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Pitcher plants of Lambir Hill in Miri, Sarawak State of Malaysia

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Abstract: Three species and two varieties of pitcher plants were recorded from Lambir Hill in Miri, Sarawak State of Malaysia. They were *Nepenthes ampullaria* Jack, *Nepenthes gracilis* Korthals, *Nepenthes hookeriana* Lindley, *Nepenthes rafflesiana* Jack var. *subglandulosa* Adam and Hafiza var. *nova* and *Nepenthes mirabilis* (Loureiro) Druce var. *echinostoma* (Hook fil) Adam and Wilcock. A dichotomous key to these taxa was given. *Nepenthes ampullaria* was found from 50 to 150 m. *Nepenthes gracilis* and *Nepenthes rafflesiana* var. *subglandulosa* was recorded at 100 m altitude but absent at 50 m altitude. *Nepenthes hookeriana* and *Nepenthes mirabilis* var. *echinostoma* were confined at altitude 50 m but were absent from altitude 100-150 m. These taxa can easily be identified by their morphological characters. *Nepenthes ampullaria* differs from the other species by possessing the paniculate inflorescence, bracteolate flowers, having only lower pitchers which is urceolate in shape, the lids sizes are distinctly smaller the mouth of the pitcher, lower lid surface glandless and trifid spurs *Nepenthes gracilis* differs from the other four taxa by its sessile leaves, leaves base being decurrent into two wings, the stem triangular in shape, inconspicuous peristome teeth, very thin peristome (≤ 1 mm) and inner surface of pitcher wall covered with exposed digestive glands. *Nepenthes hookeriana* differs from *Nepenthes ampullaria* by the present of both upper and lower pitchers in the former species and the absence of upper pitcher in the later species. *Nepenthes hookeriana* differs from *Nepenthes gracilis* by its cylindrical upper stem, infundibulate upper pitcher and inner pitcher cavity of both upper and lower pitchers covered with digestive glands; *Nepenthes hookeriana* can be distinguished from *Nepenthes rafflesiana* var. *subglandulosa*, *Nepenthes mirabilis* var. *echinostoma* by possessing inner pitcher cavity wall wholly covered with digestive glands and lower lid surface sparsely covered with honey glands. *Nepenthes mirabilis* var. *echinostoma* strikingly differs from the other four taxa in having flattened and very thick peristome and the upper pitcher shape differentiate into tubulose upper half and infundibulate lower half.

Key words: Sarawak, taxonomy, species composition, dichotomous key, *Nepenthes*, morphology

INTRODUCTION

The distribution of *Nepenthes* is restricted to but scattered throughout the tropics with the center of distribution in Borneo, Sumatra, Malay Peninsular, Philippines and New Guinea. The genus was also recorded from Madagascar, Ceylon, Seychelles Island, Assam and Queensland in Australia (Adam, 1995; Adam *et al.*, 1992, 1994; Kurata, 1976; Philipps and Lamb, 1996).

They grow from sea level to 3400 m. They can be classified into two groups namely the lowland group and the highland group (Kurata, 1976). The lowland species preferred growing in open habitats (Adam *et al.*, 2004, 2005; Clarke, 1997; Holttum 1969; Normawati 2002; Selle, 2002) and commonly found at 100 m and below occasionally found up to <1000 m. The highland species were recorded from >1000 m altitude but

sometimes may occur <1000 m. The highland species are generally found growing in open mountain forest on ridges (Adam *et al.*, 2005), but failed to grow in tall canopy forest.

Nepenthes are carnivorous or insectivorous plants of the tropical rain forest. This mode of life explain their ability of the pitcher plants to grow in low nutrient habitats such as heath forest, peat swamp forest, on degraded soil, on ex mining sites, forests on limestone rock, secondary vegetation, forests on bris soil, on road side embankment growing together with *Dicranopteris linearis* (Adam, 2002a). Pitcher plants are pioneered species in recently disturbed habitats in both the highland and lowland areas and later succeeded by *Dicranopteris linearis* and *Matonia pectinata*. The Pitcher plants such as *Nepenthes rajah*, *Nepenthes villosa*, *Nepenthes burbidgeae* are capable of growing in the forests underlying ultramafic rocks.

Previous researchers reported the occurrence of the natural hybrids involving, resulting from crossing between two different species of pitcher plants growing in the same habitat (Adam and Wilcock, 1995a; Clarke, 2002; Green, 1967). *Nepenthes* display a carnivorous syndrome: they attract, retain, kill and digest and absorb nutrient (Adam, 1997; Adam and Omar, 2002; Juniper *et al.*, 1989). The pitchers act as passive traps (Adam, 1997, 2002b; Lloyd, 1942), increasing their efficiency of the traps by seductive devices, the secretion of nectar by honey glands on the lower surface of the pitcher lids (Fig. 1, 7 and 8) on the tendrils, on the leaves and marginal glands in between or on the lip teeth or peristome (Fig. 2, 3, 9 and 10) (Adam, 2002b). The effectiveness of the trap is enhanced by the presence of waxy slippery surface on the upper half on inner pitcher wall (Fig. 4, 9 and 10), sharp descending inner peristome teeth (Fig. 9 and 10). The digestive glands (Fig. 5 and 6) on the lower part of the inner pitcher wall secrete on insect prey in the pitcher from various species in Borneo. They include insect groups such as fromicidae, diptera, isoptera, coleoptera, plecoptera, homoptera digestive fluid containing enzymes that will drown and

digest it preys (Fig. 11). Adam (1997) found various types and dermaptera. Jensen (1910) recorded the presence of centipede, cockroaches, butterflies, scorpion in pitchers of pitcher plants from Tjibodas in Java. Our field observation showed the common inhabitant of the pitchers was the spider that feed on the dead insects (Fig. 12).

