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The Diversity of *Nepenthes* Species and Their Rhizosphere Soil Properties around the Lore Lindu National Park Area, Central Sulawesi, Indonesia

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Abstract

Lore Lindu National Park is one of the most important ecosystem protection areas in Central Sulawesi. However, currently, the conservation area is threatened by mining activities, both legal and illegal, such as gold mining, which of course threatens the sustainability of the biological resources in it. On the one hand, research on endemic flora and their potential for symbiosis with soil microbes is still lacking, especially in conservation areas. This study aims to determine the diversity of *Nepenthes* spp that grow both outside and inside the Lore Lindu National Park area, their ecological characteristics and the potential for symbiosis with soil microbes. The results showed that in each research location two types of *Nepenthes* were found, namely *Nepenthes mirabilis* with 23 individuals in Padang Padaeha and 71 individuals in pine stands, then *Nepenthes tentaculata* with 77 individuals in Padang Padaeha and 109 in pine stands. Both types of *Nepenthes* are associated with other plant species such as *Eucalyptus deglupta*, *Imperata cylindrica*, *Selaginella plana*, *Gleichenia linearis*, *Rhodomyrtus tomentosa*, *Blechnum* sp, *Stenoclaena palustris*, *Dicranopteris linearis*, *Lycopodiella cernua*, *Lygodium microphyllum*, *Clidemia hirta* and *Digitaria* sp. The *Nepenthes* species diversity index in both locations was in the low category. Furthermore, the fungal population was also higher than the bacterial population in both research sites as effects of soil characteristics. The results of this study can be used as a basis for in-situ conservation of these species in the future, especially in the national park area.

Keywords: Diversity, *Nepenthes* spp, Soil Microbes, Lore Lindu National Park

Introduction

Nepenthes is an understory that has the ability to attract, trap, digest prey on various animals species so it is classified as a carnivorous plant and generally lives on nutrient-poor soils (Latif et al., 2014; Rembold et al., 2010). This species can grow as a liana or grow terrestrially (Mansur, 2012). *Nepenthes* has a unique way of trapping insects as food. In addition to being able to trap insects, *Nepenthes* are also capable of trapping frogs or birds that enter their pockets (Frankie and Maloedyn, 2006).

Nepenthes has many uses, including the stems that can be made into handicrafts, the large pouches are used to cook rice and other traditional foods, the liquid in the pouch is used as a medicine for sore eyes, coughs, stomachaches, burns, skin diseases, made of rope and as a ornamental plants (Danser., 1928; D'amato., 1998; Handayani., 2001; Mansur., 2008; Pitopang et al., 2018; Tamin and Horta., 1986). Its unique and diverse form

is very popular with plant enthusiasts so it is hunted for collection and as a result of its higher value many types of *Nepenthes* are being hunted by people (Rismita, 2009).

As many as 129 species of *Nepenthes* are reported, which are widely distributed in the Malesian region, as the center of their biodiversity (Mey., 2010; Robinson et al., 2009). Research on the diversity of *Nepenthes* species has been carried out by several previous researchers (Jeffrey et al (2017) reported that in the Germplasm Conservation Area (KPPN) PT. The estuary of the Landak River, Siantan District, Mempawah Regency, West Kalimantan, consists of 3 species, namely *Nepenthes ampullaria*, *Nepenthes bicalcarata* and *Nepenthes rafflesiana*. Furthermore, Latif et al., (2014) also found five species of *Nepenthes* in five habitats in Brunei Darusaalam. On the island of Sulawesi, research on *Nepenthes* spp was also reported by (Julianto et al., 2021), who found as many as three types of *Nepenthes* in Lore Lindu National Park, Central Sulawesi Indonesia..

The existence of *Nepenthes* in its natural habitat has begun to be threatened due to several factors, including conversion to agricultural and mining land, damage to natural habitat due to disasters or human actions, and overexploitation (Puspitaningtyas & Wawangningrum, 2007; Handayani et al., 2005). Based on these facts, *Nepenthes* plants are included in protected plants based on the IUCN, WCMC, and Government Regulation No. 7 of 1999 concerning Preservation of Plants and Animals. *Nepenthes* is known to be very well adapted to grow in nutrient-poor soils which have very low macro nutrients such as Nitrogen, Phosphorus and Potassium and high levels of soil acidity which are generally limiting factors for plant growth (Bauer et al., 2008; Cheek & Jebb, 2016; Rembold et al., 2010; Wistuba et al., 2007).

