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Species Composition and Dispersion Pattern of Pitcher Plants Recorded from Rantau Abang in Marang District, Terengganu State of Malaysia

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Abstract: The study to determine the species composition and community structure of pitcher plants in Rantau Abang, Terengganu was carried out using plot method. *Nepenthes gracilis* was recorded in plots 1-3 at 10, 30 and 50 m, *N. rafflesiana* was recorded in P2 and *N. ampullaria* in P3. *Nepenthes gracilis* differs morphologically from the other two species by its sessile leaves, decurrent leaf base, angular stem shape, very thin peristome and partly glandular inner pitcher cavity wall. *Nepenthes ampullaria* differed by its panicle inflorescence, cuneate lids' shape, narrower than the mouth glandless, lower lid surface, bearing up to 6-flowered bracteolate pedicels and urceolate lower pitcher. *Nepenthes rafflesiana* differed by infundibulate and ellipsoid upper and lower pitcher, densely glandular lower lid surface, toothed inner peristome margin. Population structures of these species comprised of seedlings, saplings and matured plants. These species consist of 52.61% of juvenile stage (seedlings and saplings) and 47.39% of matured stage. A total 5.68 and 2.84% of these species population bear male and female inflorescence. Morisita's Index of Dispersion Pattern and Chi-square test showed that the dispersion pattern of all life stages of these species was significantly aggregated. Their I_d values were from 1.12 to 3.78. Matured plants and sapling of *N. gracilis* recorded the lowest and biggest I_d. These species grow in soil that is acidic and low organic matter content. *Nepenthes gracilis* grows in sandy loam, loam and sandy clay; *Nepenthes ampullaria* and *Nepenthes rafflesiana* grow in sandy clay and loam.

Key words: Tropics, secondary vegetation, *Nepenthes*, ecology and population structure

INTRODUCTION

Pitcher plants are fascinating group of carnivorous flowering plant, luxuriously growing in disturbed and natural tropical rainforest from sea level up to 2000 m in Peninsular Malaysia. The plants are climbing perennial. The flowers of pitcher plants are small and arranged along the stem known as inflorescences. The genus is dioecious in which the male and female inflorescence are borne on different plants. The members of the genus display a carnivorous habit: the pitchers developed on the tip of the leaf tendril are capable of attracting, trapping, killing, digesting and absorbing nutrients from their digestive prey (Siti Norhafizah and Adam, 2009; Phillipps and Lamb, 1996). This absorbing material enables pitcher plants to grow in very poor soil where otherwise they could not flourish (Mansur, 2002). The pitcher provides an ideal habitat for various types of fauna (Adam *et al*., 1994). In Peninsular Malaysia, the typical lowland species which occur in lowlands below 1000 m, includes *Nepenthes albo-marginata, N. ampullaria, N. benstonei, N. gracilis, N. mirabilis* and *N. rafflesiana* and *N. sharifah-hapsahii* (Adam *et al*., 2004, 2005, 2009; Adam and Hafiza, 2007). Some of these species can be found growing at altitude above 1000 m (Adam *et al*., 2009). Species of pitcher plants commonly found growing in mossy forest of tropical montane, shrubs along the roadside embankment, exposed ridges and on summit of mountains with gnarled vegetation of Peninsular Malaysia includes *N. sanguinea, N. gracillima* and *N. macfarlanei* (Hafiza and Adam, 2009). Pitcher plants were previous reported to grow in various type of habitats in tropical region of the world (Mansur, 2002). The lowland species generally grow in secondary vegetation often referred toas shrubs, belukar or padang. These species may also be found growing in heath forest or BRIS forest (Adam *et al*., 2005). Study on the community and population of pitcher plants of the highland and lowland species have carried out previously elsewhere in Peninsular Malaysia (Adam *et al*., 2004; Liliwirianis *et al*.,