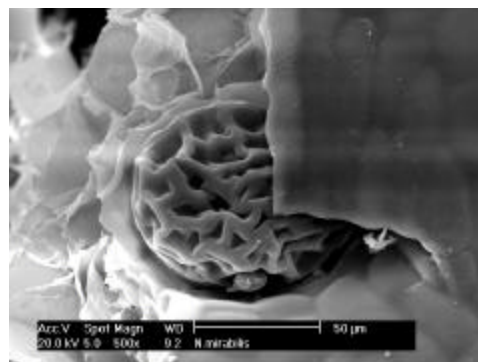


Fig. 3: Marginal gland on the peristome of *Nepenthes mirabilis*

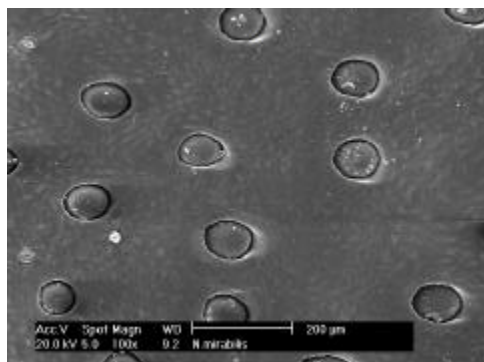


Fig. 1: Honey glands on the lower lid surface of *Nepenthes mirabilis*

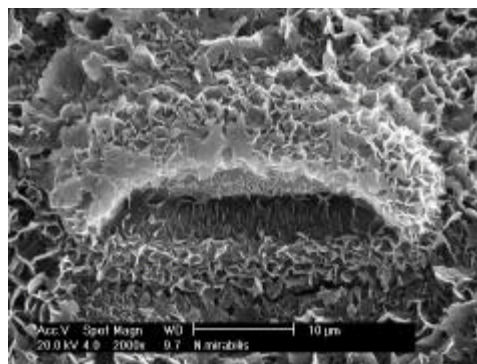


Fig. 4: Pruinoso zone of the inner pitcher wall of *Nepenthes mirabilis* covered with wax and deformed stomata

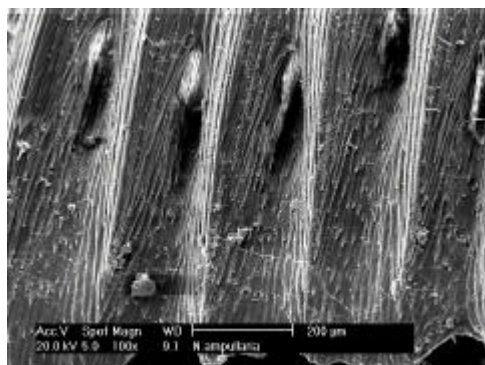


Fig. 2: Marginal glands on the peristome of *Nepenthes ampullaria*

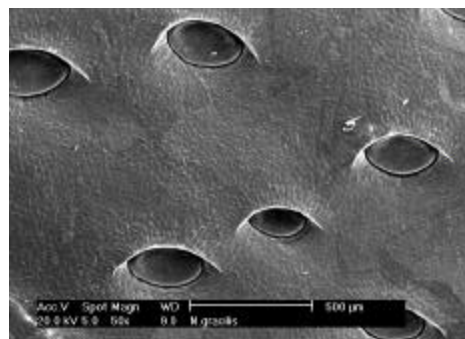


Fig. 5: Exposed digestive glands on the inner pitcher wall of *Nepenthes gracilis*

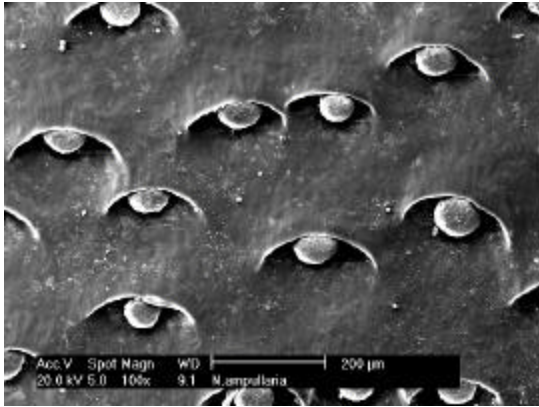


Fig. 6: Overarched digestive glands on the inner pitcher wall of *Nepenthes ampullaria*



Fig. 9: Peristome teeth and whitish waxy inner layer pitcher wall of *Nepenthes kinabaluensis*



Fig. 7: Honey glands on the lower lid surface of *Nepenthes gracilis*



Fig. 10: Peristome teeth, whitish waxy and landular inner pitcher wall of *Nepenthes edwardsiana*



Fig. 8: Honey glands on the lower lid surface of *Nepenthes rafflesiana*



Fig. 11: Ants trap by the pitcher of *Nepenthes gracilis*



Fig. 12: Spider living in the pitcher of *Nepenthes gracilis*

MATERIALS AND METHODS

The study to determine the morphological description of the species, distribution and species composition of *Nepenthes* species from Lambir Hill in Miri, Sarawak was carried out based on the examination of the herbarium specimens collected by both authors.