Currently, research on the diversity of *Nepenthes* spp. species in Central Sulawesi is still lacking, especially its symbiosis with soil microbes. Completeness of information is an essential factor in formulating conservation plans and strategies for managing biological natural resources, so it is necessary to conduct research on the population and distribution pattern of the *Nepenthes* spp in conservation areas, which can be used as a source of information and the preparation of conservation strategies that can be pursued. in the future. This study aims to know the diversity and characteristics of the rhizosphere soils of *Nepenthes* spp. around Lore Lindu National Park, Central Sulawesi, Indonesia.

Materials and Methods

Study Sites and Objects

This research was carried out in two places, namely in Padang Padaeha (Within the Lore Lindu National Park area) and in the *Pinus merkusii* Stand (Outside the Lore Lindu National Park area), Central Sulawesi, Indonesia. The characteristics of each research location can be seen in table 1 and a map of the research location is presented in Figure 1.

Tabel 1. Characteristics of research locations

Location	Village	Status of Area	Altitude	Coordinate	Temperature	RH
Padang Padaeha	Sedoa	Within Lore Lindu National Park	1695 m asl	S 01°19.986' E 120°19.581	24°C	87%
Pine stand	Watutau	Outside of Lore Lindu National Park	1627 m asl	S 01°35.156' E 120°25.882	25°C	85%

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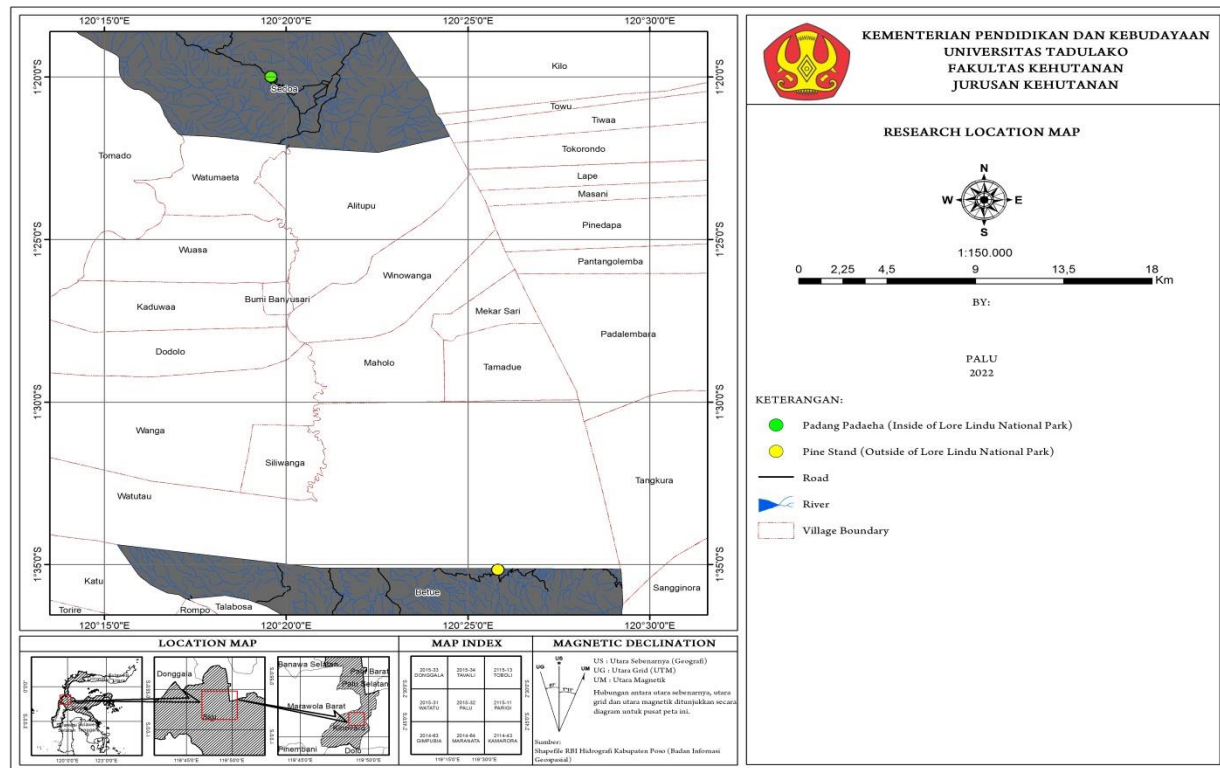


Figure 1. Research location map

The object of research is the types of *Nepenthes* spp that exist outside and within the Lore Lindu National Park area. The primary data obtained from direct observations in the field by observing and collecting data on number of individual pitcher plants (*Nepenthes* spp) (Yelli, 2013), also their association with other plants in each plot.

