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ECOLOGICAL STUDY OF THE SUNDA PANGOLIN (*Manis javanica*) IN THE NATURE TOURISM PARK OF BUKIT TANGKILING, CENTRAL KALIMANTAN, INDONESIA

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ABSTRACT

The Sunda pangolin, also known as Manis javanica, is a vulnerable mammal that can be found in Java, Sumatra, and Kalimantan. Unfortunately, due to hunting, poaching, land changes, and forest fires, particularly in Kalimantan, this species is now categorized as endangered on the IUCN Red List. To support conservation efforts and sustainability of the Sunda pangolin, it is crucial to gather more evidence about its ecological study and habitat. Therefore, this study aimed to determine the characteristics of the habitat and distribution of the Sunda pangolin in the Bukit Tangkiling Nature Park, Central Kalimantan. We surveyed between February and June 2022 using a Visual Encounter Survey (VES) combined with burrow count methods and camera traps. The survey included vegetation, potential nest and prey, and abiotic factors for the Sunda pangolin. We found a total of two individuals using a camera trap in plot one and direct observation in plot 3. We located five potential Sunda pangolin nests. According to the distribution map, the Sunda pangolin can be found in hilly and valley areas, with an estimated population of 7.14 individuals/Ha. Vegetation analysis revealed an importance value index (IVI) of 148.84% for Acacia mangium. Based on PCA results, the abiotic factors of air and soil humidity support the existence of the Sunda pangolin and its nests. We also identified eight species of Hymenoptera and one species of Isoptera, which are potential food sources for the Sunda pangolin.

INTRODUCTION

Indonesia, as a tropical country with four major biodiversity hotspots in the world, is included in the three mega biodiversity countries (Myers et al., 2000; von Rintelen et al., 2017). The diversity of mammal species reaches 773 in Indonesia, with 221 terrestrial species inhabiting various niches (Maryanto et al., 2020). The island of Borneo, especially Kalimantan, as the third largest island in the world, presents a variety of habitats, including peat swamp forests, heath forests, mangroves, limestones and mountain rainforests (Stephan et al., 2017), which is home to rare species such as *Pongo pygmaeus, Helarctos malayanus, Neofelis nebulosa diardi, Dicerorhinus sumatrensis* and Sunda pangolin (*Manis javanica*) (Chong et al., 2019; Kelt, 2016; Panjang et al., 2024). Your expertise in this field is crucial for understanding and preserving these diverse habitats and species.

The Sunda pangolin, a unique mammal known for its toothless jaws, protective scales, and solitary nature, can be found throughout several Southeast Asian countries (Challender et al., 2019; Chong et al., 2019; Panjang et al., 2024)), including Indonesia. Unfortunately, this species is critically endangered (CE), according to the IUCN (International Union for Conservation of Nature), due to illegal hunting, meat consumption, traditional medicine practices, and international trade (Challender et al., 2019). The changing land use and forest logging practices in the Sundanese pangolin’s natural habitat, which includes primary and secondary forests and rubber and oil palm plantations, pose additional threats to the survival of this species (Pietersen & Challender, 2019; Takandjandji & Sawitri, 2016). Therefore, a deeper understanding of the habitat and environmental factors that support the existence of pangolins is essential for developing appropriate conservation strategies.

Bukit Tangkiling Nature Tourism Park (TWA Bukit Tangkiling) in Palangka Raya City, Central Kalimantan, serves as a vital nature conservation area and habitat for the Sunda pangolin. However, more information must be available regarding the distribution and habitat of the Sunda pangolin within TWA Bukit Tangkiling. Consequently, further research is not just essential, but promising in understanding better the distribution and habitat characteristics of the Sunda pangolin in this region, which will significantly enhance conservation efforts. The study primarily focused on observing and measuring the Sunda pangolin (*Manis javanica*) and the surrounding vegetation, including seedlings, saplings, poles, and trees.

MATERIALS AND METHODS

Study site

This research will be carried out from February to June 2022 at TWA Bukit Tangkiling, Banturung Village, Bukit Batu District, Palangka Raya City, Central Kalimantan Province. This unique area has a Nature Reserve (CA) area of 2061 Ha and a TWA Bukit Tangkiling of 533 Ha in accordance with the Decree of the Minister of Agriculture of the Republic of Indonesia No. 046/Kpts/Um/1/1977 on January 25, 1997. Geographically, TWA Bukit Tangkiling is located between 113°30’ - 113°45' E Longitude to 01°45’ - 02°00’ S Latitude. The topography of the TWA Bukit Tangkiling area varies from lowlands and hills with very steep slopes of around 2% - 45%, with a height of 25 - 170 meters above sea level (Priono, 2012).

