Studies of Morisita's Index of Dispersion and Chi Square (χ^2) of Nepenthes species at different altitude on Gunung Pulai, Johore

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ABSTRACT

Four species of Pitcher plants, namely Nepenthes ampullaria, N. gracilis, N. x hookeriana and N. rafflesiana were recorded on Mt.Pulai. The distribution of pitcher plants according to altitude on the mountain slope was found to differ between the species recorded. Nepenthes rafflesiana was found at all elevations that is 150 m, 500 m, 550 m and 600 m. N. ampullaria was recorded at 500 m, 550 m, and 600 m. Nepenthes gracilis was present at 500 m, 550 m and N.x hookeriana was recorded at 550 m only. The population dispersion pattern of Nepenthes rafflesiana and N. x hookeriana seedlings and matures plants N. ampullaria and N. gracilis were contagious. Mature plants saplings of N. rafflesiana, seedlings of N. ampullaria and saplings of N. gracilis were random and contagious.

Key Words: *Malaysia, pitcher plants, altitude, diversity, dispersion.*

Introduction

Pitcher plants are extraordinary plants in the plant kingdom, for their handsome hanging pitchers from the tips of the leaves tendrils are most remarkable and unleaf- like, that it not suprising that the public and even scientists almost confuse them with flowers (Slack, 1979). Their structures coupled with their carnivore mode of nutrition have made them a source of fascination. *Nepenthes* is the only genus in the family of Nepenthaceae. Rohana (1988) listed 10 species and 5 hybrids in Penisular Malaysia but Adam et al (2005a) reported 9 species and in addition one species was very recently described (Adam & Hafiza 2007). Studies on the taxonomy of pitcher plants of Peninsular Malaysia including Mt. Pulai have been carried out by Rohana (1988). However no work has been done on the ecological study of pitcher plants on Mt. Pulai, eventhough several ecological studies have been carried out elsewhere in Penisular Malaysia by previous researchers (Rabiatul Adawiyah et al 2005; Adam et al 2004 & 2005a-c).

Materials and Methods

This study was carried out along the slope of Mt. Pulai in Johore, a southern state of Malaysia. It is a recreational forest reserve which is situated 45 km to the south of Johore Baharu and about 10 km from the nearest town of Kulai. It was once a popular recreational destination for family picnics and company outings. The main park area comprise mainly of two levels, one at the foot of the waterfall and the second level on the summit of the waterfall. The summit of the mountain is not accessible to the public due to the existence of Malaysian Telecommunication Receiving Station (MTRS). The location of the four study plots and plot area, plot size GPS position and vegetation types are summarized in Table 1 below.

TABLE 1. Description of the research plots at four elevations along the slope of Mt. Pulai.

Plot No.	Plotsize (m)	PlotArea (m^2)	Altitude (m)	GPS Location	Vegetation Type
P1	10m x 100m	1000m^2	150m	01°35.49N 103°31.68E	Secondary vegetation Dominated by *Dicanopteris linearis*
P2	10m x 100m	1000m^2	300m	01°35.84 N103°32.68E	Secondary vegetation Dominated by *Dicanopteris linearis*
P3	10m x 100m	1000m^2	450m	01°35.95 N103°32.72E	Secondary vegetation Dominated by *Dicanopteris linearis*
P4	10m x 100m	1000m^2	600m	01°60.73 N103°54.70E	Secondary vegetation Dominated by *Dicanopteris linearis*

In this study, each plot was subdivided into 10 subplots, each measuring 10 m x 10 m. The purpose of these subdivisions was to ease the enumeration of *Nepenthes* population, and determination of population dispersion pattern of pitcher plants species using Morisita Index of Population Dispersion (I_d). In each plot an inventory of all pitcher plant seedlings, saplings, and mature plants was made. Every species' enumerated plots will be collected and curate by standard herbarium methods. These herbarium specimens are identified using the key to the species of pitcher plants in Peninsular Malaysia (Shivas 1984) and Sabah (Kurata 1976).

The population dispersion pattern of every species of *Nepenthes* mapped according to life stages was determined by Morisita's Index of Dispersion denoted here as I (Brower & Zar 1977). We can calculate I_d as follow:

$$I_d = n \sum X^2 N$$

Where n is the number of subplots, N is the total number of individuals counted in all n subplots, and $\sum X^2$ is the squares of the number of individuals per subplot, summed over all subplots. If the dispersion is random, then I_d=0; if perfectly uniform, I_d=0; and if maximally aggregated (i.e. individuals in one subplot), I_d = n.

It is necessary that the departure of an observed dispersion pattern from randomness be assessed statistically, by calculating

$$\chi^2 = \frac{n\sum X^2}{} - N$$

The calculated value (cv) of chi-square may then be compared to the appropriate critical value (crv) in χ^2 table with n-1 degree of freedom. If cv <crv we may conclude that the dispersion pattern is not significantly different from random and vice versa.

Result And Discussion

Species composition of *Nepenthes*

A total of 552 pitcher plants representing three species and one hybrid in the 0.1 hectares sampling area were recorded. They were *Nepenthes ampullaria, N. gracilis, N. rafflesiana* and *Nepenthes x hookeriana.* (Table 2). This result on species composition conformed with the findings of Rohana (1998).

The occurrence of these species was found to differ between altitudes (table 2). The table shows that only *Nepenthes rafflesiana* was recorded at 150 m. Whilst, all these species occurred at 500 m. At 550 m *N. ampullaria, N. ampullaria, N. refflesiana* and *N. gracilis* were present and two species namely *N. rafflesiana* and *N. ampullaria* were recorded at 600 m. This result on the altitude distribution of these species conforms with the findings of previous researchers (Adam et al 1992 & 1994; Clarke 2001; Hafiza 2005; Philipps & Lambs 1996 &1998; Rabiatul Adawiyah et al 2005; Rohana 1988; Shivas 1984).

