Diversity of Lowland *Nepenthes* (Pitcher Plants) in Bangka Belitung Islands

S Rizqiani\(^1\)*, N S Ariyanti\(^1\) and Sulistijorini\(^1\)

\(^1\)Biology Department, Faculty of Mathematics and Natural Science, Bogor Agricultural University, Dramaga Campus, Bogor, West Java, 16680, Indonesia

*E-mail: sakinarizqianisofyan@gmail.com*

**Abstract.** *Nepenthes* is a carnivorous plant that mostly grows in nutrient-poor soils. Such soil conditions are commonly found at lowland habitats in Bangka-Belitung Islands. The existence of *Nepenthes* in this island is threatened caused by habitat destruction and over exploitation. This study aims to inventory the diversity of lowland *Nepenthes* in Bangka Belitung Islands. The inventory was conducted by exploring various lowland habitats 0-1000 meter above sea level in the islands. Seven species of *Nepenthes* were found at the study area, consisted of *N. gracilis*, *N. mirabilis*, *N. ampullaria*, *N. rafflesiana*, *N. reinwardtiana* and two natural hybrid species of *N. hookeriana* (*N. rafflesiana* x *N. ampullaria*) and *N. neglecta* (*N. gracilis* x *N. mirabilis*). Those pitcher plants occur in heath forest, secondary forest, swamps, lowland forest and post-mining land. The most common and widespread species of the pitcher plants in Bangka Belitung is *N. gracilis*.

**Keywords:** carnivorous plant, Nepenthaceae, threatened species

1. Introduction

*Nepenthes* is a genus of carnivorous plants in monotypic family *Nepenthaceae*. This genus has pitchers (cups) that hung from the leaves. The pitcher develops from the leaf apex that is modified for trapping prey [1]. *Nepenthes* that is also known as tropical pitcher plant or monkey cups (Indonesian: periuk kera, kantong semar) is distributed in Southeast Asia, the Seychelles, Madagascar, and Australia. The diversity of *Nepenthes* comprises about 80 species throughout its distribution regions in 1996 [2]. It increased to about 139 species in 2013 [3]. The centre diversity of *Nepenthes* is Southeast Asia, included Indonesia with 68 species. Record on the diversity of *Nepenthes* in Indonesia had been adequately reported from the large islands such as Sumatra (34 species), Kalimantan (22 species), Java (3 species), Celebes (11 species), Moluccas (3 species) and Papua (11 species) [3]. However, its diversity in small islands such as Bangka Belitung has not been sufficiently reported.

Altitudinal distribution of *Nepenthes* ranges from sea level to highland or mountain. Most species of *Nepenthes* are considered as highland plant since they are most conspicuous and commonly grow in montane rain forest (about 1000 – 3000 m). Other species that commonly grow at elevation below 1000 m are categorized as a lowland group. The lowland *Nepenthes* frequently grow in various opened habitat such as secondary bushes associated with *Gleichenia* ferns, road side embankments, edges of a forest, swampy area, heath forest, peat (swamp) forest and gaps in lowland dipterocarp forest [4]. Such habitats are common in the islands of Bangka and Belitung. Unfortunately, a large natural lowland habitat in Bangka Belitung were loss caused by anthropogenic activity such as deforestation, land use
transformation, and tin mining. The deterioration of habitat is one of the causes of many *Nepenthes* species are threatened with extinction. Some species are already scarce and grow only in a few localities due to over exploitation. The uniqueness and variation of the pitchers attract people to collect *Nepenthes* for ornamental plants. Others are collected for its utilitarian such as for preparing traditional food and medicine.

This study aimed to record the diversity and habitat types of lowland *Nepenthes* in the islands of Bangka Belitung. This data is required for the further utilization and designing conservation strategy of *Nepenthes* in the islands.

2. Study sites and methods

Inventory of pitcher plants in Bangka Belitung Islands was conducted in July-August 2016. The plants were collected by exploring various types of lowland habitats in 20 localities (figure 1). The ecology of the respective localities was assessed based on field data, such as air temperature, humidity, light intensity, soil (pH) and soil temperature. The collected plants were prepared to dried specimen in laboratory. The specimen are deposited in the Herbarium Bogoriense (BO) and the duplicate specimen are reserved in the Herbarium of Department Biology, Faculty Mathematics and Natural Science, Bogor Agricultural University.