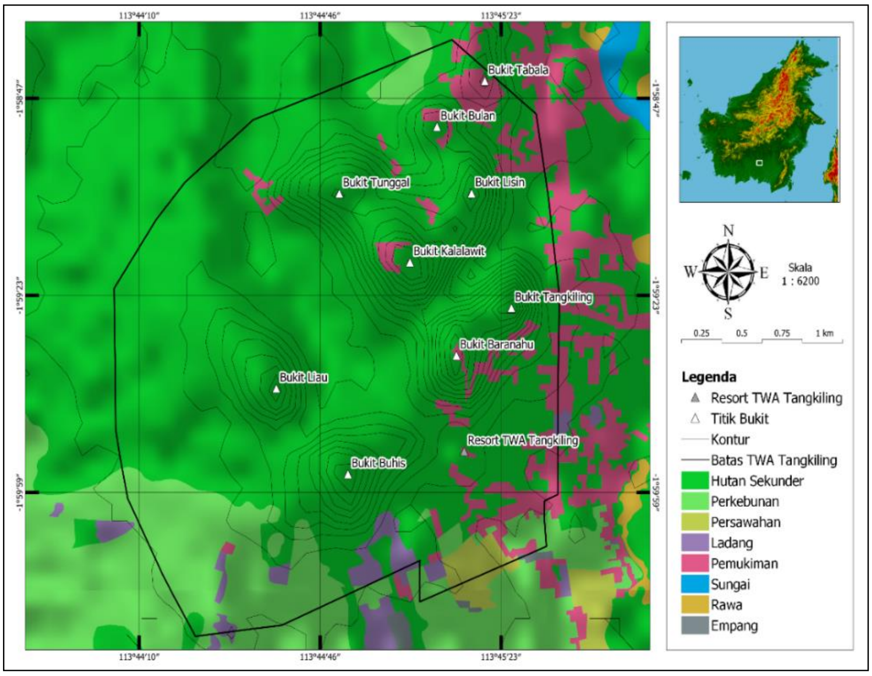

Figure 1. Map of research locations at TWA Bukit Tangkiling, Central Kalimantan

Materials

The research was conducted using a range of advanced tools, including a headlamp, thermometer, soil thermometer, Garmin 78s GPS, digital camera, Bushnell HD camera trap, 1.5 m tape measure, roll meter, raffia rope, and tally sheet. These tools, each carefully selected for their specific functions, ensured the accuracy and reliability of our data collection process.

Methods and data collecting procedures

The field survey was meticulously conducted to gather information on the Sunda pangolin habitat in TWA Bukit Tangkiling. The data collection was carried out during the day (10.00 am-3.00 pm) and at night (8.00 pm-06.00 am), ensuring a comprehensive understanding of the pangolin's activities. Unstructured interviews and a thorough exploration of the area were conducted. Camera traps were used to observe the presence and movements of the pangolins, while photography was used to document their behaviour and habitat characteristics. The study used the Visual Encounter Survey (Heyer et al., 1994) and combined it with Burrow Counts to locate Sunda pangolins (IUCN SSC Pangolin Specialist Group, 2018). The method involved exploring various ecosystem types and stopping at specific points when pangolins or their nests were found. GPS coordinates were recorded for each pangolin nest or individual found, providing valuable data for understanding their distribution and location in the study area.

We used the quadratic method (20 m x 20 m to trees; 10 m x 10 m to poles; 5 m x 5 m to saplings; 2 m x 2 m to seedlings) to gather data on vegetation structure and composition (Mueller-Dombois & Ellenbergh, 2013). Plots were established at locations with pangolin nests (purposive sampling), and we recorded details on seedlings, saplings, poles, and trees (Kusmana, 2017). In addition, we collected abiotic data randomly with three repetitions in each plot. The environmental data collected included air humidity, air temperature, soil pH, soil moisture and geographic position (altitude).