The method used is the line transect method which is placed by purposive sampling inside or outside the Lore Lindu National Park area where there are types of *Nepenthes*. Observation plots were made discontinuously with each plot size of 10 m x 10 m. There are seven number of transects in the field with the length of each transect is 50 m. Types of *Nepenthes* that are not yet known will be transport to UPT.Sumberdaya Hayati Sulawesi, Tadulako University, Palu, Indonesia for further identification.

Collection and Determination of soil Physico-chemical-Biological characteristics

Ten samples of root soil and rhizosphere from each species of *Nepenthes* spp were taken randomly from each location. Root samples were taken by pulling out the entire plant very carefully to get intact roots. The plant was gently cleaned to remove soil particles and adhering debris and rinsed with tap water. Soil sample ca. 100 g was collected from each type of plant to a depth of 10 cm. Root and soil samples from the rhizosphere soil in the same species of *Nepenthes* were collected to obtain a composite sample from each site. The rhizosphere soil samples were collected separately in plastic bags, labeled and stored. The moisture content was determined by drying a number of rhizosphere soil samples in an oven at 105°C for 24 hours.

Soil properties was detemined by standart protocols, namely; pH of soil (digital pH meter). Total N and total Organic Carbon (Anderson and Ingram., 1993). Phosphorous (P) by molybdenum blue method (Allen, 1974).

Determination of fungi and bacteria population was using serial dilution plate method (Johnson and Curl, 1972). Isolation of fungi was by using Rose Bengal Agar medium (Martin, 1950) and for bacteria by using Nutrient Agar. There are three replication for each sample. The inoculated petridishes were then incubated at 25

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$\pm 1^{\circ}\text{C}$ for 3 days in a sterile laminar air flow. Coloni forming unit (CFU) of fungi and bacteria per gram of dry soil was determined on the dry weight basis.

Data Analysis

The Shannon-Wiener diversity index of *Nepenthes* was counted as used by Margalef (2008).

$$H' = \sum (n/N) \log_c(n/N)$$

Where H' is the diversity index, N is the total number of individuals of all *Nepenthes* species and n is the total number of individuals of the individual species.

The Simpson diversity index of *Nepenthes* was counted as suggested by Simpson (1949).

Simpson Index of Diversity = $1-D$

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where n is the total number of organisms of a given species, N is the total number of organisms of all species and D is the Simpson's Index.

Results and Discussions

The results showed that two types of *Nepenthes* were found in both research sites, namely *Nepenthes mirabilis* (Lour.) Druce and *Nepenthes tentaculata* Hook.f. (Figure 2). The number of types of *Nepenthes* found in this study was less when compared to the results of research by Rawi and Shahrudin., (2021), where they found as many as five types of *Nepenthes* in the Bris Ecosystem, Setiu Trengganu, Malaysia, namely *N. gracilis*, *N. ampullaria*, *N. rafflesiana*, *N. x hookeriana* and *N. x trichocarpa*. Setiawan et al., (2018) found a higher number of species, namely nine types of *Nepenthes* in the ex-mining area, Sintang district, West Kalimantan, Indonesia, namely *N. ampullaria*, *N. bicalcarata*, *N. gracilis*, *N. mirabilis*, *N. rafflesiana*, *N. xhookeriana*, *N. xkuchingensis*, *N. xneglecta* and *N. xtrichocarpa*.



