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Research Article

A Baseline Study of *Nepenthes* spp. in Bukit Tangkiling Nature Tourism Park, Palangka Raya, Central Kalimantan, Indonesia

Muhammad Rizki[1,2]*, Helen Oktafiani[1], & Desimaria Panjaitan[1]

[1] Biology Study Program, Faculty of Mathematics and Natural Science, University of Palangka Raya, Palangka Raya 73111, Central Kalimantan, Indonesia
[2] Plant Biology Doctoral Program, Department of Biology, Faculty of Mathematics and Natural Sciences, IPB University, IPB Dramaga Campus, Bogor 16680, West Java, Indonesia

*Corresponding author: rizki.tarsius@gmail.com

ABSTRACT

Pitcher plants (*Nepenthes* spp.) are carnivorous plants that flourish in the Bukit Tangkiling Nature Tourism Park (BTNTP), Palangka Raya, Central Kalimantan. Searches of global biodiversity databases and relevant literature revealed no prior records of *Nepenthes* from this area. This study aimed to document and provide a baseline record of *Nepenthes* species occurring within BTNTP. The study was conducted from March to May 2022 using exploration and purposive sampling methods to collect plant specimens. Three species, namely *Nepenthes gracilis* Korth*, Nepenthes mirabilis* (Lour.) Druce, and *Nepenthes rafflesiana* Jack, were recorded across various habitats, including scrub forest, heath forest, secondary forest, and peat forest, all below 100 m above sea level. These findings contribute to the species inventory of BTNTP and serve as a scientific reference for future ecological monitoring and management strategies aimed at maintaining habitat quality and supporting long-term *Nepenthes* conservation efforts in the region.

Keywords: habitat, species record, pitcher plants, *Nepenthes*, Kalimantan

Introduction

Nepenthes spp. (Nepenthaceae) includes about 180 species of dioecious pitcher plants (Mansur et al., 2021). According to Murphy et al. (2020), it has unique morphologies and trapping mechanisms. These plants are found across the Palaeotropics, ranging from Madagascar to New Caledonia. Indonesia and the Philippines host the highest species diversity. In 2021, 80 species, or approximately 44% of all *Nepenthes* (total of 181 species), were recorded from Indonesia (Mansur et al., 2021), with diversity concentrated in Borneo and Sumatra. Among the 40 species of *Nepenthes* present in Kalimantan, 29 species are endemic, making it the central distribution of *Nepenthes* in Indonesia (Dančák et al., 2022).

Nepenthes typically grow on barren substrates like heath forest, white sands, ultramafic soils, montane forests, and, occasionally, limestone soils. The key morphological adaptation of these species is their pitcher, which is a modified jug-like container at the end of the leaves that is designed to hold liquid and has a slippery peristome or waxy zone to trap and retain prey (Bauer et al., 2012; Benz et al., 2012; Clarke, 1997). However, different pitchers have evolved to catch different types of prey (Lam et al., 2018; Thorogood et al., 2018). The prey provides the plant with additional nutrients and helps it grow in deficient soils.

This study aimed to document and provide a baseline record of *Nepenthes* species occurring within Bukit Tangkiling Nature Tourism Park (BTNTP), including their habitat types and associated environmental factors, as a reference for future ecological monitoring and conservation planning.

Materials and Methods

This study was conducted from March to May 2022 within the ecosystem of BTNTP, which is part of the Natural Resources Conservation Center of Central Kalimantan (BKSDA) in Palangka Raya City, Central Kalimantan Province, during the period just before the dry season to ensure optimal observation conditions. Observations were carried out at nine location sites to identify the habitat of *Nepenthes* spp., including Liau Hill, Buhis Hill, Baranahu Hill, and the forest behind residential areas, which are still included in the BTNTP area. Figure 1 displays a map of the research sites with red dots.

In this research, various equipment was used, including meters, soil testers, cameras, GPS, scissors, calipers, stationery, machetes, hand sprayers, as well as reference books such as "*Nepenthes* of Borneo" (Clarke, 1997) and "*Nepenthes*: Kantong Semar yang Unik" (Mansur, 2007a). Research materials included collections of *Nepenthes* spp., hanging labels, cardboard, used newspapers, insulation, double tips, and 70% alcohol.

