Diversity and conservation status of *Nepenthes* in Rokan Hulu Regency, Riau Province, Indonesia

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Abstract. This study investigated the diversity, distribution, population status, habitat characteristics, and conservation status of *Nepenthes* species in Rokan Hulu Regency, Riau Province, Indonesia. Field surveys were conducted from June to December 2025 using direct habitat exploration across forest, shrubland, and riparian ecosystems. Species identification was performed through detailed morphological examination, focusing on pitcher shape, coloration, peristome structure, leaf morphology, and tendril characteristics, with reference to standard taxonomic literature. A total of three species were documented: *Nepenthes eustachya*, *N. gracilis*, *N. longifolia*. All recorded species are listed under Appendix II of CITES and are generally classified as Least Concern (LC) by the IUCN, indicating low extinction risk but requiring regulated trade and monitoring. Species distribution was relatively balanced between the Rokan IV Koto and Sungai Bungo areas, indicating the persistence of suitable microhabitats despite extensive land-use change. Most recorded species were associated with upland and nutrient-poor environments characterized by high humidity and heterogeneous vegetation structure. Although large portions of natural forest in Rokan Hulu have been converted into oil palm plantations, observed populations appeared relatively stable at the time of study; however, ongoing habitat transformation poses potential long-term risks.
Keywords: carnivorous plants, species distribution, habitat, tropical forest, land-use change.

Introduction. *Nepenthes* spp., commonly known as tropical pitcher plants or monkey cups (Indonesian: *kantong semar*), comprise a genus of carnivorous plants in the family Nepenthaceae and are widely distributed throughout Southeast Asia, the Seychelles, Madagascar, and parts of Australia. They are characterized by specialized leaf adaptations that develop into pitcher-shaped structures, enabling survival in nutrient-poor habitats through the attraction, capture, retention, and digestion of predominantly insect prey (Moran & Clarke, 2010).

Indonesia is widely recognized as one of the most biodiverse countries in the world. As an archipelagic country comprising approximately 17,000 islands situated along the equator in Southeast Asia, around 6,000 of these islands are inhabited. The country encompasses at least 47 distinct natural ecosystems that support a remarkable diversity of flora and fauna, including a high number of endemic island species. Indonesia is estimated to harbor approximately 1.46 million known species, including about 42,584 plant species, of which roughly 39% are endemic and distributed across various regions of the archipelago (Nainggolan et al., 2020). Among this rich plant diversity, Nepenthes spp. is recognized as one of the most prominent and well-known groups of carnivorous pitcher plants (Fitmawati et al., 2023). The Indonesian archipelago, covering approximately 1,919,440 km², lies at the center of the geographical distribution of *Nepenthes*, which extends from Madagascar to New Caledonia. As of 2021, a total of 80 species, representing approximately 44% of the 181 recognized *Nepenthes* species worldwide, have been recorded in Indonesia (Mansur et al., 2021). The diversity of *Nepenthes* is particularly concentrated in Borneo and Sumatra. Over the past few decades, numerous new species have been formally described, especially from Indonesia,

Malaysia, and the Philippines. Within the last three years alone, three new species have been identified in Sumatra, including *Nepenthes putaiguneung* from Kerinci Seblat National Park (Metusala et al., 2020), *N. longiptera* Victoriano in Aceh (Victoriano, 2021), and *Nepenthes harauensis* from West Sumatra (Hernawati et al., 2022). To date, a total of 39 *Nepenthes* species have been recorded in Sumatra (Hernawati et al., 2022; Akhriadi et al., 2009; Armanda et al., 2020; Rinanda & Mahrudin 2025; Nurhaliza et al., 2024). Mansur et al., (2022) recently documented 22 species occurring in North Sumatra; however, information from other provinces remains limited. This is particularly evident in provinces traversed by the Barisan Mountain range, which are likely to support high *Nepenthes* diversity due to their pronounced topographic heterogeneity (Nerz, 2005).

