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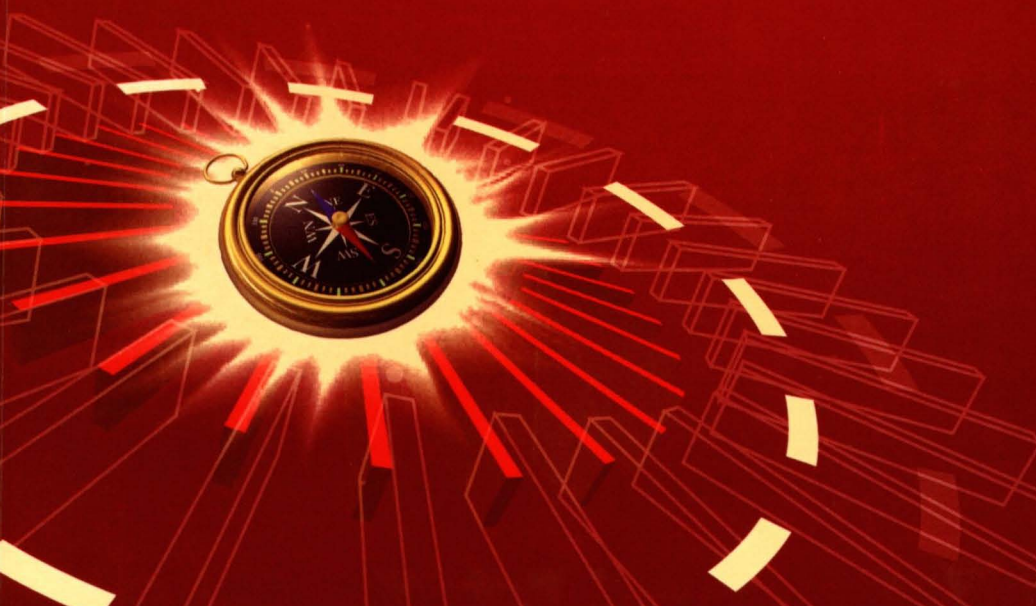

Population Density and Age Structure of *Nepenthes gracilis, Nepenthes ampullaria, Nepenthes rafflesiana* and *Nepenthes hookeriana*

Liliwirianis Nawi

ABSTRACT

A study of population density and age structure of Nepenthes gracilis, N. ampullaria, N. rafflesiana and N. hookeriana was carried out in 0.1 ha plot at 150 m, 500 m, 550 m and 600 m altitude along the slope from the foothill to the summit of Gunung Pulai, Johor. Age structures of all four species studied were dominated by matured plants with 276 individuals, followed by 128 saplings and 88 of seedlings. Meanwhile, estimated density of Nepenthes species in 0.1 hectares plot was shown to differ in different altitudes. Highest estimated density recorded by N. ampullaria with 660/ha, followed by N. rafflesiana with 420/ha, then distantly followed by N. gracilis and N. hookeriana were respectively 80/ha and 70/ha.

Keywords: *population density, age structure, Nepenthes gracilis, N. ampullaria, N. rafflesiana N. hookeriana*

Introduction

Peninsular Malaysia is one of the centre of distribution of tropical pitcher plants of the world. These pitchers belong to genus *Nepenthes,* known locally in Malaysia as *periuk kera* (Malays, Peninsular Malaysia), *entuyud* (Iban), *akah tuyud* (Melanau, Matu and Daro), *somboi-somboi* (Brunei Malays) and *kekuanga* (Dusun, Sabah) (Adam & Hafiza, 2007).

Nepenthes are carnivorous plants which produce jug-shaped pitcher – designed to attract, trap and digest its prey, especially small insects. In Peninsular Malaysia, there are 81 species of *Nepenthes* have been recorded. 61 species are endemic and the other 20 species are geographically widespread species (Adam, 1995; Jebb & Cheek,1997). Rohana (1988) was recorded 10 species and five hybrids of *Nepenthes* found in Peninsular Malaysia. However, the exact number of the species cannot be concluded since the genus forms hybrids very easily.

