



Identification and Cluster Analysis of Pitcher Plant (*Nepenthes* spp.) from South Sumatera Indonesia

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Abstract

Nepenthes spp. is a typical plant of Southeast Asia especially Indonesia which has a special leaf modification called a pitcher. The largest number of *Nepenthes* spp. species in Indonesia is on the island of Sumatra. The purpose of this research was to identify and analyze cluster *Nepenthes* spp. from South Sumatra based on morphological characteristics. The specimens were collected from the forest of Tekorejo Village, Air Itam Village and cultivation location in Palembang city of South Sumatra. Identification of morphological characters performed on the characteristics of root, stem, leaves, and pitcher. The morphological data is used for cluster analysis using NTSYS software version 2.02. The identification results showed 9 variants of *Nepenthes* spp. which belong to the species *N. mirabilis*, *N. gracilis*, and *N. sumatrana*. Dendrogram analysis results form two main clusters with a similarity value of 22%. The first cluster consists of *N. mirabilis* and *N. sumatrana*. The second cluster consists of *N. gracilis*. Based on the results of this study can be concluded that the species *Nepenthes* spp. South Sumatra is *N. mirabilis*, *N. gracilis*, and *N. sumatrana*. The results of this study will be dedicated to updating information about the existence of *Nepenthes* spp. from South Sumatra and his cluster.

How to Cite

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INTRODUCTION

Indonesia is a country that has richness and distinctiveness of biodiversity. The biodiversity consists of food crops, ornamental plants, vegetables, medicinal plants, and others. The variety of character possessed by a plant shows variations that can be explored and studied more deeply (IBSAP, 2015). Some of these plant species are stored in forest areas in South Sumatra province.

South Sumatra has lowland tropical rain forest area (Hernawati, 2004). Tropical rain forests support very high biodiversity. The types of vegetation found in these forests are more diverse than other forest types (Scheon, 2004). One of the plant found in this forest is pitcher plant (*Nepenthes* spp.) (Hernawati, 2004).

Nepenthes spp. is a typical plant in Southeast Asia, especially Indonesia. This plant is distributed in Madagascar, Southeast Asia, South China, Queensland, New Caledonia, New Guinea, and Seychelles (Clarke, 2001). A number of species of *Nepenthes* spp. the world is 139 species and 68 species of which grow on various islands of Indonesia, such as the island of Sumatra (34 species), Kalimantan (22 species), Java (3 species), Sulawesi (11 species), Maluku (3 species) and Papua (11 species) (Mansur, 2013).

Nepenthes spp. known as carnivorous plants (Anniwat *et al.*, 2009) originating from the Nepenthaceae family (Bunawan *et al.*, 2017). This plant has a special leaf modification called a pitcher with varying shapes, sizes, and shades of color (Buch, *et al.*, 2015). This pitcher serves as an insect trap and contains aspartic protease enzymes (Rottloff *et al.*, 2011). Aspartic protease enzymes play a role in digesting insects (Buch, *et al.*, 2015). *Nepenthes* spp. using its prey as an additional source of nutrients to supplement nitrogen uptake (Rembold *et al.*, 2013). Based on these abilities, *Nepenthes* spp. able to grow in nutrient-poor habitat as producer and balancing ecosystem (Benz, 2012). *Nepenthes* spp. has many variations of phenotype or morphological characters. This phenotype variation can occur because of *Nepenthes* spp. is a plant that can hybridize naturally (Mansur & Yulita, 2012).

Mansur (2013) states that the island of Sumatra is part of the spread of *Nepenthes* spp. most in Indonesia with 34 types. According to Hernawati (2004) species found in South Sumatra are *N. gracilis* and *N. mirabilis*. Both studies identified the presence of *Nepenthes* spp. on the island of Sumatra, but has not conveyed yet the specific location of the discovery of each species

from South Sumatra. A review of the existence of the species *Nepenthes* spp. in South Sumatra until now has not been done, so the information on the existence of species *Nepenthes* spp. certainly in the area is not known yet.