Riau Province has an area of approximately 8,915,016 Ha, which is administratively divided into 12 regencies/cities, 154 districts, and 1,739 villages/urban wards. Among these regions, Indragiri Hilir Regency is the largest, contributing about 15.48% of the total area, followed by Pelalawan Regency at 13.91%, while the smallest area is Pekanbaru City, covering approximately 0.71%. Geographically, Riau stretches from the foothills of the Bukit Barisan to the Strait of Malacca, and is located between 1°05' South Latitude and 2°25' North Latitude, as well as 100°00' East Longitude and 105°05' East Longitude. Its administrative boundaries include North Sumatra Province to the north and west, Riau Islands Province and the Strait of Malacca to the east, and Jambi Province and West Sumatra Province to the south. In terms of topography, the region is characterized by landforms ranging from flat to very steep, with most areas consisting of low slopes (0–2%), followed by moderately steep (15–40%) and very steep slopes (>40%). Furthermore, the average elevation of Riau is around 10 meters above sea level; however, certain areas such as Pasir Pengaraian are situated at a higher elevation of approximately 91 meters, while most other cities, including Tembilahan, Siak, Bengkalis, Bagan Siapi-api, Rengat, and Dumai, are located at elevations below 10 meters above sea level (Riau Province Investment and One-Stop Integrated Services Agency, n.d.).

Rokan Hulu Regency, known as the "land of a thousand suluk," has an area of approximately 7,898.18 km² and is located between 1°25' North Latitude and 0°20' South Latitude, as well as 100°42' to 101°28' East Longitude. Geographically, this region is bordered by Rokan Hilir Regency and North Sumatra Province to the north, XIII Koto Kampar and Bangkinang Barat Districts (Kampar Regency) to the south, West Sumatra Province to the west, and Tapung and Bangkinang Districts (Kampar Regency) to the east. Furthermore, Rokan Hulu Regency is administratively divided into 16 districts with varying land areas, where Ujung Batu District is the smallest, covering approximately 90.57 km² (1.21%), while Tambusai District is the largest, with an area of about 1,127.50 km² (15.04%). In terms of topography, the region lies at an elevation of 70 to 86 meters above sea level; the western part is characterized by undulating terrain that forms part of the Bukit Barisan mountain range (approximately 15%), whereas the majority of the area (around 85%) consists of relatively fertile lowlands that support agricultural activities and the livelihoods of the local population (Riau Province Investment and One-Stop Integrated Services Agency, n.d.).

As a continuation of its geographical and topographical conditions, the plantation sector in Rokan Hulu Regency also plays a significant role in supporting the regional economy. In 2022, the plantation area was dominated by oil palm, covering 271,286.09 ha, followed by rubber with an area of 73,508.51 ha. In addition, other commodities such as coconut, coffee, and cocoa were also cultivated, although on a smaller scale, with areas of 986.64 ha, 184.00 ha, and 194.77 ha, respectively. This condition indicates that land use in Rokan Hulu is highly oriented toward the plantation sector, particularly oil palm, which serves as the leading commodity and a primary driver of the local community's economic activities (BPS-Statistics Indonesia, Riau Province, 2024a,b).

In addition to the dominance of the plantation sector, forest cover conditions also represent an important aspect in describing the environmental characteristics of Riau Province, particularly Rokan Hulu Regency. In 2024, Riau still possesses extensive and diverse forest areas, consisting of protected forests covering 229,776.00 ha, nature reserves and conservation areas covering 630,623.00 ha, limited production forests

covering 1,013,165.00 ha, permanent production forests covering 2,329,904.00 ha, and convertible production forests covering 1,149,035.00 ha, resulting in a total forest and aquatic conservation area of 5,352,503.00 ha. Meanwhile, at the regency level, Rokan Hulu also contributes significantly to forest areas, with protected forests covering 71,646.00 ha, nature reserves and conservation areas covering 1,347.00 ha, limited production forests covering 118,713.00 ha, permanent production forests covering 64,184.00 ha, and convertible production forests covering 137,756.00 ha, bringing the total forest and aquatic conservation area to 393,646.00 ha. This condition indicates that, in addition to being oriented toward the plantation sector, the region also possesses substantial forest resources that must be managed sustainably to maintain ecological balance and support regional development (BPS-Statistics Indonesia, Riau Province, 2024a,b; Ahmal et al., 2022).