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2009), Sabah (Adam, 2002a-c) and Sarawak (Adam and Ping, 2005). The study on general ecology, species composition and morphological description have also been previous carried out by various authors from various localities in Malaysia (Adam *et al*., 2005; Adam and Hafiza, 2006; Adam and Hamid, 2006). Research on the physico-chemical characteristics of the soil in pitcher plants habitat have only been carried out in the last decade (Adam *et al*., 2009; Hafiza and Adam, 2009). The study by Hafiza and Adam (2009) from Cameron Highlands, Pahang State of Malaysia showed that *Nepenthes sanguinea* and *Nepenthes macfarlanei* grow on acidic, humid sandy loam soil and with high organic matter content. The study by Adam *et al*. (2009) similarly showed that *Nepenthes gracilis, Nepenthes ampullaria* and *Nepenthes rafflesiana* similarly grew in acidic soil from heath forest in Endau-Rompin National Park in Pahang. However, the soil analysis showed that these species grew on various soil textures ranging from loam, sandy loam, clayed loam and sandy clayed loam. According to this study, *Nepenthes gracilis* grew well soil with high sand content and *Nepenthes rafflesiana and Nepenthes ampullaria* grew on soil with high clay content and capable of retaining water. The main objective of the study was to determine the species composition and structure community of the pitcher plant species in the study area.

MATERIALS AND METHODS

A plot measuring 10×100 m was established each respectively at 10, 30 and 50 m altitude at Rantau Abang in Marang District, Terengganu State of Malaysia in 2009. Each of these plots was each divided into 10 small compartments, each measuring 10×10 m. This division was required to determine the population pattern of pitcher plants species from the study site. The analysis of these data using Morisita's Index (Brower and Zar, 1977) of Dispersion needed this division.

The dispersion pattern of pitcher plant species according to three different life stages namely seedlings, saplings and matured plants as define by Adam *et al*. (2004) was obtained using Morisita's Index of Dispersion (I_d) and the departure of an observed dispersion pattern from randomness was identified using Chi-square test (χ^2).

According to Brower and Zar (1977), if the dispersion is random, then $I_d = 1.0$; if uniform, $I_d = 0$ and if maximally aggregated $I_d = n$.

The Chi-square test is necessary, to determine the departure of an observed dispersion from randomness.

Soil properties

pH determination: The soil for pH determination is mixed with water ratio to soil 1:5. Ten gram of soil that was mixed with 25 mL beaker was stirred with magnetic stirrer for 30 min. The soil pH is measured with pH meter (WTW INOLAB Level 1).

Soil texture: Soil texture was determine by pipette method (Gee and Bauder, 1986).

Soil organic matter analysis: Five to ten grams of air dried soil in crucible was put into the furnace at 400°C overnight. Then, the fully ignited sample was cooled in the desiccators and weighted the ash:

$$\%\,\text{LOI (Loss on Ignition)} = \frac{\text{Dry weight of soil-Ash weight}}{\text{Dry weight soil}} \times 100$$

RESULTS AND DISCUSSION

Species composition: Three species of pitcher plants were recorded from the plots at 10, 30 and 50 m. These species were *Nepenthes ampullaria, N. gracilis* and *N. rafflesiana*. *Nepenthes gracilis* was recorded at all elevations (10-50 m), whereas *N. rafflesiana* and *N. ampullaria* was recorded present in plots at 30 and 50 m, respectively. Combination of species of pitcher plants community may be the same or different between locality (Adam *et al*., 2004, 2009; Adam and Hafiza, 2007). Adam *et al*. (2009) recorded the same combination of species from Padang Tujuh as recorded by this study; whereas Adam and Hafiza (2007) recorded different combination of species that is *Nepenthes ampullaria, Nepenthes gracilis, Nepenthes mirabilis, Nepenthes sharifah-hapsahii* and *Nepenthes x trichocarpa* from Universiti Kebangsaan Malaysia Campus; Adam and Hamid (2006) found a combination of *Nepenthes ampullaria, Nepenthes gracilis, Nepenthes hookeriana, N. mirabilis* var. *echinostoma, Nepenthes rafflesiana* var. *subglandulosa* from Lambir Hill in Miri, Sarawak; Adam and Ping (2005) recorded *N. ampullaria, N. gracilis, N. mirabilis* and *N. rafflesiana* growing together in secondary belukar at Sungai Merah in Sibu, Sarawak.