Materials and Methods

Plot Design

Four plots, each with a size of 10 m x 100 m were set up at 150 m, 500 m, 550 m and 600 m altitude along the slope from the foothill to just below the peak of Gunung Pulai, Johor. Each of the plots was subdivided into 10 subplots, each measuring 10 m x 10 m. Each of these subplots was treated as quadrate of sample. The LUX meter was used to get the light intensity of the plot.

The population density, D_i, were calculated by counting the total number of individuals or plants per sampling area by using this formula:

$$D_i = \frac{n_i}{A}$$

where D_i is density of the species I, n_i is the total number of individuals or plant counted in the sampling area, and A is the size sampling area (m^2 or hectare).

Age Population Structure

The age structure or life stages of pitchers plants is classified into seedlings, saplings, matured sterile, male matured plants and female matured plants. According to Adam (2002a, 2002b), the age structure of pitcher plants can be divided arbitrarily in three categories:

i. Seedlings: Seedlings represent the rosette stage and plant having the stem length which is less than 10 cm
ii. Sapling: Saplings are erects plants from 10 – 40 cm high, producing uncurled tendril and forming lower pitchers only
iii. Matured plants: Matured plants have the stem length of greater than 40 cm, producing curled tendrils, have both lower and upper pitcher. Fertile matured plants produced either male or female inflorescence of the stem apex.

Results and Discussion

Density of the Species

Density of *Nepenthes* species in 0.1 ha plot was different for all the species (as shown in Table 1 and Table 2). Previous study reported that this is normal since the density between species is different in certain area because only one species is dominant to the specific area (Adam, 2002a; Noratiza, 2002; Dayani, 2002).

A total of 492 pitcher plants which belong to four species of pitcher plants were enumerated in the study plot at 150 m, 500 m, 550 m and 600 m, within the area of 0.4 hectare. Thus, total estimated density were 1230/ha. The actual count and estimated density was shown to differ between species. The highest estimated density was recorded by *N. ampullaria* (660/ha), followed by *N. rafflesiana* (420/ha), *N. gracilis* (80/ha) and *N. hookeriana* (70/ha).

Table 1: Density per 0.1 ha of *Nepenthes* Species at Different Altitudes

Altitude (m)	Density of individual/0.1 ha			
	N. rafflesiana	*N. ampullaria*	*N. gracilis*	*N. hookeriana*
150	29	0	0	0
500	7	77	16	28
550	4	143	16	0
600	128	44	0	0

Table 2: Density per ha of Nepenthes Species at Four Altitudes

Altitude (m)	Di (N/ha)			
	N. rafflesiana	*N. ampullaria*	*N. gracilis*	*N. hookeriana*
150	290	0	0	0
500	70	770	160	280
550	40	1430	160	0
600	1280	440	0	0

N. rafflesiana

The highest density for the *N. rafflesiana* was recorded at 600 m at the summit zone of the mountain with 128/0.1 ha, 27 000 LUX of light density,

followed distinctively by the population at 150 m with 29/0.1 ha, then at 500 m and 550 m with 7/0.1 ha and 4/0.1 ha respectively. The study showed that the higher altitudes received light intensity less than the lower altitudes. However in this case, the light intensity cannot be used to measure the density of the species because this species lived both in low and higher light intensity. Field observation also showed that this species have a very strong preference to grow on the steep road embankment, and tolerate high cover of late succession secondary vegetation dominated by *Dicranopteris linearis*.

N. ampullaria

For *N. ampullaria*, the highest and the second highest density were recorded in the middle parts of the mountain slope which are 550 m and 500 m; the density of the species enumerated at these altitude were 143/0.1 ha and 77/0.1 ha. The highest density received 181 000 LUX light intensity and it was the highest light intensity value of all light intensity in all plots and the second highest density received 85 000 LUX.

The density of the species decreased abruptly to 44/0.1 ha at the 600 m. This species grew on the gentle and flat road embankment in open area but was absent in heavy thicket of ferns at 600 m altitudes. Meanwhile, the gentle road embankment, open vegetation and humidity at 500 m and 550 m favored the establishment of the species at these elevations.