Therefore, this study aims to identify and document *Nepenthes* species found in Rokan Hulu District, Riau Province, as well as analyze their diversity, distribution, and habitat characteristics. This study links changes in land use to oil palm plantations (Edram et al., 2007) with the population of *Nepenthes* species in Rokan Hulu.

Material and Method. Field studies were conducted from June to December 2025 in Rokan Hulu Regency. *Nepenthes* species were documented through direct exploration of habitats considered suitable for their growth and development. Species names and geographic locations were recorded in situ at the time of discovery. Further taxonomic identification was carried out in the Biology Education Laboratory of Pasir Pengaraian University, referring to *Nepenthes* of Sumatra and Peninsular Malaysia (Charles Clarke). Identification was based on morphological characteristics, including the shape of each plant organ, coloration, size, and the scientific name of each *Nepenthes* species identified. The identification process was further conducted by matching each recorded *Nepenthes* species with its conservation status listed on the International Union for Conservation of Nature (IUCN) Red List and by referring to information regarding the international trade of protected species provided by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This comprehensive identification approach is expected to provide an appropriate basis for developing sustainable conservation strategies for *Nepenthes* species in Rokan Hulu.

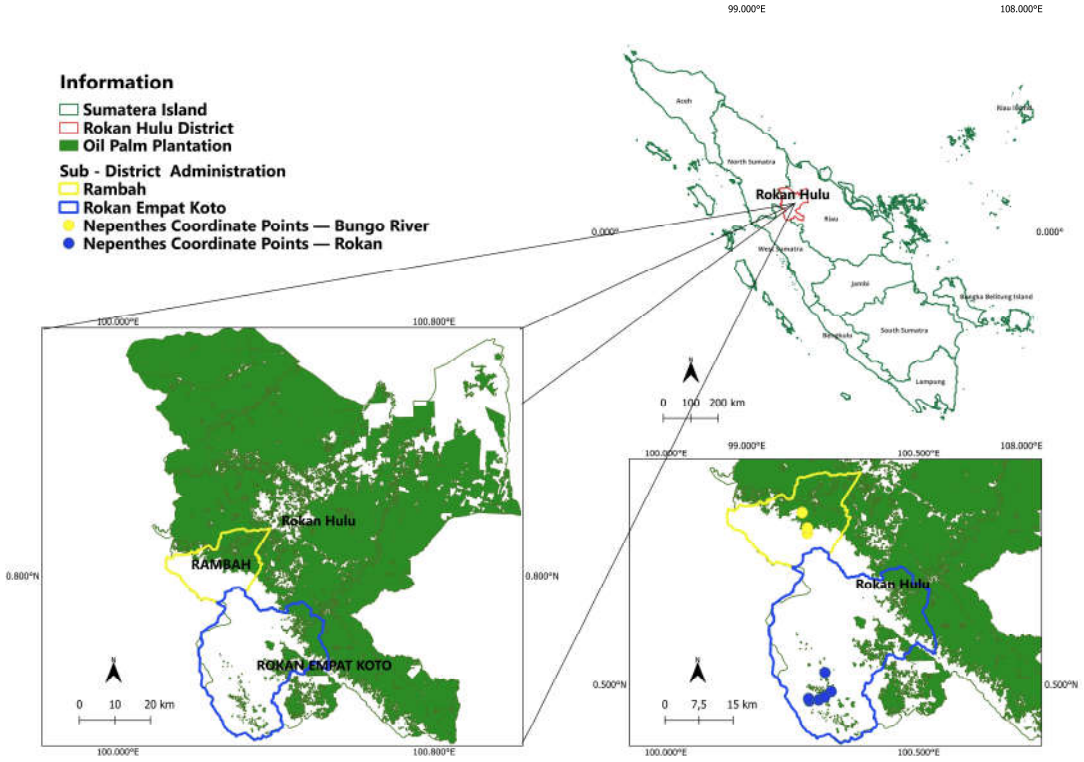

Figure 1. The location of discovery of *Nepenthes* species in Rokan Hulu, Riau, Indonesia.