TABLE 2 Species composition of *Nepenthes* at different altitudes on Mt. Pulai

Plot & Altitude	*N. rafflesiana*	*N. ampullaria*	*N. gracilis*	*N. hookeriana*
1/150 m	+	-	-	-
2/250 m	+	+	+	+
3/550 m	+	+	+	-
4/600 m	+	+	-	-

Population dispersion pattern of *Nepenthes*

The results of the study on the population dispersion pattern of three Nepenthes species and one hybrid at four elevations at MT. Pulai are summarized in Table 3. The analysis is important in order to classify population dispersion pattern systematically because field observation does not give true result on population dispersion pattern of the species.

The I_d and χ^2 of all *Nepenthes* taxa representing three life stages (seedlings, saplings, & matured plants) at all altitudes are listed in Table 3 below. The I_d values of *N. rafflesiana* at four altitudes (150-600m), altitudes were all g >1, that is ranging from 2.23 to 10. The I_d values >1 indicate that the population dispersion pattern of *N. rafflesiana* studied belongs to the contagious type as suggested by Brower & Zar (1997). However the χ calculated $<\chi_{0.05,9}$ for saplings (P2:500m) and mature plants (P3:550m) show that population dispersion pattern of the *N. rafflesiana* is random.

Similarly the population dispersion pattern of *N. ampullaria* is random and contagious. All the I_d values obtained were >1, ranging from 1.95 to 7.92 which indicate the contagious type of population dispersion pattern. However, the saplings of the species at 500m and 600m and the seedlings at 600m have their χ^2 values calculated at $<\chi^2_{9,0.05}$=16.919d. Thus, the population dispersion pattern of the saplings and seedlings of *N. camplullaria* at these altitudes were therefore random.

The population dispersion pattern for matured plants of *Nepenthes gracilis* and seedlings at 500m & 550 m and saplings at 500m were significantly contiguous. Their I_d values ranged from 4.9 to 10. However, the population dispersion of saplings and seedlings of *Nepenthes gracilis* at 500m were random. Meanwhile, *Nepenthes x hookeriana* population dispersion was significantly contiguous. The I_d value is 4.646 within its χ^2 value calculated.$>\chi_{0.05,9}$.

TABLE 3 The Values of Morisita's Index of dispersion (Id) and Chi Square (χ^2) of Nepenthes species at different altitudes on Gunung Pulai, Johore.

Plot & Altitude	Species	Life stages	I_d	χ^2	$\chi^2_{0.05,9}$	Dispersion pattern
P1:150m	*N. rafflesiana*	Mature plants	2.23	20.89	16.919	Contagious
		Saplings	5.57	36.56	16.919	Contagious
		Seedlings	10	18	16.919	Contagious
P2:500m	*N. rafflesiana*	Seedlings	10	54	16.919	Contagious
P4:600m	*N. rafflesiana*	Mature plants	2.54	89.3	16.919	Contagious
		Saplings	4.35	201.13	16.919	Contagious
		Seedlings	3.79	19.5	16.919	Contagious
P2:500m	*N. ampullaria*	Mature plants	7.92	332.02	16.919	Contagious
		Saplings	2.93	11.57	16.919	Contagious
P3:550m	*N. ampullaria*	Saplings	2.19	32	16.919	Contagious
		Seedlings	3.48	44.68	16.919	Contagious
P5:600m	*N. ampullaria*	Mature plants	1.95	30.33	16.919	Contagious
P2:500m	*N. gracilis*	Mature plants	4.9	39	16.919	Contagious
P3:550m	*N.gracilis*	Mature plants	10	54	16.919	Contagious
		Saplings	10	90	16.919	Contagious
P2:500m	*N. hookeriana*	Seedlings	4.65	98.43	16.919	Contagious
P2:500m	*N. rafflesiana*	Saplings	9	9	19.919	Random
P3:500m	*N. rafflesiana*	Mature plant	4.67	11	16.919	Random
P2:500m	*N. ampullaria*	Saplings	2.93	11.57	16.919	Random
P4:600m	*N. ampullaria*	Saplings	2.36	9.5	16.919	Random
		Seedlings	2.83	13.67	16.919	Random
P2:500m	*N. gracilis*	Saplings	4.67	11	16.919	Random
		Seedlings	9	9	16.919	Random

Conclusions

Three species and one natural hybrid were recorded from four elevations on Mt. Pulai. They were *Nepenthes ampullaria, N. gracilis, N. rafflesiana* and *N. x hookeriana*. All these taxa belong to the lowland species group. The species composition was found to vary between altitudes. *Nepenthes rafflesiana* was found at all four altitudes; *Nepenthes ampullaria* was recorded at 500m, 550m and 600m; *Nepenthes gracilis* was present at 500m and 550m and *N.x hookeriana* was recorded at 500m altitude. The Id values of seedlings, saplings and mature plants of all species obtained were >1 that is ranging from 1.95-10. The χ^2 test shows that the population dispersion pattern of *Nepenthes rafflesiana* and *N.x hookeriana* seedlings, *N ampullaria* and *N. gracilis* mature plants were significantly contagious. However mature saplings of *N.rafflesiana* were random and contagious. Lastly, it was also observed that the population dispersion pattern of the *N. gracilis* seedlings was random.

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