RESULTS AND DISCUSSION

Dichotomous key and taxonomic descriptions to three species and two varieties of *Nepenthes* from the study area were given below. The morphological characters of the stems, leaves, the shape of the upper and lower pitchers, the distribution of the honey or nectar glands on the lower lid surface and on the peristome termed as marginal glands, distribution and type of digestive glands on the inner wall surface of lower and upper pitchers and spur were used in the construction of dichotomous key and morphological description of all the species and varieties.

Key to species of *Nepenthes* of lambir hill in miri:

1. Leaves base decurrent and stems triangular in shape.....*Nepenthes gracilis*
1. Leaves base not decurrent and stem cylindrical in shape.....2
2. Lower pitchers urceolate in shape..... *Nepenthes ampullaria*
2. Lower pitchers shape other than urceolate3
3. Inner pitcher wall of the upper pitcher wholly covered with digestive glands.....*Nepenthes hookeriana*
3. Inner pitcher wall of the upper pitcher covered with digestive glands on the lower part only4

4. Peristome of the pitcher very broad up to 2 cm thick and flattened; lower lid surface densely and wholly covered with honey glands.....*Nepenthes mirabilis* var. *echinostoma*
4. Peristome of the pitcher up to 1 cm thick and cylindrical; lower lid surface densely covered with honey glands on the outer part and glandless on the middle part..... *Nepenthes rafflesiana* var. *subglandulosa*

DESCRIPTIONS

Nepenthes ampullaria Jack, *Companion to Botanical Magazine* 1: 271 (1835).

Plants: climbers. Lower and upper stems: cylindrical in shape, 8-10 mm thick. Leaves of upper stems: coriaceous; lanceolate and elliptic, 3-5×8-21 cm, base obtuse, apex acute. Longitudinal and pennate nerves: inconspicuous. Petiole: 1-3 cm long. Internodes: 2.5-3 cm long. Lower pitchers: Group in rosettes, urceolate in shape (Fig. 13), 4-6×5-8 cm, anteriorly with fringed wings, fringed wings 2-5×3-5 cm, 1.5-2 cm apart. Lids: cuneate in shape, 3-12×1.5-3 cm, deflexed and smaller than the size of the mouth, lower lid surface glandless. Mouth: orbiculate, 1-2×1.5-3.5 cm, horizontal. Peristome: cylindrical, 0.5-1 cm thick vertically flattened inside; peristome teeth distinct, 0.1 mm long. Marginal glands in shallow pouches on the surface of the peristome (Fig. 2). Inner pitcher wall cavity: wholly glandular which is covered with overarched digestive glands (Fig. 6). Spurs: flattened, trifid, 6-8 mm long, inserted on the lid base. Upper pitchers: absent. Male and female inflorescence: a panicle (Fig. 14 and 15), 32-35 cm long; peduncle 6-8 cm long; rhachis 23-27 cm long; pedicels: 0.5-2 cm long, 2-flowered to 3-flowered, 2-flowered towards the tip, bracteolate; bract 1-2×10-15 mm, filiform. Sepal 4, staminal column 1-2 mm long.

Specimens examined: JHA8332, Sarawak State of Malaysia, Miri, Bukit Lambir, on the roadside to Telekom Malaysia Receiving Station; Fiza 32, Sarawak State of Malaysia, Miri, Bukit Lambir Miri, on roadside to Telekom Malaysia Receiving Station.

Notes: It was found widespread and recorded from lower slope of Lambir Hill below Telekom Station that is at Station 1 (04°11.89N and 114°02.59E; Altitude 50 m), Station 2 (04°11.89N and 114°02.45E; Altitude 100 m) and Station 3 (04°11.85N and 114°02.79E; Altitude 150 m).

It occurs in Borneo, Peninsular Malaysia, Sumatra and New Guinea. It is a common species in Sarawak; it has been recorded from Bako Park, Kuching, Sungai Dua



Fig. 13: Urceolate lower pitcher of *Nepenthes ampullaria*



Fig. 15: Paniculate male inflorescence of *Nepenthes ampullaria* protruding on the top of the vegetation



Fig. 14: Paniculate female inflorescence of *Nepenthes ampullaria*

Baram, Pulau Bruit, Kayangkeran forest reserve, Kelapaan, Sungai Raya, Selalang forest reserve, Kpg Bawang, Bau, Sibul, Sri Aman, Sungai Tutus and Sebanding forest reserve (Adam, 2002a). It is a lowland species, commonly grows at 100 m and below sometimes can be found up to 900 m (Adam and Wilcock, 1990) sometimes above 1000 m. It grows in secondary vegetation along the roadside embankment together with *Dicranopteris linaeris*, secondary peat swamp forest and heath forest and in the forest of primary lowland species. Previous workers reported the species growing in damper habitat that rarely dry out (Phillipps and Lamb, 1988); in semi-shaded and peat swamp forest or sterile ground such as peat moor, exposed habitats by the stream (Kurata, 1976); in alang forest, peat swamp and heath forest (Smythies, 1965). It grows together with *N. albomarginata* and *N. rafflesiana* (Adam, 2002a).