The above figure is a map of the discovery of *Nepenthes* species found in Rokan Hulu (Figure 1).

Laboratory procedures. The collected *Nepenthes* specimens were preserved as dry herbarium samples. The drying process was conducted in the Biology Laboratory of Pasir Pengaraian University, Rokan Hulu. Initially, all plant parts were carefully washed with water to remove adhering debris and subsequently dried using absorbent tissue paper. Once cleaned, the specimens were sprayed with 75% ethanol to prevent fungal growth and decomposition.

Each specimen was then arranged on a sheet of cardboard, ensuring that all morphological organs were clearly visible for identification purposes. The arranged sample was covered with an additional sheet of cardboard and securely pressed to maintain its position. The cardboard sheets were tightly bound using plastic rope to prevent movement during the drying process.

Drying was carried out in a Memmert oven at 65°C for three days. After oven-drying, the specimens were removed and mounted on herbarium sheets. The dried samples were affixed using adhesive and reinforced by stitching at several points to prevent detachment. Each herbarium sheet was labeled with relevant information, including taxonomic classification and the geographic location where the specimen was collected.

Results and Discussion. In total, three *Nepenthes* species were identified in Rokan Hulu Regency, as shown in Table 1.

Table 1

Nepenthes and their conservation status based on the International Union for Conservation of Nature (IUCN) Red List and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Species	*Habitat*	*Elevation*	*IUCN Red List category*	*CITES category*
Nepenthes eustachya	Forest/shrubland	Mid-elevation (M)	Least Concern	Appendix II
Nepenthes gracilis	Shrubland	Lowland (L)	Least Concern	Appendix II
Nepenthes longifolia	Forest/riparian	Mid-elevation	Least Concern	Appendix II

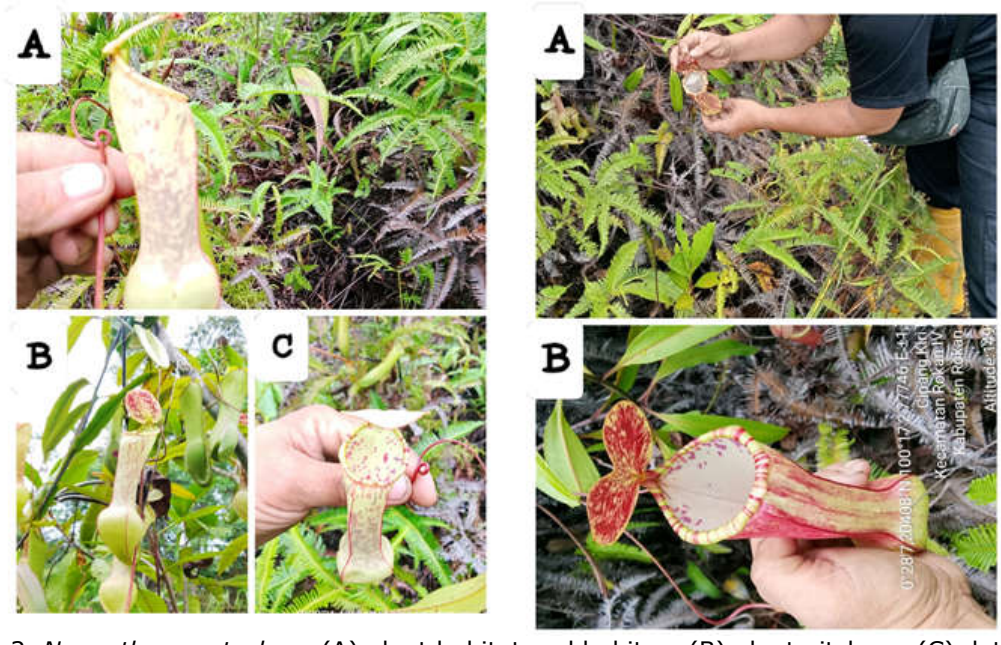

Figure 2. *Nepenthes eustachya*: (A) plant habitat and habitus, (B) plant pitchers, (C) detailed pitcher shapes.