Species description

Nepenthes ampullaria: Lower and upper stems are cylindrical in shape, the stems are climbing up to 5 m high and the stem diameters are 4-7 mm thick. The base of older stems produces many lateral rosettes with pitchers. Leaves of the climbing stems are shortly petiolate; the lamina are spathulate, elliptic to lanceolate in shape, rounded at the apex, the base gradually attenuates into the petiole; 3-5 pairs of longitudinal nerves, originating

from the midrib. Rosettes pitchers are urceolate in shape, with a pair of fringed wings running over the whole length. The mouths are horizontal and ovate in shape and peristome narrowly involved in the outer part, flat and almost vertical in the inner part. They have finely ribbed with 0.2 mm apart. The inner peristome margins are shortly toothed and inner pitcher cavity walls are wholly covered with over arched digestive glands. The lids are narrowly cuneate in shape, rounded the apex, as long as the mouth, mostly folded into 2 keels, without glandular crest on the lower surface and not covered with nectar glands. Spurs are simple or branched, inserted neat to the lid base. Pitchers of the lower leaves are similar to the rosettes. Inflorescence is a panicle; the panicle bears bracteolate flowered, each of the pedicels can produce up to 6 flowers and bears 1-2 flowered towards the tip.

Nepenthes gracilis: Lower and upper stems are triangular in shape, the stems are climbing up to 5 m high and the stem diameters are 2-5 mm thick. Leaves are sessile; the lamina are lanceloate to linear-lanceolate in shape with acute apex, the base extended or decurrent into two wings beyond one internode; the lamina have 3-5 pairs of longitudinal nerves, the nerves are originating from the leaf base. The shapes of lower pitchers are ventricose on the lower half and cylindrical on the upper half part, with a pair of fringed wings running over the entire length. The mouths of pitchers are orbiculate in shape and orientated obliquely, peristome are cylindrical and very thin with 1 mm thick. The peristome ribs and inner peristome teeth are inconspicuous with inner pitcher cavity wall are covered with digestive glands on the lower ventricose part and covered with layer of wax on the upper cylindrical part. The digestive glands are very slightly hidden by little extension of roof epidermal layer, this type of digestive glands are termed exposed glands in this study. The lids are orbiculate in shape and the bases are cordate, the lower lid surfaces are sparsely covered with nectar glands and without glandular crest. Spurs are simple and they are inserted very close to the lid base. Upper pitchers are like those of the lower pitchers. They differ from the upper pitchers by the present of two midribs instead of a pair of ringed wings running over their whole length. Inflorescence is a raceme; the raceme bears ebracteolate 1-flowered pedicel.

***Nepenthes rafflesiana*:** Lower and upper stems are cylindrical in shape, the stems are climbing up to 7 m high and the stem diameter is 4-10 mm thick. Leaves are petiolate; the lamina are elliptic, oblong to lanceloate in shape with apex rounded and the base is contracted into the petiole; the lamina have 4-5 pairs of longitudinal nerves, the nerves are originating from the base of the midrib; the petioles are 5-10 cm long and narrowly winged. Lower pitchers are ellipsoidal in shape and with pair of fringed wings running over the whole length. The mouths are ovate in shape and greatly elevated towards the lids. The peristome are flattened to cylindrical and they are coarsely ribbed with the ribs are 0.5-1 mm apart. The inner peristome margins are distinctly toothed, inner pitcher cavity walls are partly covered by digestive glands; the glands are almost covered by epidermal roofing extension termed in this study as overarched glands. The lids are orbiculate in shape, slightly vaulted, with 2 keels formed by two main nerves; there is no glandular crest on the lower lid surface. Spurs are simple and up to 15 mm long; it is inserted on the lid base. Upper pitchers are infundibulate of funneled in shape and with two prominent ribs instead of fringed wings running over the whole length in front. The mouths are ovate in shape, horizontal in front and strongly elevated towards the pitcher lids. The peristomes are flattened-cylindrical in shape forming a trapezoid in front and coarsely ribbed with 0.5-1 mm apart. The inner peristome margins are distinctly toothed and inner pitcher cavity walls are almost wholly covered with overarched digestive glands. The lids are orbiculate, with 2 keels and there is no glandular crest on the lower lid surface. Inflorescence is a raceme; the raceme bears ebracteolate 1-flowered pedicle.

