**Identification and Cluster Analysis *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 pitcher. The largest number of *Nepenthes* spp. species in Indonesia is on the island of Sumatra. Nepenthes spp. has a lot of phenotypic variations, because it can hybridize naturally. The purpose of this reseach was to identify and analyze cluster *Nepenthes* spp. from South Sumatra based on morphological characteristics. The specimens were collected from forest of Tekorejo Village, Air Itam Village and cultivation location in Palembang city of South Sumatera Indonesia. Identification of morphological characters performed on the characteristics of root, stem, leaves, and pitcher. The morphological data is converted to multivariate data. The 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.* Phenogram analysis results form two main clusters with a similarity value of 0.22. The first cluster consists of two sub-clusters consisting of *N. mirabilis* and *N. sumatrana.* The second cluster consists of *N. gracilis*.

Keywords: Cluster analysis; *Nepenthes* spp., Phenogram; South Sumatra; UPGMA

**INTRODUCTION**

Indonesia is a country that has richness and distinctiveness of biodiversity. 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. This forest consists of shrubs, trees with a height of 10-20 m and trees with a height of more than 20 m. The types of vegetation found in these forests are more diverse than other forest types. One of the vegetation found in this forest is Kantong Semar (*Nepenthes* spp.) (Hernawati, 2004).

*Nepenthes* spp. is a typical plant in Southeast Asia, especially Indonesia. *Nepenthes* spp. 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 to meet nitrogen requirements (Buch, *et al*., 2015). 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 *Nepenthes* spp. is a plant that can hybridize naturally (Mansur and 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). Population extinction or genetic erosion causes 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 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 taxa, where the same character will group the taxa into one and separate and separate the different characters (Ubaidillah and Sutrisno, 2009).

Based on the above description, related to the status of *Nepenthes* spp. endangered species, the ability to hybridize naturally, species diversity, 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.

**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. Measurement of physical environmental factors in which the growth of *Nepenthes* spp. including altitude, air temperature and soil pH (Wahab, 2012).

Observations were made on the morphological 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 descriptive method based on identification characters of *Nepenthes* spp. (Cheek and Jeep, 2001).

The result data of the character identification of the samples obtained are arranged in the OTU (Operational Taxonomic Unit) matrix. In this study, 19 characters were selected for the phenetic study using cluster analysis (Table 1). The selected characters have variations that can distinguish each sample being observed. The characters were coded as multivariate data. The calculation of the similarity between taxon, grouping, and phenogramming was done by UPGMA (Unweighted Pair Group Method with Arithmetic Mean) method in Numerical Taxonomy System for personal computer (NTSYSpc) version 2.02 (Rohlf, 2000).

**Table 1**. List of characters selected for cluster analysis of the *Nepenthes* spp.

|  |  |  |
| --- | --- | --- |
| **No** | **Characters** | **Character set (code)** |
| 1 | The shape of the stem | cylindrical (0), triangular (1) |
| 2 | Stem color | green (0), maroon (1) |
| 3 | Leaf completeness | petiolate (0), sheets only (1) |
| 4 | Build leaf | lanceolatus (0), elliptic-lanceolatus (1) |
| 5 | Leaf base | truncate (0), acute (1) |
| 6 | Leaf color  | green (0), green with some maroon (1) |
| 7 | Leaf apex | acute (0), acuminate (1) |
| 8 | Leaf margin | glabrous (0), lower leaves fimbriate (1), lower leaves entire (2) |
| 9 | Leaf meat | chartaceous (0), cariaceous (1) |
| 10. | Leaf bone color | white (0), maroon (1) |
| 11. | Leaf base | sessile (0), decurrent (1) |
| 12 | Form the upper pitcher | Infundibular below and cylindrical above (0), ovoid below and cylindrical above (1), funnel shape (2) |
| 13 | Color of upper pitcher | green (0), maroon (1), red (2), green below and maroon above (3), green with maroon spots (4), chocolate (5)  |
| 14 | Upper pitcher peristome color | green (0), red (1), maroon (2), red with white lines (3) |
| 15 | Upper pitcher peristome structure | thick (0), thin (1) |
| 16 | Form the lower pitcher | ovoid below and cylindrical above (0), oval below and cylindrical above (1) |
| 17 | Color of lower pitcher | green (0), red with green spots (1), maroon (2), red (3), chocolate (4), green with chocolate spots (5) |
| 18 | Lower pitcher peristome color | green (0), white with maroon lines (1), maroon (2) |
| 19 | Lower pitcher peristome structure | thick (0), thin (1) |