The habitat and growth habit of *Nepenthes eustachya* (Figure 2) are associated with humid tropical forest environments dominated by fern vegetation. This species is characterized by its extremely slender and elongated pitchers, with distinct spotted patterns present on the inner wall of the pitcher and on the underside of the lid. The tendrils are narrow near the leaf attachment but become markedly swollen toward the pitcher stalk. Detailed morphological observations of the insect-trapping pitchers reveal a reddish and patterned peristome that functions in attracting and trapping prey into the digestive fluid. Overall, these structures reflect the carnivorous adaptations of the plant for nutrient acquisition in nutrient-poor habitats. The upper pitchers measure approximately 11–24 cm in length and only 2.5–4.5 cm in width.

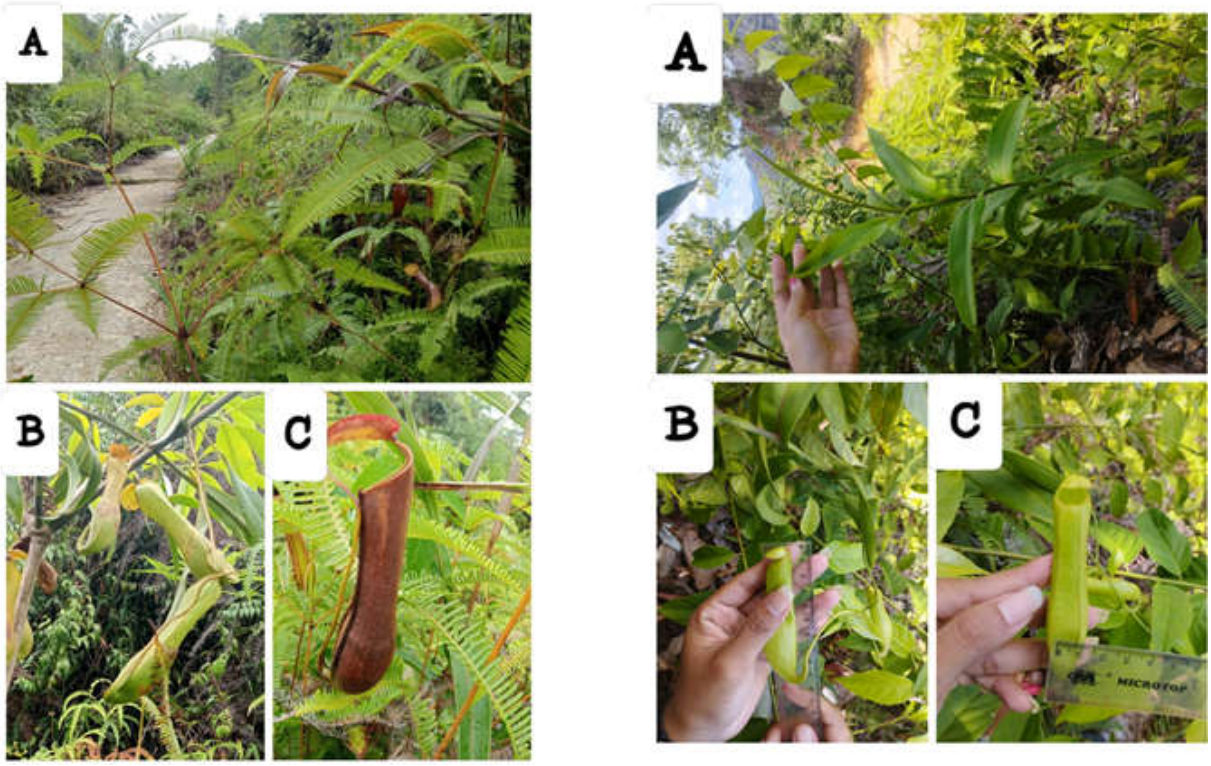

Figure 3. *Nepenthes gracilis* green variant and black variant: (A) plant habitat and habitus, (B) plant pitchers, (C) detailed pitcher shapes.