![Figure 1](image-url)  
*Figure 1.* Map of Bangka Belitung Islands showing the locations and various habitat included in the study (Yellow Spot: Location of the Survey). Note: West Bangka District (1. Mentok, 2. Jebus, 3. Pelangas, 4. Simpang Teritip, 5. Petaling), Bangka Induk District (6. Belinyu, 7. Sungai Liat), Pangkal Pinang City (8. Pangkal Pinang, Giri Maya), Center of Bangka District (9. Namang, 10. Sungai Selan, 11. Koba), Kabupaten Bangka Selatan (12. Air Gegas 13.,14. Toboali), Belitung District (16. Sijuk, 17. Membalong), East Belitung (18. Simpang Pesak, 19. Kelapa Kampit, 20. Manggar).

3. Results

3.1 Total diversity.

The diversity of *Nepenthes* recorded in this study comprises of seven species, *N. gracilis*, *N. mirabilis*, *N. ampullaria*, *N. rafflesiana*, *N. reinwardtiana*, *N. hookeriana* and *N. neglecta*. Two latest species are the natural hybrid of *N. rafflesiana* x *N. ampullaria* and *N. gracilis* x *N. mirabilis*, respectively. The diversity of *Nepenthes* in Bangka and Belitung islands is about one-seventh of that in Sumatra and a quarter of that in Borneo. Bangka Belitung has more species of *Nepenthes* than Java (table 1).
## Table 1. Species number of the *Nepenthes* in Bangka Belitung Islands compared to other islands nearby

| Island          | Number species | Information                                           |
|-----------------|----------------|-------------------------------------------------------|
| Bangka          | 5 species      | Based on Rizqiani’s exploration 2016                  |
| Belitung        | 4 species      | Based on Rizqiani’s exploration 2016                  |
| Sumatra         | 34 species (29 endemic) | Based on “*A field guide to the Nepenthes of Sumatera*” publication 2006 |
| Borneo          | 22 species (15 endemic) | Based on “*Nepenthes of Borneo*” publication 1997     |
| Malay Peninsula | 11 species     | Based on “*Nepenthes of Sumatera and Peninsular Malaysia*” publication 2001 |
| Java            | 3 species      | Based on “*Nepenthes of Borneo*” publication 1997     |

### 3.2 Nepenthes morphology characteristic and its distribution in Bangka Belitung Islands.

*N. gracilis* (figure 2A and 2B) has a cylindrical pitcher with waist and narrowed peristome. The pitchers are slightly enlarged in the lower one-third. The color of the pitcher are various, red, green and yellowish or patterned with those three colors. This species is the most common pitcher plants found in these study. It occurred in 18 location with the altitude 7-38 m asl. This species thrives opened habitat (swamps and post-mining areas) as well as more vegetated habitat (secondary and heath forest). The plants that grow in opened habitat with full light intensity have red and larger pitcher while those grow in shaded habitat have green and more waist pitchers.

*N. mirabilis* (figure 2C and 2D) has also a cylindrical pitcher with peristome that thicker than *N. gracilis*. The color of the pitcher are red and green. This species also found in opened habitat in Bangka Belitung Islands such as swamps, heath forest and also secondary forest. It occurred with the altitude 14-38 m asl. This species can also survive in places that are flooded.

*N. ampullaria* (figure 2E and 2F) has spatulate until lanceolate leaves which coriaceous-haired, short petiole (climber stem) and rosette as its another form. It also has a like-jar pitcher with oblanceolate pitchers lid. There are three color variations of the pitcher which green, patterned green-brown and patterned brown with red peristome. This species found in three habitat type such as heath forest, secondary forest and lowland rainforest in the lower altitude. *N. ampullaria* generally grown *N. gracilis* (figure 2A and 2B) has a cylindrical pitcher with waist and narrowed peristome. The pitchers are slightly enlarged in the lower one-third. The color of the pitcher are various, red, green and yellowish or patterned with those three colors. This species is the most common pitcher plants found in these study. It occurred in 18 location with the altitude 7-38 m asl. This species thrives opened habitat (swamps and post-mining areas) as well as more vegetated habitat (secondary and heath forest). The plants that grow in opened habitat with full light intensity have red and larger pitcher while those grow in shaded habitat have green and more waist pitchers.

