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DIVERSITY OF *NEPENTHES* SPECIES IN NORTH SUMATRA PROVINCE

[*Keanekaragaman Jenis Nepenthes Di Provinsi Sumatra Utara*]

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ABSTRACT

Sumatra is the second island after Borneo, which has the highest diversity of *Nepenthes* species, spread from the lowlands to mountain forests, but until now there has been no study in each province. There are 38 species of *Nepenthes* recorded on Sumatra Island, and 33 of them are endemic. The study was conducted in 2019 and 2022 to know the diversity, distribution, population, and habitat conditions of *Nepenthes* in each of the studied locations in North Sumatra Province. The results showed that 22 species of *Nepenthes* were recorded in North Sumatra Province, consisting of 12 highland species, 3 midland species, and 7 lowland species. *N. tobaica* is a highland species with a very wide distribution, spread over eight regencies in North Sumatra with a very abundant population, while *N. sumatrana*, *N. rigidifolia*, *N. jamban*, *N. lingulat*a, and *N. naga* have limited distribution with a very small population and are potentially extinct.

Keywords: Diversity, *Nepenthes*, North Sumatra

ABSTRAK

Pulau Sumatra merupakan pulau kedua setelah Borneo yang memiliki keanekaragaman jenis *Nepenthes* tertinggi yang tersebar mulai dari dataran rendah hingga hutan pegunungan, namun sampai saat ini belum ada penelitiannya di setiap provinsi. Pada saat ini, *Nepenthes* di Pulau Sumatra tercatat ada 38 jenis dan 33 diantaranya adalah endemic. Penelitian dilakukan pada tahun 2019 dan 2022 dengan tujuan untuk mengetahui keanekaragaman, distribusi, populasi, dan kondisi habitat *Nepenthes* di masing-masing lokasi yang diteliti di Provinsi Sumatra Utara. Hasil penelitian menunjukkan bahwa sebanyak 22 jenis *Nepenthes* ditemukan di Provinsi Sumatra Utara, terdiri dari 12 jenis dataran tinggi, 3 jenis dataran menengah, dan 7 jenis dataran rendah. *N. tobaica* termasuk jenis dataran tinggi dengan persebaran sangat luas yakni tersebar di delapan kabupaten di Sumatra Utara dengan populasi yang sangat melimpah, sedangkan *N. sumatrana*, *N. rigidifolia*, *N. jamban*, *N. lingulate*, dan *N. naga* persebarannya terbatas dengan populasi yang sangat sedikit dan berpotensi punah.

Kata Kunci: Keanekaragaman, *Nepenthes*, Sumatra Utara

INTRODUCTION

Nepenthes is the only genus in the *Nepenthaceae* family that is classified as a carnivorous plant (Phillipps and Lamb, 1996; Clarke, 2001). Indonesia is the center of the distribution of *Nepenthes* in the world (Mansur, 2013). Until 2021, there are 79 species or 43.4% of the total number in the world (182) (Mansur *et al*., 2021). Over the past four decades, many new species have been discovered, especially in Indonesia, Malaysia, and the Philippines.

Sumatra Island, with an area of 473,481 km^2, is the third largest island in Indonesia after Papua (786,000 km^2) and Borneo (743,330 km^2). The existence of the Sumatra forest is very important as one of the buffers for Indonesia's nature which has a lot of beauty. The Bukit Barisan Mountains, which stretch from South Sumatra to Aceh, are the largest contributor to Sumatra's biodiversity, including *Nepenthes* (Lee *et al*., 2006). On the island of Sumatra, there are 38 species of *Nepenthes* and 33 of them are endemic. The high number of *Nepenthes* species recorded in Sumatra makes it the second largest center of diversity after Borneo, and several *Nepenthes* experts state that Sumatra is a hotspot for *Nepenthes* evolution (Wistuba *et al*., 2007). The number of endemic species from Sumatra is also more than in Borneo (Hernawati and Akhriadi, 2005). This high species diversity allows the discovery of several taxa that have not been recorded on the island of Sumatra, which is relatively high (Wistuba *et al*., 2007).