Data analysis

We used a comprehensive approach to analyze the data. QGIS version 3.28.11 was employed to analyze the distribution of the Sunda pangolin, providing a detailed understanding of their habitat. Principal Component Analysis (PCA) in Past 4.03 software was performed to understand the relationship between abiotic components and the Sunda pangolin habitat. For the analysis of habitat characteristics, vegetation composition data was tabulated in Microsoft Excel format tables for analysis using the diversity index (Ludwig & Reynolds, 1988), Importance Value Index (Mueller Dombois, 1974), and Shannon-Wiener Index (H') (Ludwig & Reynold, 1988), ensuring a comprehensive understanding of the pangolin's habitat.

RESULTS AND DISCUSSION

Our research has led to a significant finding-the appearance of the Sunda pangolin (Figure 2). The Sunda pangolin was captured by three camera traps in plot one at a crucial time, around 22:30 WIB. Plot 1, located in a hilly valley at an altitude of 36.70 meters above sea level, was the setting for this important discovery. The Sunda pangolin, when caught on camera, was found resting near its nest. Our direct observation of the Sunda pangolin in plot 3, on a hill cliff during the day at 12:24 WIB, at an altitude of 86 meters above sea level, was another significant finding. The Sunda pangolin was found in its nest hole, engaged in its daily activity of resting and sleeping (**Figure 2**).

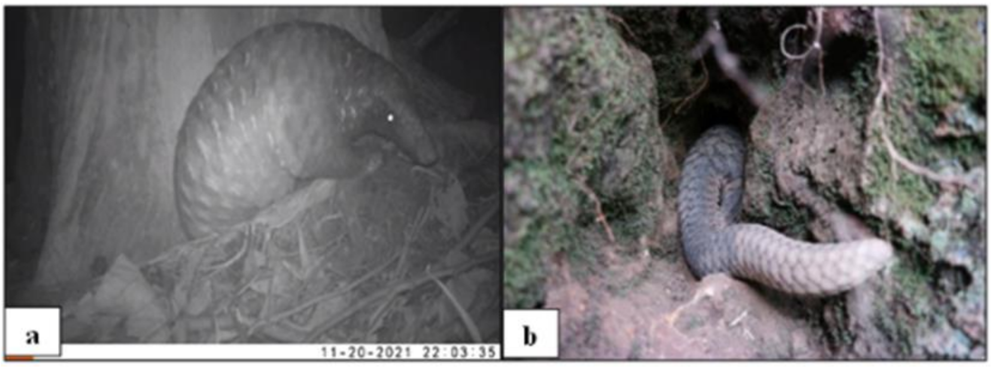

Figure 2. Sunda pangolin encounter; a) Pangolin encounter with the camera trap

Based on direct observation, five nests were found that have the potential to be thriving habitats for the Sunda Pangolin (Manis javanica), as presented in **Table 1**. The nests were identified in several locations: Plots 1 and 2 are located in the Baranahu Hill Valley, 3, 4, 5, and 6 are in Tisin Hill, and Plot seven in Buhis Hill. The height of the identified nest locations ranged from 36.35 to 117 meters above sea level (masl). This survey's types of pangolin encounters included camera trap captures, direct encounters, and nest discoveries.

Table 1. Encounter plot table, elevation, and camera trap results

No.	Plot	Sites	Elevation (m)	Encounter type
1.	1	Bukit Baranahu	36.70	*Camera Trap*
2.	2	Bukit Baranahu	36.35	Nest
3.	3	Bukit Tisin	86	Direct encounter
4.	4	Bukit Tisin	60.82	Nest
5.	5	Bukit Tisin	98	Nest
6.	6	Bukit Tisin	117	Nest
7.	7	Bukit Buhis	88.53	Nest

Table 2. Types of Sunda Pangolin nests in TWA Bukit Tangkiling, Central Kalimantan

No.	Plot	Nest Type	Widht	Depth	Nest location
1.	1	Ground	28 cm	41 cm	Bukit Baranahu valley
2.	2	Ground	29 cm	43 cm	Bukit Baranahu valley
3.	3	Rock	29 cm	68 cm	Bukit Tisin
4.	4	under the weeds	24 cm	62 cm	Bukit Tisin
5.	5	Ground	30 cm	81 cm	Bukit Tisin
6.	6	Rock	26 cm	51 cm	Bukit Tisin
7.	7	Rock	22 cm	62 cm	Bukit Buhis

According to research conducted by (Withaningsih et al., 2018), there are three types of pangolin nests: ground nests, stone nests, and tree nests. The study found that of the seven nests discovered, ground nests and stone nests were the most commonly used. Notably, these nests were found in a diverse range of environmental conditions, as illustrated in **Figure 3**, showcasing the adaptability of pangolins.