*N. rafflesiana* (figure 2G and 2H) has a really different pitcher shape between upper and lower. Upper pitcher mostly like a trumpet but the lower pitcher has a crock-shape. It has lanceolate leaves and coriaceous. There are 3 variations of pitcher colors, red, green and brown patterned. Compare among the lowland *Nepenthes* that found in Bangka Belitung Islands, *N. rafflesiana* has the largest pitcher. *N. rafflesiana* found in secondary forest, heath forest, and post-mining area. It occurred in 6 locations with the altitude 27-89 m asl in Bangka Belitung Islands.

*N. reinwardtiana* (figure 2I dan 2J) has lanceolate leaves and a cylindrical pitcher with two eye spots in the surface of the inner pitcher's wall. There is 2 colors variation of a pitcher; green and red with yellow peristome. This species found in 3 locations with the 89-1000 m asl altitude. *N. rafflesiana* are generally found in lowland rainforest in this island such as the top of Mt. Maras, top of ex-mining area namely Tourist Area Open Pit in Sub-district Kelapa Kampit and top of Mt. Tajam in Belitung Island.
$N. \text{ hookeriana} \ (N. \text{ rafflesiana} \times N. \text{ ampullaria})$ (figure 2K) has combined the character of both mains; there are an oval pitcher like $N. \text{ rafflesiana}$ and thick peristome that mostly a typical character of $N. \text{ ampullaria}$. It only found in 1 location from 37 research sites on 32 m asl. The habitat type is a secondary forest that associated with $\text{Myrtaceae}$ in Desa Bentaian, Kecamatan Manggar, Belitung Timur.

![Figure 2](image)

Figure 2. $Nepenthes$ morphology found in Bangka Belitung. Note: (A-B) $N. \text{ gracilis}$; (C-D) $N. \text{ mirabilis}$; (E-F) $N. \text{ ampullaria}$; (G-H) $N. \text{ rafflesiana}$; (I-J) $N. \text{ reinwardttiana}$; L. $N. \text{ hookeriana}$.

$N. \text{ neglecta} \ (N. \text{ mirabilis} \times N. \text{ gracilis})$ (figure 2L) also has combined the character of both mains; there are cylinder pitcher-shape like $N. \text{ gracilis}$ with jagged leaves and thick peristome that mostly a typical character of $N. \text{ mirabilis}$. It only found in 1 location from 37 research sites. The habitat is in secondary forest and climbed on a tree. $N. \text{ neglecta}$ found in Pelawan Forest, Namang, Central Bangka and it's 38 m asl. There is no parent from both around the study site.

3.3 Habitat Type.
$Nepenthes$ is found in various lowland habitat in the islands of Bangka Belitung includes swamps, heath forest, secondary forest, lowland rainforest and post-mining area. The most common habitat of $Nepenthes$ in the Bangka Belitung Islands is secondary forest habitats. Six species of $Nepenthes$ occur
in the sixteen locations observed in the Bangka Belitung Islands, mostly found in the secondary forest (table 2).

**Table 2.** The frequency of *Nepenthes* occurred on various habitat types in Bangka Belitung Islands.

| Species      | Habitat Types | Frequency (%) |
|--------------|---------------|---------------|
| *N. gracilis* | SWP<sup>a</sup> | 51.3          |
| *N. mirabilis* | HEF<sup>b</sup> | 40.5          |
| *N. amplugaria* | SEF<sup>c</sup> | 13.5          |
| *N. rafflesiana* | LPF<sup>d</sup> | 8.1           |
| *N. reinwardtiana* | PMA<sup>e</sup> | 8.1           |
| *N. hookeriana* | Explorated Habitats | 2.7          |
| *N. neglecta* | Total : 37 location | 2.7          |

<sup>a</sup>SWP=swamps  
<sup>b</sup>HEF=heath forest  
<sup>c</sup>SEF=secondary forest  
<sup>d</sup>LPF=lowland rain forest  
<sup>e</sup>PMA=post mining area

The swamp (figure 3) habitat in Bangka Belitung Islands is an opened area dominated by sedge species of *Cyperaceae, Gleichenia* sp and the shrub species of *Melastoma malabathricum* (local name Bangka Belitung: kedebek). The swamp located in the village of Air Kabel, Sub-district Merawang, District Bangka Induk. It has character of soil pH around swamps 5.6, soil moisture 69%, air temperature 30.6°C. Species diversity of *Nepenthes* in the swamps is poor and lower than another habitat types. We can only found *Nepenthes gracilis* and *N. mirabilis* in this place.

