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FULL PAPER

Exploring the distribution of *Rhizanthes infanticida* banziger in the bukit barisan protected forest, padang panjang city: an ecological assessment

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This study, conducted from May to June 2023 in the Bukit Barisan Protected Forest, Padang Panjang City, presents a comprehensive analysis of *Rhizanthes infanticida Banziger*, a vital part of this ecosystem. By integrating census and purposive sampling, the study thoroughly investigated *R. infanticida*'s habitat and associated flora. Employing nested plot methods at four forest points, we categorized plant life stages (trees, poles, saplings, and seedlings) to assess various growth stages of *R.infanticida* and neighboring plant species. The study also considered abiotic factors like temperature, humidity, elevation, and canopy cover, measured using a hygrometer thermometer, and digital imagery. We discovered 47 *R infanticida* knops across five growth phases, and identified 25 plant species from 18 families, with dominant species varying by life stage: Ptisana salicina (seedlings), Tetrastigma papillosum (saplings), Polyalthia jucunda (poles), and Litsea sp. (trees). The average environmental conditions were 25.1 ºC temperature, 73.55% humidity, elevation of 1,059 meters, and 76.01% canopy cover. This study provides crucial insights into *R. infanticida*'s ecological dynamics within the Bukit Barisan Protected Forest, highlighting its distribution, relationship with surrounding vegetation, and environmental conditions, thereby contributing significantly to our understanding of this unique forest ecosystem.

KEYWORDS

Bukit Barisan forest; ecological dynamics; environmental factors; habitat analysis; *Rhizanthes Infanticida*.

Introduction

Indonesia home to the world's third-largest forest area after Brazil and Congo, boasts approximately 125.76 million hectares of rich, bio-diverse forests [1,2]. These ecosystems are crucial habitats for a myriad of flora and fauna, including various rare flowering plants such as those from the *Rhizanthes* genus. Within this biological treasure trove, *Rhizanthes infanticida*, a member of the *Rafflesiaceae* family, emerges as a particularly intriguing species. Notably, these plants are true parasites, completely reliant on host plants for their survival, lacking conventional roots, stems, and leaves [3-5]. While *R. infanticida* is

not currently recognized as a protected species under CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) or the IUCN (International Union for Conservation of Nature) Red List, its rarity, and the challenges in locating it in the wild necessitate urgent conservation efforts [6].

The unique ecological role and limited distribution of this species underscore its significance and the need for in-depth ecological studies. Predominantly found in West Sumatra, *Rhizanthes infanticida* shares familial ties with the more popular Rafflesia, but differs markedly in size, morphology, and the number of edge lobes [7]. Despite its less prominent status compared to Rafflesia, the ecological importance and rarity of *Rhizanthes infanticida* warrant thorough scientific investigation. West Sumatra is dotted with seven protected forest areas, among which the Bukit Barisan Protected Forest in Padang Panjang City, covering an area of about 72.38 hectares, is a notable location for this species [8-11]. Within this forest, the presence of *R. infanticida* has been recorded, yet there remains a significant gap in scientific literature regarding its population distribution and habitat characteristics.

This study aims to bridge this knowledge gap by examining the population distribution and habitat of *R. infanticida* in the Bukit Barisan Protected Forest, Padang Panjang City. The study is pivotal for understanding the ecological dynamics of this rare species and for informing conservation strategies within the region's unique forest ecosystems.

Methods

This study was carried out from May to June 2023 in the Bukit Barisan Protected Forest Area, Padang Panjang City, the tools used in the study were GPS (Global Positioning System), Android smartphone, digital camera, mater tape/ dbh meter, caliper, thermometer, hygrometer, and stationery, while the materials used are raffia rope and the Avenza Maps application. The object studied is the *R. infanticida* plant.