The habitat and growth habit of *Nepenthes gracilis* (Figure 3) are associated with humid tropical forest environments dominated by ferns and shrub vegetation. This species characteristically exhibits a climbing growth habit. The pitcher coloration varies from red, green, to reddish-brown. The pitcher shape is cylindrical in the upper part and ovate in the lower part. The peristome is green in color, while the pitcher lid generally matches the coloration of the pitcher and is occasionally marked with reddish spots on the outer surface. The inner surface of the pitcher is whitish with purple or brown speckling. The pitchers can reach up to 15 cm in height.

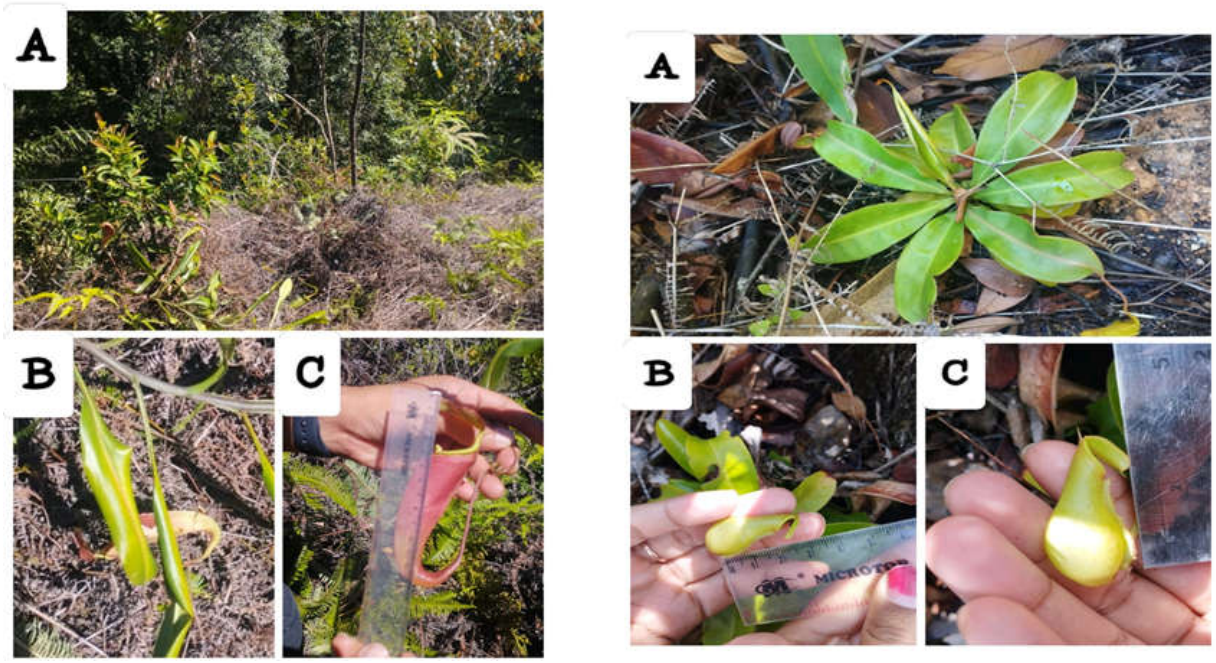

Figure 4. *Nepenthes longifolia,* upper pitcher and lower pitcher: (A) plant habitat and habitus, (B) plant pitchers, (C) detailed pitcher shapes.

The habitat and growth habit of *Nepenthes longifolia* (Figure 4) are associated with humid tropical forest environments dominated by ferns and shrubs. This species grows at elevations ranging from 300–1100 meters above sea level. A distinctive characteristic of this species is the shape of the upper pitcher, which is funnel-shaped at the lower part, rounded in the middle, and cylindrical toward the upper portion. The tendrils may reach approximately 100 cm in length, whereas the pitchers are only about one-tenth of the tendril length. The tendrils of the rosette pitchers are considerably shorter than those of the upper pitchers. In the upper pitchers, the tendril attachment is positioned at the rear side of the pitcher.