Heath forest (figure 3) is a type of forest characterized by the forest floor covered with white quartz sand and derived from ultrabasic rock [5]. In addition to Kalimantan forests, the forest can be found in large numbers in the islands of Bangka and Belitung. Generally, the growing tree has a low canopy height and a small stem and leaf size with tight bangs and twigs on each tree [6]. Types of trees commonly found in the forests of Bangka Belitung Islands include *Tristaniopsis obovata, Rhodomyrtus tomentosa, Papilionante, Baecke frutescens, Melaleuca leucandendra, Alterfolium pleurarium* (Riang) and *Gleichenia* sp. Measurement results in the village of Cit, Sub-district Riau Silip, Bangka Induk District noted that the average value of pH 5, soil moisture 15%, minimum temperature 28°C and maximum 32°C.

Secondary forest (figure 3) is a habitat that characterized by types of trees commonly found in secondary forests in the Bangka Belitung Islands include *Tristaniopsis obovata, Schléri barbata, Nepholaelpis bisserata, Cyclosorus sp, Ficus apocarpa, Cymplocos adenophylla, Caloplyllum sp, Syzygium sp*. Measurement results in the village of Bahria, Sub-district Manggar, East Belitung District noted that the average value of pH 6.8, soil moisture 90%, average air temperature 31°C.

Primary lowland rainforest habitat type in the Bangka Belitung Islands (figure 3) is characterized by the discovery of plant species such as *Leptospermum polygalifolium, Tristaniopsis merguensis*, and *Myrsine sandwicensis*. The forest floor is slightly sandy and rocky, there is a type of Lycobriaceae moss around the rocky place and close to the water source. The results of environmental parameters measurement at the peak of Mount Maras, Sub-district Riau Silip, Bangka Induk District noted that the average value of soil pH 6.6, soil moisture 89% and air temperature 27°C. The habitat type of *Nepenthes* in the peak of Mount Maras is a low primary forest with open habitats.

Post-mining area (figure 3) is characterized by a sand texture dominated by sand, a small portion of dust and clay [7]. Types of plants commonly found in post-mining areas left by mining activities in Bangka Belitung Islands include *Commersonia* sp. (Local Name: Mentenuk), *Trema orientalis* (Local
Name: Mengkirai), *Melastoma malabathricum* (Local Name: Kedebik) and *Vitex* sp. (Leban). The result of measurement of environmental parameters at Water Jangkang village, Merawang, Bangka Induk District noted that the average value of pH 5.8, soil moisture 60.3% and air temperature 34.6° C. There are two types post-mining area that found in Bangka Belitung Islands. First is post-mining area that located in Air Kabel village, Merawang, Bangka Induk District, its an opened area and it’s a new area of ex-mining. Second is a post-mining area (open pit) located in the village of Senyubuk, Sub-district Kelapa Kampit, East Belitung District is a post-mining area that has been abandoned for a long time since 1990 so that the vegetation has gradually followed the vegetation as in secondary forest in general, characterized by the discovery of *Artocarpus* sp. As well as other tree species found in primary forest.

![Image of habitat types]

*Figure 3. Nepenthes* Habitat Types in Bangka Belitung Islands. A. Swamps near post mining area in Air Kabel village; B. Heath forest near road side; C. Heath forest near garden; D. “Padang” with podsolik soil; E. Mt Maras heath forest; F. Open pit area; G. Post-mining area; H. Lowland primary forest floor in the top of Mt. Maras; I. Batubentas waterfall, lowland rainforest, HLGT (Hutan Lindung Gunung Tajam) or protected forest Mount Tajam in Belitung.

Based on the research sites, there was recorded a kind of pure new record for the Bangka Belitung Islands, namely *N. mirabilis* and two natural hybrids of *N. hookeriana*, *N. neglecta*. The previous *Nepenthes* study reported four types of *Nepenthes* in Bangka Belitung Islands, namely *N. gracilis*, *N. ampullaria*, *N. rafflesiana* and *N. reinwardtiana* [8,9]. The results of this exploration can certainly add new information from the diversity of *Nepenthes* in the Islands of Bangka Belitung.