In the 1980s, half of Sumatra's landmass was tropical rainforest, but now more than half of the forest has been lost, making Sumatran forests the highest threat in Indonesia (WWF, 2010). The forest area based on its function in North Sumatra Province in 2019 was 3,009,212.23 ha, consisting of Production Forest 1,309,794.76 ha, Protected Forest 1,199,236.17 ha, Conservation Forest 421,150.85 ha, and Convertible Production Forest 79,030.45 ha (Source: BPS-North Sumatra Province, update 21 April 2021).

North Sumatra Province has a diverse topography, ranging from lowlands (< 500 m asl) to mountains (> 1000 m asl) with flat slopes (0–8%), sloping (8–15%), rather steep (15–25%), steep (25–45%) to very steep (> 45%) (RPJMD-North

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Sumatra 2019–2023). This condition allows the North Sumatra to have a relatively high level of *Nepenthes* species diversity ranging from lowland (0–500 m asl), midland (500–1000 m asl), and highland (> 1000 m asl) species. However, until now, there is no data on the number of *Nepenthes* in North Sumatra Province. Therefore, this study was conducted to determine the diversity of species, distribution, population, and habitat conditions in each location studied in the Province of North Sumatra. These data can provide the additional information and complement the data on *Nepenthes* in North Sumatra Province.

MATERIALS AND METHODS

Exploration along ± 820 km was carried out in November 2019 by tracing the road using four-wheeled vehicles through seven regencies, starting from Sidikalang (Central Tapanuli), North Tapanuli, Humbang Hasundutan, Karo, Dairi, Tobasa, and Simalungun, North Sumatra Province (Figure 1) to collect *Nepenthes*. Study of literature and herbarium specimens were checked at Herbarium Bogoriense-Cibinong. It was carried out in May and June 2022 to add information data on the species of *Nepenthes* in North Sumatra.

Figure 1. Study site and exploration routes for *Nepenthes* in seven regencies, North Sumatra Province. (*Gambar 1. Lokasi penelitian dan rute perjalanan eksplorasi Nepenthes di tujuh Kabupaten, Provinsi Sumatra Utara*).

A plot of 0.09 ha (30 x 30 m) was established at Mount Sibuatan to determine the abundance of *Nepenthes* and the species of trees growing in its habitat. Each species of *Nepenthes* in the nine subplots (10 x 10 m each), the number, and the position (x and y) were recorded. Trees (Ø> 5 cm) in each subplot were measured for trunk diameter, free-branch height, total height, and recorded for species name, number species, and position (x and y). All data collected was processed and analyzed according to the (Mueller-Dombois and Ellenberg method, 1974) to obtain values for Basal Area (BA), Relative Frequency (RF), Relative Density (RD), Relative Dominance (RDo), and Importance Value Index (IVI).

The calculation of associations between plant species was carried out using a 2 × 2 contingency table (Ludwig and Reynolds, 1988; Sutomo *et al*., 2011; Handayani *et al*., 2019) (Table 1) on plant species that had an Important Value Index > 10% (Zulkarnaen *et al*., 2017). The calculated chi-square (X^2) value is then compared with the chi-square (X^2) table at the 5% test level, which is 3.84. If the value of X^2 count > (X^2) table, then there is an association, whereas if the value of X^2 count < X^2 table, then there is no association between the two species of plants (Mueller-Dombois and Ellenberg, 1974). Furthermore, the association level was calculated using the Ochiai Index. The Ochiai Index value ranges from 0–1, i.e. the higher the

association relationship between the two plant species, the closer the index value is to 1. On the contrary, the lower the association relationship between the two species of the index value, the lower or closer to 0 (Ludwig and Reynolds, 1988). The association index developed by Ochiai appears consistently and is quite well applied in ecological studies (Shaukat *et al.,* 2014).

Table 1. Chi-square test (X^2) of the species present/absent data on a 2 x 2 contingency table. (*Uji Chi-kwadrat (X^2) dari data ada/tidaknya spesies pada tabel contingensi 2 x 2*).