The method that will be used in collecting data in this research is the census method by determining observation plots using purposive sampling with point placement based on the discovery of *R. infanticida*. For each point a plot measuring 20 m x 20 m is made for trees, 10 m x 10 m for poles, 5 m x 5 m for stakes, 2 m x 2 m for seedlings. The data taken is *R. infanticida*, plant type, coordinate points, and physical factors. The following is an example of a plot shown in Figure 1. The data in this research is quantitative data in the form of habitat vegetation data on the distribution of the *R. infanticida* population with analysis. Vegetation analysis data is processed to obtain the Important Value Index (IVI) (Indriyanto, 2006):

$$\text{Density} = \frac{\text{number individual of a species}}{\text{area measuring plot}}$$

$$\text{Relative Density} = \frac{\text{density of a species}}{\text{density all species}} \text{ x } 100\%$$

$$\text{Frequency} = \frac{\text{number of plot a species found}}{\text{number of all plot observation}}$$

$$\text{Relative Frequensi} = \frac{\text{Frequency one species}}{\text{Frequency all species}} \text{ x } 100\%$$

$$\text{Dominance} = \frac{\text{number base area a species}}{\text{total plot area}}$$

$$\text{Relative Dominance} = \frac{\text{Dominance a species}}{\text{Dominance all species}} \text{ x } 100\%$$

$$\text{Canopy cover: } \frac{\text{pixel figure closing}}{\text{total pixel figure}} \text{ x } 100\%$$

Important Value Index (IVI) = KR+FR (for seedling level)
Important Value Index (IVI) = KR+FR+DR (for the level of stakes, posts and trees)
Analysis of the percentage of canopy cover was done using the Hemispherical Photography method using ImageJ software (Jenning et al., 1999).

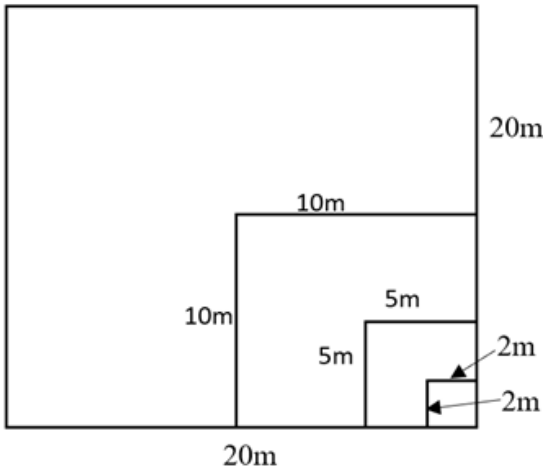


FIGURE 1 Diagram sampling plot research for habitat vegetation of *R. infanticida*

Results and discussion

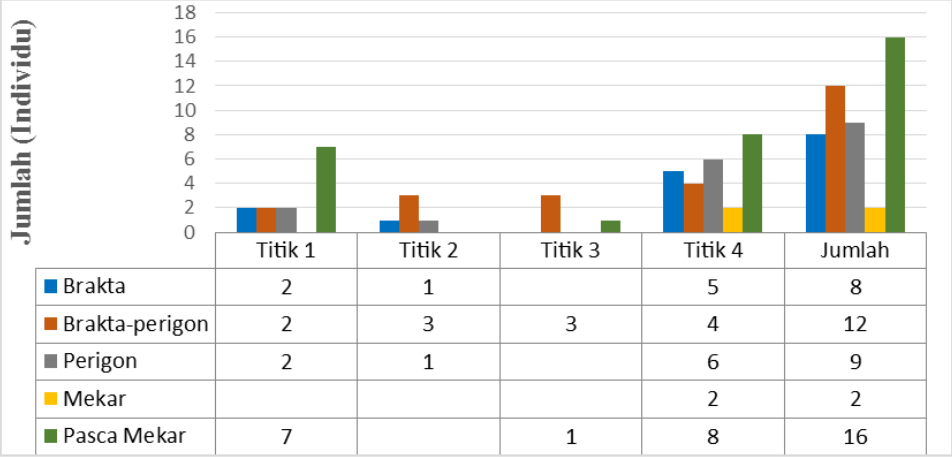
Population of R. infanticida

The study conducted in the Bukit Barisan Protected Forest, Padang Panjang City, yielded significant findings regarding the population of Rhizanthes infanticida. A total of 47 individuals of R. infanticida were identified across four designated research plots. These individuals were observed in various stages of their lifecycle, including buds and blooming phases. The life stages were categorized as live buds, live blooming, and post-blooming (dead blooming). This variation in developmental stages offers valuable insights into the reproductive ecology and lifecycle patterns of the species within this protected forest area.