A review needs to be done because of the presence of *Nepenthes* spp. in South Sumatra is increasingly endangered every year. Extinction can occur due to lack of attention from the community, the existence of forest fires, the conversion of natural habitats into rubber and oil palm plantations (Hernawati, 2004). Due to the extinction of conservation status of *Nepenthes* spp. according to IUCN 2013 data, type *N. tentaculata* Hook.f included in the eroded status. In addition, two other species included in CITES Appendix I are *N. rajah* and *N. khasiana*, and other *Nepenthes* species included in CITES Appendix II. Population extinction or genetic erosion cause this plant to become scarce and its potential can not be utilized for the benefit and welfare of human beings.

Along with the threat of extinction of *Nepenthes* spp. in South Sumatra, the diversity and grouping of *Nepenthes* spp. which can survive to be known before the ongoing species extinction. This diversity and grouping can be determined by morphological characteristics.

Morphological identification is done by a phenetic approach through observation of outer plant structure characteristics. This approach is also used to identify *Nepenthes* spp. clustering. This approach emphasizes the similarity or different character of each taxon, where the same character will group the taxa into one and separate and separate the different characters (Ubaidillah & Sutrisno, 2009).

Based on the above description, related to the status of *Nepenthes* spp. endangered species, the ability to hybridize naturally, specific location/area of discovery and *Nepenthes* spp. kinship relationships. in South Sumatera that is not known yet, it is necessary to do research on identification and analysis cluster *Nepenthes* spp. from South Sumatra. Thus, this study is useful to provide information on the species of *Nepenthes* spp. and its grouping in South Sumatra follows the morphological character.

METHODS

This study used 27 accessions of *Nepenthes* spp. which consists of 9 variants with 3 repetitions. Sampling was done in Tekorejo Village forest, Air Itam Village and *Nepenthes* spp. cultivation location in Palembang city of South Sumatra. Observations were made on the mor-

phological character of all accessions of *Nepenthes* spp. Observations include habitus, root, stem, leaf, and pitcher. A total of thirty-one morphological characters were selected. The thirty-one morphological characters observed include 1 character stature, 1 root character, 7 stem characters, 12 leaf characters and 10 pitcher characters. Morphological analysis was done by a descriptive method based on identification characters of *Nepenthes* spp. (Cheek & Jeep, 2001).

In this study, 19 characters were selected (Table 1) for the phenetic study using cluster analysis. The selected characters have variations that can distinguish each sample being observed (Riandini, 2015). The characters were coded as multivariate data and analyzed using the SM coefficient (Simple Matching). Grouping and programming were done by UPGMA (Unweighted Pair Group Method with Arithmetic Mean) method in Numerical Taxonomy System for personal computer (NTSYSpc) version 2.02 (Rohlf, 1998).

RESULT AND DISCUSSION

A total of 9 variants *Nepenthes* spp. found in Tekorejo Village (TR), Air Itam Village (AI), and cultivation location in Palembang city (BP) of South Sumatera. Identification and cluster analysis is based on morphological characteristics. Traditionally, morphological characters have been used to characterize species and patterns of diversity (Bhau *et al.*, 2009). Morphological characterization is the easiest activity to identify species because it is simple, cheap and useful for determining interconnected species (Priadi *et al.*, 2016).

Nepenthes spp. has high variation in morphological characters. The results of identification by matching the characteristics of the sample with the reference image and the identification book "*Flora Malesiana Nepenthaceae*" indicate that the type of *Nepenthes* spp. which grew in the study sites were *N. mirabilis* (TR1, TR2, TR3, BP1), *N. gracilis* (BP2, AI1, AI2, AI3), and *N. sumatrana* (BP3). Based on the results of morphological

Table 1. Morphological Character for Cluster Analysis of the *Nepenthes* spp.