4. Discussion
The total diversity of *Nepenthes* varies on each of the larger and closest islands of the Bangka Belitung Islands. The diversity of *Nepenthes* species of Bangka Belitung is higher than Java Island but not more than Sumatra Island, Borneo Island and other island (table 1). The diversity of *Nepenthes* in the world
is influenced by several factors, altitudes and variations of habitat types. The altitude affect the number of varieties of Nepenthes species, 29 species of Nepenthes present in Sumatra, 17 grow in the highlands (1,000 m asl), 5 species grow in lowland (500 m asl) and 7 species grow at altitude medium between 500-1000 m above sea level [10]. Bangka Belitung is an islands that categorized to the lowlands, where the highest mountain in this islands ranges only 1000 m asl e.g Mount Tajam, Belitung.

The diversity of habitat variations suitable for Nepenthes growth is another important factor. Nepenthes in these islands vary in secondary forest habitats, but are abundant for certain species in heath forest (figure 3). It has been reported that Nepenthes gracilis is found in many types of forest with open canopy and lowland [11,12]. But not only in the forest, Nepenthes is also reported to grow terrestrially and epiphytically in mossy forest and mountain peaks at an altitude of 1100-2900 m asl [10]. However, from both factors it can be concluded that the type of Nepenthes prefers the place to grow in open condition or rather open [13]. This may be because the secondary forest in the Bangka Belitung Islands is made up of trees but with the closure of the tree canopy that is not tight; so it still allows light to enter to the forest floor, has a water source, and has many plants that can be associated with Nepenthes, such as moss (Leucobriaceae), Myrtaceae and other secondary forest trees dwellers in the Bangka Belitung Islands.

N. gracilis is the most common species found in the Bangka Belitung islands with the greatest frequency of 51.3% (table 2). N. gracilis is always dominant compared to N. ampullaria. This is similar to the research conducted in the Padang Tujuh Endau Rompin State Park, Pahang-Malaysia, also found the most dominant population of N. gracilis compared to other species [14]. This is caused by N. gracilis has a higher adaptability compared with other Nepenthes so that this type is found in various places. N. gracilis is able to live in different types of habitats and soil types, with high adaptability [13,15]. While N. ampullaria is commonly found in closed areas or area with thick canopy of plants [16], N. gracilis and N. mirabilis are said to be the most common species in lowland areas 0-1000 meter above sea level [17]. Fifth pure Nepenthes species found to be classified as lowland Nepenthes, species such as N. gracilis, N. ampullaria, N. mirabilis, N. rafflesiana and N. reinwardtiana commonly found in lowland.

Nepenthes from Bangka Belitung Islands based on observations has 2 different pockets in the same type e.g N. rafflesiana (figure 2). Generally Nepenthes form two shape of pitcher, the lower pitcher and upper pitcher. The bottom pitcher refers to the pitcher structure formed on a young stem that grows near the surface of the soil, which sometimes clumps in the form of a rosette. While the upper pitcher refers to the structure of the pouch formed on the grown-up plant stems, and the shape of the sleeve is more slim like a funnel [15,18]. Generally the upper and lower pitcher are somewhat different, but differences in the structure of the upper and lower pockets are not always clear [19].

In addition to 5 pure species, 2 natural hybrid Nepenthes are also found in this exploration i.e. N. hookeriana and N. neglecta. The species is found not far from their original parental. It is said that Nepenthes is a plant of liana (climber), two homes, male and female flowers are separated in different individuals, so natural hybrids and crossings between Nepenthes species in a population are highly likely [20].

