infected by *R. patma*. Beaman et al. (1988) also reported that *Tetrastigma* infected by *Rafflesia* had soft roots and woody tissue with large pores which allowed *Rafflesia* to spread its vegetative organs within *Tetrastigma* organs.

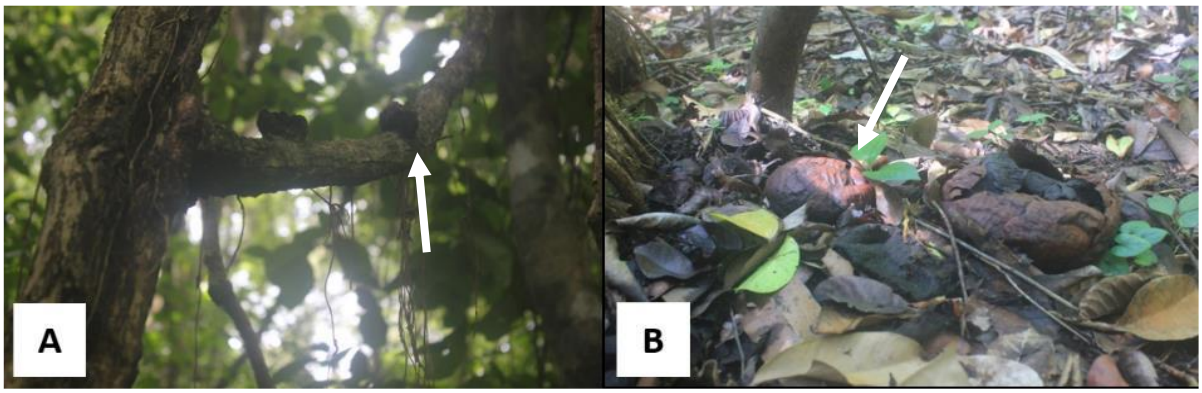

Figure 2. Habitus parts of *T. leucostaphylum* overgrown with *R. patma*: A. Stems, B. Roots.

Tetrastigma is included to intolerant plants (Zuhud, 1998), this can be seen from the height of the *Tetrastigma* which always follows the height of the plants it climbs and tries to reach the highest crowns of plants around the habitat of *R. patma*. The plants that *T. leucostaphylum* climbed the most

in the observation plots were salam (*Syzygium polyanthum*), laban (*Vitex pubescens*), ki beunteur (*Macutia diversifolia*), and ki calung (*Diospyros truncata*). The plants that *Tetrastigma* climbed at the observation site were large diameter plants and had tall crowns, thus providing an opportunity for *Tetrastigma* to obtain light for their survival compared to small diameter trees. *Rafflesia* conservation cannot be separated from the preservation of its host plant (*Tetrastigma*) and its supporting plants. Because these plants influence each other, therefore all plant forms (lifeforms) and this area must be equally conserved.

Figure 3. Plants climbed by *T. leucostaphylum*: A. Salam (*S. polyanthum*), B. Ki calung (*D. truncata*), C. Laban (*V. pubescens*), dan D. Ki beunteur (*M. diversifolia*).

Vegetation conditions

The survival of *R. patma*, *Tetrastigma*, and other plants in the Pananjung Pangandaran Nature Reserve area are interconnected with one another. Associations within the area involve *R. patma* and its host (*Tetrastigma*) which provide a source of nutrition for the life of *R. patma*, as well as *Tetrastigma* with other plants which become the foundation for *Tetrastigma* to climb (Susatya, 2011). A species association in an area is a type of interspecific interaction in a community with a variety of species expressed in the number of species present (species richness) and the relative abundance of species (similarity) (Nugroho et al., 2022).

The number of plant species found around the habitat of *R. patma* is 251 individuals belonging to 28 species and 20 families. These plants are spread over 5 observation areas namely Gua Parat (15 species), Badeto (10 species), Cilegon (12 species), Curug Leutik (10 species), and Pasir Putih (15 species). The most common vegetation family found in the observed locations is the Myrtaceae family. The Myrtaceae family has the highest number of species, with 5 species at the study site, because this family spreads mainly in the tropics, then in the subtropics, and relatively few in temperate climates (Stefanello et al., 2011).