Figure 3. Types of Sunda pangolin nests found: a) Nests under trees; b) Nests among tree roots; c) Nests on rock cliffs; d) Nests under weeds; e) Nests under rocks (plot 5); f) Nests under rocks; g) Nests in rock crevices

Various Sunda pangolin nests with different characteristics were found at the observation location. In Plot 1, located in the Bukit Baranahu Valley, the nest was found under a *Shorea balancer* tree with a diameter of 190 cm, a width of 28 cm, and a depth of 41 cm, and there were several small trap holes around it. In Plot 2, the nest was an excavation under tree roots on a sloping ground surface, with a width of 29 cm and a depth of 43 cm. Meanwhile, in Plot 3 on Bukit Tisin, the nest was found in a rock hole on a hillside, measuring 29 cm wide and 68 cm deep, located 7 meters above ground level. In Plot 4, the nest was under dense weeds in the bushes with a width of 24 cm and a depth of 62 cm. In Plot 5, the nest was in the form of an excavation under a large rock with a width of 30 cm and a depth of 81 cm, and there were small trap holes around it. In Plot 6, the nest was located in a rock wall with a width of 26 cm and a depth of 51 cm, with damp soil around it due to standing water. Finally, in Plot 7 in Bukit Buhis, the nest was found in a rock hole with a width of 22 cm and a depth of 62 cm, without any bends. These nests show the adaptation of the Sunda pangolin to various habitat conditions, both under trees, rocks, and bushes.

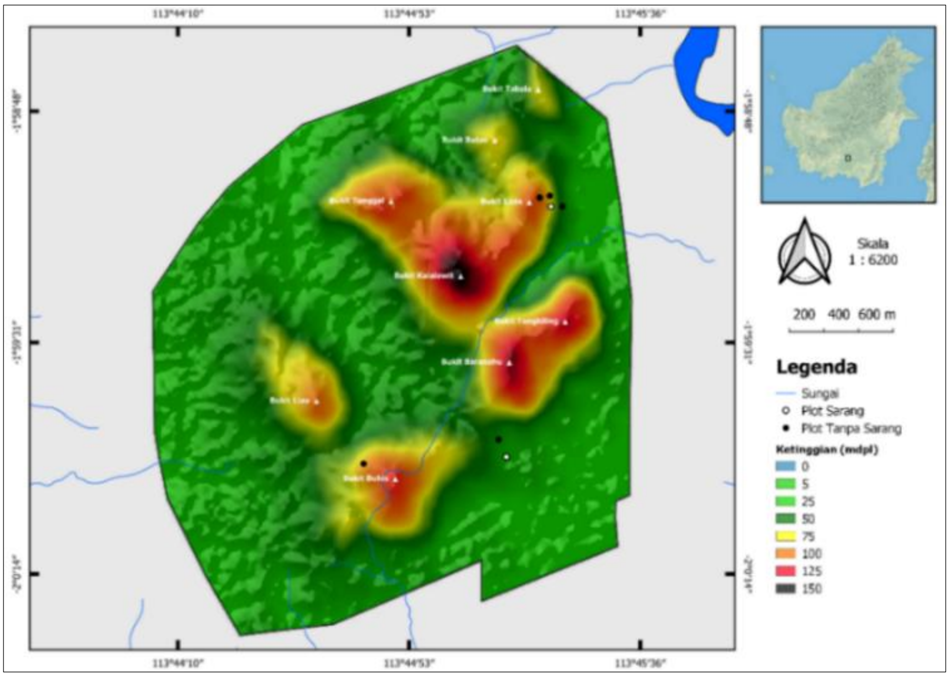

Figure 4. Distribution map based on the locations of Sunda pangolin nests

In Plot 2 and Plot 3, Sunda pangolin nests were discovered on watercourse cliffs and rock cliffs, a strategic location thought to be chosen to avoid predators by rolling their bodies and rolling into steep areas to escape quickly. Some nests were also cleverly covered with leaves or litter, serving as effective camouflage. The water sources around the nests were generally calm, shallow, clear streams, and close to food sources, with a width of less than 4 meters. Plot 1 and 2, located in the lowlands, have a small spring 5-8 meters from the nest, used by pangolins for drinking. In Plot 3 to Plot six on Bukit Tisin, water flows were only at the foot of the hill and dried up during the dry season, while in Plot 7 on Bukit Buhis, a stagnant water source was found under a large rock close to the pangolin nest.