The study utilized an exploratory, descriptive research approach with structured steps, which included identifying potential observation locations and analyzing data from exploration results. Previous exploration of the BTNTP ecosystem involved setting up observation points and using meters, soil testers, cameras, and GPS to measure environmental parameters and document morphological traits.

The researchers conducted direct observations by measuring and recording

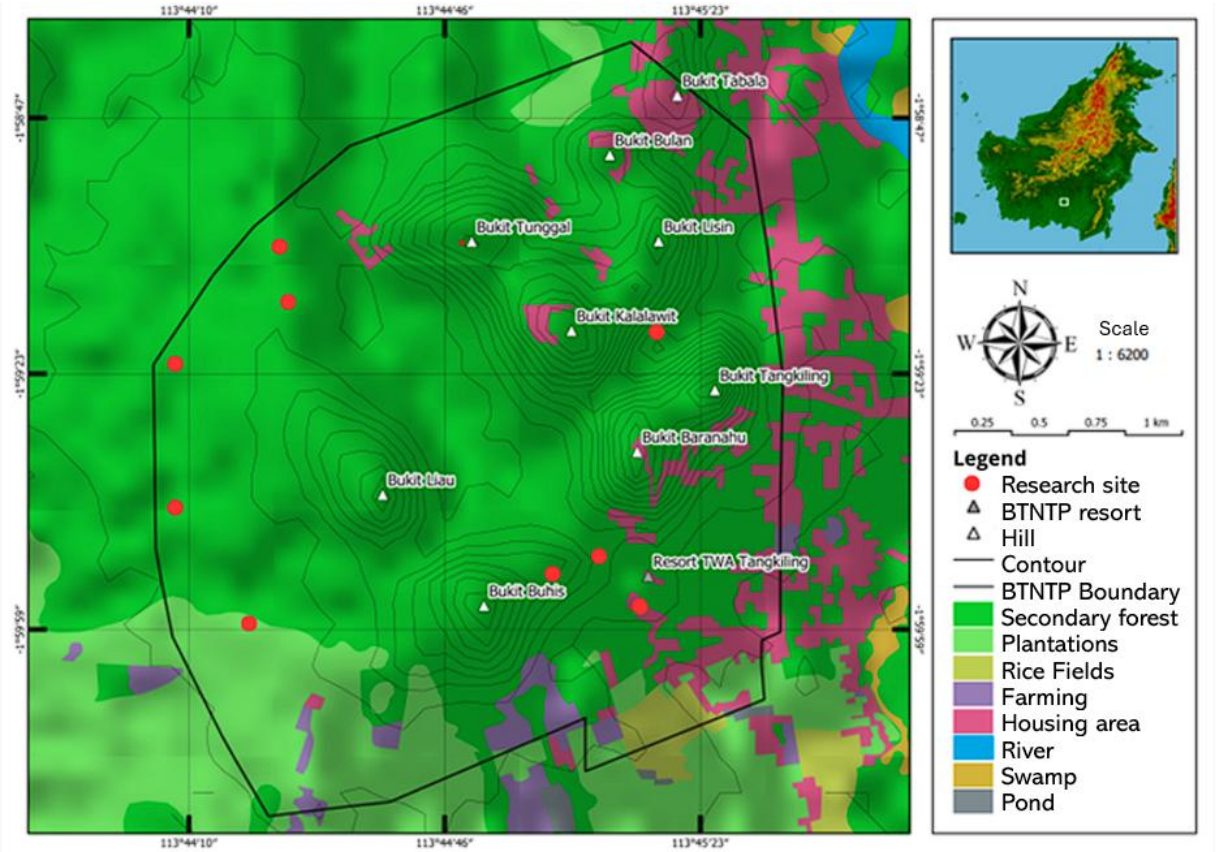

Fig. 1. Map of research locations in the Bukit Tangkiling Nature Tourism Park (BTNTP) ecosystem area, Palangka Raya, Central Kalimantan with the red dots as research sites.