N. gracilis

The density of *N. gracilis* was comparatively very low to the preceding species. The density recorded for the species at 500 m, 550 m were 16/0.1 ha with 85 000 LUX and 181 000 LUX of light intensity and no record at 150 m and 600 m with 133 000 LUX and 27 000 LUX. The open vegetation represented the early succession stage of the vegetation favoured the establishment of the species. Previous researchers found it as pioneered species in recently disturbed habitat and later were eliminated by tall secondary forest dominated by ferns and common secondary forest (Adam, 2002a; Noratiza, 2002; Nazuha, 2002; Normawati, 2002; Selle, 2002). According to them, low light intensity due to the shade caused by tall vegetation cover hindered the germination of the seed of the species.

N. hookeriana

For *N. hookeriana*, no plants were enumerated at 150 m, 550 m and 600 m. A total of 28 plants of the species were enumerated at 500 m altitudes. The light intensity in this area was 85 000 LUX. The differences in the density of these species at all elevations was governed by combination of ecological factors including soil texture, slope angle, light intensity, shade, altitude, dampness and succession stage of the habitat. The field observation showed that the species grew in wetter and open area of the vegetation.

Adam (2002a), Adam et al. (2005), and Noratiza (2002) recognized that local ecological factors, heterogeneity or different ecological setting were responsible for the differences in the population density between species and between the same species in different locality. The different ecological setting at different elevation on Gunung Pulai explained this variability.

Age Population Structure of the *Nepenthes*

In a regenerating or dynamic population, there was higher number of seedlings and sapling and fewer matured plants representing successive mortality as plants grow older (Adam, 2002a; Adam et al., 2005; Nazuha, 2002; Noratiza, 2002; Safiah, 1992; Selle, 2002). On the other hand, stable population was represented by almost equal number of seedling, sapling and matured plants. The dying population comprised of more adult than the juvenile plants.

Age structure of all four species being dominated by matured plants with 281 individuals, then followed by sapling with 135 individuals and 64 individuals for saplings. The age population structures of *N. rafflesiana*, *N. ampullaria*, *N. gracilis* and *N. hookeriana* at four different elevations on Gunung Pulai were shown in Table 3.

N. rafflesiana

Table 3 above showed that the populations of *N. rafflesiana* were dying populations at 150 m and 550 m, regenerating population at 500 m and stable population at 600 m. The populations of *N. rafflesiana* were dominated by matured plants and saplings and fewer seedling plants at 600 m with 59, 61 and 8 individuals. The matured plants grew well with *Dicranopteris linearis* and the fern thicket act as the support of the climbing plants of *N. rafflesiana* and stood well above the vegetation in

Table 3. The Age Population Structures of *N. rafflesiana*, *N. ampullaria*, *N. gracilis* and *N. hookeriana*

Altitude	Species	Matured	Sampling	Seedling
150	*N. rafflesiana*	18	9	2
	N. ampullaria	0	0	0
	N. gracilis	0	0	0
	N. hookeriana	0	0	0
500	*N. rafflesiana*	0	5	1
	N. ampullaria	50	9	21
	N. gracilis	11	4	1
	N. hookeriana	0	0	28
550	*N. rafflesiana*	4	0	0
	N. ampullaria	96	28	0
	N. gracilis	10	9	0
	N. hookeriana	0	0	0
600	*N. rafflesiana*	59	61	8
	N. ampullaria	33	10	3
	N. gracilis	0	0	0
	N. hookeriana	0	0	0

order to get enough supply of light which is vital for the survival of *N. rafflesiana*; the tall thicket of fern hindered the germination of the seed. The low light intensity due to shade by tall *D. linearis* accounted for the low number of *N. rafflesiana* seedlings at the altitude. Adam (2002a) called this type of age structures as mid-succession stage of *D. linearis*. The population at 550 m was represented by four mature plants of *N. rafflesiana*. The recent eroded soil on the road embankment in the study site account for the absent of seedling and sapling of the species. The open road embankment was favorable for the germination of the seeds of the species. It was envisaged that with unspecific time scale, many new plants of this species will emerge on eroded embankment.