DENSITY

The number of pitcher plant count is variable between study plots and between species (Table 1). A total of 880 pitchers plants representing *N. ampullaria, N. gracilis* and *N. rafflesiana* are recorded from these three plots with a total area of 0.3 ha. Thus, this count gave us an estimated density of 2933 ha^{-1}. Of these, 465 (52.83%) is recorded in P2, 235 (26.72%) and 180 (20.45%) pitcher plants are recorded, respectively in P1 and P3, respectively (Table 1). The high number of counts in P2 can be explained by the existence of loose ground covering and open sections of this plot. *Ploiarium alternifolium* and the loose ground cover of bracken ferns dominated the open sections of P2. These open or loose sections of the plot are conducive environment for the growth of these two pitcher plants species. The low number of count in P1 and P3 was due to the tall dense ground cover of bracken ferns and bushy shrub of *Dillenia suffructicosa* and *Melastoma malabathricum*. The juvenile pitcher plants of both species in P1 and P3

Table 1: Density count of species of pitcher plants recorded from three study plots at 10, 30 and 50 m altitude at Rantau Abang in Marang District, Terengganu State of Malaysia

Plot and altitude (m)	Species		No. (%) of plants in 0.1 ha	Estimated density ha^{-1}
P1: 10	*Nepenthes gracilis*		235	
		Σ	235 (26.72%)	2350
P2: 30	*Nepenthes gracilis*		115	
P2: 30	*Nepenthes rafflesiana*		350	
P2: 30		Σ	465 (52.83%)	4650
P3: 50	*Nepenthes ampullaria*		40	
P3: 50	*Nepenthes gracilis*		140	
P3: 50		Σ	180 (20.45%)	1800
		Σ P1 + P2 + P3	880 (100%)	2933

failed to grow under the dense canopy due to low light intensity despite the conducive humid condition of the soil. The pitcher plants in these plots grow in open gaps left by the dead leaves of brackened ferns and along the fringed of this secondary vegetation. The matured plants of both species growing well above the dense cover represent the remnant of pitcher plants cohort established during the early succession stage of the plant community in the study area. Adam and Ping (2005) explained the high count of *Nepenthes gracilis* and *Nepenthes rafflesiana* in their study area were due to environmental factors. According to them these two species established successfully in exposed and disturbed habitats, young secondary scrub with loose vegetation. They also found out that these species were unable to grow in old secondary vegetation with dense thicket of tall trees of *Macaranga* sp., *Mallotus* sp., *Dillenia suffructicosa* and *Vitex pubescens*. These two species favored growing in open area and partly shaded underneath by secondary plant species such as *Melastoma malabathricum, Dicranopteris linearis* and *Blechnum orientale* (Adam and Wilcock, 1996; Adam *et al*., 2005; Adam, 2002a,b; Adam and Ping, 2005).

The matured plants of these three species, were found to climb up tree and among the tall secondary bushes and none of the juvenile plants were recorded growing under very deep shaded sections of the study plots. These species were unable to tolerate very low light intensity due to very deep shade create by dense vegetation covering above. The dense vegetation canopy intercept the light from reaching the forest floor and thus drastically reduce the light intensity and this floor condition hindered the germination of seeds and thus the establishment of juvenile plants (Adam and Ping, 2005). The formation of gaps due to forest disturbance and dying of the plant leaves increase the light intensity on the floor and thus favored the germination of pitcher plants seeds and establishment of juvenile plants (Adam, 2002a, b; Adam and Ping, 2005).

The total of pitcher plant counts differ between species in every study plot (Table 1). In P1, 235 plants of *N. gracilis* were inventoried; this gave us the estimated density of 2350 ha^{-1}. In P2, Nepenthes *rafflesi*ana count is greater than *Nepenthes gracilis*. The total of 465 counted, 75.3% or 350 *Nepenthes rafflesiana* and 24.7% or 150 *Nepenthes gracilis* was recorded here. Similarly in P3, 140 or 77.8% of *Nepenthes gracilis* was recorded thus surpassed the total count of *Nepenthes gracilis*. The possible explanation for the count is already noted in the preceding paragraph above.

Population structure: This study revealed that the population of *Nepenthes ampullaria, Nepenthes gracilis* and *Nepenthes rafflesiana* comprises of plants with three different life stages that is seedlings, saplings and matured plants (Table 2). The matured plants contained sterile male and female individuals. All of the species of pitcher plants were dioecious in which the male and female reproductive structures were found on different plants. In other word, the pitcher plants are unisexual. There are similar finding on the composition of these three life stages and dioecious of the same pitcher plant species was reported by previous researchers in Malaysia (Adam, 2002a, b).