Nepenthes morphology and environmental parameters such as air temperature, soil temperature, soil moisture, humidity, and pH. To create a herbarium, the researchers utilized a purposive sampling method and followed up with identification based on morphological characteristics to the species level using relevant literature (Rugayah, 2005). We analyzed the observation and measurement data by selecting five individuals from each species as representative samples, a number chosen to capture morphological variation while ensuring manageable data collection, without counting the total number of individuals at each observation site, and entered them into an analysis table to obtain various results based on habitat conditions.

Results and Discussion

Three types of pitcher plant species, namely *Nepenthes gracilis* Korth, *Nepenthes mirabilis* (Lour.) Druce, and *Nepenthes rafflesiana* Jack, were discovered in the BTNTP area. The study recorded these species in three different habitats: heath forest, peat forest, and secondary forest. Table 1 shows the species mentioned above. The relative abundance observed during the survey indicates that, while these species remain present across multiple habitat types, certain populations appear fragmented and potentially vulnerable to human disturbance as well as seasonal fire events.

The study recorded three species in the BTNTP ecosystem area: *N. gracilis*, *N. mirabilis*, and *N. rafflesiana*. These three species of *Nepenthes* are distributed in Indonesia's Kalimantan and Sumatra regions. However, *N. gracilis* also occurs in Sulawesi, while *N. mirabilis* has been recorded in Java, Maluku, and New Guinea (Clarke, 1997). Various national parks, such as Sebangau, Katingan, and Palangka Raya, host populations of these plants (Dewi et al., 2020; Hidayat et al., 2018). *N. gracilis* and *N. mirabilis* are also present in Bukit Rawi and Kalampangan (Mansur, 2010). *N. gracilis* and *N. rafflesiana* are distributed worldwide, including Peninsular Malaysia, while *N. mirabilis* is found in Thailand, South China, the Philippines, and Australia. Moreover, *N. rafflesiana* also occurs in New Guinea and Singapore (Mansur, 2013). In terms of conservation status, although all three species are currently listed as Least Concern (LC) by the International Union for Conservation of Nature (IUCN), localized threats such as land conversion, encroachment, and peatland degradation in BTNTP could lead to population declines if not properly managed.

Description of N. gracilis Korth

Terrestrial habitat. Climbing or scrambling, triangular, purple, green, 13.5–105.0 cm long and 0.2–1.4 mm wide. Lamina without petiole, with an acute apex, thick, green, purple, and brown leaf margin, 7.9–10.7 cm long and 1.7–2.1 cm wide.

The tendrils of the upper pitcher are circular/twisted, green, and brown, located behind the pitcher, and 13.9–18.0 cm long. The lower pitcher tendrils are straight, brown, and green, located in front of the pitcher, and 4.0–6.9 cm long. The tendrils of the rosette pitcher are located at the front of the pitcher, purple, and 0.9–1.3 cm long.

Table 1. Pitcher plant *Nepenthes* species discovered in the BTNTP ecosystem area, Palangka Raya, Central Kalimantan.

No.	Species	Habitat				Conservation status	
		KF	PF	SF	P.106	IUCN Red List category	Cites appendix
1	*N. gracilis*	√	√		√	LC (Clarke, 2018)	II
2	*N. mirabilis*	√		√	√	LC (Clarke, 2014)	II
3	*N. rafflesiana*		√	√	√	LC (Clarke, 2018)	II

KF = kerangas forest, PF = peat forest, SF = secondary forest, P.106 = protected under Minister of Environment and Forestry (Regulation No. P.106/2018 concerning Protected Plant and Animal Species), LC = least concern.

The study recorded three pitcher types, namely upper, lower, and rosette. Mature plants form upper pitchers on elongated stems. Saplings, young plants, produce the lower pitcher or stems that are still rosettes. Rosette pitchers are produced from seedlings, producing leaves and pitchers on short stalks. The arrangement of opposite leaves crosses on very short or non-spreading stems. The morphological traits of *N. gracilis* are illustrated in Figure 2.

