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PREY COMPOSITION OF Nepenthes gymnamphora Reinw. Ex Nees AT MOUNT BISMO, DERODUWUR HIKING TRAIL, WONOSOBO, CENTRAL JAVA

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ABSTRACT

Nepenthes gymnamphora (kantong semar, paleotropic pitcher plant) is a carnivorous plant that spreads across the mountains of Java, one of which is on Mount Bismo, Dieng Mountains, Central Java. The prey composition N. gymnamphora has not been studied before. The purpose of this study was to identify the composition of prey of N. gymnamphora in the Deroduwur Hiking Trail, Mount Bismo, Wonosobo, Central Java. The method used was the identification of prey in the pitcher that has been opened, both the upper and lower pitcher types. The main prey of N. gymnamphora are invertebrates from the ordo of Hymenoptera, Blattodea, Diptera, Araneae, and Diplura. Based on the prey composition analysis, there was a tendency for pitcher dimorphism, namely the upper pitcher of N. gymnamphora tended to contain flying invertebrates, while the lower pitcher tended to contain terrestrial invertebrates. This is influenced by the morphology of the pitcher. The upper pitcher tends to be lighter in color than the lower pitcher so that it is more attractive to fly invertebrates. In addition, the pitcher of N. gymnamphora provides a microhabitat for the larvae of Culicidae and Syrphidae.

Key words: *carnivorous plants, palaeotropic pitcher plant, pitcher dimorphism, pitcher morphology*

INTRODUCTION

Nepenthes is a plant known for its uniqueness as a carnivorous plant. The name of the *kantong semar* is derived from the unique feature of this plant, namely the pitcher-shaped (*kantong*) trap organ. This organ is a modification of the leaf tip tendril. The adaptation *Nepenthes* as a carnivorous plant aims to meet nutritional needs because it generally lives in nutrient-poor habitats such as habitats with thin and rocky soil layers, acid soil, undergoing nutrient leaching, secondary ecosystems, or as epiphytic plants (Mansur 2012).

Nepenthes can trap various prey, especially from the class of arthropods to get nutrition. Inside the *Nepenthes* pitcher, some enzymes and bacteria help to break down protein and chitin molecules from their prey (Siegara and Yogiara 2009). The trapping ability and composition of trapped prey are influenced by several factors such as pitcher structure (Moran and Clarke 2010; Clarke and Moran 2016), pitcher types (Gaume *et al.* 2016), and external factors such as climate (Moran *et al.* 2013; Clarke and Moran 2016). Common prey that is found in the *Nepenthes* pitcher is from the order of Diptera, Blattodea, Coleoptera, Thysanoptera, Hymenoptera, and Lepidoptera (Chin *et al.* 2014). The dominant prey insect taxa of various *Nepenthes* in Sumatra and Kalimantan are Formicidae (Chin *et al.* 2014; Maysarah 2016). However, *Nepenthes* pitchers are often attractive or modified to trap non-arthropod taxa.

Some species *Nepenthes* have specific strategies for trapping prey or in symbiosis with organisms from taxa other than arthropods. The pitcher morphology determines the difference in prey preferences, especially in the pitcher lip (peristome), wax zone, and digestive zone (Bauer *et al.* 2012). For example, *Nepenthes albomarginata* has a lichen-like peristome structure that attracts a genus of termites and *Nepenthes lowii* 's pitcher structure allows the mountain shrew *Tupaia montana* to come and defecate in its pitcher (Pavlovič 2012). This specification mainly appears in species that are in the same habitat to avoid nutrient uptake competition between species (Chin *et al.* 2014).

Studies on the prey of *Nepenthes* have been carried out although they have not covered the entire species. In addition, these studies have not represented the entire bioregion of the distribution of *Nepenthes*, including those on the island of Java. *Nepenthes gymnamphora* is one of 3 species of *Nepenthes* in Java whose population is getting depressed due to habitat degradation and poaching. The natural distribution of *N. gymnamphora* is limited to habitats in the mountains of Java at an altitude of 1000-2750 m asl (Batoro and Wartono 2017). One of the important habitats of *N. gymnamphora* that is threatened due to increasingly widespread human activities is on Mount Bismo which is included in the Dieng Mountains, Central Java (Iqbal 2015; Syamsul *et al.* 2017, Mayangsari *et al.* 2017). Research on the prey composition of *N. gymnamphora* has been conducted by Rangkuti *et al.* (2015) whose samples were taken from Mount Aseupan, Banten. However, the study only identified prey from insect taxa.