Species A	Species B		Sum
	Present	Absent	
Present	a	b	a + b
Absent	c	d	c + d
Sum	a + c	b + d	N= a + b + c + d

a= The number of sampling unit where both species occur
b= The number of sampling unit where species A occur but not B
c= The number of sampling unit where species B occur but not A
d= The total number of sampling unit

Then a chi square test statistic is employed to test the null hypotheses of independence in the 2 x 2 table:

$$\frac{X^2 = (ad - bc)^2 N}{(a + b)(a + c)(b + d)(c + d)}$$

Ochiai Index (OI) = $a/ (\sqrt{a+b})(\sqrt{a+c})$

RESULTS

In total, 22 species of *Nepenthes* in North Sumatra Province were recorded, consisting of sixth species from the survey (*N. ampullaria*, *N. eustachya*, *N. gracilis*, *N. sumatrana*, *N. tobaica*, and *N. spectabilis*), 13 species of herbarium specimens traced (*N. albomarginata*, *N. flava*, *N. jamban*, *N. pectinata*, *N. lingulata*, *N. longifolia*, *N. mikei*, *N. mirabilis*, *N. ovata*, *N. rafflesiana*, *N. reinwardtiana*, *N. sp-Dairi*, and *N. sp-Taminii*) and three species from literature i.e. *N. naga* (Akhriadi *et al*., 2009), *N. rhombicaulis* (Ritonga, 2019), and *N. rigidifolia* (Akhriadi *et al*., 2004). The number of species, distribution, and conservation status of each species are listed in Table 1. Generally, consist of highland (12 species), midland (3 species), and lowland (7 species). *N. tobaica* is a highland species with a very wide distribution, spread over eight regencies in North Sumatra Province, even spreading to Mount Bandahara-Aceh (Clarke, 2001) with a very abundant population, while *N. rigidifolia*, *N. jamban*, *N. lingulate,* and *N. naga* distribution is limited to only found in one location (Regency) with a very small population and potentially extinct.

Sixteen of the 22 species of *Nepenthes* recorded in North Sumatra Province are classified as endemic species. This number is 49% of the total number of *Nepenthes* recorded as endemic on the island of Sumatra. Endemic *Nepenthes* generally have a low level of adaptation to the surrounding environment, so their distribution is limited to specific locations. The endemic *Nepenthes* species are generally challenging to cultivate conventionally due to endemic species requiring certain soil types and microclimates suitable for growth. Extreme climate change can threaten its existence in nature. In contrast, non-endemic *Nepenthes* species generally have a high degree of adaptation to the surrounding environment. They can grow fast compared to endemic species, making their distribution quite wide and generally easy to cultivate conventionally (stem cuttings, separation of tillers, seed seedlings). Three examples of these species are *N. mirabilis*, *N. ampullaria* and *N. gracilis*, which are widely distributed in Southeast Asia.

Table 2. List of species, distribution, altitude, and conservation status of each *Nepenthes* species recorded in North Sumatra Province. (*Daftar jenis, distribusi ketinggian tempat dan status konservasinya dari masing-masing jenis Nepenthes yang tercatat di Provinsi Sumatra Utara*).

No.	*Nepenthes*	Regencies (*Kabupaten*)													Altitude	IUCN Status	IUCN Criteria
		NT	CT	ST	HH	DR	KR	TB	SM	MN	LB	BB	PB	DS			
1	*albomarginata*	+	+	+											ML	LC	ver 3.1
2	*ampullaria*		+	+				+							LL	LC	ver 3.1
3	*eustachya*		+												ML	LC	ver 3.1
4	*flava*						+						+		HL	DD	Not assessed
5	*gracilis*		+									+			LL	LC	ver 3.1
6	*jamban*			+											HL	DD	Not assessed
7	*pectinata*					+	+			+			+		HL	LC	ver 2.3
8	*lingulata*			+											HL	DD	Not assessed
9	*longifolia*			+											ML	LC	ver 3.1
10	*mikei*						+	+					+		HL	VU	D2; ver 2.3
11	*mirabilis*		+								+	+			LL	LC	ver 3.1
12	*naga*									+					HL	VU	D2; ver 3.1
13	*ovata*			+			+	+							HL	LC	ver 3.1
14	*rafflesiana*		+												LL	LC	ver 3.1
15	*reinwardtiana*			+					+	+					LL	LC	ver 3.1
16	*rhombicaulis*			+		+		+							HL	VU	D2; ver 2.3
17	*Rigidifolia*						+								HL	CR	A2ad+3d; B1ab(iv,v)+ 2ab(iv,v); C2a(i,ii);D
18	*N. sp-Dairi*					+									HL	DD	Not assessed
19	*N. sp-taminii*									+					HL	DD	Not assessed
20	*spectabilis*					+	+	+						+	HL	VU	D2; ver 2.3
21	*sumatrana*		+	+											LL	CR	A3c; B1ab(I,ii,iii,v)
22	*tobaica*		+		+	+	+	+	+		+			+	HL	LC	ver 3.1

