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Research Article

Diversity of Insects Trapped in *Nepenthes* at Gunung Kuyit Forest, Jambi Province, Indonesia

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Abstract

Background and Objective: *Nepenthes* is a marsupial plant that is a modification of the leaf tip and serves to trap insects. The difference in the position of the pitcher is expected to distinguish the insects that inhabit it. One of the locations *Nepenthes* was Gunung Kuyit which is included in the Kerinci Seblat National Park Area. Insects trapped in the *Nepenthes* can be studied through taxonomic studies. The objectives of this study were to determine the diversity of insects trapped in the *Nepenthes* and to know the species of *Nepenthes*. **Materials and Methods:** The research was conducted from February to May, 2022. The study used a survey method by direct observation in the field. **Results:** The insects found in the *Nepenthes* consisted of 3 orders, 7 families and 10 species. The most insects found to be *Crematogaster* sp., (82 individuals) and the least insects *Sceliphron* sp. and *Dasiops* sp. (5 individuals). At the research site, three species of *Nepenthes*, *N. bongso*, *N. gymnamphora* and *N. inermis* at an altitude of 1,768-1,993 meters above sea level (m.a.s.l.). **Conclusion:** The insect diversity index in the upper pitcher was 1.79 and for the lower pitcher position was 1.31, so it was categorized as a medium level.

Key words: Insect, diversity, pitcher plant, *Nepenthes*, Sumatra

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Nepenthes is a plant typical of the tropics known as pitcher plant, including vines that have pitchers which are modifications of the leaf tips and their function is to trap insects or other small animals pitcher *Nepenthes* contain fluid to attract insects, trap insects or other small animals into the pitcher^{1,2} and are equipped with multicellular glands to obtain nutrients from the trapped animals³.

Handayani⁴ conducted a research on insects that visited one of the pitcher plants (*Nepenthes mirabilis*) from East Kalimantan, Indonesia. *Nepenthes mirabilis* Druce is a commercial ornamental pitcher plant belonging to the Nepenthaceae. The plant is used in traditional medicine, rope-making, handicraft and bouquets. The staminate inflorescences were visited by a variety of flower visitors, ranging from stingless bees (*Trigona* spp.), ants, wasps, flies (hoverflies and green bottles), moths and mosquitoes⁴.

Sumatra had 39 species of *Nepenthes*, which were previously known to occur in only 29 species⁵. Sumatra Island has several national parks, one of which is the Kerinci Seblat National Park. One part of Kerinci Seblat National Park is Gunung Kuyit in Jambi Province. This area is one of the habitats for phytotelmata (*Nepenthes*) plants. Based on the preliminary survey in the field, it is suspected that there are several species of *Nepenthes* and several species of insects found in the bag. However, there is limited information regarding the insects found and *Nepenthes*. Based on these problems, to obtain more detailed information, especially the biological aspects (species diversity) of *Nepenthes* and insects trapped in the pitcher, this research was carried out. This research was a contribution to the development of science in the field of diversity and can provide new information about insects in the highlands.

MATERIALS AND METHODS

Study area: This research was conducted from February to May, 2022. The research location is in Gunung Kuyit Forest, Kerinci Regency, Jambi Province. Gunung Kuyit is located in the Full River Resort area of Kerinci Seblat National Park classified as Type A (wet), a height of 2,151 meters above sea level (m.a.s.l.). The location of this mountain is approximately 32 km from Sungai Penuh City.

Collecting of insects in the field: Insect samples were taken from the *Nepenthes* containing water using a pipette/straw

that was adjusted to the size of the *Nepenthes*. In each insect sampling, the lower and upper pitcher were distinguished. The bottom pitcher is $\pm 0-15$ cm from the ground, while the top pitcher is $\pm 1-1.5$ m from the ground. Each pitcher position is represented by 10 pitchers. Types of insects that have a large size are taken using tweezers and put into a collection bottle. Samples in the form of larvae that are still alive are reared in the laboratory until they become adults and samples that die are immediately given 70% alcohol.

Samples in the form of live larvae were put into a sample bottle which had been filled with water from the *Nepenthes* itself and covered with gauze. When the larvae have hatched and become adults, the insects are transferred to the microtubes. To facilitate the identification process, insect samples were made into wet preserves by inserting insects into microtubes and given 96% ethanol, labeled and then specimens were identified based on their morphological characters.