Cylindrical upper pitcher (green, purple, green with purple spots), 8–12 cm long, 1.1–1.9 cm upper width, and 2.2–2.7 cm lower width. The length of the lid is 2.4–2.9 cm, the width is 2.4–3.1 cm, the color (green, purple, green with purple spots), and the spur length is 0.1–0.9 cm, lip (peristome) 0.1 cm thick, green and purple. The lower pitcher is oval, with a color (green and purple with green flecks), length 6.7–9.6 cm, upper body width 0.4–1.9 cm, and lower body width 1.4–2.6 cm. Lid length 1.5–2.1 cm, width 1.7–2.3 cm, color (green, purple, green purple with green flecks), spur short and curved 0.2–0.5 cm, peristome thickness 0.1 cm, green and brownish green. Purple rosette pitcher, 1.4–2.6 cm long, upper body width 0.6–1.0 cm, lower body width 0.8–1.1 cm and purple. The lid is up to 1.2 cm long and 1.0 cm wide, purple with green flecks, peristome 0.1 mm thick and green.

The inflorescence is up to 17 cm long, and the number of flowers in panicles is 98–140. Flowers are borne on 1-flowered partial peduncles, usually without bracts, a dark brown and brownish green stalk. Triangular fruit, green, 1.3–2.1 cm long, stalk 15.0–20.2 cm long, smooth, thread-like seeds, 0.6–0.9 mm long, and seed wing length 17.0–21.3 cm. All parts of the foliage are glabrous. The diminutive size of the foliage and the pitchers of *N. gracilis* help distinguish it from most other *Nepenthes* (McPherson & Robinson, 2012).