Note (*Keterangan*): NT= North Tapanuli; CT= Central Tapanuli; ST= South Tapanuli; HH= Humbang Hasundutan; DR= Dairi; KR= Karo; TB= Tobasa; SM= Simalungun; MN=Mandailing Natal; LB=Labuhan Batu; BB= Batu Bara; PB=Pakpak Bharat; DS=Deli Serdang, LL= Lowland, ML= Midland, HL= Highland, LC=Least Concern; DD= Data Deficient; VU= Vulnerable; CR= Critically Endangered

Population

The population of *Nepenthes* was only measured on the species *N. sumatrana* which has a critical conservation status (Critically Endangered), *Nepenthes spectabilis* with a vulnerable status (Vulnerable) and *N. tobaica* with a status requiring little attention (Least Concern). *N. sumatrana* was found in Central Tapanuli Regency as many as 28 individuals in an area of approximately 17 ha (Figure 2) with a composition of 17 mature plants and 11 seedlings. *N. sumatrana* at this location grows in open areas with an altitude between 20–75 m above sea level and is sympatric with *N. ampullaria*, *N. mirabilis*, and *N. gracilis* which both grows on limestone soils with hilly topography. The location is covered with shrubs, and the condition of the habitat is deplorable because it is around the final waste disposal site. In addition, the location is also very vulnerable to fires and land clearing for smallholder oil palm plantations.

The dominant vegetation in the habitat of *N. sumatrana* is ferns, the *Gleichenia* spp. Other plants recorded in the habitat of *N. sumatrana* are generally bush, i.e; *Melastoma malabathricum*, *Rhodamnia cinerea*, *Ficus microcarpa*, *Ploiarium alternifolium*, *Vitex* sp., *Commersonia* sp., *Leptopteris* sp., *Timonius flavescens*, *Ficus grossularioides*, *Macaranga heynei*, *Schima wallichii*, *Imperata cylindrical,* and *Curculigo* sp.