Observations at the TWA Bukit Tangkiling underscore the critical importance of the identified habitat types for the Sunda pangolin: secondary forests, hilly areas, and bushes. These habitats are not just places where the pangolin lives, but they are vital to its survival. As Lakagul & McNeely (1988) pointed out, pangolins can thrive in a variety of habitats, including primary and secondary forests, plantations, and open and hilly areas, demonstrating their adaptability and wide roaming range. According to Medri & Mourao (2005), Bailey (1984), and Morrison (2002), the pangolin's habitat provides the necessary conditions for breeding, feeding, resting, and sheltering. These results highlight the urgent need to protect these diverse habitats, as they are home to a species that can adapt to various altitudes, temperatures, climates, and other natural conditions.

According to the King equation, a widely used method in ecology for estimating population density, it is estimated that there are approximately 7 Sunda pangolin individuals per hectare in the research area. This calculation is based on the number of nests found and two encounters with the pangolins at the observation location.

Habitat Characteristics

The important value index (IVI) of plants in a community is a way for a species to show its role. According to Hidayat (2018), the higher the IVI of a species, the more important its degree of control over the area and vice versa. In our study, we used the IVI to understand the role of different plant species in the Sunda pangolin's habitat. The important value index of vegetation ranges from 0 ≥ 300. For vegetation data at the tree, pole, sapling, and seedling levels, see Table 3-6 below:

Table 3. Highest Importance Value Index (IVI) at five tree levels

No	Nama Ilmiah	Family	RDn (%)	RF (%)	RD (%)	IVI (%)
1	*Acacia mangium*	Fabaceae	44,64	23,33	80,87	148,84
2	*Vitex pinnata*	Lamiaceae	17,86	16,67	8,83	43,35
3	*Macaranga trichocarpa*	Euphorbiaceae	7,14	6,67	2,75	16,56
4	*Shorea balangeran*	Dipterocarpaceae	5,36	6,67	3,60	15,62

No	Nama Ilmiah	Family	RDn (%)	RF (%)	RD (%)	IVI (%)
5	*Campnosperma coriaceum*	Anacardiaceae	7,14	6,67	1,79	15,60

Description: RF = Relative frequency; RDn = Relative density; RD = Relative dominance; IVI = Importance Value Index

Furthermore, 21 species from 10 families were identified in the pole-level plants. *Acacia mangium* dominates with an IVI=62.96% and H'=0.36. Laban (*Vitex pinnata*) dominates the second order with an IVI=39.60%, followed by *Glochidion lutescens* with an INP=10.86%.

Table 4. Highest Importance Value Index (IVI) at five pole levels

No	Nama Ilmiah	Family	RDn (%)	RF (%)	RD (%)	IVI (%)
1	*Acacia mangium*	Fabaceae	28	27,63	7,69	62,96
2	*Vitex pinnata*	Lamiaceae	18,42	18,42	2,76	39,60
3	*Glochidion lutescens*	Phyllanthaceae	5,26	5,26	0,34	10,86
4	*Xylopia fusca*	Annonaceae	5,26	5,26	0,32	10,85
5	*Shorea ovalis*	Dipterocarpaceae	3,95	3,95	0,21	8,11

Description: RF = Relative frequency; RDn = Relative density; RD = Relative dominance; IVI = Importance Value Index

The identified pole-level plants in all observation plots consisted of 21 species from 10 families, with Acacia mangium being the dominant species. The analysis showed that Acacia mangium had an INP value of 62.96% (high category), indicating its dominance, and a diversity value of H'=0.36 (low category), highlighting its presence in the plots. The second dominant species was Vitex pinnata, with an INP value of 39.60% (high category), while Glochidion lutescens was in third place with an INP value of 10.86% (medium category).