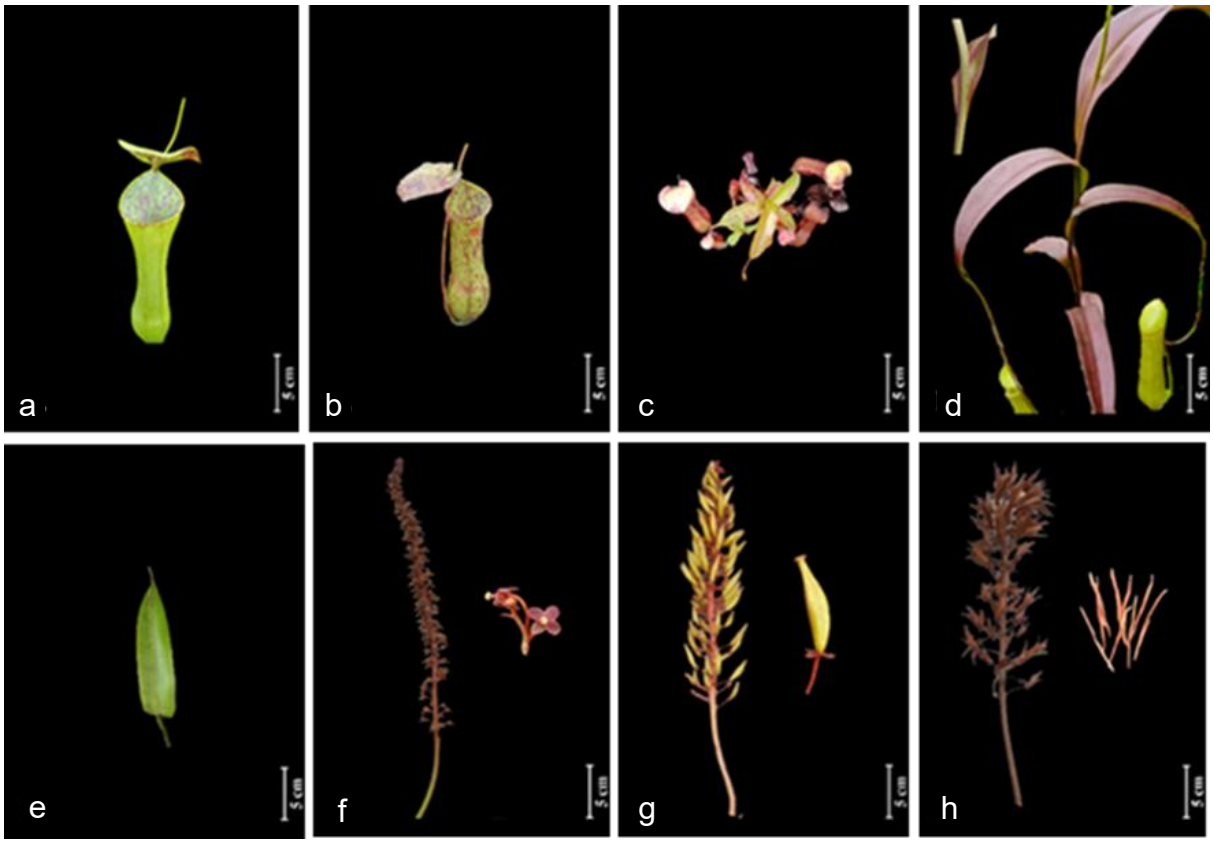

Fig. 2. Morphology of *Nepenthes gracilis*. (a) upper pitcher, (b) lower pitcher, (c) rosette pitcher, (d) stem, (e) leaves, (f) male flowers, (g) fruits, (h) seeds.

Description of N. mirabilis (Lour.) Druce

Terrestrial habitat. Climbing or scrambling, cylindrical, green, up to 3 m long and 0.4–4.1 mm in diameter. Lamina with petiole, thin, green, with an acute apex, margins that are often fimbriate, 20.8–25.5 cm long and 6.3–7.9 cm wide.

The tendrils of the upper pitcher are circular, green and brown, and 12.1–19.0 cm long. The lower pitcher tendrils are straight, brown, green, and 2.5–9.2 cm long. The rosette pitcher tendrils are green and 1.2–1.5 cm long at the front of the pitcher. Three types of pitchers were found. The morphological characteristics of *N. mirabilis* can be seen in Figure 3.

The upper pitcher is green (spotted and reddish), with a length of 7.7–14.4 cm, an upper part width of 0.9–1.9 cm, and a lower part width of 1.2–2.7 cm. The lid length is 1.7–3.4 cm, the width is 1.3–3.1 cm, green and red with green spots, and the spur length is 0.1–0.8 cm. The peristome is 0.1–0.3 cm thick, green, and red. The lower part is ovate and variably swollen, narrowing above to form a slight hip, color (green and green with red spots), length 4.6–9.4 cm, upper body width 0.7–1.6 cm and lower body width 1.1–2.4 cm. Lid length 1.7–3.4 cm, width 1.1–1.8 cm, green and red with green spots, spurs 0.1–0.6 mm, peristome thickness 0.2–0.3 mm, green and red. The green rosette pitcher is 0.7–1.1 cm long; the upper part width is 0.4–1.2 cm, the lower part width is 0.2–0.9 cm, and the green. Lid length 0.4–0.6 mm, width 0.4–0.5 mm, green, peristome 0.1 cm thick and green. Leaves, thin and oval to lanceolate, stalked, ≤ 30 cm long, ≤ 7 cm wide, leaf veins longitudinal, leaf margins mostly found hairy/serrated.

The inflorescences are bunch-shaped with a length of 15.0–23.4 cm, and the number of flower clusters is 81–102. Each flower stalk has one flower, red and green stems. The fruit is triangular, green 1.3–2.1 cm, and the stalk is 15.0–20.2 mm.

Description of N. rafflesiana Jack

Terrestrial habitat. Stems are climbing, cylindrical, green, and brown, up to 2 m in length, and 2.4–5.5 mm in diameter. Leaves are petiole-thick, with brown leaf margins, 12.2–29.2 cm long and 3.5–6.0 cm wide.

The upper pitcher tendrils are spiral/twisted, green and brown, located behind the pitcher, and 15.2–26.7 cm long.