Table 2 showed that the pitcher plants community found from the study area contained 880 individuals. Of these, 38.98% was matured sterile plants, 29.55% was seedlings, 23.07% was saplings, 5.68% was matured male and 2.84% was matured female plants. This study also showed that 5.68 and 2.84% of the pitcher plants in the community produce male and female inflorescence. Pitcher plants were found to produce 50 male and 25 female plants with the ratio of 2:1.

Population structure of *Nepenthes gracilis* at 10 m indicated a low representation of seedlings and saplings combined compared with the matured plants (Table 2). A total of 25 or 10.64% of seedlings and saplings with 210 or 89.36% matured plants of *Nepenthes gracilis* were recorded at this elevation.

On the other hand, population structure of *Nepenthes gracilis* at 30 m were higher for seedlings and saplings combined compared with matured plants. A total

Table 2: Population structure of *Nepenthes ampullaria, N. gracilis* and *N. rafflesiana* in P1, P2 and P3 at 10, 30 and 50 m, adjacent to Rantau Abang Recreational Forest in Terengganu State of Malaysia

Plot altitude (m)	Species	No. of seedlings	No. of saplings	Matured sterile	Matured male	Mature female	Σ
P1: 10	*N. gracilis*	15.00	10.00	195.00	10.00	5.00	235
P2: 30	*N. gracilis*	42.00	26.00	35.00	8.00	4.00	115
P2: 30	*N. rafflesiana*	140.00	135.00	57.00	12.00	6.00	350
P3: 50	*N. ampullaria*	18.00	12.00	4.00	4.00	2.00	40
P3: 50	*N. gracilis*	45.00	20.00	51.00	16.00	8.00	140
Σ		260.00	203.00	342.00	50.00	25.00	880
%		29.55	23.07	38.86	5.68	2.84	100

of 68 or 59.13% of seedlings and saplings and 47 or 42.87% of matured plants were recorded here. There is similar result on the abundance of seedlings and saplings compared with matured plants as that of *N. gracilis* above was obtained for *Nepenthes rafflesiana* at this same elevation. A total of 275 or 78.57% of seedlings and also of saplings and 75 or 21.43% of matured plants were also recorded here.

The population structure of *Nepenthes ampullaria* also showed higher percentage of representation of seedlings and saplings combined compared with representation of matured plants at 50 m. *Nepenthes ampullaria* was represented by 75% of seedlings and saplings and 25% of matured plants. Conversely, *Nepenthes gracilis* was represented by 53.57% of matured plants compared to 46.43% of seedlings and saplings.

The result of this study clearly indicated that all of the three species of pitcher plants recorded in all plots produced more male than female plants that are with the ratio of 2:1.

Table 2 shows above the highest count of matured plants of three species of pitcher plants in the study area compared to seedlings and saplings. This study also indicated that the juvenile stage which includes seedlings and saplings of these three species, was greater than the matured plants. The high count in juvenile stages showed the pitcher plants in the study area are a regenerating community. This study also showed higher number of count of male than the female plants for all species. The high number of male inflorescence produces ensures effective cross-pollination process of these species. It is known that the species of this genus have unisexual flowers and located on different plants.

Population dispersion pattern: Previous researchers argued that the field observation in not a good method to classify the dispersion pattern of pitcher plant population (Adam and Ping, 2005; Adam, 2002a). The analysis using Morisita's Index of Dispersion and chi-square test is important to determine the population dispersion pattern systematically because the field observation does not give accurate results (Liliwirianis *et al*., 2009; Hafiza and Adam, 2009). In this research, Morisita's Index of Dispersion and Chi-square test (χ^2) as proposed by Brower and Zar (1977) have also been used to identify the type of population dispersion pattern of seedlings, saplings and matured plants of *Nepenthes ampullaria*, *Nepenthes gracilis* and *Nepenthes rafflesiana* in all plots studied. The results of this quantitative analysis were listed in Table 3.