Table 5. Highest Importance Value Index (IVI) for five levels of stakes

No	Nama Ilmiah	Family	RDn (%)	RF (%)	RD (%)	IVI (%)
1	*Acacia mangium*	Fabaceae	26,76	15,63	66,83	109,21
2	*Vitex pinnata*	Lamiaceae	9,86	6,25	12,55	28,66
3	*Ficus benjamina*	Moraceae	7,04	12,50	3,90	23,45
4	*Ficus aurata*	Moraceae	5,63	6,25	2,90	14,78
5	*sp 2*	-	4,23	6,25	1,39	11,87

Description: RF = Relative frequency; RDn = Relative density; RD = Relative dominance; IVI = Importance Value Index

At the sapling level, *the dominance of Acacia mangium* is pronounced, with 19 individuals, an IVI of 109.21 (placing it in the high category), and a diversity value of H'=0.35. *Vitex pinnata* follows with seven individuals and an INP value of 28.66, while

Ficus benjamina is in third place with five individuals and an INP value of 23.45. According to the INP criteria, *Acacia mangium* is in the high category, while *Vitex pinata* and *Ficus benjamina* are in the medium category.

Tables 1-3 show that *Acacia mangium* and *Vitex pinnata* dominate at all levels of vegetation, including trees, poles, and seedlings. The high INP values in these two types indicate good adaptation and competitiveness, especially in the Bukit Tisin and Bukit Buhis areas. *Acacia mangium*, as an invasive species, tends to be dominant and difficult to control in new ecosystems (Sutedjo & Warsudi, 2017). In the hilly areas, vegetation is dominated by pole and sapling-level plants. However, in the Bukit Baranahu valley area (plots 1 and 2), the vegetation is a testament to the richness of the ecosystem, with a diverse range of large trees, such as *Shorea balangeran*, *Campnosperma coriaceum*, *Syzygium palawanense*, and *Shorea stenoptera*.

Table 6. Highest Importance Value Index (IVI) for five levels of seedlings and undergrowth

No	Nama Ilmiah	Family	RDn (%)	RF (%)	IVI (%)
1	*Scleria* sp	Cyperaceae	18,44	18,44	36,88
2	*Dicranopteris linearis*	Gleicheniaceae	9,38	9,38	18,75
3	*Imperata cylindrica*	Poaceae	8,13	8,13	16,25
4	*Dianella ensifolia*	Asphodelaceae	7,81	7,81	15,63
5	*Nephrolepis* sp	Polypodiaceae	7,19	7,19	14,38

Description: RF = Relative frequency; RDn = Relative density; RD = Relative dominance; IVI = Importance Value Index

Our analysis of seedling vegetation revealed a rich diversity, with 320 individuals representing 27 species across 19 families. Notably, *Scleria* sp emerged as a standout, boasting the highest IVI value of 36.88 (moderate category). It was followed by *Dicranopteris linearis*, with 30 individuals and an IVI value of 18.75 (low category), and *Imperata cylindrica*, with 26 individuals and an IVI value of 16.25 (low category). The forest structure indicates that the Sunda pangolin favors secondary forests as its habitat, which are predominantly populated by pole-level plants. Kuswanda & Setyawati's (2016) findings suggest that pangolins forage and nest in habitats in the form of seedlings. What's particularly impressive is the Sunda pangolin's adaptability, as it does not have a specific habitat preference for foraging or nesting, but instead utilizes a variety of available habitats (Kuswanda & Setyawati, 2016; Manshur et al., 2015).

Environmental factors

Environmental physical factors such as temperature, humidity, and light intensity play a crucial role in shaping the forest ecosystem, particularly in supporting plant growth that sustains animal life. As Akande et al. (2018) point out, these abiotic factors are instrumental in creating lush vegetation and providing abundant food sources, thereby maintaining the delicate balance of the food chain. The abiotic factors we measured during our observations include air humidity, air temperature, soil pH, soil moisture, and altitude.