Data analysis: Diversity data were analyzed by calculating:

Density⁶:

$$D = \frac{\text{Number of individual of insects}}{\text{Volume of water in the pitcher } Nepenthes}$$

Relative density:

$$RD (\%) = \frac{\text{Density of a species}}{\text{Density of whole species}} \times 100$$

Attendance frequency:

$$AF (\%) = \frac{\text{Number of bags containing insects}}{\text{Total number of bags}} \times 100$$

Insect diversity (H'): Insect species diversity was calculated using the Shannon-Wiener Diversity Index⁷:

$$H' = -\sum p_i \ln p_i$$

Information:

- H' = Shannon Wiener Diversity Index
- p_i = Number of species or relative abundance (n_i/N)
- N = Total number of individuals of all species
- n_i = Number of individuals

Index criteria:

- <1 = Low diversity
- 1-2 = Medium diversity
- >2 = Diversity high

Insect similarity index: The similarity of insect species between *Nepenthes* and between pouch positions can be calculated using the Sorensen Similarity Index⁸:

$$S = \frac{2C}{A+B}$$

Information:

- S = Similarity Index
- C = Number of the same insect species in two different communities

Compared:

- A = Number of insect species in pitcher A
- B = Number of insect species in pitcher B

RESULTS

***Nepenthes* species in Gunung Kuyit:** Results of research conducted in the Gunung Kuyit found three species of *Nepenthes*, namely *Nepenthes bongso* Korth (Fig. 1a), *Nepenthes gymnamphora* Ness (Fig. 1b) and *Nepenthes inermis* Danser (Fig. 1c). In the Gunung Kuyit Area, *N. bongso* was found only in 3 plots with a total of 23 individuals at an altitude of 1896-1988 m.a.s.l. The *N. gymnamphora* dominated the Gunung Kuyit Area, it was most commonly found in 7 plots with a total of 147 individuals. This species grows in mossy mountain forest habitats.

Diversity of insects trapped in *Nepenthes*: The results of the study on the diversity of insects trapped in *Nepenthes* in the

Gunung Kuyit obtained data on three orders with seven families and ten species. The three orders were Blattodea (one species), Diptera (three species) and Hymenoptera (six species). Most species of insects were found in the order Hymenoptera, family Formicidae. There were four species of the Formicidae family, namely *Crematogaster* sp., *Paratrechina longicornis*, *Tapinoma melanocephalum* and *Tetramorium khepera*.

Insect community structure in *Nepenthes*: In the pitcher of *N. bongso*, the total density was found to be 0.052 ind mL⁻¹ in the upper pitcher and 0.014 ind mL⁻¹ in the lower pitcher position. In the upper pitcher, the highest density was obtained from *Culex* sp., with 0.038 ind mL⁻¹ and in the lower pitcher the highest density was obtained from *Crematogaster* sp., with 0.005 ind mL⁻¹. For the frequency of presence of insects based on the position of the pitcher, *N. bongso* in the upper pitcher has a frequency of presence ranging from 9.09-100%, while for the position of the lower pitcher, the frequency of presence ranges from 12.50-50.00% (Table 1).

The total density of *N. gymnamphora* was 0.038 ind mL⁻¹ in the upper pitcher and 0.143 ind mL⁻¹ in the lower pitcher. In the upper pitcher, the highest density was obtained from *Culex* species, with 0.009 ind mL⁻¹ and in the lower pitcher the highest density was obtained from *Crematogaster* sp. species, with 0.081 ind mL⁻¹ (Table 2).

For the frequency of insect presence based on the position of the pitcher, it was seen in *N. gymnamphora* for the position of the upper pitcher ranged from 4.35-21.74% and for the frequency of the presence of insects in the lower pitcher position ranged from 7.89-39.47%. The frequency of the presence of insects in the type of *N. gymnamphora* in both the upper and lower pitcher showed that the presence of insect species was generally accidental.



Fig. 1(a-c): *Nepenthes* species are found in Gunung Kuyit Forest, (a) *Nepenthes bongso*, (b) *Nepenthes gymnamphora* and (c) *Nepenthes inermis*

Table 1: Density, relative density and frequency of insect presence on *N. bongso* by pitcher position