The purpose of this study was to identify the prey of *N. gymnamphora* that grows on Deroduwur Hiking Trail, Mount Bismo. Research on the prey composition of *N. gymnamphora* is one of the basic aspects of understanding the bioecology of this species, especially in terms of prey trapping mechanisms. Research on the prey composition of *N. gymnamphora* on Mount Bismo is expected to be a comparison, see the potential for prey other than insect taxa, and become the basis for studies of trapping strategies in *N. gymnamphora*.

RESEARCH METHOD

Data collection was carried out on the hiking trail of Deroduwur Village, a protected forest area of Mount Bismo, Kejajar District, Wonosobo Regency, Central Java, in April-May 2021. The tools used in this study included: sample bottles, measuring tubes, pH meters, and a stereomicroscope. The materials used in this study were ethanol and pitcher fluid samples of *N. gymnamphora*. The objects observed in this study were pitcher fluids and prey of *N. gymnamphora* that were found on Mount Bismo.

The pitcher fluid sample was selected by purposive sampling, specifically by selecting pitchers that were already open and filled with prey from all the individuals present at the location. Of the 15 *N. gymnamphora* at the study site, only 7 individuals were accessible and had pitchers that met the criteria. Obtained 11 samples of pitcher fluid consisting of 4 lower pitchers and 7 upper pitchers from these 7 individuals

Fluids were taken from at least one *Nepenthes* that had been opened from each individual found. Prey was identified from organisms trapped in *Nepenthes* pitcher fluid. The pitcher liquid containing the prey was preserved by adding 70% ethanol and stored in a sample bottle. Then, these samples were counted and identified using an identification book (*Freshwater Invertebrates* and *Pest of Crops in Indonesia*), a website (http://www.bugguide.net), and an artificial intelligence-based identification application (iNaturalist).

RESULT AND DISCUSSION

1. Characteristics of Pitcher Fluid

Volume and pH analysis were taken from 10 samples of pitcher fluid from 7 individuals of N. gymnamphora consisting of 4 upper and 6 lower pitchers. Evaluated from the results of the analysis, the upper pitcher tends to have a larger volume than the lower pitcher even though each pitcher has a fairly large volume range (Table 1). While the pH is not much different in each type of pitcher. The liquid N. gymnamphora was identified as having a pH with a weak acid category. The acidity of the Nepenthes is influenced by proton pump activity and/or nutrient ion transport that supports enzymatic activity (Gaume et al. 2016).

2. Prey Composition

Analysis of prey trapped in 11 pitcher fluid samples (4 lower pitchers and upper 7 pitchers) from 7 individuals. The total trapped prey was 155 individuals in the upper pitcher and 34 individuals in the lower pitcher. The prey taxa are quite numerous from the invertebrate phylum (Figure 1). The upper pitcher has 12 orders while the lower pitcher contains 8 orders with a total of 14 orders that fall into the classes of Insecta, Arachnida, Myriapoda, Malacostraca, and Gastropods. The most trapped invertebrate orders were Hymenoptera 65.61%, Blattodea 9.03%, Diptera 5.82%, Araneae 5.29%, and Diplura 4.76%.

All of these orders except Diptera are found in each pitcher type. The upper pitcher tends to trap a more diverse order of invertebrates than the lower pitcher. This can be influenced by the number of samples of the upper pitcher which is more than the lower pitcher. However, the difference between the orders of invertebrates trapped in the upper and lower pitches is the order which generally has wings and can fly. The orders of winged and flightless invertebrates found only in the upper pitcher are Diptera and Orthoptera. Meanwhile, the order of invertebrates found only in the lower pitcher is Slocopendromorpha which are generally terrestrial arthropods.

Most prey orders belong to the class of Insecta, namely Hymenoptera, Blattodea, Diptera, Diplura, Coleoptera, and Orthoptera (Figure 2). The prey composition *N. gymnamphora* on Mount Bismo was quite different from that of *N. gymnamphora* on Mount Aseupan, Banten, which consisted of Hymenoptera, Coleoptera, Diptera, and Orthoptera (Rangkuti *et al.* 2015). Common prey found in the *Nepenthes* is those of the orders Diptera, Blattodea, Coleoptera, Thysanoptera, Hymenoptera, and Lepidoptera (Chin *et al.* 2014).

Table 1 Volume and pH of Nepenthes gymnamphora.