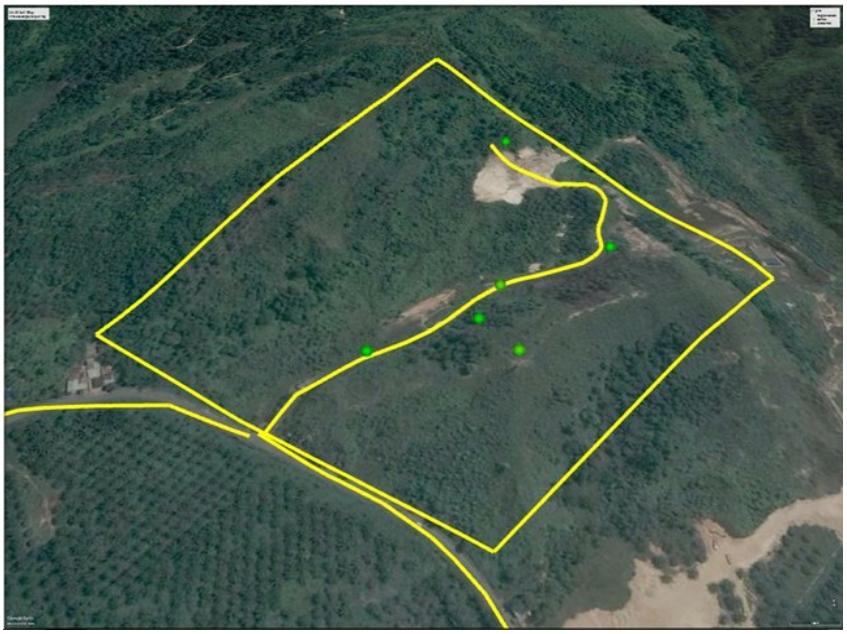
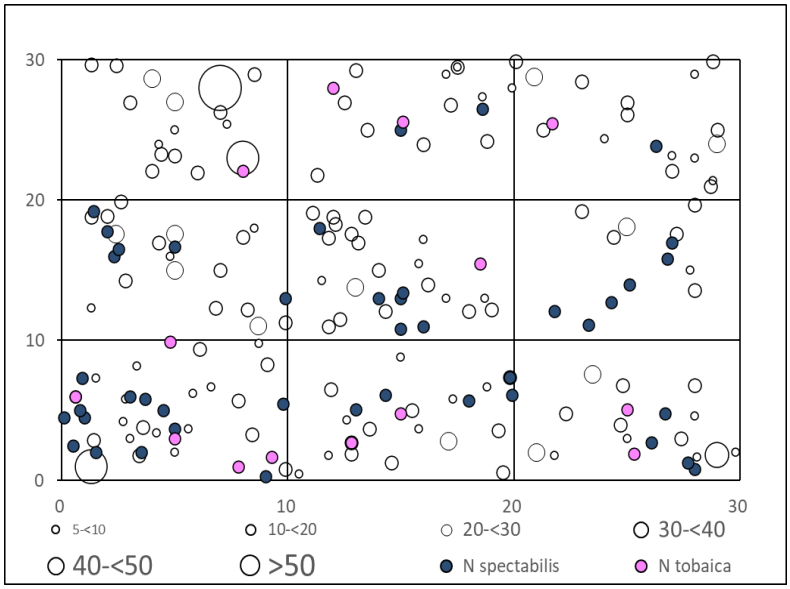


Figure 2. The distribution of *Nepenthes sumatrana* (17 ha area) at Aek Nabobar Village (*Distribusi Nepenthes sumatrana pada luasan 17 hektar di Desa Aek Nabobar*).

In a plot area of 0.09 ha (30 x 30 m) in the Lae Pondom Protected Forest, Mount Sibuatan, Karo Regency, only two *Nepenthes* species were recorded, namely *Nepenthes spectabilis* (44 individuals; nine males and two females) and *Nepenthes tobaica* (14 individuals). There were 138 individuals with 13 tree species divided into six classes of trunk diameter, namely the 5–10 cm diameter class (44 individuals), followed by the 10–20 cm diameter class (77 individuals), diameter class 20–30 cm (13 individuals), diameter class 30 –40 cm (one individual), diameter class 40–50 cm (two individuals), and more than 50 cm (one individual). The distribution of *N. spectabilis* and *N. tobaica* is presented in Figure 3. It can be explained that *N. spectabilis* lives sympatrically with *N. tobaica* in a shaded canopy area. The type of forest in the habitat of *N. spectabilis* is a secondary forest at an altitude of 1750 m asl with a hilly topography sloping to steep. The condition is still quite good and undisturbed, although not too far from district Street. Besides of Mount Sibuatan,

N. spectabilis was also found on Mount Sibayak, Mount Sinabung, and in the Sicike-cike Nature Tourism Park (Ritonga, 2019).

Ternstroemia gymnanthera, *Myrsine avensis*, *Syzygium zeylanicum*, *Litsea resinosa*, and *Lithocarpus bennettii* were the five dominant tree species recorded in the habitat of *N. spectabilis* and *N. tobaica* in the Lae Pondom Protected Forest, Mount Sibuatan, Karo Regency, North Sumatra Province. The five plants respectively has The Importance Values Index 53.84; 48.12; 42.29; 35.16; and 26.50 respectively (Table 2). The five dominant tree species significantly influenced the association between trees and *Nepenthes* species.



Note (*Keterangan*): O = Trees stem diameter class. (*Kelas diameter batang pohon*)
Figure 3. Distribution of *N. spectabilis* and *N. tobaica* in a 900 m^2 observation plot. (*Distribusi N. spectabilis dan N. tobaica di dalam petak pengamatan 900 m^2*).