The discovery of these 47 individuals is particularly noteworthy, providing a basis for comparison with other studies in the region. It highlights the variability in population density and distribution patterns of Rhizanthes species across different forest ecosystems in Indonesia. This also underscores the importance of protected forest areas in conserving these rare and ecologically significant species. The R. infanticida presence in varying developmental stages within the Bukit Barisan protected forest suggests a stable and sustaining environment for their growth and reproduction [12]. This aspect of the research contributes to a deeper understanding of the species' habitat requirements and ecological interactions.

Furthermore, the findings from Bukit Barisan Protected Forest can pave the way for broader ecological studies focusing on the conservation status and habitat preferences of Rhizanthes species across their native ranges. The results of this study not only shed light on the population dynamics of R. infanticida in a specific protected area but also contribute to the larger conversation on biodiversity conservation and forest ecosystem management. It underscores the need for continuous monitoring and research to ensure the sustainability of these rare plant species and their habitats. The following is a diagram of the life phases of R. infanticida found in the Bukit Barisan Protected Forest, Padang Panjang City, which can be seen in Figure 2.

The study in the Bukit Barisan Protected Forest revealed intriguing insights into the survival patterns of *Rhizanthes infanticida*. A notable observation was the higher survival rate of the species in post-blooming stages, which is a critical phase in their lifecycle. Interestingly, no rotting bracts were found during the study. However, there was a significant presence of post-blooming knobs of *R. infanticida*. This phase is characterized by the knobs turning black and developing a distinctive hole at the base, signifying their attachment point to the host plant.



	Titik 1	Titik 2	Titik 3	Titik 4	Jumlah
Brakta	2	1		5	8
Brakta-perigon	2	3	3	4	12
Perigon	2	1		6	9
Mekar				2	2
Pasca Mekar	7		1	8	16

FIGURE 2 Individuals in each life phase of R. infanticida in the Bukit Barisan Protected Forest, Padang Panjang City

This pattern of survival aligns with the findings from [13] study on *R. deceptor* in the Biological Education and Research Forest (HPPB) of Andalas University. Saleh's research indicated a disproportionately high survival rate during the post-blooming phase compared to the rate of knob mortality. This similarity in survival trends across different species within the *Rhizanthes* genus suggests a possible commonality in their ecological adaptations and lifecycle processes.

Figure 3 illustrates the condition of R. infanticida as rotten/dead after blooming in the Bukit Barisan Protected Forest, Padang Panjang City. Despite this, the prevalence of post-blooming knobs in the Bukit Barisan Protected Forest indicates a successful reproductive phase for R. infanticida, even in the absence of rotting bracts. This phase is crucial as it marks the completion of the reproductive cycle and potentially the dispersal of seeds or spores. The presence of a hole at the base of the dead knobs, where they attach to the host, might also provide insights into the parasitic relationship between R. infanticida and its host plants, shedding light on the species' unique survival strategies.

These findings contribute significantly to our understanding of the ecological and reproductive dynamics of *Rhizanthes infanticida*. The comparison with Saleh's research further emphasizes the importance of examining various lifecycle stages in understanding the survival and propagation of parasitic plant species in forest ecosystems. Such studies are vital for informing conservation strategies and ensuring the sustainability of these unique and ecologically important species.

FIGURE 3 The condition of R. infanticida is rotten/dead after blooming in the Bukit Barisan Protected Forest, Padang Panjang City

One of the key aspects of this study was analyzing the size distribution of the *R. infanticida* populations within the Bukit Barisan Protected Forest. Referencing the work of [6], it was observed that the diameters of *R. infanticida* individuals ranged from 4.6 to 160 mm. Notably, the majority of the population fell within the smaller diameter range of 0-30 mm, accounting for 135 individuals. This suggests that younger or smaller-sized individuals of *R. infanticida* are

more prevalent in the area, potentially indicating a thriving regeneration rate of the species.