At 500 m altitude, the populations of *N. rafflesiana* at 500 m comprised of five individuals of saplings and 1 seedling and no matured plants. The population at 150 m has 18 matured plants and 9 seedlings and 2 saplings. Masrimas (1979) studied the effect of light intensity on *Nephentes* and she concluded that the growth of *Nepenthes* species became slower with the decrease of light intensity. The light intensity recorded at 150 m and 500 m were 133 000 LUX and 85 000 LUX. The shade caused by other plants at these elevations reduced greatly

the light reaching the forest floor account for the germination failure of seeds of *N. rafflesiana.*

Population of *N. rafflesiana* at 150 m altitude contained 18 matured plants, 9 saplings and 2 seedlings. At this altitude, *N. rafflesiana* was confined in well-defined patch, grew in open areas, along the margin and underneath the small canopy of common shrub *Dicranopteris linearis* and *Dillenia suffructicosa. N. rafflesiana* can survive because juvenile of the species will succeed the dying matured plants if succeeded by *Dicranopteris linearis*, *Melastoma malabathricum* and *Dillenia suffructicosa* (Alex, 2002). Meanwhile Rohana (1988) discovered that *Dicranopteris linearis* was regarded as an indicator species for the existence of some *Nepenthes* species like *N. ampullaria, N. gracillis, N. hookeriana, N. albomarginata* and *N. rafflesiana.*

N. ampullaria

The dominancy of *N. ampullaria* matured plants is presented in Table 3. It became the predominant age structure of all the 3 plots except there was no occurrence of *N. ampullaria* in 150 m altitude. All the other plots showed that the species grew in the plots with all age structure. Healthy and regenerating population structure of pitcher plants comprised large number of seedlings and saplings and normally outnumbered the number of matured plants (Clarke 2001, 1997; Philips & Lamb, 1996).

Matured plants were great at 550 m altitudes, with 96 individuals and the sapling plants were also outnumbered in that plot with 28 individuals. However, the seedling plants dominated at 500 m altitudes with 21 individuals. Meanwhile, the most deficient of seedling plants occured in 600 m altitudes with 3 individuals and the plots also contained less number of mature plants – 33 individuals. The most deficient sapling plants were spotted at 500 m altitudes with 9 individuals.

N. gracillis

The age population structure on *N. gracillis* enumerated at four elevations is shown in Table 3. The population of this species was recorded at 500 m and 550 m. Both elevations recorded the occurrence of matured plants and saplings but no seedling was present at 550 m. At 500 m only one seedling was recorded. Matured climber plants predominated at 500 m with 11 individuals but at 550 m saplings dominated with 10 individuals. Both plots received high intensity of light in open area and along the

fringe of tall thicket of fern and on eroded embankment. The matured plants climbed among the fern thicket, protruded well above the vegetation cover to ensure enough light required by the plants to perform photosynthetic process needed for production of flowers. The seeds cannot germinate and seedling cannot thrive under the thick vegetation cover due to lack of light vital for the growth of pitcher plants (Adam, 2002a; Green, 1967; Masrimas, 1967; Shivas, 1984).

N. hookeriana

N. hookeriana was recorded at 500 m but was absent at the other three elevations. The population of this species comprised of 28 seedlings and no saplings and matured plants (Table 3). The species were restricted and growing together with mosses in moist area and open portion of the study plot. Shivas (1984) reported the species was a lowland species that grows in swampy areas and restricted to the southern half of the Peninsular Malaysia. The drier conditions of the habitats at the other three elevations were responsible for the failure of the species to grow there.

Conclusion

Density of *Nepenthes* species in per 0.1 hectares plot was shown to differ for all species in four altitudes studied. The age structure of *N. rafflesiana*, *N. ampullaria* and *N. gracilis* were dominated by matured plants except the *N. hookeriana* that was dominated by the seedlings. Further study on soil can be done to determine the contributing factors of the result of this study. Besides it can provide detailed information on all the species.

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LILIWIRIANIS NAWI, Faculty of Applied Science, Universiti Teknologi MARA Pahang. liliwirianis@pahang.uitm.edu.my