The I_d values of seedlings, saplings and matured plants of *Nepenthes ampullaria, Nepenthes gracilis* and *Nepenthes rafflesiana* at all elevations were found from as low as 1.12 in matured plants of *Nepenthes gracilis* at 10 m to 3.74 in saplings of *Nepenthes gracilis* at 50 m altitude. The chi-square test showed that the population dispersion of all stages of *Nepenthes ampullaria, Nepenthes gracilis* and *Nepenthes rafflesiana* were aggregated. The Chi-square test showed that the values $X\Lambda$ of these species were all greater than $\chi^2_{0.05, 9} = 16.92$. The results strongly supported the dispersion pattern of all life stages of all species in all plots were significantly aggregated.

The pitcher plants in this study preferred to grow in open areas, under the loose thicket of bracken fern and the fringed of dense thicket. The pitcher plants particularly the seedlings and saplings failed to grow under heavy thicket of bracken ferns (*Dicranopteris linearis*), *Dillenia suffructicosa, Melastoma malabathricum* and *Ploiarium alternifolium*. The lack of sunlight reaching the ground surface is a limiting factor germination of seeds of these pitcher plant species. However, the matured pitcher plants were able to grow protruding above the tall bushes and some of the bearing either male or female inflorescences. The matured pitcher plants found here were the remnants of the pioneers of the early stage of succession.

The high tendency of pitcher plants species to grow contagiously in open spaces of secondary vegetation and partially disturbed habitats both in the lowlands and highlands of Malaysia (Adam and Ping, 2005; Adam, 2002a-c). Past researchers found that pitcher plants prefer to grow in aggregation with high density in open habitats for example young secondary forest, BRIS forest, heath forest, in forest gap of primary forest and on open ridges and mossy forest on high mountain areas. These pitcher plants failed to establish under heavy shaded vegetation due to low light intensity.

Table 3: The Id and Chi-square test (X^2) and dispersion pattern of seedlings, saplings and matured plants of three species of *Nepenthes* enumerated in the study plots at 10, 30 and 50 m altitude, adjacent to Rantau Abang Recreational Forest in Terengganu State of Malaysia

Plot altitude (m)	Species	Life stages and No. of plants	I_d	χ^2	$\chi_{0.05,9}$	Dispersion pattern
P1: 10	*N. gracilis*	Seedlings: 15	2.09	24.33	16.92	Aggregated
		Saplings: 10	2.67	24.00	16.92	Aggregated
		Matured plants: 210	1.12	33.42	16.92	Aggregated
P2: 30	*N. gracilis*	Seedlings: 42	1.71	38.00	16.92	Aggregated
		Saplings: 26	2.18	38.62	16.92	Aggregated
		Matured plants: 47	1.88	49.81	16.92	Aggregated
P2: 30	*N. rafflesiana*	Seedlings: 140	1.71	108.29	16.92	Aggregated
		Saplings: 135	1.91	131.00	16.92	Aggregated
		Matured plants: 75	1.77	66.20	16.92	Aggregated
P3: 50	*N. ampullaria*	Seedlings: 18	2.09	27.56	16.92	Aggregated
		Saplings: 12	2.88	29.67	16.92	Aggregated
		Matured plants: 10	3.56	32.00	16.92	Aggregated
P3: 50	*N. gracilis*	Seedlings: 45	3.32	111.22	16.92	Aggregated
		Saplings: 20	3.74	61.00	16.92	Aggregated
		Matured plants: 75	2.25	101.13	16.92	Aggregated

I_d = Value of Morisita's Index of Dispersion, χ^2 = value calculated of χ^2, = Value of χ at 95% confident level and degree of freedom of 9

Table 4: pH, texture and organic matter content of soil at three different localities and altitude, adjacent to rantau abang recreational forest in terengganu

Plot altitude (m)	Species	Soil pH	% Sand	% Clay	% Silt	Soil texture	Organic matter (%)
P1: 10	*N. gracilis*	3.95	69.16	17.7	13.14	Sandy loam	2.85
P2: 30	*N. gracilis* and *N. rafflesiana*	3.78	52.00	20.0	28.00	Loam	2.10
P3: 50	*N. ampullaria* and *N. gracilis*	3.60	46.00	40.0	14.00	Sandy clay	2.95