In contrast, the populations within the larger diameter ranges of 60.1-90 mm and 120.1-160 mm were significantly lower, with only 18 and 20 individuals found, respectively. These figures indicate a decline in population as the size increases, which could be attributed to various ecological factors such as the lifespan of the species, predation, or environmental conditions affecting growth and survival. In the current study, a detailed analysis of the diameter range of live and dead blooming phases of *R. infanticida* was conducted. It was found that the diameter of live blooming individuals ranged from 91.3 to 144.2 mm, whereas the dead blooming individuals had a diameter range of 86 to 160 mm. This observation is crucial as it provides insights into the growth patterns and lifecycle stages of *R. infanticida*. The larger diameters in the blooming phases suggest that the species reaches a considerable size during its peak reproductive phase, which is an important aspect of its ecological role within the forest ecosystem. The size distribution data from this study, in conjunction with the findings of [6], offer a comprehensive understanding of the demographic structure of *R. infanticida* populations in the Bukit Barisan Protected Forest. These insights are vital for conservation efforts, as they help in identifying the stages of the lifecycle that might require more focused protection or study, thereby aiding in the development of effective management strategies for this rare and ecologically significant species. An integral part of understanding the ecology of *Rhizanthes infanticida* involves comprehensively examining its flower development stages. As documented by [14], the developmental process of *Rhizanthes* flowers encompasses a series of overlapping stages, which can be visually divided into four distinct parts: the bractal phase, perigon bractal phase, perigon phase, and blooming phase [15-17]. Initially, the flower starts as a small growth, resembling a wart, which then enlarges to the size of a marble, approximately 1 cm in diameter. During this growth, the flower exhibits coloration similar to dry leaves. The transformation from a marble-sized bud to a fully developed and open flower is a slow and gradual process, typically spanning around 20 months.

Before the flower fully blooms, *Rhizanthes* flowers take on an oval shape with a milky white hue. Upon blooming, the center of the flower reveals a distinct brown color. The flower's unique characteristics include dense hairs, approximately 1 cm in length, and a rounded form with a diameter of about 4 cm. Moving outwards, the petals display a white color in a 5 cm wide area, adorned with short brown hairs. In the course of this study, every phase of the *R. infanticida* life cycle, as described above, was encountered in the Bukit Barisan Protected Forest. The discovery of these various developmental stages within the same ecosystem provides a rare and comprehensive view into the life cycle of this unique species. Observing these stages in their natural habitat not only enhances our understanding the developmental of biology the species' but also informs conservation strategies, as different developmental stages may have varying ecological requirements and vulnerabilities.

This detailed observation of *R. infanticida*'s floral development stages within the Bukit Barisan Protected Forest offers invaluable insights into the species' reproductive strategies and adaptations, contributing significantly to the broader understanding of its ecological role in the forest ecosystem.

Distribution of Rhizanthes infanticida

Based on field observations, there are four points of presence of *R. infanticida. R. infanticida* found in the Bukit Barisan Protected Forest, Padang Panjang City, was 47 knobs.

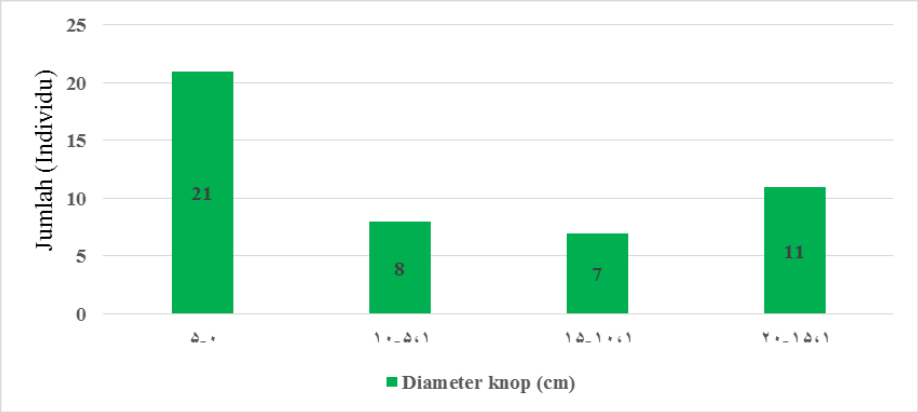


FIGURE 4 Number of knop R. infanticida based on diameter in the Bukit Barisan Protected Forest Padang Panjang City