Table 3. List of tree species and their abundance in the habitat of *N. spectabilis* and *N. tobaica* in the Lae Pondom Protected Forest, Mount Sibuatan, Karo Regency, North Sumatra Province (*Daftar jenis pohon dan kelimpahannya pada habitat N. spectabilis dan N. tobaica di Hutan Lindung Lae Pondom, Gunung Sibuatan, Kabupaten Karo, Provinsi Sumatra Utara*)

No.	Species (*Jenis*)	BA/900m^2 (LBD) (%)	RD (KR) (%)	RF (FR) (%)	RDo (DoR) (%)	IV (INP) (%)
1	*Ternstroemia gymnanthera (Wight & Arn.) Sprague*	0.48	20.29	15.38	18.16	53.84
2	*Myrsine avenis* (Blume) A.DC	0.37	18.84	15.38	13.90	48.12
3	*Syzygium zeylanicum* (L.) DC.	0.34	15.94	13.46	12.88	42.29
4	*Litsea resinosa* Blume	0.30	12.32	11.54	11.30	35.16
5	*Lithocarpus bennettii* (Mig.) Rehder	0.22	8.70	9.62	8.19	26.50
6	*Cinnamomum verum* J.Presl	0.16	7.97	11.54	5.89	25.40
7	*Dacrydium elatum (Roxb.) Wall.ex Hook*	0.46	2.17	5.77	17.27	25.21
8	*Diplycosia heterophylla* Blume	0.08	5.80	7.69	2.85	16.34
9	*Sp.1 (Myrcinaceae)*	0.23	4.35	1.92	8.66	14.93
10	*Psychotria malayana* Jack	0.01	1.45	1.92	0.41	3.78
11	*Polyalthia littoralis* (Blume) Boerl.	0.01	0.72	1.92	0.22	2.87
12	*Daphniphyllum glaucescens* Blume	0.01	0.72	1.92	0.17	2.82
13	*Leptospermum flavescens Sm.*	0.00	0.72	1.92	0.09	2.73
	Sum (Jumlah)	2.63	100.00	100.00	100.00	300.00

Note: BA= Basal Area, RD= Relative Density, RF= Relative Frequency, RDo= Relative Dominance, IV= Importance Value (LBD= Luas Bidang Dasar, KR= Kerapatan Relatif, FR= Frequensi Relatif, DoR= Dominan Relatif, INP= Indek Nilai Penting)

Association

The Ochiai Index (OI) showed that *N. spectabilis* could positively associate with *N. tobaica* (OI= 0.88) and with other plant species. *Cinnamomum verum* (OI= 0.88), *Ternstroemia gymnanthera* (OI= 0.88), *Myrsine avensis* (OI= 0.88), *Syzygium zeylanicum* (OI= 0.88), and *Lithocarpus benettii* (OI= 0.79) have a very high association level with *N. spectabilis*, while with other species, classified as high to very low (Table 3). Some tree species can coexist with certain plant species as part of biological interactions in the form of positive or negative associations (Sutomo *et al*., 2015). The existence of associations between species illustrates that these species have the same habitat and life needs, which can cause the distribution pattern of plants to be clustered in a habitat (Mueller-Dombois and Ellenberg, 1974). Various direct factors from biotic and abiotic influences can cause positive and negative association patterns between species (Susilowati *et al.,* 2021). Positive interspecific associations may increase over time, supporting the view that facilitation is more prominent in highly disturbed habitats than in competition (Sutomo *et al*., 2011).

Table 4. The calculated Chi-square (X^2) value and Ochiai Index (OI) association of *Nepenthes spectabilis* with other plant species in the Lae Pondom Protected Forest, Mount Sibuatan, Karo Regency, North Sumatra Province **(***Nilai Chi-square (X^2) hitung dan Indeks Ochiai (IO) asosiasi Nepenthes spectabilis dengan jenis tumbuhan lain di Hutan Lindung Lae Pondom, Gunung Sibuatan, Kabupaten Karo, Provinsi Sumatra Utara*)