N. mirabilis



N tentaculata

Figure 2. Types of *Nepenthes* found in the research site

The number of individuals of each type of *Nepenthes* and the index of species diversity in each research location are presented in Table 2 below:

Table. 2. Number of individuals and index of species diversity of *Nepenthes* spp at the study site

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Research location	Species	Number of Individual	Diversity Index	
			Shannon-Wiener (H')	Simpson (1-D)
Padang Padaeha (Within the Lore Lindu National Park)	<i>Nepenthes mirabilis</i>	23	0.80	0.35
	<i>Nepenthes tentaculata</i>	77		
Pine stands (Outside the Lore Lindu National Park)	<i>Nepenthes mirabilis</i>	71	0.96	0.47
	<i>Nepenthes tentaculata</i>	109		

Table 2 above shows that the highest number of individuals was found in *Nepenthes tentaculata* as many as 109 individuals in pine stands and 71 in Padaeha fields, while for *Nepenthes mirabilis* as many as 71 individuals in pine stands and 23 in Padaeha fields. The *Nepenthes* species diversity index in both study sites is also low with a species diversity index (H') value of less than 1. Many factors affect the density of *Nepenthes*, for example soil, habitat, light intensity and water availability (Adam et al., 2011).

Based on field observations, *Nepenthes spp.* found in the two research sites are also associated with several other plant species which are presented in table 3 below:

Table. 3. Association of *Nepenthes spp* with other plant species in the two research sites.

Research Location	Plants type	Notes
Padang Padaeha (Within of Lore Lindu National Park)	1. <i>Eucalyptus deglupta</i> Blume. 2. <i>Imperata cylindrica</i> L. 3. <i>Selaginella plana</i> (Desv.ex Poir.) 4. <i>Gleichenia linearis</i> (Burm.f.) S.W. Clarke 5. <i>Rhodomyrtus tomentosa</i> (Aiton) Hassk. 6. <i>Blechnum sp</i> 7. <i>Stenoclaena palustris</i> (Burm.F.) Bedd. 8. <i>Dicranopteris linearis</i> 9. <i>Lycopodiella cernua</i> (L.) Pic. Serm. 10. <i>Lygodium microphyllum</i> m (Cav.) R. Br. 11. <i>Clidemia hirta</i> (L) D.Don. 12. <i>Digitaria sp.</i>	<i>Nepenthes mirabilis</i> is more dominant and grows in groups and is associated with other plant species
Pine Stands (Outside of Lore Lindu National Park)	1. <i>Pinus merkusi</i> Jungh et de Vriese 2. <i>Imperata cylindrica</i> L. 3. <i>Selaginella plana</i> (Desv.ex Poir.) 4. <i>Mallotus sp</i> 5. <i>Gleichenia linearis linearis</i> (Burm.f.) S.W. Clarke 6. <i>Blechnum sp</i> 7. <i>Euphorbia hirta</i> L. 8. <i>Clidemia hirta</i> (L) D.Don. 9. <i>Digitaria sp.</i>	<i>Nepenthes mirabilis</i> is more dominant and grows in groups and is associated with other plant species

The number of plant species associated with *Nepenthes* in Padang Padaeha (In the Lore Lindu National Park area) is more than 12 plant species, while in pine stands (Outside the Lore Lindu National Park area) there are only 9 plant species. The number of plant species associated with *Nepenthes* in this research location is less when compared to the results of research by Hidayat et al., (2018), who found 19 plant species of *Nepenthes* in peat swamp forest in *Nepenthes* habitat the Botany Gardens, Central Kalimantan, Indonesia. Furthermore Pitopang et al., (2018) who reported that as many as 40 other plant species were found in the habitat of *Nepenthes pitopangi* in Lore Lindu National Park.

This *Nepenthes* functions as a foothold for the branches and tendrils of *Nepenthes* to spread and becomes a way for insects or other animals to enter the *Nepenthes* pouch. According to Frazier (2000) that in the *Nepenthes* bag there is an acidic liquid with a pH <4, which can kill animals that enter it. Furthermore, the glands in the wall of the *Nepenthes* pouch secrete proteolase enzymes which will break down proteins and other compounds contained in the animal carcasses, which in turn are broken down into nitrogen, phosphorus,

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potassium and other minerals (Buckley et al., 2003; Miller & Kneitel, 2005). Furthermore, according to Takeuchi et al., (2011; 2015) that the microbes present in the liquid in the *Nepenthes* pouch contribute significantly to the amount of enzymes produced which may play an important role in nutrient mineralization. This is one of the mechanisms why *Nepenthes* can grow and survive in soils that are poor in nutrients, especially Nitrogen. Confirmed by Moran & Clarke (2010) that *Nepenthes* usually grows in nitrogen-poor soil.