The all-species distribution pattern shows a relatively balanced composition, with three species recorded in the Rokan IV Koto and three others found in the Sungai Bungo area. This finding indicates that both locations still provide habitat conditions that support the persistence of the genus *Nepenthes*. The majority of the observed species belong to the highland group, which is ecologically associated with hilly to mountainous habitats. These environments are generally characterized by high humidity, fluctuating light intensity, and nutrient-poor soils. Such edaphic conditions are known to play a crucial role in limiting vegetation competition, thereby supporting the adaptive strategy of *Nepenthes* as carnivorous plants. The presence of *Nepenthes* spp. at the study sites suggests that certain microhabitats in Rokan Hulu Regency continue to maintain environmental conditions suitable for the growth and survival of these species.

Nepenthes in Rokan Hulu Regency are generally found in lowland to hilly areas at an altitude of about 50–1,000 meters above sea level, this observation is supported by Clarke (2001), who reported that the species predominantly occurs in secondary forest habitats, shrublands, and open areas with high humidity and relatively acidic soil. All *Nepenthes* species recorded in Rokan Hulu Regency are included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This classification indicates that these species are not currently considered threatened with extinction; however, they may become at risk if international trade is not properly regulated and strictly monitored (Table 1) (CITES 2026).

Furthermore, according to the assessment of the International Union for Conservation of Nature (IUCN), these species are generally categorized as Least Concern (LC), indicating that they currently face a relatively low risk of extinction. Nevertheless,

conservation efforts, habitat management, and continuous population monitoring remain essential to ensure the long-term survival of these species in their natural habitats and to prevent potential population declines in the future (Table 1) (IUCN, 2026).

The populations observed during the survey appeared to be relatively stable. This finding is noteworthy, considering that the forest landscape in Rokan Hulu Regency has experienced significant ecological pressure due to the conversion of forests into oil palm plantations (Fauzi et al., 2006). Despite these land-cover changes, pitcher plants (*Nepenthes*) still exhibited relatively high levels of occurrence at several study sites. This phenomenon suggests a degree of ecological tolerance to habitat disturbance or an ability to exploit the remaining microhabitat niches (Clarke, 2001). Several studies have demonstrated that certain *Nepenthes* species are capable of persisting in disturbed habitats, including secondary forests, forest edges, and open areas modified by human activities (McPherson, 2009). Furthermore, the morphological and physiological adaptations of these plants enable them to persist in nutrient-poor soils and in environments undergoing changes in vegetation structure (Moran et al., 2003).

However, the currently observed population stability does not necessarily guarantee long-term sustainability, particularly if the rate of landscape transformation continues to accelerate. The relatively even distribution of species between Rokan IV Koto and Sungai Bungo reflects variations in local ecological conditions that continue to support *Nepenthes* diversity. This pattern is likely associated with habitat heterogeneity, including differences in humidity, vegetation structure, light availability, and soil characteristics. Such environmental variation has the potential to create suitable microhabitats for species with differing ecological preferences.

Conclusions. This study documented three *Nepenthes* species in Rokan Hulu Regency, with a relatively balanced distribution between the Rokan IV Koto and Sungai Bungo regions. The majority of the recorded species belong to the upland group, reflecting a strong association with the humid, nutrient-poor conditions characteristic of hilly habitats. Although the forest landscape within the study area has experienced pressure from the expansion of oil palm plantations, the observed *Nepenthes* populations appear to remain relatively stable, suggesting that certain microhabitats continue to provide suitable conditions for species survival. However, ongoing habitat alteration has the potential to threaten long-term population stability. Conservation efforts emphasizing the protection of remaining habitats, along with sustainable landscape management, are essential for maintaining the persistence of *Nepenthes* diversity in Rokan Hulu Regency.

All three recorded species are currently categorized as Least Concern (LC) under the International Union for Conservation of Nature (IUCN) Red List, indicating that they are not considered to be at immediate risk of extinction. Nevertheless, all *Nepenthes* species are listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which regulates international trade to prevent exploitation that could threaten their survival. This highlights that, despite their LC status, continuous monitoring and conservation measures remain important to ensure the long-term sustainability of these species in their natural habitats. Therefore, even though these species are currently not classified as threatened, their natural populations must still be actively conserved and managed to prevent future decline due to ongoing environmental pressures.

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