5. Conclusion
The Bangka Belitung Islands has five species of Nepenthes namely N. gracilis, N. mirabilis, N. ampullaria, N. rafflesiana and N. reinwardtiana and two natural hybrids that are N. hookeriana and N. neglecta. Nepenthes of Bangka Belitung Islands reported in this study are found in various lowland habitat (7-690 m asl), swamps, healthy forest, secondary forest, lowland rainforest and post mining land. The opened secondary forest has higher diversity of Nepenthes than other habitats in location studied. The growing preference of Nepenthes species in Bangka Belitung Islands is a habitat that is slightly over sheltered and close to water sources. From 36 research sites, it is known that the spread of N. gracilis and N. mirabilis species is wider than N. rafflesiana, N.ampullaria and N. reinwardtiana. While N. hookeriana and N. neglecta have limited distribution.
Acknowledgements
This research is funded by Non-Degree Superior Scholarship P3SWOT Batch1 2016 DIKTI. Thanks to the Provincial Government. Bangka Belitung islands that give research permission. Thank you to the Forest Service of East Belitung Regency which has helped all the facilities during the research in Belitung. Also to Mr. Mansur from LIPI Puslit Biologi, Cibinong who has supported and provided guidance during this research conducted.

References
[1] Mansur M 2001 Potential of Nepenthes as an ornamental plant and its collection in Herbarium Bogoriense Proc. Seminar Sehari dalam Rangka Hari Cinta Puspa dan Satwa Nasional p244-254
[2] Phillips A and Lamb A 1996 Pitcher Plants of Borneo Kota Kinabalu, Sabah (Kinabalu: Natural History Publications (Borneo))
[3] Mansur M 2013 Berita Biologi 12 (1) 1-7
[4] Adam J H and Wilcock C C 1992 Reinwardtia 11(1) 35-40
[5] Mansur M 2007 Nepenthes as an unique plant (Jakarta: Penebar Swadaya)
[6] Whitten A J, Anwar J, Damanik S J and Hisyam N 1984 Ecology ecosystem of Sumatra (Yogyakarta: UGM Press)
[7] Lestari T, Abdi Z, Widodo J and Yohanes 2008 Enviargo 2(2) 1-28
[8] Hidayat S, Hidayat J, Hamzah, Suhandi E and Ajidin T 2003 Biodiversitas 4(2) 93-96
[9] Munawaroh S 2012 Diversity, Distribution Pattern and Association of Nepenthes in Heath Forest, East Belitung, Provisni Kepulauan Bangka Belitung [undergraduated thesis] (Bogor: Bogor Agricultural University)
[10] Clarke C. 2001. Nepenthes of Sumatra and Peninsular Malaysia. (Kota Kinabalu, Sabah: Natural History Publication (Borneo))
[11] Riswan S 1985 Kerangas Forest at Gunung Pasir, Semboja East Kalimantan. Its Structural and Floristic Composition. Article forthe Third Round Table Conference on Dipterocarps at the Mulawarman University, Samarinda East Kalimantan
[12] Kissinger 2002 Keanekearamagan Jenis tumbuhan, Struktur Tegakan, dan Pola Sebaran Beberapa Spesies Pohon Tertentu di Hutan Kerangas [graduated thesis] (Bogor: Bogor Agricultural University)
[13] Azwar, F. A. Kunarso and Rahman S T 2006 Kantong Semar (Nepenthes sp.) di Hutan Sumatera, Tanaman yang Unik Semakin Langka. Article for research exose. Padang. www.dephut.go.id.
[14] Adam J H, Maisarah J N, Norhafizah A T S, Harun M Y and Azman H 2009 Kepadatan dan Taburan Tiga Fasa Hidup Nepenthes di Padang Tujuh Taman Negeri Endau Rompin, Pahang. In Adam, J.H, M.B. Gasim and Z. Sarkawi (eds.). Proc. Bio. Kefuruteraan dan Kelestarian ekosistem. Universiti Kebangsaan Malaysia. Malaysia
[15] Puspitaningtyas D, Murti and H Wawainingrum 2007 Biodiversitas 8(2) 152-156
[16] Mansur M 2008 Jurnal Teknik Lingkungan 9(1) 67- 73
[17] Adam J H, Daiman D H, Gopir G K, Besar AK J P, Omar R and Hamid H A 2004 Pertanika Journal Tropical Agricultural Science 27(1) 39-46
[18] Clarke CM 1997 Nepenthes of Borneo. (Kota Kinabalu, Sabah: Malaysia Natural History Publication)
[19] Jebb M and Cheek M 1997 Blumea 42(1) 1- 106
[20] Mansur M 2000 Koleksi Nepenthes di Herbarium Bogoriense: Prospeknya sebagai Tanaman Hias. Proc. Seminar Hari Cinta Puspa dan Satwa Liar