This is thought to be related to the level of soil fertility in each of the research locations. The results of the analysis of the physical, chemical properties and microbial population of the rhizosphere soil in table 4 show that there are differences between the two locations of *Nepenthes* habitat. Soil pH in Padang Padeha was higher at 5.20 while the soil pH in pine stands was 4.92.

Table 4. Characteristics of Soil Physical, chemical, biological and microbial population at each research location

No.	Parameters	Soil sampling location	
		Padang Padaeha	Pine stands
1.	pH (H ₂ O)	5.20	4.92
2.	Organic-C (%)	0.47 (low)	2.76 (high)
3.	N-Total (%)	0.04 (low)	0.16 (high)
4.	Cation exchange capacity cmol (+)kg ⁻¹	11.70 (low)	15.20 (low)
5.	P ₂ O ₅ (ppm)	4.52 (low)	3.30 (low)
6.	Permeability (cm/jam)	5.34 (high)	0.48 (low)
7.	Bulk Density (gr/cm ³)	1.57 (low)	1.58 (low)
8.	Porosity (%)	39.90 (high)	40.04 (high)
9.	Soil Texture	Sandy clay	Clay
10.	Population of Bakteri (cfu/g soil)	21.7 x 10 ⁷	16 x 10 ⁷
11.	Populasi of Fungi (cfu/g soil)	52.8 x 10 ⁴	26.4 x 10 ⁴

The results of the study in table 4 above show that the population of soil fungi was higher in the Padeha field, namely 52.8 x 10⁴ cfu compared to the pine stand, which was only 26.4 x 10⁴ cfu. This was due to the large number of plant species found to be associated with *Nepenthes* in the Padeha field compared to that in the stand. pine (Table 3). According to Hackl et al., (2000) that species of the plants also affect the population and diversity of soil fungi. This may be related to production of the root exudates by plants, which are a nutrition source for microorganisms in the rhizosphere. Root exudates released by plant roots play a main role in the development and population of fungal communities in both the rhizosphere and rhizoplane areas (Broeckling et al., 2008; Kawasaki et al., 2016).

The results of this study also indicated that the fungal population was also higher than the bacterial population. This is influenced by the soil pH which in both locations is acidic. According to Grantina et al., (2011) that fungi prefer an acidic environment compared to bacteria. The results of this study are supported by the research results of Majwa et al., (2015) which showed that the population of fungi in the rhizosphere *N. khasiana* Hook.,f. positively influenced by soil temperature, soil water content, pH and organic carbon.

Conclusions

Two types of *Nepenthes* were found within and outside the Lore Lindu National Park area, namely *Nepenthes mirabilis* and *Nepenthes tentaculata*. The highest number of species was found in *Nepenthes tentaculata* as many as 109 individuals in pine stands and 77 individuals in Padaeha fields, compared to

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Napenthes mirabilis which was only 71 individuals in pine stands and 23 individuals in Padaeha fields. Furthermore, there were 12 plant species associated with *Napenthes spp* in Padang Padaeha (within the Lore Lindu National Park area), and as many as 9 other plant species in pine stands (outside the Lore Lindu National Park area). The species diversity index of *Napenthes spp* in both study sites is also low with an H' value of less than 1. Furthermore, the fungal population was also higher than the bacterial population in both research sites as effects of soil characteristics. The results of this study are very important for future *Napenthes* conservation efforts, especially in the Lore Lindu National Park area.