FIGURE 5 R. infanticida in various life phase (a) brakta phase, (b) brakta-perigon phase, (c) perigon phase, (d) blooming phase, and (e) past-blooming phases in the Bukit Barisan Protected Forest Padang Panjang City

At the first point, 13 knobs of *R. infanticida* were found, at the second point 5 knobs were found, at the third point 4 knobs were found; at the fourth point 25 knobs were found. Figure 4 presents the Number of knop R. infanticida based on diameter in the Bukit Barisan Protected Forest Padang Panjang City, providing a detailed understanding of their size distribution across these locations. This data is particularly relevant in understanding the growth stages and ecological adaptations of the species within its natural habitat.

The presence of *R. infanticida* was obtained from encounters in the field starting from the bractate, bractate-perigon, perigon, blooming, and post-blooming phases. Figure 5 illustrates R. infanticida in various life phases including (a) brakta phase, (b) brakta-perigon phase, (c) perigon phase, (d) blooming phase, and (e) past-blooming phases in the Bukit Barisan

Protected Forest Padang Panjang City. This comprehensive visual representation aids in understanding the complete lifecycle of the species as observed in its natural environment. At the second and third points, canopy cover is low, due to human activity which causes the land to open up, so sunlight can easily enter the area. This can cause *R. infanticida* to die and no longer live in that place. At the first and second points the tree canopy at this location is still dense so it is difficult for sunlight to penetrate the tree canopy which has a relatively low temperature and high humidity. The following is a map of the location of the distribution points for the presence of *R. infanticida* in the Bukit Barisan Protected Forest, Padang Panjang City, as demonstrated in Figure 6.

Habitat Vegetation of Rhizanthes infanticida

The condition of the vegetation in the area where *Rhizanthes infanticida* grows affects the habitat of *Rhizanthes infanticida* [18,19]. There is still a lot of vegetation at the sapling level. The vegetation observed during the research consisted of seedlings, saplings, poles and trees. The following is data regarding the vegetation around habitat *R. infanticide*, as presented in Table 1. Based on the results of study that has been carried out on the composition of plant species around the *R. infanticida* plant, 25 plant species were found from four observation plots.

Based on Table 2, it can be seen that the species has the highest IVI starting from the growth level of seedlings, saplings, poles and trees, namely, the seedling level is *Ptisana salicina* (Fern) with an IVI of 53%, the sapling level is the *T. papillosum* (Inang) type with an INP of 62.26%, the pole level is the *Polyalthia jucunda* (Kasumuik) type with an INP of 53.11% and the tree level is the *Litsea* sp. (Medang) with an INP of 99.27%. A species can be said to play a role if the INP value at the seedling and sapling level is ≥10%, while the INP value at the pole and wood level is ≥15% [20].

Physical Factors in Habitat of Rhizanthes infanticida

Temperature and Humidity

The survival of a plant can be influenced by the temperature and humidity of the air in the habitat [21,22]. Temperature and humidity measurements were carried out for three times in the morning, afternoon and evening. Temperature and humidity measurements were measured using a digital thermohygrometer. The results of temperature and humidity measurements are summarized in Table 2. It is known that the overall temperature ranges from 24.4 °C to 26.3 °C. The average temperature in each *R. infanticida* habitat plot is 25.1 °C. Humidity in the Bukit Barisan Protected Forest, Padang Panjang City, which was examined in 4 *R. infanticida* observation plots, ranged from 72.3-75.3%.