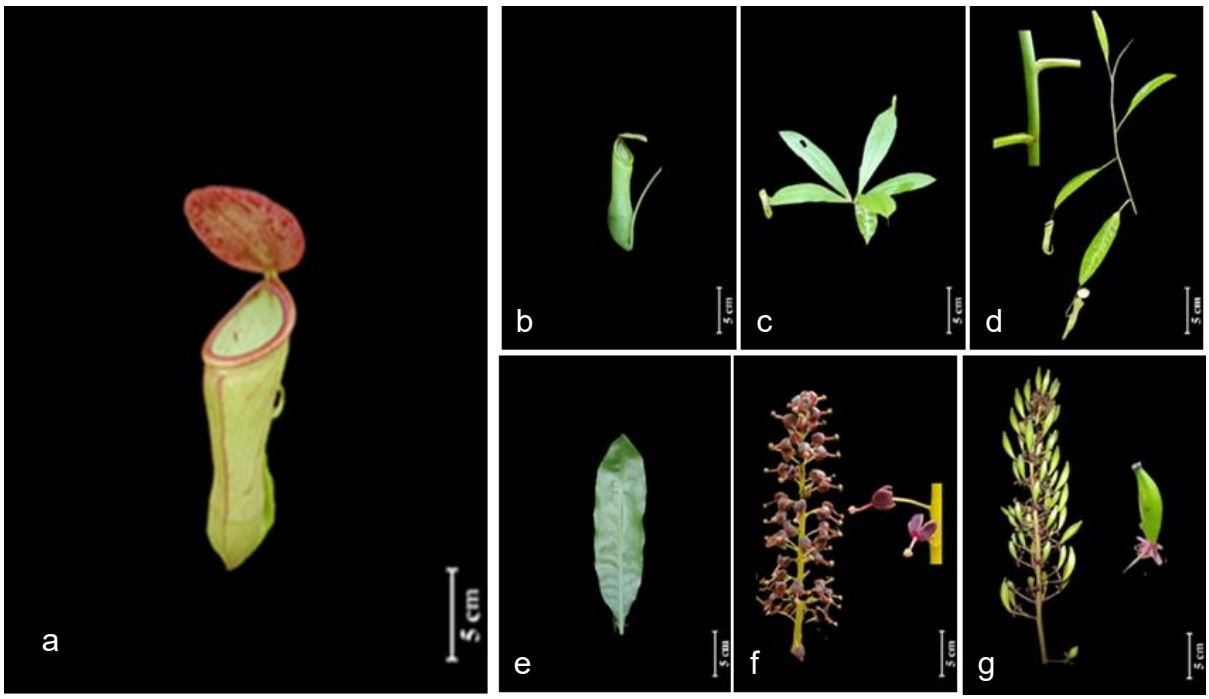

Fig. 3. Morphology of *Nepenthes mirabilis*. (a) upper pitcher, (b) lower pitcher, (c) rosette pitcher, (d) stem, (e) leaves, (f) flowers, (g) fruits.

The lower pitcher tendrils are straight, brown, and green, located at the front of the pitcher, and 11–24 cm long. The tendrils of the rosette pitcher are purple, located at the front of the pitcher, and are 1–3 cm long. The morphological characteristics of *N. rafflesiana* can be seen in Figure 4.

The upper pitcher of funnel/trumpet, color (green with red spots and red with green spots), length 18.0–23.2 cm, upper part width 5.0–7.2 cm, and lower part width 1.2–2.2 cm. The length of the pitcher lid is 4.8–6.3 cm; the width is 1.2–4.5 cm; the color (green with red spots and red with green spots) and the spur length is 0.6–1.3 cm. The peristome is 1.1–1.3 cm thick and has greenish-red stripes. The lower pitcher is ovate, with a color (purple and red with green spots), length 8.0–18.5 cm, upper part width 2.1–5.6 cm, and lower part width 1.2–2.2 cm. Lid length 2.1–6.0 cm, width 0.9–4.0 cm, red with green spots, spurs 0.2–0.5 cm, peristome thickness 0.4–10.0 mm, green and brownish green. Green rosette pitcher with purple flecks, 1.4–2.6 cm long, upper part width up to 1 cm, lower part width up to 1.1 cm, and purple. Lid length up to 1.2 cm, width up 1 cm, purple with green spots, peristome 0.6–0.9 mm thick, and greenish red stripes.

Habitat and Distribution

The BTNTP area is home to diverse habitats, including peat swamp forests, grasslands, shrubs, and heath forests. Although classified as a secondary forest, some parts of the area function as plantation forest. Despite the presence of various human activities such as tree felling, forest fires, and gardening—which pose threats to *Nepenthes* through habitat degradation, peatland disturbance, and increased risk of population fragmentation—the region's ecology remains relatively intact. Land conversion occurs in the border areas adjacent to the conservation zone, and several sites have also been affected by fires resulting from land clearing near the conservation area.