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References

- i. Adam J.H., Hamid H.A., Juhari M.A.A., Tarmizi S.N.A., Idris W.M.R., 2011. Species composition and dispersion pattern of pitcher plants recorded from Rantau Abang in Marang District, Terengganu State of Malaysia. *Inter. J. Bota.* 7: 162-169.
- ii. Allen S.E., Grinshaw H.M., Parkinson J.A., Quaramby C., 1974. Chemical analysis of ecological materials. Blackwell Scientific Publications, Oxford.
- iii. Anderson J.M and Ingram J.S.I., 1993. (Eds.) Tropical soil biology and fertility. A handbook of methods. C.A.B. International, Oxford. 296: 1694-1697.
- iv. Broeckling, C.D, Broz, A.K, Bergelson, J., Manter, D.K. and Vivanco, J.M. 2008. Root exudates regulate soil fungal community composition and diversity. *Appl Environ Microb.*, 74: 738–744
- v. Buckley H.L, Miller T.E, Ellison A.M & Gotelli N.J., 2003. Reverse latitudinal trends in species richness of pitcher-plant food webs. *Ecol Lett* 6: 825–829.
- vi. Cheek, M., & Jebb, M., 2016. A New Section in *Nepenthes* (Nepenthaceae) and A New Species From Sulawesi, *Blumea*, 61 (2): 59-62.
- vii. Danser B.H., 1928. The Nepenthaceae of the Netherlands Indies. *Bulletine Jardin Botanique de Buttenzorg*. 3:330-357.
- viii. D'amato P., 1996. The savage garden. Berkeley, CA. Ten. Speed Press.
- ix. Frankie H., dan Maloedyn S., 2006. Petunjuk Praktis Perawatan *Nepenthes*. Agromedia Pustaka. Jakarta
- x. Frazier C.K., 2000. The enduring controversies concerning the process of protein digestion in *Napenthes* carnivorous. *Plant Newsletter*. 29(2): 56-61.
- xi. Grantina L., Seile E., Kenigvalde K., Kasparinskis R., Tabors G., Nikolajeva V., Jungerius P., Muiznieks I., 2011. The influence of the land use on abundance and diversity of soil fungi: comparison of conventional and molecular methods of analysis. *Environmental and Experimental Biology*. 9:9-21.
- xii. Hackl E., Bachmann G., Boltensstern-Zechmeister S., 2000. Soil microbial biomass and rhizosphere effects in natural forest stands. *Phyton*. 40:83-90.
- xiii. Handayani T., 2001. *Nepenthes spp.* koleksi Kebun Raya Bogor yang berpotensi sebagai tanaman hias. *Warta Kebun Raya*. 3(1):26-31.
- xiv. Handayani, T., Latifah, D., & Dodo., 2005. Diversity and Growth Behaviour of *Nepenthes* (Pitcher Plants) in Tanjung Puting National Park, Central Kalimantan Province. *Biodiversitas*, 6(4), 248-252.
- xv. Hidayat S., Helmanto H., Dodo, Purnomo D.W., Supriyatna I., 2018. Habitat of *Nepenthes spp.* in the area of Sampit Botanic Garden, Central Kalimantan, Indonesia. *Biodiversitas*. 19(4): 1258-1265. <https://doi.org/10.13057/biodiv/d190411>