The Myrtaceae family represents most part of this botanical richness, with 121 genera represented by approximately 5800 species of perennial trees or shrubs with edible fruits distributed around tropical and subtropical areas (Farias et al., 2020). The family includes well-known and economically important genera such as *Eucalyptus*, *Melaleuca*, *Leptospermum*, *Syzygium*, and *Psidium*. Australia has the highest representation of Myrtaceae, with taxa from 14 of the 17 tribes in its flora. The family also occurs in South America, Southeast Asia, Africa, India, New Caledonia, and many Pacific Islands, extending as far as north Hawaii. The majority of species are lowland vegetation, mostly growing in evergreen forests and less common in seasonal forests. The Myrtaceae family is found in a variety of habitats and can thrive in nutrient-poor soils and seasonally dry areas. Many species grow in swamp forests, lowland forests, and mountain forests. The habitus of Myrtaceae species is in the form of perennial trees and shrubs (Wilson, 2010).

Table 3. Plant species with the highest Importance Value Index (IVI) at *R. patma* habitat.

Locations	Family	Spesies	INP (%)	
			Sapling	Tree
Gua Parat	Myrtaceae	*Syzygium antisepticum*	44.58	
	Euphorbiaceae	*Alchornea rugosa*		95.66
Badeto	Menispermaceae	*Stephania capitata*	50.38	
	Myrtaceae	*Syzygium antisepticum*		110.07
Cilegon	Flacourtiaceae	*Casearia* sp.	61.22	
	Verbenaceae	*Vitex pubescens*		162.2
Curug Leutik	Anacardiaceae	*Buchanania arborescens*	61.19	
	Myrtaceae	*Syzygium antisepticum*		116.8
Pasir Putih	Myrtaceae	*Syzygium antisepticum*	55.25	
	Verbenaceae	*Vitex pubescens*		101.2

Interspecific interactions are observed, one of which is the dominance of one species over species another in the habitat of *R. patma* as evidenced by the species Important Value Index. Based on the results of the calculation of the Important Value Index (IVI) in 5 observation areas in the Pananjung Pangandaran Nature Reserve, the plant species with the highest IVI for the sapling category were *S. antisepticum*, *S. capitata*, *Casearia* sp., and *B. arborescens,* while for the tree categories, the plant species with the highest IVI were *A. rugosa*, *S. antisepticum*, and *V. pubescens* (table 3). Plants that have high IVI values indicate that these species have better adaptability than other species. This reflects differences in the ability of a species to adapt and reproduce within a community (Raymond et al., 2010). Furthermore, Suwartini et al. (2008) stated that a high Importance Value Index (IVI) in a plant species indicates a higher level of mastery of that plant species compared to other plant species.

The dominant species is the one with the highest Importance Value Index when compared to other species. Rahma et al. (2017) stated that the dominant species is the species that can use environment more efficiently than other species in the same location. Species that have a higher IVI will be more stable, both from the preservation of the species and from its growth. This also reflects the high ability of these species to adapt to the existing environment and can compete with other species (Tadese et al., 2021). According to Wahab et al., (Wahab et al., 2021), the density of a species shows the number of individual species with a certain area unit, so the density value is an illustration of the number of these species in the research location. Plant density is influenced by environmental conditions suitable for life processes.

Table 4. Diversity and Evenness for species at *R. patma* habitat.

Locations	Category	H’	E
Gua Parat	Sapling	2.08	0.45
	Tree	1.5	0.84
Badeto	Sapling	2.05	0.59
	Tree	0.81	0.36
Cilegon	Sapling	2.14	0.42
	Tree	0.69	0.35
Curug Leutik	Sapling	2.08	0.69
	Tree	1.39	1.04
Pasir Putih	Sapling	2.06	0.49
	Tree	1.1	0.73

Plant species at each location where *R. patma* habitat was found have a moderate level of diversity, according to the Shannon Wiener diversity index, because the H' values obtained ranged from 1 to 3. The highest diversity index at the sampling rate was found at the Cilegon location with a value of H'=2.14 and the highest diversity index at the tree level was found at the Gua Parat location with a value of H'=1.5. This value is not much different from the research of Suwartini et al. (2008) in the Leuweung Sancang Nature Reserve (H=2.81) and research by Ali et al. (2015) in the Bojong Larang

Jayanti Nature Reserve (H=2.80) that plant species in the habitat of *R. patma* belong to a moderate level of diversity. Ludwig & Reynolds (1988) stated that species diversity in a community will be maximum if the abundance of species in the community has an almost equal number of individuals. The value level of the diversity index of a species is influenced by the number of species and the number of individuals found. A high number of species and individuals will increase species diversity in a community (da Silva et al., 2017).