Fig. 4. Morphology of *Nepenthes rafflesiana*. (a) upper pitcher, (b) lower pitcher, (c) rosette pitcher, (d) stem, (e) leaves.

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This study identified pitcher species *N. gracilis*, *N. mirabilis*, and *N. rafflesiana* at nine locations in the BTNTP area (Figure 5). Four locations are within the BTNTP, specifically at locations I, II, III, and VIII. The remaining five sites, namely locations IV, V, VI, VII, and IX, surround the BTNTP area.

N. gracilis can be found in various locations: IV, V, VI, VII, and IX (red dots on the map). Locations IV, VI, and IX are known to have peaty soil, while locations V and VII feature heat forest habitats and resam ferns (*Dicranopteris linearis*) habitat. According to Hidayat et al. (2018), *N. gracilis* prefers areas with high light intensity and lots of water. It is often found on shrubs and vines that compete with *N. gracilis*, especially ferns such as *Stenochlaena palustris*. Research by Kissinger et al. (2015) and Mansur (2010) found that the *N. gracilis* type can survive on open land, especially in heat forests with high light intensity.

N. mirabilis was discovered in locations I, II, III, VII, and VIII (blue dots on the map), with locations I, II, and VIII featuring secondary forests and bushes and locations III and VII featuring heat forests and resam ferns habitat. *N. mirabilis* is found in various habitats but is usually most prevalent in disturbed areas, swamps, or grasslands. Most are found in the lowlands (up to 200 m above sea level) but can occur up to 1,000 m above sea level and, more rarely, up to 1,400 m above sea level (Hidayat et al., 2018). According to Agustiorini et al. (2022), Dino and Kartiwati (2016), and Mansur (2013), *N. mirabilis* can thrive in various environments, including shaded and open areas, and has a widespread distribution. *N. mirabilis* commonly grows alongside shrubs.

N. rafflesiana and *N. gracilis* were recorded in location IX, indicating their shared preference for secondary forest and mossy peat soil. According to Mansur (2010) and Rizki et al. (2021), *N. rafflesiana* typically grows in relatively open habitats. This species of *Nepenthes* thrives in somewhat open places that provide sufficient access to sunlight and air. Research conducted at nine *Nepenthes*