- xvi. Jackson M.L. 1973. Soil chemical analysis. Ist Edn., Pretice Hall of India Pvt. Ltd., New Delh, India.
- xvii. Jeffry W., Rafdinal, Turnio M., 2017. Keanekaragaman jenis kantong semar (*Nepenthes* spp.) di kawasan Pelestarian plasma nutfah (KPPN) PT. Muara Sunga Landak Kabupaten Mempawah. Protobiont. 6(3):42-50.
- xviii. Johnson, Leander F., and Elroy A. Curl. 1972. Methods for Research on the Ecology of Soil-Borne Plant Pathogens. 426 So. Sixth St., Minneapolis Burgess Publishing Company.
- xix. Julianto E.D., Mallombasang S.R., Labiro E., 2021. Keanekaragaman jenis kantong semar (*Nepenthes* spp.) di Padang Padeah Taman Nasional Lore Lindu. Jurnal Warta Rimba. 9(2): 101-108.
- xx. Kawasaki, A., Donn, S., Ryan, P. R., Mathesius, U., Devilla, R., Jones, A., et al., 2016. Microbiome and exudates of the root and rhizosphere of *Brachypodium distachyon*, a model for wheat. PLoS One 11:e0164533. doi: 10.1371/journal.pone.0164533
- xxi. Latiff N.A, Sukri R.S, Metali F., 2014. *Nepenthes* diversity and abundance in five habitats in Brunei Darussalam. Reinwardtiana 14: 67-71.
- xxii. Majaw A.P., Makdoh K., Devi H.R., Kayang H., 2015. Fungal diversity in the rhizosphere of *Nepenthes khasiana* Hook., f., an endemic and endangered insectivorous plant of Meghalaya, India. International Journal of Advanced Research in Biological Sciences. 2(10): 96-102.
- xxiii. Mansur, M. 2008. Penelitian Ekologi *Nepenthes* di Laboratorium Alam Hutan Gambut Sabangau Kereng Bangkirai Kalimantan Tengah. Jurnal Teknologi Lingkungan 9(1):67- 73.
- xxiv. Martin J.P. 1950. Use of acid, rose bengal, and streptomycin in the plate method for estimating soil fungi. Soil Sci., 69:215- 232
- xxv. Mey F.S., 2010. Introduction to the pitcher plants (*Nepenthes*) in Cambodia. Cambodian J. Nat. Hist. 2:106-117.
- xxvi. Miller T.E., Kneitel J.M., 2005. Inquiline communities in pitcher plants as a prototypical metacommunity. Metacommunities: Spatial Dynamics and Ecological Communities, (Holoyak M, Leibold MA & Holt R, eds), pp. 122–145. University of Chicago Press, Chicago, IL.
- xxvii. Pitopang R., Thaha I., Amar A.L., Lee C.C., 2018. Has *Nepenthes pitopangii* Chi C. Lee, S. Mc Pherson, Bourke & M. Mansur a rare and endemic flowering plant of Sulawesi, been extinct in its original nature? Natural Science: Journal of Science and Technology. 7(3): 358-370.
- xxviii. Puspitaningtyas, M.D., & Wawangningrum, H., 2007. Keanekaragaman *Nepenthes* di Suaka Alam Sulasih Talang, Sumatera Barat. Biodiversitas, 8(2): 152-156
- xxix. Rawi N.A and Shahrudin R., 2021. Species Richness and soil properties in *Nepenthes* habitat at Bris Ecosystem, in Setiu Trengganu. University Malaysia Trengganu Journal of Undergraduate Research. 3(4); 67-72.
- xxx. Rembold K., Fischer E., Wetzell M.A., Barthlott W., 2010. Prey composition of the pitcher plant *Nepenthes madagascariensis*. Journal of Tropical Ecology. 26:365–372.
- xxxi. Rismita S., 2009. Keanekaragaman jenis kantong semar (*Nepenthes* spp.) dan manfaatnya bagi masyarakat lokal. Seminar Nasional Etnobotani, Cibinong Science Center-LIPI, 18 Mei 2009.
- xxxii. Robinson A.S., Fleischmann A.S., Mcpherson S.R., Heinrich V.B., Gironella E.P., Pena C.Q., 2009. A spectacular new species of *Nepenthes* L. (Nepenthaceae) pitcher plant from Cenryal Palawan, Phillipines. Bot. J. Linn. Cocc. 159:195-202.
- xxxiii. Setiawan H., Wardhani H.A.K., Kamaludin, Hutagaol RR., Afriani R., 2018. The diversity of *Nepenthes* at the post-mining area in Sintang District, West Kalimantan, Indonesia. 19(5): 1820-1827.
- xxxiv. Takeuchi, Y., Salcher, M.M., Ushio, M., Shimizu-Inatsugi, R., Kobayashi, M.J., Diway, B., von Mering, C., Pernthaler, J., Shimizu, K.K., 2011. In situ enzyme activity in the dissolved and particulate fraction of the fluid from four pitcher plant species of the genus *Nepenthes*. PLoS ONE 6, e25144.
- xxxv. Takeuchi Y., Chaffron S., Salcher M.M., Shimizu-Inatsugi R., Kobayashi M.J., Diway B., von Mering C., Pernthaler J., Shimizu k.k., 2015. Bacterial diversity and composition in the fluid of pitcher

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plants of the genus *Nepenthes*. Systematic and Applied Microbiology. 38: 330-339.
<https://doi.org/10.1016/j.syapm.2015.05.006>

- xxxvi. Tamin R., Hotta M., 1986. *Nepenthes* in Sumatera. The genus *Nepenthes* of Sumatera island. In Hotta M (ed.). Diversity and Dynamic of Plant Life in Sumatera. Kyoto: Kyoto University.
- xxxvii. Wistuba, A. N., Fleischmann, A. (2007). *Nepenthes Flava*, A New Species of Nepenthaceae From the Northern Part of Sumatera, Blumea, 52 (2), 159-163.
- xxxviii. Yelli, F. 2013. Induksi Pembentukan Kantong dan Pertumbuhan Dua Spesies Tanaman Kantong Semar (*Nepenthes* spp.) Pada Berbagai Konsentrasi Media Ms Secara In Vitro. Jurnal Agrotropika 18(2): 56-62