Although this species possess several distinct characters such as urceolate shape of lower pitcher (Fig. 13), glandless on the lower lid surface, the paniculate inflorescence (Fig. 14 and 15), it was reported that the species exhibit certain morphological variations. Macfarlane (1908) recognized var. *microsepala* from New Guinea with sepals which are uniform and small in size.

Beccari (1886) described var. *longicarpa* with long staminal column and fruits and var. *geelvinkiana* with a lax inflorescence. Som (1988) reported that Andre in 1877 described var. *vitata major*, which differs from the typical variety by its pitchers which are large and having striking purple streak. Adam and Wilcock (1990) recognized var. *racemosa* from Borneo. It differs from the typical variety by having raceme female inflorescence, pedicels 2-flowered and without bract. *Nepenthes ampullaria* was also recorded to hybridize with *Nepenthes mirabilis* in Peninsular Malaysia (Som, 1988).

***Nepenthes gracilis* Korthals, In C.J. Temminck, Verhandelungen Over Der Natuurlijke Geschiedenis Der Nederlandsch Overzeeche Bezittingen: 22 (1830).**

Plants: climbers or scramblers. Lower and upper stems: triangular in shape, 3 mm thick. Leaves: coriaceous, lanceolate, 2.5-3×8-9 cm, base obtuse, apex acute; sessile, leaf base decurrent. Longitudinal and pennate nerves: inconspicuous. Lower and upper pitchers: similar but differs by the presence of two fringed wings anteriorly in the lower pitcher and replaced by two ribs in the upper pitchers, tubulose-ventricose in shape, 2.5-3×7-7.5 cm, fringed wings and ribs 9 mm apart. Lids: orbiculate in shape, 2×1.5 cm, sparsely covered with honey glands below (Fig. 7). Mouth: orbiculate, 2×3 cm, horizontal in front and slightly elevated towards the lid. Peristome: cylindrical, 1 mm thick, peristome rib 0.1 mm apart. Spurs: flattened, not branched, 3 mm long, attached on the lid base. Inner cavity wall: covered with exposed digestive glands (Fig. 5) on the lower ventricose part only. Male inflorescence and female inflorescences: a raceme (Fig. 16), 16-18 cm long, rhachis 3-4 cm long, peduncle 12-15 cm long, Pedicels 5-15 mm long, 1-flowered, ebracteolate. Sepals 4, upper surface covered with nectar glands (Fig. 17 AND 18).

Specimens examined: JHA8334, Sarawak State of Malaysia, Miri, Bukit Lambir, on the roadside to Telekom Malaysia Receiving Station.

Notes: This species was recorded at Station 2 (04°11.89N and 114°02.45E; Alt. 100 m) and Station 3 (04°11.85N and 114°02.79E; Alt. 150 m) but it was found absent at Station 1 (04°11.89N and 114°02.59E; Alt. 50 m)

It is geographically widespread, found occurring in Borneo, Sumatra, Peninsular Malaysia and Celebes. The species occurs throughout Sarawak which includes Matu, Daro, Batang Baram, Bau, Kuching, Sri Aman, Sarikei, Bako Park, Batu Kawa, Betong-Saribas forest reserve, Lundu, Marudi, Melugu, Mt. Matang and Sungai Rayu.



Fig. 16: Female raceme of *Nepenthes gracilis*



Fig. 17: Lower pitchers of *Nepenthes gracilis*



Fig. 18: Upper pitchers of *Nepenthes gracilis*

The species grows on roadside embankment together with *Dicranopteris linearis*, heath forest, secondary vegetation, forest on bris soil, commonly at below 100 m altitude rarely up to 1000 m altitude. It is widely distributed in Sabah, Sarawak and Peninsular Malaysia. It is common road side plant, climbing among the *Dicranopteris linearis*, *Ploiarium alternifolium*, *Melastoma malabathricum*, on podsolic soil of *Baeckea frutescens* heath forest, at the edge of secondary peat swamp forest growing together with *Nepenthes mirabilis* and *Nepenthes rafflesiana*, in secondary peat swamp forest and on ex mining sites. Smythies (1965) reported the species from padang alan forest and padang keruntum forest. Other researchers also found *Nepenthes gracilis* preferred to grow on the dry and exposed habitats associated with *Dicranopteris linearis* (Adam, 2002c; Nazuha, 2002; Noratiza, 2002). Several varieties have been reported in this species. The species includes *Nepenthes gracilis* var *elongata* Blume having bigger leaves, *Nepenthes gracilis* var *longinodis* with long internodes, *Nepenthes gracilis* var *arenaria* with short stem (Danser, 1928; Som, 1988).

***Nepenthes hookeriana* Lindley, The Gardener's Chronicle:87 (1848).**

Plants: climbers or scramblers up to 5 m tall. Lower stems: cylindrical in shape, 10 mm thick and internodes 9-10 cm long. Leaves of lower stem: scattered, coriaceous, linear