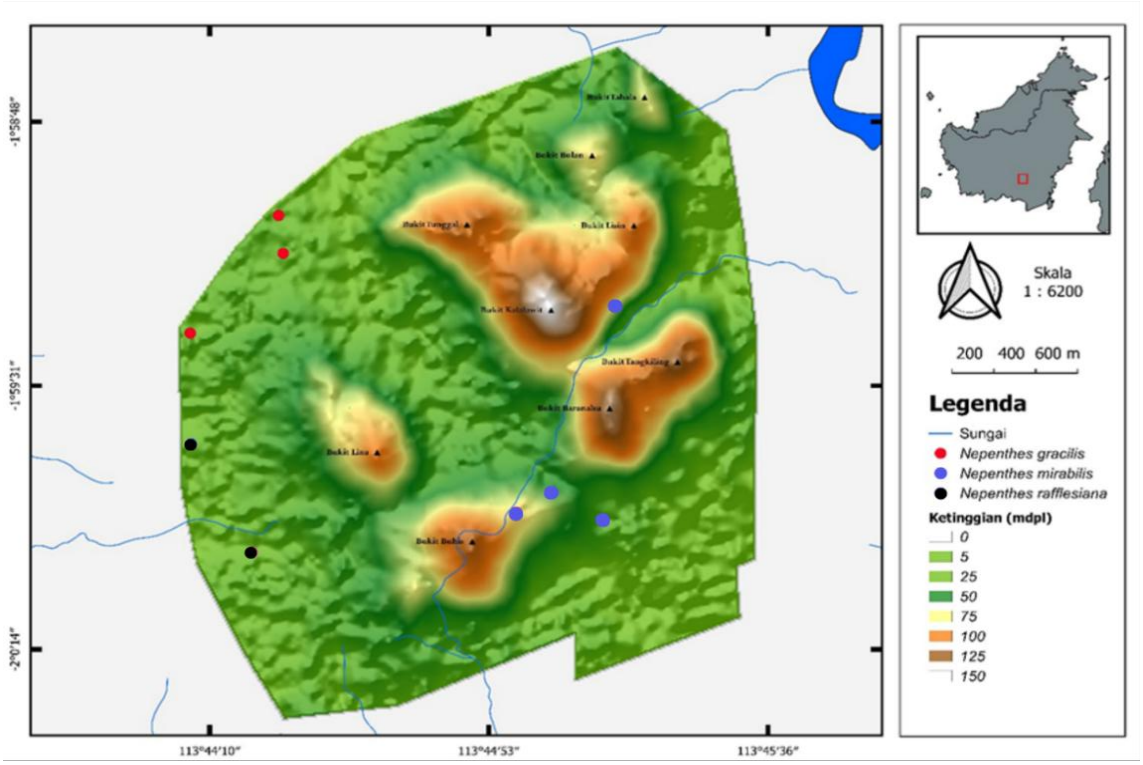

Fig. 5. Locations of *Nepenthes gracilis*, *Nepenthes mirabilis*, and *Nepenthes rafflesiana* in the BTNTP ecosystem area.

encounter sites within the BTNTP area revealed that all identified *Nepenthes* species, including *N. gracilis*, *N. mirabilis*, and *N. rafflesiana*, occur at elevations below 100 m above sea level. This study is similar to the research conducted by Rizki et al. (2021) and Sunariyati et al. (2022). They discovered three *Nepenthes* species in the peat forest area of Palangka Raya University's campus. According to Mansur (2007a; 2007b; 2013), all three are classified as lowland *Nepenthes*, although these three types can live at an altitude of > 100 m above sea level to 1,000 m above sea level. Air temperatures of 27.6–30.8°C and air humidity of 85.1–92.4% at the research location influence the growth of pitcher plants (Fitri & Patana, 2015), which, according to Mansur (2007a), can live at temperatures of 22–34°C and air humidity of 70–95%. Young plants typically produce terrestrial pitchers that are ovoid; as the plant grows, aerial pitchers are produced (Moran et al., 2013).

The soil's pH level is a crucial environmental factor that affects the growth of pitcher plants. Lestariningsih and Setyaningsih (2017) said *Nepenthes*' habitat in peat forests has a pH of 4.0 to 6.5. The soil pH level at this location is measured to be between 5–6, with a soil moisture level of 50–70%. Due to the presence of peat soil, the soil tends to be acidic, which is beneficial for the growth of pitcher plants, as confirmed by Lestariningsih and Setyaningsih (2017). Additionally, studies have shown that pitcher plant species such as *N. gracilis* and *N. rafflesiana* thrive in peat soil, as stated by Mansur (2007a). However, it is essential to note that pitcher plants can also grow in alkaline soil with a pH level greater than 7, as Murni et al. (2020) discovered.

Although this study did not quantify population sizes, field observations indicate that *N. gracilis* and *N. mirabilis* are more frequently encountered across multiple sites, whereas *N. rafflesiana* was recorded in more limited areas. Several populations appeared fragmented, with some growing in proximity to human activities such as small-scale agriculture and areas affected by past fires. These observations suggest that while *Nepenthes* species in BTNTP are still present in multiple habitats, they may be vulnerable to habitat disturbance, peatland degradation, and seasonal fires. The documentation of these species and their habitats in BTNTP provides an important baseline for future monitoring and serves as a key resource for preventing *Nepenthes* extinction and ensuring the long-term availability of genetic material for conservation and research purposes.

Conclusion

This study documents three distinct *Nepenthes* species, namely *N. gracilis*, *N. mirabilis*, and *N. rafflesiana*, occurring in three habitat types: heath forest, peat forest, and secondary forest, within the BTNTP area, Palangka Raya, Central Kalimantan. These findings provide valuable insights into the biodiversity of *Nepenthes* in the region, highlighting the specific species and habitats that were the subject of investigation. These findings underscore the urgency of monitoring population trends and mitigating threats to ensure the long-term persistence of these carnivorous plants in Central Kalimantan, and recommend strengthening habitat protection in border areas, preventing land conversion and fires, and incorporating *Nepenthes* habitat monitoring into regular conservation management activities.

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Conflict of Interest

All authors have no conflicts of interest to disclose.

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