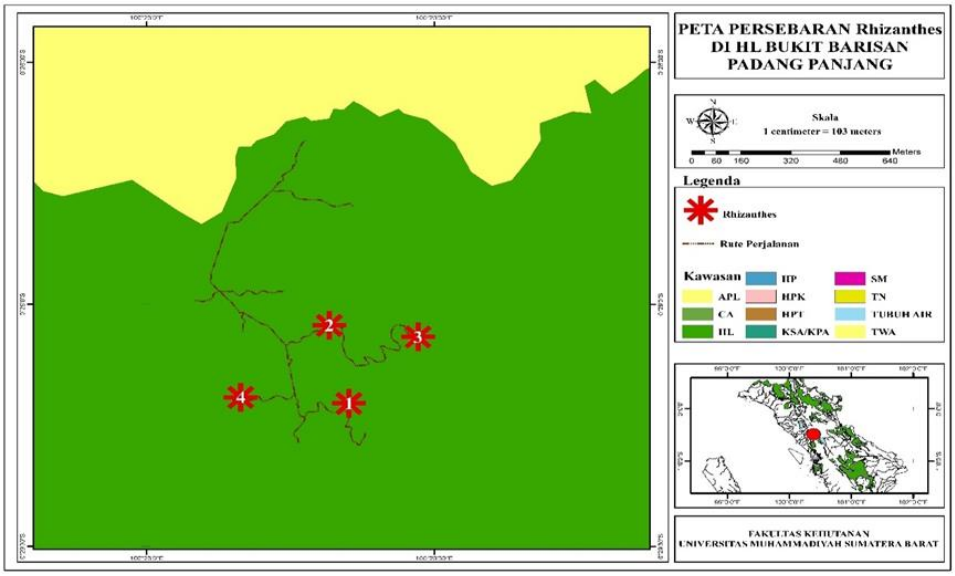


FIGURE 6 Distribution map R. infanticida on the new tracking in the Bukit Barisan Protected Forest Padang Panjang City

TABLE 1 Vegetation analysis on habitat distribution *R. infanticida* in the Bukit Barisan Protected Forest Padang Panjang City

Scientific Name	Local Name	IVI%			
		Seedling	Sapling	Pole	Tree
Justicia gendarussa	Gandarusa	24.5			
Pangium edule	Kepayang		32.46	14.97	35.53
Stelechocarpus burahol	Burahol			20.22	52.19
Polyalthia jucunda	Kasumuik			53.11	
Typhonium flagelliforme	Keladi	42.75			
Calamus sp.	Rotan		31.95		
Salacca zalacca	Salak rimbo	20.5			
Alsatonia scholaris	Pulai		11.42	16.55	
Garcinia xanthochymus	Asam kandih		14.26	16.35	
Pterocarpus indicus	Angsana		12.41	34.59	
Castanopsis sp.	Barangan		31.49	34.25	
Quercus sp.	Paniang-paniang		25.73	21.13	
Litsea sp.	Medang		29.16		99.27
Cinnamomum verum	Kayu manis			18.53	
Cinnamomum sp.	Minyak-minyak	10.25			
Artocarpus elasticus	Tarok				28.02
Ficus variegate	Aro		14.26	20.13	
Ficus hispida	Ampaleh			50.16	41.49
Ceiba petandra	Kapuk				43.51
Ptisana salicina	Pakis	53			
Helicia sp.	-		21.45		
Eurya acuminate	Jirak		13.16		
Laportea sp.	Jilatang	34.75			
Vitex pubescens	Laban	14.25			
Tetrastigma papillosum	Inang		62.26		

The average humidity in each *R. infanticida* habitat plot is 73.55%. One of the factors that cause relatively lower humidity is the study location ecosystem in the form of mountain forests with relatively low temperatures and high humidity, as well as weather conditions at the time of research and data collection in the field which causes rain to fall. According to [6], the type *R. infanticida* was found to live in an air temperature range of 20 °C to 29 °C. In the research on the species *R. infanticida* which was carried out on the Mount Kerinci climbing route, the relative humidity at the location ranged from 96.5-99.0%.

Topography

Topographic factors were measured at the location where *R. infanticida* individuals were found and observation plots were made. Based on the results of measurements at four observation points, it was found that *R. infanticida* grows at an altitude of 1,045-1,078 m above sea level with an average height of 1,059 m above sea level. *R. infanticida* is also found in Sumatra at an altitude of 950-1,050 m above sea level. According to [6], *R. infanticida* grows at an altitude of 1,010-1,119 m above sea level.