The diversity of a community is also seen in the distribution of species within the community which is expressed in the evenness index (Ludwig & Reynolds, 1988). Evenness is an indicator of the dominance of each species in the community (Laird et al., 2003). The evenness index value is in the range 0.00 <E <0.4 with low evenness, so the species in the community are not evenly distributed; if the index value is between 0.4 - 0.6 with moderate evenness, the species in the community are spread quite evenly; and if the index value is > 0.6 then the species are spread evenly so that no species is dominant.

The species evenness index of the 5 research sites in the Pananjung Pangandaran Nature Reserve is different. The calculation results show that the evenness of species at the Curug Leutik location is higher compared to other locations with each having a sapling value=0.69 and trees=1.04, which means that the vegetation species in this location have high evenness and all species have an abundance the same one. While the lowest evenness of species because the evenness value is between 0.00 < E < 0.4 is found in the Cilegon location (sapling=0.42 and trees=0.35). In consequence, this indicates that these locations have an unequal evenness value, this also affects the low level of diversity.

Conservation strategy recommendations

As a parasitic plant, the existence of *Rafflesia* will never be separated from the existence of its host. Information about the existence of *Rafflesia* hosts and the existence of vegetation around the *Rafflesia* habitat is very important. Hence, conservation management focusing on *Tetrastigma* and vegetation surrounding the *Rafflesia* habitat is also required. According to Pelser et al. (2016) one of the *Tetrastigma* conservation strategy efforts is to plant rooted, rooted *Tetrastigma* cuttings planted on one of the host plants in order to increase host availability. This data is needed to carry out *in situ* conservation. The most promising approach in *Rafflesia* conservation is *in situ* conservation that based on the ecological, environmental, biological characteristics, attributes of local habitat and social economics of surrounding villages (Latiff, 2018; Lestari et al., 2020).

Another *in situ* conservation strategy that can be implemented is the development of ecotourism to raise public awareness regarding conservation. According to Hidayati & Walck (2016), ecotourism is a viable option that provides economic returns to local communities without destroying habitat. Communities should be informed that the survival of *R. patma* lives near them. They must not damage or kill their host plants to maintain the survival of the population because of the sustainable *Rafflesia* which is an important aspect of ecotourism (Lestari & Susatya, 2022). However, because most of the habitat in Pangandaran is in the forest and steep cliffs that are difficult to access, ecotourism development must be carefully planned.

In Indonesia, *Rafflesia* has long been one of the protected flora. However, concrete actions to protect it fallen short due to classic problems such as a lack of qualified experts and a lack of good cooperation with various stakeholders. Efforts can be made by conducting collaborative research with other stakeholders and disseminating information to the local community. Collaborative research is needed because many other aspects related to the basic biology of *Rafflesia* are still not studied (Wicaksono et al., 2016) and information dissemination is needed to build awareness about *Rafflesia* conservation (Jayasilan et al., 2004; Lestari et al., 2020).

CONCLUSION

R. patma in the Pananjung Pangandaran Nature Reserve, West Java, lives parasites on the roots and stems of *T. leucostaphylum*. The results of vegetation analysis in the population found a total of 251 individuals and 28 species consisting of 20 families in the *R. patma* habitat. The plant species with the highest Importance Value Index (IVI) were *Syzygium antisepticum*, *Stephania capitata*, *Casearia* sp., and *Buchanania arborescens* for the sapling category, as well as *Syzygium antisepticum* and *Vitex pubescens* for the tree category. The condition of the vegetation around the habitat of *R. patma* is quite dense with a moderate diversity index value.

Limitations and future direction

For further research, it is necessary to intensively manage the *Rafflesia* habitat and population by mapping the population of *R. patma* in the Pananjung Pangandaran Nature Reserve, conducting studies on the life cycle of *R. patma*, periodically monitoring the *Tetrastigma* population and vegetation around the habitat of *R. patma* and monitoring sex ratio of *R. patma* to determine the blooming time of *R. patma* flowers and their sustainability.

Acknowledgements

Authors would like to thank West Java Natural Resources Conservation Center (BBKSDA) Region III Ciamis and Pangandaran Natural Reserve Conservation Resort for permitting the research. We are also grateful to Manap Trianto and Mohamad Dahri Kisman for assistance with data analysis.

Declarations

B.A.A. is major author of this manuscript and S.H. and P is co-author. B.A.A. designed the research, collected and analyzed the data. B.A.A., S.H. and P wrote, revised, and approved the manuscript. The authors state there is no conflict of interest.

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