**RESULT AND DISCUSSION**

Sampling was conducted in Tekorejo Village, Air Itam Village, and cultivation location in Palembang city of South Sumatera. Both villages are areas with the conversion of forest land to plantations. Location of cultivation of *Nepenthes* spp. in the city of Palembang is the location of cultivation of *Nepenthes* spp. the largest in South Sumatra.

The result of environmental factor measurement shows that *Nepenthes* spp. growing at an altitude of 91-129 mdpl, air temperature 29-34.1oC, and pH 6.8-7.8. Site height measurement results show that *Nepenthes* spp. found in research sites growing in the lowlands. According Mansur (2013) lowland is in the range of altitude 0-500 mdpl. *Nepenthes* spp. who live in lowland tropical rainforest habitats grow upright and climb on stems or branches of other trees.

Cluster identification and 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 indicate that the type of *Nepenthes* spp. which grew in the study sites were *N. mirabilis*, *N. gracilis*, and *N. sumatrana*. Based on the results of morphological identification there are key characters that distinguish the three species of *Nepenthes* spp. found. The key characters are shown in the following table.

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Morphological character** | ***N. mirabilis*** | ***N. gracilis*** | ***N. sumatrana*** |
| 1 | The shape of stem | Cylindrical | Triangular | Cylindrical |
| 2 | Leaf completeness | Petiolate | Sheets only | Petiolate |
| 3 | Leaf margin | Lower leaves fimbriate | Glabrous | Lower leaves entire |
| 4 | Leaf meat | Chartaceous | Cariaceous | Cariaceous |
| 5 | Build leaves | Elliptic-lanceolatus | Lanceolatus | Elliptic-lanceolatus |
| 6 | Leaf base | Decurrent | Sessile | Decurrent |
| 7 | Form the upper pitcher | Infundibular below and cylindrical above | Ovoid below and cylindrical above | Funnel shape |
| 8 | Form the lower pitcher | Ovoid below and cylindrical above | Ovoid below and cylindrical above | Oval below and cylindrical above |
| 9 | Peristome structure | Thick | Thin | Thick |

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 the identification of species by morphological characters is as follows:

1.a. Stem triangular ...................................................................................... ***N. gracilis***

 b. Stem cylindrical ................................................................................................... 2

2. a. Margin of lower leaves fimbriate ...................................................... ***N. mirabilis***

 b. Margin of lower leaves entire*.*.............................................................................. 3

3.a. Leaf base decurrent or adnate .......................................................... ***N. sumatrana***

 b. Leaf base amplexicaul atausessile, if decurrent, then only as a ridge ................4

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

*Nepenthes gracilis* Korth.

**Habitus**: herba. **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 simpodial. **Leaves:** sheets only, long : wide sheets = 9.6 cm : 1.3 cm, lanceolate, base truncate, color green, apexacute, margin glabrous, cariaceous, slippery surface, single type, bone color (white, maroon), length of tendrils 8.5 cm, sitting on the stem of folia sparsa, 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, apex of rounded lid, and lid base rounded.

*Nepenthes mirabilis* (Lour.) Druce.

**Habitus:** herba. **Tall:** 199.27 cm. **Root:** tunggang. **Stem:** cylindrical, 0.74 cm in diameter, internodes 5.88 cm, color (maroon, green), herbaceous, slippery surface, and climbing, and branching simpodial. **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, tepi (*margofolii*) 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 deccurent. **Upper pitcher:** infundibular below and cylindrical above, tall 12.4 cm, wide 4.07 cm, color (green with maroon spots, green, hijau 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, 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 peristomegreen, thick peristome structure, oval lid form, lid size 3.43 cm : 3.07, apex of rounded lid, and lid base rounded. Spesies *Nepenthes mirabilis* yang ditemukan memiliki keanekaragaman genetik pada warna batang, daun, kantong, dan *peristome.*

*Nepenthes sumatrana* (Miq.) Beck.