lanceolate to linear elliptic in shape, 5-7×27-30 cm; base obtuse, apex acuminate. Longitudinal nerves: 2-4 pairs, running parallel in the outer half of the lamina, originated from the leaf base. Petiole: canaliculate, up to 10-12 cm long, expanded and slightly decurrent at the base. Tendrils: 20-25 cm long. Upper stems: cylindrical in shape, 12 mm thick, internodes 10-11 cm long. Leaves of upper stem: scattered, coriaceous, lanceolate to elliptic in shape, 4-6×24-30 cm; base obtuse, apex acute. Longitudinal nerves: 2-3 pairs, running parallel in outer half of the lamina, originated from the leaf base; pennate nerves inconspicuous. Petiole: canaliculated, 10-15 cm long, expanded at the base and semi-amplexicaul. Tendrils: 10-16 cm long. Lower pitchers: ellipsoidal in shape, anteriorly with two fringed wings, 2 cm apart, fringed wings 2-7×9-13 cm. Lids: ovate in shape, 3×5 cm, sparsely covered with honey glands below. Mouth: ovate, 3×4 cm slightly elevated or horizontal in front and slightly elevated towards the lid. Peristome: cylindrical, outer margin involute and inner margin flattened, 1 cm thick, peristome ribs 0.5 mm apart. Peristome teeth distinct, 0.5 mm long. Inner cavity wall: wholly covered with overarched digestive glands. Spurs: flattened, not branched, 20 mm long, attached 3 mm the lid base attachment. Upper pitchers: infundibulate in shape, 3.5-6×8-12 cm, anteriorly with two fringed wings or ribs, 1.5 cm apart, fringed wings 1×10 cm. Lids: ovate in shape, 3×4-4.5 cm, emarginated or rounded on the apex, sparsely but wholly covered with honey glands below. Mouth: ovate, 3×3.5 cm, horizontal in front and slightly elevated towards the lid into a short neck. Peristome: cylindrical, outer margin involute and inner margin flattened, 0.5-1.5 cm thick, peristome rib 0.5 mm apart, inner peristome teeth distinct, inner pitcher cavity wall totally covered with overarched digestive glands. Spurs: flattened, not branched, 8-15 mm long, attached 3 mm below the lid base attachment (Fig. 19 and 20).

Inner cavity wall: wholly covered with overarched digestive glands Male and female inflorescence unknown.

Specimens examined: JHA8335, State of Malaysia, Miri, Bukit Lambir, along the roadside to Telekom Malaysia Receiving Station, found on the lower slope of the hill in secondary forest dominated by fern *Dicranopteris linearis*.

Notes: This species was recorded at Station 1 (04°11.89N and 114°02.59E; Alt. 50 m) but it was found absent at Station 2 (04°11.89N and 114°02.45E; Alt. 100 m) and Station 3 (04°11.85N and 114°02.79E; Alt. 150 m).

It is recorded from Borneo, Peninsular Malaysia and Sumatra. It grows from sea level to 450 m but rarely up to 1000 m altitude. It grows in secondary vegetation, commonly found growing on road side



Fig. 19: Urceolate shape of lower pitcher of *Nepenthes hookeriana*



Fig. 20: Infundibulate shape of upper pitcher of *Nepenthes hookeriana*

embankment together with *Dicranopteris linearis*, *N. gracilis*, *N. ampullaria* and *N. rafflesiana* var *subglandulosa*. It can also be found in heath forest, forest on bris soil dominated by *Melaleuca leucadendron*, *Baeckea frutescens* scrub forest and on ex mining areas.

***Nepenthes mirabilis* var. *echinostoma* (Hook. fil) Adam and Wilcock, Malayan Nature Journal 46: 75-84 (1992)**

Plants: climbers or scramblers. Upper stems and lower stem: cylindrical in shape, 0.6-1 cm thick. Leaves of upper and lower stems: coriaceous, lanceolate, elliptic and oblong in shape, 6-9×17-28 cm; base obtuse, apex acute. Longitudinal nerves: 4-7 pairs, originated from the leaf base; pennate nerves inconspicuous. Petiole: canaliculate, 5-10 cm long. Internodes: 3-4 cm. Upper and lower pitchers: tubulose upper $\frac{1}{2}$ and infundibulate lower $\frac{1}{2}$; lower pitchers and upper pitchers have a pair of fringed wings and ribs, respectively and 1-1.5 cm apart, 3-5×14-23 cm. Lids: ovate in shape, 2-3×3-5 cm, densely covered with honey glands below (Fig. 1). Mouth: ovate, 1-1.5×3-3.5 cm, oblique. Peristome: flattened and very thick, 1-2 cm thick, peristome rib 0.5 mm apart, peristome teeth distinct, 0.1 mm long. Spurs: flattened, not branched, 5-6 mm long, attached on the lid base. Inner cavity wall: covered with overarched digestive glands on the lower infundibulate part and covered with waxy layer on the upper tubulose part (Fig. 4). Male and female inflorescence unknown.

Specimens examined: JHA8331 and Fiza 31, State of Malaysia, Miri, Lambir Hill, on the lower slope to the Telekom Malaysia Receiving Station; growing together with *Nepenthes mirabilis* var. *echinostoma* and *Nepenthes ampullaria* in open vegetation dominated by *Dicranopteris linearis*.

Notes: This species was recorded at Station 1 (Lambir Hill 04°11.89N and 114°02.59E; Altitude 50 m) but it was found absent at Station 2 (Lambir Hill 04°11.89N and 114°02.45E; Altitude 100 m) and Station 3 (Lambir Hill 04°11.85N and 114°02.79E; Altitude 150 m).

This species occurs in Borneo, Peninsular Malaysia, Java, Sumatra, Thailand, Indo-China, Southern China, Moluccas, Philippines, Celebes, New Guinea and Australia. The typical species is widely distributed in Borneo and has been mostly collected from the northern and western part of Borneo. It is a lowland species, commonly grows in damp habitats, secondary peat swamp forest, secondary vegetation growing together with *Dicranopteris linearis*, *Dillenia suffruticosa*, *Melastoma malabathricum*, *Nepenthes gracilis*, *Nepenthes ampullaria* and *Nepenthes hookeriana*

(Adam and Wilcock, 1992). The species was recorded from sea level up to 1000 m but most of the habitats were found at 100 m and below.