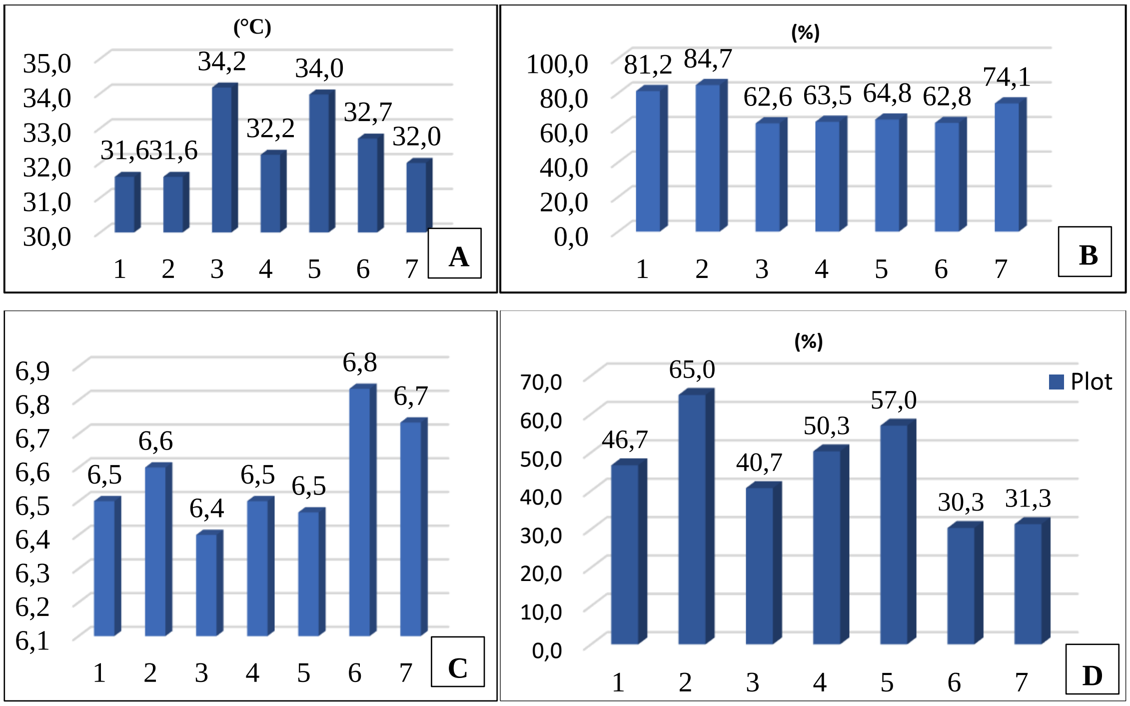

Figure 5. Results of abiotic component analysis, A) Air Temperature, B) Air Humidity, C) Soil pH, D) Soil Moisture

The PCA results, a significant achievement in our quest to understand Sunda pangolin biology, show that among the abiotic factors measured, air, soil pH, and soil humidity have the most influence on the existence of pangolin nests. In contrast, air temperature has less impact. This discovery is a key to understanding the habitat preferences of Sunda pangolins, who tend to choose humid nest habitats and require a neutral soil pH to support their biological needs (Darusman et al., 2012; Kuswanda & Setyawati, 2016). The presence of this humidity also supports the presence of ants and termites, the leading food of pangolins, which are often found near their nests.

Feed Potential

Understanding the feed potential and distribution of feed sources is crucial in determining the presence of Sunda pangolins and the distribution of their habitat and population (Borror et al., 1992). Our observations show that pangolin nests are often found near feed sources, such as ant and termite nests. This knowledge can be applied in the field to locate potential pangolin habitats. The main feed of pangolins is ants and termites, so they are classified as myrmecophages (Abensperg-Traun & Boer, 1992; Lim & Ng, 2008; Manshur et al., 2015). The selection of Hymnoptera by *M. javanica* as the main feed is due to the higher energy content of this type of feed compared to termites per unit body area (Abensperg-Traun & de Boer, 1992).

However, pangolins also consume a variety of other invertebrates, such as bee larvae and crickets (Shepherd, 2012). The types of ants and termites in their diet include *Odontoponera transverse, Polyrhachis sp* (black ants), *Odontoponera denticulate, Cataulacus hispidulous, Camponotus sp* (hunchback ants), *Oecophylla smaragdina* (weaver ants), *Odontomachus haematodus* (ataman ants), *Crematogaster* sp, and the type of termite found is *Bulbitermes* sp. Pangolins more often choose ants from the order Hymenoptera than termites from the order Isoptera because Hymenoptera contains more energy and chitin, which are important for the composition of their scales (Abensperg-Traun & Boer, 1992; Haim et al., 1990). The selection of worker ants as food is believed to be related to specific nutritional needs that support the physiology of the pangolin’s body (McNab, 1984).

CONCLUSION

Seven Sunda pangolin nests were found, with two types of nests, namely ground nests and stone nests, where stone nests were more dominant. Nests were found at 36-117 meters above sea level, with an estimated population of 7 individuals/ha. Pangolins prefer to make ground nests under the roots of large trees, and soil and air humidity have been shown to affect the existence of nests. The area around the nests is a diverse buffet, with eight types of Hymenoptera and one Isoptera making up the pangolin's diet. Nests were found in three habitats: secondary forests, hills, and bushes, indicating that pangolins are not limited to specific habitats for making nests.

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