No.	Species couple (*Pasangan Jenis*)	Chi-square (Nilai X^2)	X^2	Ochiai Index (OI)	Note (*Keterangan*)
1	*N. spectabilis - Cinnamomum verum*	3.94	+	0.95	Very high
2	*N. spectabilis - Ternstroemia gymnanthera*	0.14	+	0.88	Very high
3	*N. spectabilis - Myrsine avenis*	0.14	+	0.88	Very high
4	*N. spectabilis - N. tobaica*	0.32	+	0.80	Very high
5	*N. spectabilis - Syzygium zeylanicum*	0.32	+	0.80	Very high
6	*N. spectabilis - Lithocarpus benettii*	1.40	+	0.79	Very high
7	*N. spectabilis - Litsea resinosa*	0.90	+	0.63	High
8	*N. spectabilis - Diplycosia heterophylla*	0.32	+	0.50	High
9	*N. spectabilis - Glikosia heterophylla*	0.32	+	0.50	High
10	*N. spectabilis - Dacrydium elatum*	2.25	+	0.41	Low
11	*N. spectabilis - Leptospermum flavescens*	0.14	+	0.35	Low
12	*N. spectabilis - Polyalthia littoralis*	0.14	+	0.35	Low
13	*N. spectabilis - Timonius flavescens*	0.14	+	0.35	Low
14	*N. spectabilis - Daphniphyllum glauscens*	0.14	+	0.35	Low
15	*N. spectabilis - Sp.1 (Myrsinaceae)*	0.90	-	0.00	Very low

Note: (+)= Association, (-)= No Association

DISCUSSION

Our inventory found 22 species of *Nepenthes* in North Sumatra Province (Table 2). Two of these species have never been described as new species. The two species are *Nepenthes* found in Dairi Regency, known as *N*. sp-dairi, and *Nepenthes* from Mandailing Natal Regency, known as *N*. sp-taminii. Both specimens are stored in Herbarium Bogoriense (BO), the collection of Wewin Tjiasmanto of the Wet Biota Conservation Foundation, which was given to Herbarium Bogoriense for further research and is an opportunity for taxonomists to describe it as a new species. In terms of species numbers, the *Nepenthes* species found in North Sumatra Province are quite diverse when compared to the number of *Nepenthes* from Central Kalimantan Province, which amounted to 16 species (Mansur, 2007), even more, diverse than in Java (3 species), Sulawesi (14 species), Maluku (5 species), and Papua (12 species) (Mansur, 2013).

In general, the population of *Nepenthes* in the lowlands are decreased sharply due to forest/land fires, changes in the function of forest areas into plantations, mining, and regional development, as happened in *N. sumatrana*, while for highland species, over collected of *Nepenthes* by encroachers for commercial purposes or collecting by collector are the cause of the decline in the population of *Nepenthes* living in the highlands, especially endemic species such as *N. rigidifolia*, *N. jamban,* and *N. naga*.

Nepenthes sumatrana and *N. rigidifolia* are two species of *Nepenthes* currently classified as Critically Endangered (CR) conservation status in the IUCN Red List of Threatened Species (Clarke, 2014). In 2019 in the village of Aek Nabobar, 28 individuals of *N. sumatrana* were still found, but currently, there are only two individuals due to land fires in 2022 (Figure 4). Based on the study for specimens at Herbarium Bogoriense, *N. sumatrana* was found not only in Central Tapanuli Regency but also in Batang Toru-South Tapanuli Regency, and even found in West Sumatra Province, namely in Pasaman Regency, Lima Puluh Kota Regency, and Sijunjung Regency. Nevertheless, all existing populations of *N. sumatrana* should be considered critically endangered, and this beautiful species requires urgent efforts to conserve the few remaining populations in the wild (Clarke, 2001). The oldest collection is a specimen collected by Meer Mohr in 1930 from Central Tapanuli, *N. sumatrana* species spread from an altitude of 60 m to 1000 m above sea level.