Type of pitcher	Average volume (ml)	Average pH
Upper pitcher	22±13.5	5.8±1.6
Lower pitcher	16±9.4	5.7±0.9

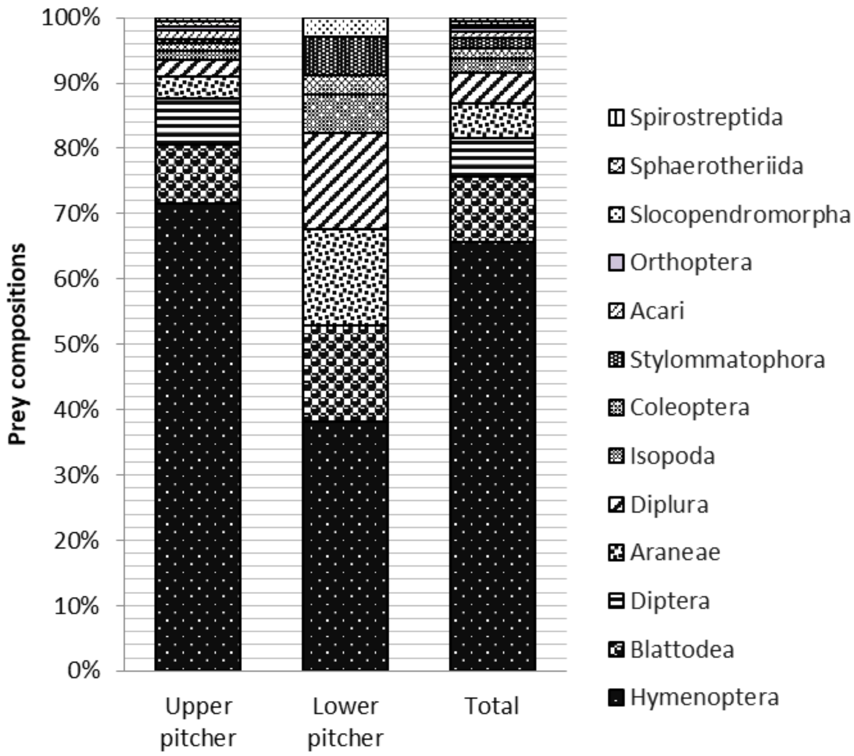

Figure 1 Prey compositions of *Nepenthes gymnamphora*

Figure 2 Example *of Nepenthes gymnamphora prey*, (a) Order Balttodea scale 3 mm, (b) Hymenoptera scale 3 mm, (c) Diptera scale 2 mm, (d) Araneae scale 4 mm, (e) Sphaerotheriida scale 5 mm, (f) Isopods scale 3 mm.

Prey composition of *Nepenthes* can be influenced by environmental conditions that affect insect diversity as well as field and *Nepenthes* conditions during sampling. Variations in prey composition can be influenced by pitcher age which affects trapping efficiency (Bauer *et al.* 2009). Another influence is the level of digestibility of prey in the pitcher. Some taxa of prey, especially small ones such as Diplura and Diptera, will be difficult to identify if a sample of pitcher fluid is taken after secretion of digestive enzymes has occurred. The enzymes chitinase and protease secreted by *Nepenthes* can digest part or all of the body of these small organisms (Higashi *et al.* 1993).

The composition of prey in the pitcher type is influenced by the structure of the pitcher. The upper and lower pitchers of *N. gymnamphora* have different structures, especially in shape and color. The upper pitcher has a dominant color of green with a purplish red pattern with green or reddish lips, while the lower pitcher is predominantly purplish red with green lips. The contrast pattern in the upper pitcher of *Nepenthes* serves to attract insects that perceive light in the ultraviolet spectrum, especially flying insects (Moran *et al.* 1999; Baurer *et al.* 2009). An unattractive lower pitcher serves to reduce the risk of the overabundance of prey which can trigger pitcher rot and protection from herbivores (Moran 1996; Gilbert *et al.* 2018). Other factors for attracting prey include the diameter of the pitcher opening, the cone of the pitcher, aroma, nectar, and the structure of the pitcher's lip which have not been studied much in *N. gymnamphora* (Bauer *et al.* 2009; Bauer *et al.* 2012; Gaume *et al.* 2016).