**Habitus:** herba. **Tall:** 11.5 cm. **Root:** tunggang. **Stem:** cylindrical, 0.925 cm in diameter, internodes 0.3 cm, color green, herbaceous, slippery surface, and climbing, and branching simpodial. **Leaves:** petiolate, long : wide sheets = 14.3 cm : 3.7 cm, elliptical-lanceolate, petiole 1.3 cm long, base acute, color green, apexacute, lower leaves entire, cariaceous, slippery surface, single type, bone color white, length of tendrils 12.7 cm, sitting on the stem of folia sparsa, and decurrent. **Upper pitcher:** funnel shape, tall 9.3 cm, wide 3.5 cm, 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, apex of rounded lid, and lid base rounded. **Lower pitcher:** oval below and cylincrical 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 el (2008) says 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.

**e**

**i**

**h**

**g**

**f**

**d**

**a**

**c**

**b**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| D:\Tugas Akhir\Dokumentasi Penelitian\Desa Tekorejo\IMG20171013133224.jpgD:\Tugas Akhir\Dokumentasi Penelitian\Desa Tekorejo\IMG20171014151439.jpg | D:\Tugas Akhir\Dokumentasi Penelitian\Desa Tekorejo\IMG20171014121907.jpg | D:\Tugas Akhir\Dokumentasi Penelitian\Nepenthes di Budidaya\IMG20171016125031.jpg | D:\Tugas Akhir\Dokumentasi Penelitian\Nepenthes di Budidaya\IMG20171016140428.jpgD:\Tugas Akhir\Dokumentasi Penelitian\Nepenthe Sumatrana\IMG20171111140537.jpg | D:\Tugas Akhir\Dokumentasi Penelitian\Nep Air Itam\IMG20171019143645.jpg | D:\Tugas Akhir\Dokumentasi Penelitian\Nep Air Itam\IMG20171019151025.jpg | D:\Tugas Akhir\Dokumentasi Penelitian\Nep Air Itam\IMG20171019160757.jpg |  |  |

Figure 1. Characteristics pitcher of *Nepenthes* spp. discovered at research sites

a. TR1; b. TR2; c. TR3; d. BP1; e. BP2; f. BP3; g. AI1; h. AI2; i. AI3

Based on the morphological character, a cluster analysis of the nine variants of *Nepenthes* was found to find out the kinship relationship. The phenogram generated from the analysis is as follows:

TR1

****

Coeficient

0.56

Ib

Ia

II

I

AI2

BP1

BP3

AI3

AI1

0.89

0.73

0.39

0.22

BP2

TR3

TR2

Figure 2. Phenogram of kinship relationship *Nepenthes* spp. from South Sumatra

The phenogram shows the phenetic relationship of *Nepenthes* spp. Result of analysis of 2 main cluster with similarity coefficient 0,22. The value indicates that the collection of Nepenthes spp. Significantly different. The differentiating characters are more widely seen in Table 1.

Cluster I consists of two sub clusters Ia and Ib with a similarity coefficient 0.49. Cluster I has similarities in cylindrical bar characters, petiolate leaf, elliptic-lanceolatus, leaf base deccurent, and peristome structure thick. Sub cluster Ia consists of species *N. mirabilis* (TR1, TR2, TR3, BP1). The four variants of *N. mirabilis* (TR1, TR2, TR3, BP1) have a variety color of stem, leaf, leaf bone, pitcher, and peristome characters. Sub cluster Ib consists of *N. sumatrana* species. Cluster II consists of species N. *gracilis* (BP2, AI1, AI2, AI3). The four variants of N. gracilis (BP2, AI1, AI2, AI3) have a variety of stem, leaf, leaf bone, pitcher, and peristome characters.

The proximity of *Nepenthes* spp. can be seen from the similarity coefficient value. In the first cluster the TR2 taxa is closer to TR3 of 0.89 and in the second cluster AI1 is closer to AI3 of 0.89. This suggests that the species has close kinship relationships. 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*.

**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 cluster with similarity value 0.22. 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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