Previous researchers reported a number of varieties in this species. Adam and Wilcock (1992) reported two varieties namely *Nepenthes mirabilis* var. *echinostoma* (Hook fil) Adam and Wilcock and *Nepenthes mirabilis* var. *biflora* Adam and Wilcock. According the authors *Nepenthes mirabilis* var. *echinostoma* (Fig. 21) differs from *Nepenthes mirabilis* var. *mirabilis* (Fig. 22) by its peristome structure, outer series with broad flattened and fixed peristome ribs, inner series of free hook-like ribs. In this study, the variety is shown to have very broad and flattened peristome (Fig. 22). This variety was up to date recorded from Kuching and Lambir Hill in Miri. It has been collected from Andalau forest reserve in Brunei. *Nepenthes mirabilis* var. *biflora* differs from the typical variety by its commonly 2-flowered pedicels. The variety has been recorded from Kampong Bawang Matu, Sarawak (type location) and Poring, Sabah. Other varieties reported by previous researchers and cited in Som (1988) includes *Nepenthes phyllamphora* var. *platyphylla* Blume possessed broad leaves, *Nepenthes fimbriata* var. *leptostachys* Blume possessed abbreviate racemes, *Nepenthes mirabilis* var. *macrantha* Hook possessed glabrous, long pedicel flowers and *Nepenthes mirabilis* var. *pediculatus* Lecomte possessed pedicelled ovaries. This species was recorded to hybridize naturally with species of pitcher plants. Som (1988) reported *Nepenthes mirabilis* to form natural hybrids in the wild which includes *Nepenthes mirabilis* x *Nepenthes rafflesiana*, *Nepenthes gracilis* x *Nepenthes mirabilis* and *Nepenthes mirabilis* x *Nepenthes ampullaria* from Peninsular Malaysia. Adam and Wilcock (1995a) recorded a natural hybrid of *Nepenthes* x *ghazallyiana* Adam and Wilcock from Sabah. It is a hybrid between *Nepenthes gracilis* and *Nepenthes mirabilis*.

***Nepenthes rafflesiana* Jack var. *subglandulosa* Adam and Hafiza var. *nova*.**

Type: JHA8333, Sarawak State of Malaysia, Miri, Lambir Hill, along the road to Telekom Malaysia Receiving Station, growing in open vegetation with *Nepenthes gracilis* and dominated by thicket of fern *Dicranopteris linearis*. Holotype (UKMB), Isotype (UKMB).

Differt a *Nepenthes rafflesiana* Jack var. *rafflesiana* Jack ascidia superiora pagina interiora 4/5 ad omnino glandulosa.

This variety differs from *Nepenthes rafflesiana* Jack var. *rafflesiana* Jack in having inner wall of upper pitchers glandular on the basal 4/5.



Fig. 21: Upper pitcher of *Nepenthes mirabilis* var. *echinostoma* showing very broad and flattened peristome



Fig. 22: Upper pitcher of *Nepenthes mirabilis* var. *mirabilis* showing narrow and cylindrical peristome

Plants: climbers. Lower stems: cylindrical. Leaves of lower stem as in the upper stem. Upper stems: cylindrical in shape, 7 mm thick. Leaves: coriaceous, oblong and lanceolate in shape, 4-4.5×16-21 cm; base obtuse, apex acute to obtuse. Longitudinal nerves: 2 pairs, position towards the margin, originated from the leaf base, more or less inconspicuous; pennate nerves inconspicuous. Petiole: canaliculate, 7-10 cm long. Internodes: 7-10 cm. Lower pitchers: ellipsoidal or tubulose on the upper ½ part and globose on the basal ½ part, 6-13 cm long, 3-7 cm wide, anteriorly with two fringed wings. Lids ovate in shape, 4-5 cm long and 2.5-3 cm wide, lower lid surface glandless in the middle portion and becoming densely glandular on the outer portion. Mouth ovate, oblique elevated into a long neck towards the lid. Peristome cylindrical, peristome teeth distinct. Spur cylindrical and simple, 18 mm long. Inner pitcher cavity glandular on the basal ½ part. Upper pitchers: tubulose-infundibulate in shape, 5×24 cm, anteriorly with two ribs, 2 cm apart. Lids: ovate in shape, 4.5×6 cm, covered with honey glands below, sparsely in the middle portion and becoming dense toward the margin. Mouth: ovate, 2×5 cm, oblique. Peristome: cylindrical, 7 mm thick, peristome rib 0.5 mm apart, peristome teeth distinct, 1 mm long. Spurs: cylindrical, not branched, 5 mm long, attached on the lid base. Inner cavity wall: covered with overarched digestive glands on the lower or basal 4/5 and covered with waxy layer on the upper 1/5 part (Fig. 23). Male and female inflorescence unknown.

Notes: This species was recorded at Station 2 (Lambir Hill, 04°11.89N and 114°02.45E; Alt. 100 m) but it was not recorded at Station 3 (Lambir Hill, 04°11.85N and 114°02.79E; Alt. 150 m) and at Station 1 (Lambir Hill, 04°11.89N and 114°02.59E; Alt. 50 m).