Soil properties

Soil pH: Soil pH in the study area was found to be acidic, ranging from 3.60 to 3.95. According to Baize (1993), the soil here was strongly acidic. This study reinforces with the study by Adam *et al*. (2009) in which they found that the same combination of species also grow in strongly acidic soil with pH between 3.74-4.41. Sahibin *et al*. (2008) showed that *Nepenthes gracilis* grow on medium to strong acidic soil with pH of between 4.17 to 5.56. Similarly, Adam *et al*. (2009) also revealed that *Nepenthes ampullaria*, *Nepenthes gracilis* and *Nepenthes rafflesiana* in heath forest of Endau-Rompin National Park in Pahang also grow on strong acidic soil with pH of between 3.74 to 4.21. Several other researchers recorded similar results that is *Nepenthes ampullaria*, *Nepenthes gracilis*, *Nepenthes mirabilis*, *Nepenthes rafflesiana* and the highland pitcher plant species in Malaysia grow on acidic soil (Clarke, 2002; Adam and Ping, 2005; Hafiza and Adam, 2009). According to them, acidic of the soil was due to heavy downpour in the tropic. The rainfall caused weathering of salt and degradation of organic matter thus releasing organic acid and mineral acid.

Soil texture: The soil of the study area was found to content a high percentage of sand ranging from 46.1 to 69.16% (Table 4). The highest percentage of sand was recorded in P1 at 10 m followed by P2 at 30 m and P3 at 50 m. The soil texture showed to differ between three study sites. The table showed that the soil texture in P1, P2 and P3 was sandy loam, sandy clay and sandy clay loam. This study also revealed that *Nepenthes gracilis* can grow all of these three soil texture types, whereas *Nepenthes rafflesiana* grow only on sand clay loam and *Nepenthes ampullaria* on sandy clay. The result showed that the pitcher plant species in the study can grow on many soil texture types. Thus, the results of this study conformed with the finding of the other previous researchers. Adam *et al*. (2009) showed that *Nepenthes gracilis* was found to grow on several soil texture types namely sandy loam, sandy clay and sandy clay loam from heath forest in Endau-Rompin National Park, Pahang. Similarly, *Nepenthes rafflesiana* was found to grow on sandy clay, sandy clay loam; *Nepenthes ampullaria* can grow on clay and sandy clay loam. These two studies generally showed that, these three species namely *Nepenthes ampullaria*, *Nepenthes gracilis* and *Nepenthes rafflesiana* preferred to grow on soil dominated by sand and clay. The clay content of the soil can retain water needed by the pitcher plants for their growth requirement (Adam *et al*., 2009; Adam and Ping, 2005).

Organic Matter Content (OMC): Organic matter content of the soil recorded from the study area is relatively low, ranging from 2.10-2.85%. The low in organic matter content showed the humus in the study area undergo high decomposition rate. The high decomposition rate in the study area was due to high temperature and constant humidity condition of the soil. The study by Adam *et al*. (2009) in heath forest of Endau - Rompin recorded high organic matter content of the soil. They found that OMC of soil associated with *Nepenthes ampullaria* was 6.85 to 20%; OMC of soil associated with *Nepenthes rafflesiana* was from 2.74 to 6.68% and for *Nepenthes gracilis* OMC was from 1.15 to 2.75%. According to them the high OMC content was due to the wet and water

logged condition of the soil thus slowing down the decomposition rate of the humus. In the water logged section of the plots, the percentage humidity of the soil was between 31.77 to 81.20%. In the dry section of the plot, the percentage humidity of the soil was between 6.24 to 17.38%. The humid condition or non water logged condition thus speeded up the decomposition rate of the humus. The faster rates of humus decomposition explain the low in OMC in their study. Similar explanation can be sought to explain the low in OMC of the soil in this study.

CONCLUSIONS

Three species of pitcher plants namely *Nepenthes ampullaria, N. gracilis* and *N. rafflesiana* were recorded present in the study area. *Nepenthes gracilis* was the most dominant species; this species contributed 56.68% of the total count, followed by *N. rafflesiana* (39.78%) and *N. ampullaria* (3.54%). All of these species were represented by plant of all the life stages namely seedlings, saplings and matured plants. The Id values of these species of all life stages were from 1.12 to 3.74. Chi-square that the dispersion pattern of all life stage of these species in all plots were significantly aggregated. These species were found to grow in acidic soil with low organic matter content. *Nepenthes gracilis* grows in sandy loam, loam and sandy clay whereas *Nepenthes ampullaria* and *Nepenthes rafflesiana* grow in sandy clay and loam, respectively.

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