Pitchers of *N. gymnamphora* are also a microhabitat for Diptera larvae, namely mosquitoes (Culicidae) and hoverflies (Syrphidae) (Figure 3). Most of the Diptera larvae live in the upper pitcher, namely 117 Culicidae larvae and 18 Syrphidae larvae, while 22 Culicidae larvae and 7 Syrphidae larvae are in the lower pitcher. Diptera larvae with *Nepenthes* are known to form a symbiotic mutualism. The role of Diptera larvae is to assist in the digestion of prey and nutrient sequestration in the *Nepenthes gracilis* (Lam *et al.* 2017). Culicidae larvae as organic particle feeders and Syrphidae as scavengers and predators for Culicidae larvae help to decompose the prey of *Nepenthes* more quickly (Mogi and Yong 1992; Adlassnig *et al.* 2011; Lam *et al.* 2019).

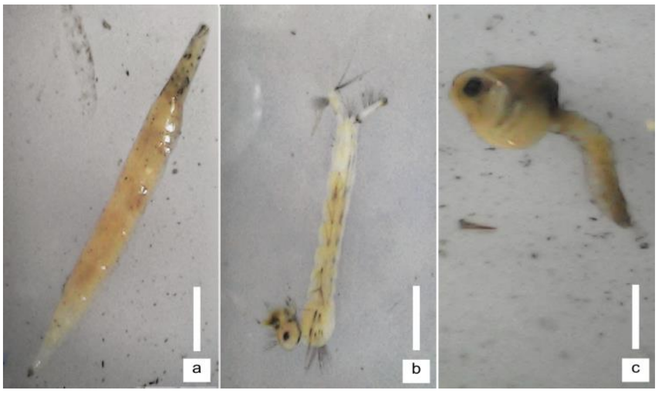

Figure 3 Diptera larvae living in the pitcher of *Nepenthes gymnamphora,* (a) Syrphidae larvae scale 2 mm, (b) Larvae of Culicidae scale 2 mm, (c) Pupae Culicidae scale 3 mm.

CONCLUSION

The prey of *N. gymnamphora* is dominated by invertebrates from the orders of Hymenoptera, Blattodea, Diptera, Araneae, and Diplura. The upper and lower pitchers of *N. gymnamphora* have different tendencies in trapping prey due to the effect of pitcher dimorphism. The types of prey that can fly tend to be trapped in the upper pitcher. While the bottom pitcher tends to trap terrestrial invertebrates. In addition, the pitcher of *N. gymnamphora* is also a microhabitat for larvae of Culicidae and Syrphidae with a symbiotic mutualism relationship.

REFERENCES

Adlassnig W, Peroutka M, Lendl T. 2011. Traps of carnivorous pitcher plants as a habitat: Composition of the fluid, biodiversity and mutualistic activities. *Ann Bot*. 107(2):181–194. doi:10.1093/aob/mcq238.

Batoro J, Wartono A. 2017. Review Status the *Nepenthes* (Nepenthaceae) from Java, Indonesia. *Indian J Plant Sci*. 6(1):12–16. http://www.neppy.ru/sites/default/files/java.pdf.

Bauer U, Clemente CJ, Renner T, Federle W. 2012. Form follows function: Morphological diversification and alternative trapping strategies in carnivorous *Nepenthes* pitcher plants. *J Evol Biol*. 25(1):90–102. doi:10.1111/j.1420-9101.2011.02406.x.

Bauer U, Willmes C, Federle W. 2009. Effect of pitcher age on trapping efficiency and natural prey capture in carnivorous *Nepenthes rafflesiana* plants. *Ann Bot*. 103(8):1219–1226. doi:10.1093/aob/mcp065.

Chin L, Chung AYC, Clarke C. 2014. Interspecific variation in prey capture behavior by co-occurring *Nepenthes* pitcher plants: Evidence for resource partitioning or sampling-scheme artifacts? *Plant Signal Behav*. 9 JAN:37–41. doi:10.4161/psb.27930.

Clarke C, Moran JA. 2016. Climate, soils and vicariance - their roles in shaping the diversity and distribution of *Nepenthes* in Southeast Asia. *Plant Soil*. 403(1–2):37–51. doi:10.1007/s11104-015-2696-x.

Gaume L, Bazile V, Huguin M, Bonhomme V. 2016. Different pitcher shapes and trapping syndromes explain resource partitioning in *Nepenthes* species. *Ecol Evol*. 6(5):1378–1392. doi:10.1002/ece3.1920.