(Akhriadi *et al*., 2004). reported that *N. rigidifolia* was found around Mount Sibuatan, Karo Regency, with a very small population of 14 individuals (Clarke, 2014). However, during the 2019 survey, this species was not found. The populations of *N. sumatrana*, *N. rigidifolia* (Akhriadi *et al*., 2004), *N. jamban* (Lee *et al*., 2006), and *N. naga* (Akhriadi *et al*., 2009) are very small; therefore, these species need to be immediately conserved by ex-situ conservation. Based on the conservation status assessed by the IUCN that Indonesia ranks second (26 species) after Brazil (28 species), which has a number of threatened *Nepenthes*, namely 12 Critically Endangered species, 9 Endangered species, and 5 Vulnerable species (Cross *et al*., 2020). On the island of Sumatra, there are 17 species of *Nepenthes* listed as endangered, namely 7 species classified as Critically Endangered, 4 species as Endangered, and 6 species as Vulnerable (Hernawati and Akriadi, 2005). Ex-situ conservation needs to be immediately carried out by means of domestication through cultivation and breeding mechanisms in order to remain sustainable, considering that almost all species of *Nepenthes* in Indonesia are protected by Undang-Undang No. 5 tahun 1990, PP No. 7 tahun 1999 (Mansur, 2006; Hernawati *et al*., 2007) and Permen LHK Nomor P.106/MENLHK/SETJEN/ KUM.1/12/2018.

N. tobaica is one of 22 species of *Nepenthes* recorded has a wide distribution and large population in North Sumatra Province, lives in open or slightly shaded places at altitudes between 1000 to 1750 m asl, grows on limestone soil on cliffs, hills or on the side of the road climbing the canopy of trees. Therefore, this species is not worried about its existence in nature.

Cinnamomum verum, *Ternstroemia gymnanthera*, *Myrsine avensis*, *Syzygium zeylanicum,* and *Lithocarpus benettii* have a very high association level with *N. spectabilis*, why is this happening? does it have anything to do with the canopy shape of the five species so as to form the microclimate needed by *N. spectabilis*? or is there something else we don't know about it? To answer some of these questions, further research is needed, especially those related to associations.

Figure 4. *N. sumatrana* habitat before burning in 2019 (left) and after burning in 2022 (right) in Aek Nabobar Village (*Habitat N. sumatrana sebelum terbakar tahun 2019 (kiri) dan setelah terbakar tahun 2022 (kanan) di Desa Aek Nabobar*).

CONCLUSION

North Sumatra Province has several *Nepenthes* species diverse compared to other provinces, even more, diverse than those in Java, Sulawesi, Maluku, and Papua Island. Twenty-two species were recorded at the study site. Two of them have not been described previously, and it is an opportunity for taxonomists to describe it as a new species, known as "*N.* sp-dairi" from Dairi Regency and *Nepenthes* known as "*N.* sp-taminii" from Mandailing Natal Regency. Both specimens are stored in herbarium collections at Herbarium Bogoriense (BO). At the study site, the population of *N. Sumatra* has decreased sharply, due to land fires. These species need to be immediately conserved ex-situ. In general, the habitat of *Nepenthes* in the highlands is still better than in the lowlands.

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Appendix: Twenty of *Nepenthes* species recorded in North Sumatra Province

N. albomarginata
(Photo by Mansur)

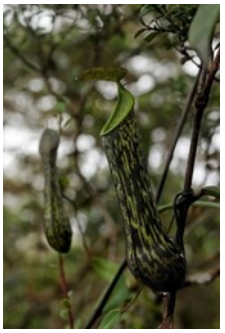
N. ampullaria
(Photo by Mansur)

N. eustachya
(Photo by Mansur)

N. flava
(Photo by Wewin)

N. gracilis
(Photo by Mansur)

N. jamban
(Photo by Alfindra)



N. mikei
(Photo by Wewin)

N. mirabilis
(Photo by Mansur)

N. lingulata
(Photo by Alfindra)

N. longifolia
(Photo by Mansur)

N. naga
(Photo by Alfindra)

N. ovata
(Photo by Wewin)

N. pectinata
(Photo by Mansur)

N. rafflesiana
(Photo by Mansur)

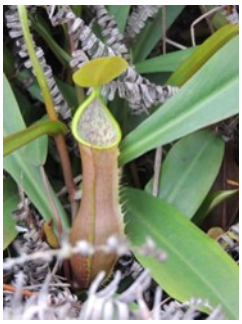
N. reinwardtiana
(Photo by Mansur)

N. rhombicaulis
(Photo by Mansur)

N. rigidifolia
(Photo by Suska)

N. spectabilis
(Photo by Mansur)

N. sumatrana
(Photo by Mansur)



N. tobaica
(Photo by Mansur)