| Order/family/species | a | | | b | | |
|---------------------------------|-------|-------|-------|-------|-------|-------|
| | D | RD | AF | D | RD | AF |
| Blattodea | | | | | | |
| Blattidae | | | | | | |
| <i>Blatta</i> sp. | 0.004 | 7.69 | 27.27 | 0 | 0 | 0 |
| Diptera | | | | | | |
| Culicidae | | | | | | |
| <i>Culex</i> sp. | 0.038 | 73.08 | 100 | 0.001 | 7.14 | 12.50 |
| Drosophilidae | | | | | | |
| <i>Drosophila melanogaster</i> | 0.005 | 9.69 | 26.36 | 0.001 | 7.14 | 12.50 |
| Lonchaeidae | | | | | | |
| <i>Dasiops</i> sp. | 0.002 | 3.85 | 18.18 | 0 | 0 | 0 |
| Hymenoptera | | | | | | |
| Formicidae | | | | | | |
| <i>Crematogaster</i> sp. | 0 | 0 | 0 | 0.005 | 35.71 | 12.50 |
| <i>Tapinoma melanocephalum</i> | 0 | 0 | 0 | 0.001 | 7.14 | 25.00 |
| <i>Tetramorium khepera</i> | 0 | 0 | 0 | 0.002 | 14.29 | 16.67 |
| <i>Paratrechina longicornis</i> | 0 | 0 | 0 | 0.004 | 28.57 | 37.50 |
| Ichneumonidae | | | | | | |
| <i>Diadegma semiclausum</i> | 0.001 | 1.92 | 9.09 | 0 | 0 | 0 |
| Sphecidae | | | | | | |
| <i>Sceliphron</i> sp. | 0.002 | 3.85 | 18.18 | 0 | 0 | 0 |
| Total density | 0.052 | | | 0.014 | | |
| Total individual of insects | 39 | | | 12 | | |

a: Upper pitcher position, b: Lower pitcher position, D: Density, RD: Relative density (%) and AF: Attendance frequency (%)

Table 2: Density, relative density and frequency of insect presence on *N. gymnamphora* based on pitcher position

| Order/family/species | a | | | b | | |
|---------------------------------|-------|-------|-------|-------|-------|-------|
| | D | RD | AF | D | RD | AF |
| Blattodea | | | | | | |
| Blattidae | | | | | | |
| <i>Blatta</i> sp. | 0.003 | 7.89 | 8.70 | 0 | 0 | 0 |
| Diptera | | | | | | |
| Culicidae | | | | | | |
| <i>Culex</i> sp. | 0.009 | 23.68 | 21.74 | 0 | 0 | 0 |
| Drosophilidae | | | | | | |
| <i>Drosophila melanogaster</i> | 0.003 | 7.89 | 8.70 | 0 | 0 | 0 |
| Lonchaeidae | | | | | | |
| <i>Dasiops</i> sp. | 0.001 | 2.63 | 4.35 | 0 | 0 | 0 |
| Hymenoptera | | | | | | |
| Formicidae | | | | | | |
| <i>Crematogaster</i> sp. | 0.007 | 18.42 | 17.39 | 0.081 | 56.64 | 39.47 |
| <i>Tapinoma melanocephalum</i> | 0.003 | 7.89 | 8.70 | 0.023 | 16.08 | 11.40 |
| <i>Tetramorium khepera</i> | 0.003 | 7.89 | 8.70 | 0.023 | 16.08 | 11.40 |
| <i>Paratrechina longicornis</i> | 0.003 | 7.89 | 8.70 | 0.016 | 11.19 | 7.89 |
| Ichneumonidae | | | 8.70 | | | |
| <i>Diadegma semiclausum</i> | 0.003 | 7.89 | 8.70 | 0 | 0 | 0 |
| Sphecidae | | | 8.70 | | | |
| <i>Sceliphron</i> sp. | 0.003 | 7.89 | 8.70 | 0 | 0 | 0 |
| Total density | 0.038 | | | 0.143 | | |
| Total individual of insects | 26 | | | 78 | | |

a: Upper pitcher position, b: Lower pitcher position, D: Density, RD: Relative density (%) and AF: Attendance frequency (%)

In the *N. inermis*, the total density was 0.066 ind mL⁻¹ in the upper pitcher and 0.148 ind mL⁻¹ in the lower pitcher. In the upper pitcher, the highest density was obtained from the species *Diadegma semiclausum* with 0.012 ind mL⁻¹ and in the lower pitcher, the highest density was obtained from the species *Crematogaster* sp., with 0.081 ind mL⁻¹. For the frequency of the presence of insects based on the position of

the pitcher, it is seen in *N. inermis* for the position of the upper pitcher ranged from 0.015-0.063 to 4.55-18.18% and for the frequency of the presence of insects in the lower pitcher position was 14.29-100% (Table 3). The frequency of the presence of insects in the *N. inermis* in both the upper and lower pitcher showed that the presence of insect species was generally accidental.