Characters	Character set (code)
The shape of the stem	Cylindrical (0), triangular (1)
Stem color	Green (0), maroon (1)
Leaf completeness	Petiolate (0), sheets only (1)
Build leaf	Lanceolate (0), <i>Elliptical</i> -lanceolate (1)
Leaf base	Truncate (0), acute (1)
Leaf color	Green (0), green with some maroon (1)
Leaf apex	Acute (0), acuminate (1)
Leaf margin	Glabrous (0), lower leaves fimbriate (1), lower leaves entire (2)
Leaf meat	Chartaceous (0), coriaceous (1)
Leaf bone color	White (0), maroon (1)
Leaf base	Sessile (0), decurrent (1)
Form the upper pitcher	Infundibular below and cylindrical above (0), ovoid below and cylindrical above (1), funnel shape (2)
The color of upper pitcher	Green (0), maroon (1), red (2), green below and maroon above (3), green with maroon spots (4), chocolate (5)
Upper pitcher peristome color	Green (0), red (1), maroon (2), red with white lines (3)
Upper pitcher peristome structure	Thick (0), thin (1)
Form the lower pitcher	Ovoid below and cylindrical above (0), oval below and cylindrical above (1)
The color of lower pitcher	Green (0), red with green spots (1), maroon (2), red (3), chocolate (4), green with chocolate spots (5)
Lower pitcher peristome color	Green (0), white with maroon lines (1), maroon (2)
Lower pitcher peristome structure	Thick (0), thin (1)

identification there are key characters (Table 2) that distinguish the three species of *Nepenthes* spp. found. According to Purwanto *et al* (2009) key characters are the characters of some parts of the plant that have differences and can help in the introduction of the species.

Table 2 demonstrates that the key characters that differentiate the species of *Nepenthes* spp. which are found in the research site are on the character of stems, leaves, and pitcher.

The key to artificial identification based on morphological characters is as follows:

- 1.a. Stem cylindrical; leaves petiole, elliptic-lanceolatus..... 2
- b. Stem triangular; leaves sheets only, lanceolatus *N. gracilis*
- 2. a. Upper pitchers infundibular below, cylindrical above *N. mirabilis*
- b. Upper pitcher funnel shape *N. sumatrana*

Description of the morphological character of three species of *Nepenthes* spp. found in the study sites are as follows:

Nepenthes gracilis **Korth.**

Habitus: herbal. **Tall:** 109.46 cm. **Root:** tunggang. **Stem:** triangular, 0.333 cm in diameter, internodes 1.93 cm, color (green, maroon), herbaceous, slippery surface, erect and climbing, and branching sympodial. **Leaves:** sheets only, long : wide sheets = 9.6 cm : 1.3 cm, lanceolate, base truncate, color green, apex acute, margin *glabrous*, coriaceous, slippery surface, single type, bone color (white, maroon), length of tendrils 8.5 cm, sitting on the stem of folia sparse, and sessile. **Upper pitcher:** ovoid below and cylindrical above, tall 7.6 cm, wide 2.8 cm, color (chocolate, green, maroon), has no wings, heart-to-round peristome shape, color peristome (green, maroon),

thin peristome structure, oval lid form, lid size 1.9 cm : 1.8, apex of rounded lid, and lid base rounded. **Lower pitcher:** ovoid below and cylindrical above, tall 4.2 cm, wide 1.4 cm, color (chocolate, green, maroon, green brown spots), has 2 wings, heart-to-round peristome shape, color peristome (green, maroon), thin peristome structure, oval lid form, Lid size 1 cm : 1.1 cm, apex of rounded lid, and lid base rounded.