The typical variety of this species described by Jack (1835) is geographically widespread species. It occurs in Peninsular Malaysia, Sumatra, Borneo and New Guinea. It is widespread in the Borneo and recorded from 0 to 1500 m altitude. It grows in various forest types including heath forest locally known as kerangas forest, forest on bris soil, secondary vegetation on roadside dominated by *Dicranopteris linearis*, waste ground, secondary bush, low altitude mossy forest. Smythies (1965) found the species growing in heath forest, Dipterocarp forest with pure stand of *Shorea albida*, peat swamp forest dominated by *Combretocarpus rotundatus*. Phillipps and Lamb (1988) reported the species growing in open habitats such as degraded, dry and waterlogged laterite and pod sol soil and in deep shaded forest of ultrabasic forest and swampy areas.



Fig. 23: Upper pitcher of *Nepenthes rafflesiana* var. *subglandulosa* showing inner pitcher partly covered with digestive glands

The distribution of *Nepenthes rafflesiana* var. *subglandulosa* is to date known the type locality in Sarawak and one other locality in Brunei. This study showed that the inner cavity wall of the lower and upper pitchers (Fig. 23) were partly covered digestive glands. However previous researchers reported the inner cavity wall of the upper pitchers were wholly glandular (Kurata, 1976; Shivas, 1984; Som, 1988) but Danser (1928) reported the inner pitcher cavity wall was partly glandular and sometimes partly glandular. The specimens of this species collected by us from Jambu Bongkok in Terengganu, Mt. Ledang (formerly known as Mt. Ophir) and Mt. Pulai in Johore showed that the inner wall of the upper and lower pitchers were always wholly glandular. Figure 24 of the species taken from Jambu Bongkok showing wholly glandular upper pitchers. Our field survey showed this variety preferred to grow in open vegetation along the road which is dominated with *Dicranopteris linearis*. Other species of pitcher plant growing with this variety was *Nepenthes gracilis*.

Several varieties of the species have been described. There was *N. rafflesiana* var. *insignis* Masters (1882), *N. rafflesiana* var. *nigro-purpurea* Masters (1882), *N. rafflesiana* var. *minor* Beccari (1886), *N. rafflesiana* var. *nivea* Burbidge (1882) and *N. rafflesiana* var. *glaberrima*



Fig. 24: Upper pitcher of *Nepenthes rafflesiana* var. *rafflesiana* showing inner pitcher wholly covered with digestive glands

Burbidge (1882). Recently Adam and Wilcock (1990) described one variety namely *N. rafflesiana* var. *alata* from Sabah. According to Adam and Wilcock (1990) this variety is rare and collected from Mt. Walker Forest Reserve and Leila Forest Reserve in Sabah. It differed from the typical variety by its winged tendrils.

MORPHOLOGICAL DIFFERENCES BETWEEN SPECIES OR TAXA

This study showed that the morphology of stems, leaves, pitchers and flowers provided good characters to differentiate three species and two varieties of *Nepenthes* determined (Table 1). The shape of the stem was triangular and the leaves were sessile and decurrent in *N. gracilis* whereas the stems were cylindrical and the leaves were petiolate and semi-amplexicaul in *N. ampullaria*, *N. hookeriana*, *N. rafflesiana* var. *subglandulosa* and *N. mirabilis* var. *echinostoma*. All of the taxa of pitcher plants in this study showed to have both lower and upper pitchers except *N. ampullaria*. In *N. ampullaria*, the shape of the lower pitchers was urceolate and not recorded in the other four species studied. On the other hand, the shape of lower pitchers of

N. rafflesiana var. *subglandulosa* was ellipsoidal and tubulose-globose and *N. hookeriana* was ellipsoidal whereas in *N. gracilis* and *N. mirabilis* var. *echinostoma*, the shape was tubulose on the lower half and ventricose or infundibulate on the upper half. The inner surface of the lower pitcher cavities of pitcher plants may be partly covered with digestive glands or wholly covered with digestive glands termed as partly glandular and wholly glandular pitchers (Adam *et al.*, 2005; Danser, 1928; Kurata, 1976). In this study, the partly glandular lower pitchers were recorded in *N. gracilis*, *N. mirabilis* var. *echinostoma* and *N. rafflesiana* var. *subglandulosa* and the wholly glandular lower pitchers were recorded in *N. ampullaria* and *N. hookeriana*. On the other hand, partly glandular upper pitchers were recorded in *N. gracilis*, *N. mirabilis* var. *echinostoma* and *N. rafflesiana* var. *subglandulosa*; wholly glandular upper pitchers were recorded in *N. hookeriana*. Two types of digestive glands were recorded in pitcher plants. They were overarched digestive glands and exposed digestive glands. In the overarched type, the glands were partly or totally hidden by the well developed epidermal roof and the exposed type the glands were totally exposed and without extended epidermal roof. In this study, exposed digestive glands were found in *N. gracilis* only. The peristome or lip of the pitcher mouth was narrow with the thickness of >1 mm in *N. gracilis* and there were >1 mm thick in the other four species. The pitcher lids of *N. ampullaria* which is distinctly small than the mouth of the pitcher distinguishing it from the other four species studied. The density and the distribution pattern of the honey glands found on the lower surface of the pitcher lids did provide very good characters to distinguish between the species. The lower lid surface of *N. ampullaria* was glandless and it was sparsely glandular in *N. gracilis* and *N. hookeriana* and densely glandular in *N. rafflesiana* var. *subglandulosa* and *N. mirabilis* var. *echinostoma*. *N. mirabilis* differed from *N. rafflesiana* var. *subglandulosa* in having lower lid surface wholly and densely covered with honey glands whereas in *N. rafflesiana*, the lower lid surface was glandless in the middle part and densely glandular in the outer part. The types of inflorescence recorded in the genus were a panicle and a raceme. The former type of inflorescence was recorded in *N. ampullaria* and the later type was recorded in *N. gracilis*. No inflorescences were of both male and female plants of *N. hookeriana*, *N. mirabilis* var. *echinostoma* and *N. rafflesiana* var. *subglandulosa* were collected from the study area.