Table 3: Density, relative density and frequency of insect presence in *N. inermis* based on pitcher position

| Order/family/species | a | | | b | | |
|---------------------------------|-------|-------|------|-------|-------|-------|
| | D | RD | AF | D | RD | AF |
| Blattodea | | | | | | |
| Blattidae | | | | | | |
| <i>Blatta</i> sp. | 0.003 | 4.55 | 1.59 | 0 | 0 | 0 |
| Diptera | | | | | | |
| Culicidae | | | | | | |
| <i>Culex</i> sp. | 0.006 | 9.09 | 3.17 | 0.03 | 17.14 | 14.29 |
| Drosophilidae | | | | | | |
| <i>Drosophila melanogaster</i> | 0.006 | 9.09 | 3.17 | 0 | 0 | 0 |
| Lonchaeidae | | | | | | |
| <i>Dasiops</i> sp. | 0.006 | 9.09 | 3.17 | 0 | 0 | 0 |
| Hymenoptera | | | | | | |
| Formicidae | | | | | | |
| <i>Crematogaster</i> sp. | 0.009 | 13.64 | 4.76 | 0.081 | 46.29 | 100 |
| <i>Tapinoma melanocephalum</i> | 0.006 | 9.09 | 3.17 | 0.018 | 10.29 | 85.71 |
| <i>Tetramorium khepera</i> | 0.006 | 9.09 | 3.17 | 0.018 | 10.29 | 85.71 |
| <i>Paratrechina longicornis</i> | 0.009 | 13.64 | 4.76 | 0.028 | 16.00 | 100 |
| Ichneumonidae | | | | | | |
| <i>Diadegma semiclausum</i> | 0.012 | 18.18 | 6.35 | 0 | 0 | 0 |
| Sphecidae | | | | | | |
| <i>Sceliphron</i> sp. | 0.003 | 4.45 | 1.59 | 0 | 0 | 0 |
| Total density | 0.066 | | | 0.148 | | |
| Total individual of insects | 22 | | | 48 | | |

a: Upper pitcher position, b: Lower pitcher position, D: Density; RD: Relative density (%) and AF: Attendance frequency (%)

Table 4: Insect diversity index based on the position of the *Nepenthes* pitcher

| Type of <i>Nepenthes</i> | H ¹ | |
|------------------------------|----------------|----------------|
| | Top pitcher | Bottom pitcher |
| <i>Nepenthes bongso</i> | 1.04 | 1.57 |
| <i>Nepenthes gymnamphora</i> | 2.16 | 1.15 |
| <i>Nepenthes inermis</i> | 2.19 | 1.22 |

Insect diversity index in *Nepenthes*. The insect diversity index obtained at each position of the *Nepenthes* in the Gunung Kunyit Forest can be seen in Table 4. Insect diversity in the three species of *Nepenthes* both in the upper and lower pitcher positions was classified as moderate because the insect diversity index criteria reached 1.79 for the upper pitcher position and 1.31 for the lower pitcher position. Categorized into a medium level which means sufficient productivity, fairly balanced ecosystem condition and moderate ecological pressure.

Insect similarity Index in *Nepenthes*. The Sorensen similarity index is used to determine the similarity between the two communities being compared. The insect similarity index between *Nepenthes* species has a high value, above 50%, ranging from 58-65%. The highest insect similarity index value was found in the pitcher of *N. inermis* and *N. bongso*, which was 65%, which means that the similarity of insects found in the two *Nepenthes* pitcher was relatively the same.

The value of the insect similarity index based on the position of the pitcher on each type of *Nepenthes* obtained

varied, ranging from 12-88%. This indicated that the insects found in the upper and lower pitcher between *Nepenthes* species were relatively different, except for the insects found in the upper and lower pitcher of *N. gymnamphora* which had a high insect similarity index value of 88%, which means in the positions of the upper and lower pitcher. *Nepenthes gymnamphora* found relatively similar insects.

DISCUSSION

Ten insect species were found in *Nepenthes* pouches, the most common species were from the order Hymenoptera, belonging Formicidae, Ichneumonidae and Sphecidae families. Formicidae is the most common animal found in *Nepenthes*^{9,10}. Many ants on *N. mirabilis* eat nectar found on stems, leaf stalks, leaf sheets, tendrils and the inside of the bag. At the lid and mouth of the bag where the nectar is produced, many ants are trapped. The slippery inside of the pouch makes it difficult for the ants to get out¹¹.

Nepenthes gymnamphora is a common mountain *Nepenthes* species found because this species is spread in almost all mountainous habitats including Java⁵. *Nepenthes inermis* was found in 4 plots with a total of 78 individuals. This species is an endemic plant at the top of the Bukit Barisan Mountains which lines the west side of Sumatra. It was known that this species is only found in the provinces of West Sumatra and Jambi¹².