Nepenthes mirabilis **(Lour.) Druce.**

Habitus: herbal. **Tall:** 199.27 cm. **Root:** tap root. **Stem:** cylindrical, 0.74 cm in diameter, internodes 5.88 cm, color (maroon, green), herbaceous, slippery surface, and climbing, and branching sympodial. **Leaves:** petiolate, long : wide sheets = 22.3 cm : 7.2 cm, *elliptical*-lanceolate, petiole 7.3 cm long, base acute, color (green, green with some maroon), apex acuminate, edge lower leaves fimbriate, chartaceous, slippery surface, single type, bone color (white, maroon), length of tendrils 17.3 cm, sitting on the stem of folia sparsa, and decurrent. **Upper pitcher:** infundibular below and cylindrical above, tall 12.4 cm, wide 4.07 cm, color (green with maroon spots, green, green below and maroon above, red), has no wings, heart-to-round peristome shape, color peristome (maroon, green, red), thick peristome structure, oval lid form, lid size 3.43 cm : 3.07 cm, apex of rounded lid, and lid base rounded. **Lower pitcher:** ovoid below and cylindrical above, tall 5.77 cm, wide 2.53 cm, color (green, red with green spots), has 2 wings, heart-to-round peristome shape, color peristome green, thick peristome structure, oval lid form, lid size 3.43 cm : 3.07 cm, apex of rounded lid, and lid base rounded. *Nepenthes mirabilis* found to have genetic diversity in the color of stem, leaves, pouches, and *peristome*.

Table 2. Distinctive Key Characteristics *N. mirabilis*, *N.gracilis*, dan *N. sumatrana*

Morphological character	<i>N. mirabilis</i>	<i>N. gracilis</i>	<i>N. sumatrana</i>
The shape of the stem	Cylindrical	Triangular	Cylindrical
Leaf completeness	Petiolate	Sheets only	Petiolate
Leaf margin	Lower leaves fimbriate	<i>Glabrous</i>	Lower leaves entire
Leaf meat	Chartaceous	Coriaceous	Coriaceous
Build leaves	<i>Elliptical</i> -lanceolate	Lanceolate	<i>Elliptical</i> -lanceolate
Leaf base	Decurrent	Sessile	Decurrent
Form the upper pitcher	Infundibular below and cylindrical above	Ovoid below and cylindrical above	Funnel shape
Form the lower pitcher	Ovoid below and cylindrical above	Ovoid below and cylindrical above	Oval below and cylindrical above
Peristome structure	Thick	Thin	Thick

Nepenthes sumatrana (Miq.) Beck.

Habitus: herbal. **Tall:** 11.5 cm. **Root:** tap root. **Stem:** cylindrical, 0.925 cm in diameter, internodes 0.3 cm, color green, herbaceous, slippery surface, and climbing, and branching sympodial. **Leaves:** petiolate, long : wide sheets = 14.3 cm : 3.7 cm, *elliptical*-lanceolate, petiole 1.3 cm long, base acute, color green, apex acute, lower leaves entire, coriaceous, slippery surface, single type, bone color white, length of tendrils 12.7 cm, sitting on the stem of folia sparse, and decurrent. **Upper pitcher:** funnel shape, tall 9.3 cm, wide 3.5 cm, the color red has no wings, heart-to-round peristome shape, color peristome red with white lines, thick peristome structure, oval lid form, Lid size 3.1 cm : 3.0 cm, the apex of the rounded lid, and lid base rounded. **Lower pitcher:** oval below and cylindrical above, tall 6.5 cm, wide 2.2 cm, color red, has 2 wings, heart-to-round peristome shape, color peristome white with maroon line, thick peristome structure, oval lid form, lid size 2.3 cm : 2.5 cm, apex of rounded lid, and lid base rounded.

Based on the description of the morphological character of *Nepenthes* spp. has a diversity of

shapes and colors of pitchers (Figure 1). Alejandro *et al* (2008) say that *Nepenthes* spp. including plants that have unique morphology because of the amazing pitchers at the leaf tips. These bags have different shapes, colors, ornaments, and sizes.