The morphology of spur as shown in Table 2 provides a good taxonomic character to differentiate between the taxa studied. *Nepenthes ampullaria* differs

Table 1: Differences of morphological characters between *Nepenthes ampullaria*, *N. gracilis*, *N. hookeriana*, *N. rafflesiana* var. *subglandulosa* and *N. mirabilis* var. *echinostoma* in Lambir Hill

Morphological Characters	<i>N. ampullaria</i>	<i>N. gracilis</i>	<i>N. hookeriana</i>	<i>N. rafflesiana</i> var. <i>subglandulosa</i>	<i>N. mirabilis</i> var. <i>echinostoma</i>
1. Stem	Cylindrical	Triangular	Cylindrical	Cylindrical	Cylindrical
2. Leaves	Petiolate	Sessile	Petiolate	Petiolate	Petiolate
3. Leaf base	Semi-amplexicaul	Decurrent	Semi-amplexicaul	Semi-amplexicaul	Semi-amplexicaul
4. Shape of lower pitcher (LP)	Urceolate	Tubulose-ventricose	Ellipsoidal	tubulose-globose	Tubulose-Infundibulate
5. Digestive glands (DG) on inner wall of LP	Wholly glandular	Partly glandular:	Wholly glandular	Partly glandular	Partly glandular:
6. Shape of upper pitcher (UP)	Absent	Tubulose-ventricose	Infundibulate	Tubulose-Infundibulate	Tubulose-ventricose
7. DG on the inner wall of UP	No upper pitcher	Partly glandular	Wholly glandular	Partly glandular	Partly glandular
8. Type of DG on the inner wall of UP and LP	Glands overarched with epidermal flap	Exposed type and without epidermal flap	Glands overarched with epidermal flap	Glands overarched with epidermal flap	Glands overarched with epidermal flap
9. Peristome	Thick (>1 mm) 0.5-1 cm	thin (≤1 mm)	Thick (>1 mm) 1 cm	Thick (>1 mm) 7 mm	Thick (>1 mm) 1-2 cm
10. Size of pitcher's lid	Smaller than the pitcher mouth	The same size of the pitcher mouth	The same size of the pitcher mouth	The same size of the pitcher mouth	The same size of the pitcher mouth
11. Honey glands on the lower lid surface	Glandless	Sparsely distributed	Sparsely distributed	Sparsely to glandless in the middle and becoming dense towards the margin	Densely distributed
12. Inflorescence type	Panicle	Raceme	Unknown	Unknown	Unknown
13. Pedicel	Branching into 2-4	Simple	Unknown	Unknown	Unknown
14. Pedicel extended by bract	Bracteolate	Ebracteolate	Unknown	Unknown	Unknown

Table 2: Morphology of spur of *Nepenthes* species

Species	Shape	Branched or unbranched	Length	Point of attachment
<i>N. ampullaria</i>	Flattened	Trifid	6-9 mm	On the lid base
<i>N. gracilis</i>	Flattened	Not branched	3 mm	On the lid base
<i>N. hookeriana</i>	Flattened	Not branched	15-20 mm	3 mm below the lid base
<i>N. rafflesiana</i> var. <i>subglandulosa</i>	Cylindrical	Not branched	5 mm	On the lid base
<i>N. mirabilis</i> var. <i>echinostoma</i>	Flattened	Not branched	5-6 mm	On the lid base

from the other four taxa by its trifid spur whereas the other taxa have simple spur. The cylindrical spur of *Nepenthes rafflesiana* var. *subglandulosa* differentiates it from the other taxa. *Nepenthes hookeriana* differs it from the other taxa by its spur which is attached about 3 mm below the lid base and very long spur which is 15-20 mm long.

CONCLUSIONS

Three species and two varieties were recorded from the study area. These species were *Nepenthes ampullaria* Jack, *Nepenthes gracilis* Korthals and *Nepenthes hookeriana* Lindley. The two varieties were *Nepenthes mirabilis* var. *echinostoma* (Hook fil) Adam and Wilcock and *Nepenthes rafflesiana* var. *subglandulosa* Adam and Hafiza var. nova. The morphology of stem, leaves, the shape of the upper and lower pitchers, distribution of honey glands on the lower lid surface and on the peristome, type and distribution of digestive glands on the surface of both lower and upper pitchers, morphology of spur and inflorescence types provided good characters

to differentiate between the taxa and very helpful to us to construct a dichotomous key. A new variety that is *Nepenthes rafflesiana* var. *subglandulosa* Adam and Hafiza was described; it differs from the typical variety in having inner wall surface of lower and upper pitcher partly covered with digestive glands.

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