Gilbert KJ, Nitta JH, Talavera G, Pierce NE. 2018. Keeping an eye on coloration: Ecological correlates of the evolution of pitcher traits in the genus

Nepenthes (Caryophyllales). *Biol J Linn Soc*. 123(2):321–337. doi:10.1093/biolinnean/blx142.

Higashi S, Nakashima A, Ozaki H, Abe M, Uchiumi T. 1993. Analysis of feeding mechanism in a pitcher of *Nepenthes hybrida*. *J Plant Res*. 106(1):47–54. doi:10.1007/BF02344372.

Iqbal M. 2015. Karakterisasi morfologis dan molekular kantong semar (*Nepenthes* spp.) di Gunung Prau dan Kembang, Jawa Tengah [thesis]. Yogyakarta: Universitas Gadjah Mada.

Lam WN, Chong KY, Anand GS, Wah Tan HT. 2017. Dipteran larvae and microbes facilitate nutrient sequestration in the *Nepenthes gracilis* pitcher plant host. *Biol Lett*. 13(3). doi:10.1098/rsbl.2016.0928.

Lam WN, Chou YY, Leong FWS, Tan HTW. 2019. Inquiline predator increases nutrient-cycling efficiency of *Nepenthes rafflesiana* pitchers. *Biol Lett*. 15(12). doi:10.1098/rsbl.2019.0691.

Mansur M. 2012. Laju Penyerapan CO2 pada Kantong Semar (*Nepenthes gymnamphora* Nees). *J Tek Lingkung*. 13(1):59–65.

Mayangsari R, Susanto AH. Yuniaty A. 2017. Profil RAPD tanaman kantung semar beberapa koleksi Kebun Raya Baturraden. *Biosfera.* 34(2):89-97. DOI: 10.20884/1.mib.2017.34.2.484.

Maysarah. 2016. Autekologi *Nepenthes ampullaria* Jack. di Cagar Alam Mandor Kalimantan Barat [thesis]. Bogor: Institut Petanian Bogor.

Mogi M, Yong HS. 1992. Aquatic arthropod communities in *Nepenthes* pitchers: the role of niche differentiation, aggregation, predation and competition in community organization. *Oecologia*. 90(2):172–184. doi:10.1007/BF00317174.

Moran JA. 1996. Pitcher dimorphism, prey composition and the mechanisms of prey attraction in the pitcher plant *Nepenthes rafflesiana* in Borneo. *J Ecol*. 84(4):515. doi:10.2307/2261474.

Moran JA, Booth WE, Charles JK. 1999. Aspects of pitcher morphology and spectral characteristics of six Bornean Nepenthes pitcher plant species: Implications for prey capture. *Annals of Botany*. 83(5):521-528.

Moran JA, Clarke CM. 2010. The carnivorous syndrome in *Nepenthes* pitcher plants: Current state of knowledge and potential future directions. *Plant Signal Behav*. 5(6):644–648. doi:10.4161/psb.5.6.11238.

Moran JA, Gray LK, Clarke C, Chin L. 2013. Capture mechanism in Palaeotropical pitcher plants (Nepenthaceae) is constrained by climate. *Ann Bot*. 112(7):1279–1291. doi:10.1093/aob/mct195.

Pavlovič A. 2012. Adaptive radiation with regard to nutrient sequestration strategies in the carnivorous plants of the genus *Nepenthes*. *Plant Signal Behav*. 7(2):295–297. doi:10.4161/psb.18842.

Rangkuti A, Firdaus N, Rachmawati D. 2015. Studi komposisi serangga yang terperangkap kantong semar (*Nepenthes gymnamphora*) di Gunung Aseupan, Pandeglang, Banten. Di dalam: Setyawan AD, Ridwan M, Lestari DF, Pamungkas DW, Kharismamurti K, Romadhon MA, Liza N, editor. *Seminar Nasional Masyarakat Biodiverstias Indonesia;* 2015 Jun 13, Bandung, Indonesia. Surakarta: Universitas Sebelas Maret. pg. 91-135. [No abstr unkown].

Siegara A, Yogiara Y. 2009. Bacterial Community Profiles in the Fluid of Four Pitcher Plant Species (*Nepenthes* spp.) Grown in a Nursery. *Microbiol Indones*. 3(3):109–114. doi:10.5454/mi.3.3.3.

Syamsul H, Puspitaningtyas DM, Hartini S, Munawaroh E, Astuti IP, Wawangningrum. 2017. *Eksplorasi Flora: 25 Tahun Menjelajah Rimba Nusantara.* Jakarta: LIPI Press.