Based on the morphological character, a cluster analysis of the nine variants of *Nepenthes* was found to find out the kinship relationship. The resulting dendrogram using a simple matching coefficient and UPGMA method based on 19 morphological characters show the phenetic relationship of *Nepenthes* spp. The dendrogram generated from the analysis is as follows:

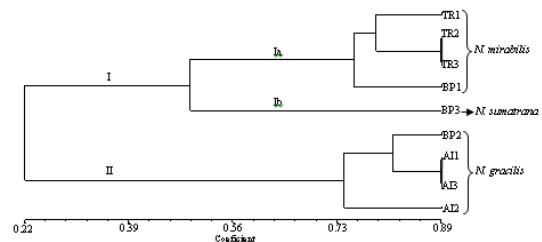


Figure 2. Dendrogram *Nepenthes* spp. from South Sumatra based on morphological characters



Figure 1. Characteristics stem (A), leaves (B), and pitcher (C) of *Nepenthes* spp. discovered at research sites. TR1; b. TR2; c. TR3; d. BP1; e. BP2; f. BP3; g. AI1; h. AI2; i. AI3

The dendrogram analysis results similarities between the variant *Nepenthes* spp. is 22-89% and consists of 2 main clusters (Figure 2). Cluster I consists of two sub clusters Ia and Ib with a similarity coefficient 49%. Cluster I has similarities in cylindrical bar characters, petiolate leaf, elliptic-lanceolatus, leaf base decurrent, and peristome structure thick. Sub-cluster Ia consists of *N. mirabilis* (TR1, TR2, TR3, BP1). The four variants of *N. mirabilis* have a variety color of the stem, leaf, leaf bone, pitcher, and peristome characters. Variants of the Ib subklaster (TR2 and TR3) have the highest similarity coefficients, ie 89%. This can happen because the difference of the two variants is found only in the color character of the pitcher. Sub-cluster Ib consists of *N. sumatrana*.

Cluster II with similarity coefficient of 74% consists of *N. gracilis* (BP2, AI1, AI2, AI3). Cluster II has triangular shapes, leaf only, smooth edges, thick flesh, lanceolate, sessile leaf base, ovoid below and cylindrical above pitcher, and thin peristome structure. The four variants of *N. gracilis* have a variety of stem, leaf, leaf bone, pitcher, and peristome characters. Variants AI1 and AI3 have the highest similarity coefficients, ie 89%. This can happen because the difference of the two variants is found only in the color character of the pitcher.

The proximity of *Nepenthes* spp. can be seen from the coefficient value similarity. According to Wijayanto et al (2013), the greater the similarity coefficient value (close to one), the closer the kinship relationship and the smaller the similarity coefficient value (close to zero) the kinship relationship further. Based on the results of the analysis it is known that based on the morphological characteristics of *N. mirabilis* has closer kinship relationship to *N. sumatrana* compared with *N. gracilis*.

Morphological characters that distinguish variations on *N. mirabilis* and *N. gracilis* are color characters. The color difference in each species is found in stems, leaves, and pouches. This genetic difference can occur because it is influenced by environmental factors. According to Pigliucci (1996) the color character of taxonomically inconsistent, because it is very influenced by environmental factors where an ordinary plant grows.

The results of this research indicate the presence of morphological variation in species *N. mirabilis* and *N. gracilis* found from South Sumatra to grouping the species based on the equation of morphological characteristics possessed. The results of this study indicate the separation between groups of species *N. mirabilis*, *N. gra-*

cilis, and *N. sumatrana*. According to Kim *et al.* (2014) this intergroup separation results in a kinship relationship between the various groups. The existence of variations of an organism and the composition of kinship relations, arising from the changes that occurred during evolution.

CONCLUSION

Based on research that has been done can be concluded that species of *Nepenthes* spp. of South Sumatra are *N. mirabilis*, *N. gracilis*, and *N. sumatrana*. Phenogram result of cluster analysis shows the formation of 2 main clusters with similarity value 22%. The first cluster consists of two sub-clusters namely *N. mirabilis* and *N. sumatrana*. In the second cluster consists of *N. gracilis*.

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