This study also found species of the order Diptera, family Culicidae in the form of larvae. The presence of enzymes contained in *Nepenthes* does not interfere with the life of the larvae so the larvae survive in the pitcher and can attract adult insects to come into the pitcher. These larvae are classified as Nepenthexene, which means that these animals do not need the presence of pitcher plants but benefit from the presence of pitcher plants. This family of Culicidae can breed in pitcher plant fluid, this is thought to be related to the high mobility ability possessed by adult Diptera, adult Diptera has well-developed eyes and a sense of smell and these insects find pouches to lay eggs¹³. In Borneo, the pitchers of *N. rafflesiana* are therefore, more than simple pitfall traps and the digestive fluid plays an important yet unsuspected role in the ecological success of the species. Ten orders comprising only 17 families of arthropods, mostly insects, could be identified from the lower pitchers, while 11 orders and up to 59 families were identified from the upper pitchers¹⁴.

The species of insects whose identification was only up to the genus were caused by the samples obtained which were still in the form of larvae and in a state of death and some parts of their bodies were damaged. Judging from the position of the bag, this study found a higher number of insects in the lower pitcher (145 individuals) when compared to the upper pitcher (80 individuals). In the lower pitcher, the volume of water is more than in the upper pitcher. In addition to the water in the pitcher, rainwater can also enter through the leaf water droplets that are around the mouth of the pitcher. In addition to the volume of water, nutrients are also more in the lower pitcher than the upper bag because the bottom pitcher opens earlier than the top pitcher¹⁵.

The frequency of the presence of insects in the *N. bongso* species, both in the upper and lower pitcher, shows that the presence of insect species is generally accidental. The species is accidental if its presence frequency is 0-25%, accessory if its presence frequency is 25-50%, constant if its presence is 50-75% and absolute if its presence frequency is >75%. Accidental type is a type that rarely exists, accessory type is a type that sometimes exists, constant if it often exists and absolute if it always exists. It can be concluded that the most common insect found in *N. bongso* is in the upper pitcher position which is dominated by *Culex* sp. This is because the pitcher of *N. bongso* has a large size and a large volume of water so many flying insects are found, such as those from the Culicidae family, which tend to lay their eggs in the upper pitcher.

Upper pitchers were shown to trap higher numbers of arthropods than lower ones, partly because they exhibited a

higher overall attraction and especially because they had a more efficient system of special retention of flying prey. Upper pitchers not only captured more arthropods than lower pitchers (up to three times more) but they also had a larger prey spectrum¹⁴. In the lower pitcher of *N. gymnamphora*, the most common insects found were from the family Formicidae, species *Crematogaster* sp., this is because the habitat of *N. gymnamphora* was found growing on soil covered with litter. *Crematogaster* sp., builds their nests in the trunk cavity using grass and litter tissue¹⁵.

The results of research on insects at the bottom and top of the five species of *Nepenthes* in North Sumatra, the highest number of individual insects found in *Nepenthes* was from the Hymenoptera order (family Formicidae)¹⁶. While the results of research on Gunung Kunyit Forest also found Hymenoptera which was found in *Nepenthes* pitcher plants. Based on this statement, *Crematogaster* sp., which is commonly found in the litter in the Gunung Kunyit Forest ecosystem, is suspected of using litter to build their nests and then being attracted to the unique pouch shape of *N. gymnamphora* with a characteristic pouch that has red spots and is then trapped in the pitcher.

The insect similarity index between *Nepenthes* species has a high value, above 50%, ranging from 58-65% which means that the similarity of insects found in the two *Nepenthes* pitchers was relatively the same. This was presumably because the pitcher of *N. inermis* and *N. bongso* have a place with the same characteristics. If the value of the similarity index is closer to 100%, it means that the two communities being compared have relatively the same species composition, while if the Sorensen similarity index value is close to 0%, it means that the species composition between communities is relatively different¹⁷.

CONCLUSION

In the Gunung Kunyit, three species of pitcher plants (*Nepenthes*) were found, namely *Nepenthes bongso*, *N. gymnamphora* and *N. inermis* at an altitude of 1,768-1,993 m.a.s.l. Insects found in the *Nepenthes* pitcher in the Gunung Kunyit consist of three orders with seven families and ten species. The most insects were found in *Crematogaster* sp., with as many as 82 individuals and the least insects were found in *Sceliphron* sp. and *Dasiops* sp., each with 5 individuals. The insect diversity index in the upper pitcher is 1.79 and for the lower pitcher position is 1.31, so it is categorized into a medium level.

SIGNIFICANCE STATEMENTS

This study provides important information regarding insect diversity in pitcher plants (*Nepenthes*). This research is a contribution to the development of science in the field mainly to know insect diversity and can provide new information about insects in the highlands.

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