TABLE 2 Average values of temperature and humidity in the *R. infanticida* habitat in the Bukit Barisan Protected Forest, Padang Panjang City

No.	Physical factors	Average measures each plot			
		1	2	3	4
1	Air temperature (°C)	24.9	26.3	24.6	24.4
2	Humidity (%)	72.3	72.6	75.3	74.0

TABLE 3 Coordinates, height, number of individuals and canopy cover of *R. infanticida* in the Bukit Barisan Protected Forest, Padang Panjang City

Plot	Coordinate	height (m.asl)	Number of Individual *R infanticida* (knob)	Canopy cover (%)
1	0°29'13"LS-100°23'25"LT	1,066	13	85.87
2	0°29'90"LS-100°23'19"LT	1,078	5	73.50
3	0°29'83"LS-100°23'19"LT	1,050	4	67.04
4	0°29'11"LS-100°23'13"LT	1,045	25	77.63
		average: 1,059	total: 47	average: 76.01

The dipterocarp forest of Mount Malintang ''Massive'', West Pasaman, West Sumatra, at an altitude of 1,100 m and 1,200 meters above sea level, three *R. infanticida* buds were found [23]. Table 3 indicates the height of the growing location for *R. infanticida* in each plot.

Canopy Cover

Canopy cover is a condition formed from overlapping branches and leaves which affects light intensity. Based on the results of measurements in each plot, it is known that canopy cover in the growing habitat of *R. infaticida* ranges from 67.04-85.87%, with an average canopy cover of 76.01%. It can be seen that each plot has different canopy cover. The denser the canopy, the more difficult it is for sunlight to penetrate the tree canopy. This can be seen in observation plot 1 which shows the highest level of canopy density and observation plot 3 which shows the lowest level of canopy density, in accordance with

conditions in the field, where in these plots there is evidence of human activity in the form of encroachment which results in the ground cover becoming exposed so that sunlight can penetrate easily.

Conclusion

Based on research results, *Rhizanthes infanticida* was found in the Bukit Barisan Protected Forest, Padang Panjang City at four observation points totaling 47 knobs. In the bract phase, 8 knobs were found, in the bract-perigon phase there were 12 knobs, in the perigon phase there were 9 knobs, in the bloom phase there were 2 knobs and in the post-bloom phase there were 16 knobs. There are 25 types of plants found in the *Rhizanthes infanticida* habitat in 18 families. The dominant plant type at the seedling level is Ptisana salicina (fern) with an INP of 53%, at the sapling level it is the *Tetrastigma papillosum* type with an INP of 62.26% and at the pole level the *Polyalthia jucunda* (kasumik) type with an INP of 53.11% and at the tree level, *Litsea* sp. (Medang) with an INP of 99.27%, average temperature of 25.1 ºC, average humidity of 73.55%, average height of 1,059 meters above sea level, and average canopy cover 76.01%.

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Authors' Contributions

Zulmardi: Zulmardi led the fieldwork, including the collection of ecological data on Rhizanthes infanticida, and played a significant role in data analysis. He also contributed to drafting and revising the manuscript, particularly the sections related to field observations.

Gusmardi Indra: Gusmardi Indra was instrumental in the design of the methodology and the statistical analysis of the collected data. He also contributed to writing the methodology and results sections of the paper.

Karmila Sari: Karmila Sari focused on the literature review and contextual analysis, providing crucial background information and theoretical framing for the study. She also assisted in the editing and finalization of the manuscript.

Adhan Efendi: Adhan Efendi contributed to the field data collection and played a vital role in mapping the distribution of Rhizanthes infanticida within the study area. He also assisted in the preparation of the graphical representations of the data.

Ridwan Yahya: Ridwan Yahya was involved in the analysis of environmental factors affecting the distribution of Rhizanthes infanticida. He contributed to writing the discussion section, particularly in interpreting ecological implications.

Mohammad Abdullah: Mohammad Abdullah focused on verifying the data accuracy and was responsible for the quality control of the ecological data. He also contributed to the writing of the methodology and results sections.

Rahadian Zainul (Corresponding author): As the corresponding author, Rahadian Zainul coordinated the research project, ensuring effective collaboration among team members. He oversaw the manuscript's drafting, provided critical revisions, and was the primary contact for editorial correspondence.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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