

THE ECOLOGY AND DISTRIBUTION OF BORNEAN *NEPENTHES*

Jumaat Haji Adam,

Jabatan Biologi, FSSA, Universiti Kebangsaan Malaysia Sabah Campus, L.B. 62, 88996 Kota Kinabalu, Sabah, Malaysia

C.C. Wilcock & M.D. Swaine

Department of Plant & Soil Science, University of Aberdeen, St. Machar Drive, Aberdeen AB9 2UD, Scotland

Received May 1991

JUMAAT HAJI ADAM, WILCOCK, C.C. & SWAINE, M.D. 1992. The ecology and distribution of Bornean *Nepenthes*. The ecology and distribution of 31 Bornean *Nepenthes* are described. The geographical distribution of *Nepenthes* is restricted to the tropical area of the world. *Nepenthes* grows from sea level to 3400 m above sea level. The species prefers exposed habitats, on nutrient poor soils. The occurrence of *Nepenthes* in these habitats is attributed to its carnivorous habit. Generally, Bornean endemic species have very restricted distribution, in some cases being found on a single mountain summit. The restricted distribution of the species may be attributed to soil factor, insufficient time for the species to spread or inadequate knowledge due to lack of the exploration of the species, particularly in the Kalimantan area. This study shows that while *N. mirabilis* is the most widespread species, *N. reinwardtiana* is confined to Borneo and Sumatra.

Key words: Bornean *Nepenthes* - ecology - distribution

JUMAAT HAJI ADAM, WILCOCK, C.C. & SWAINE, M.D. 1992. Ekologi dan taburan tumbuhan periuk kera di Borneo. Ekologi dan taburan 31 periuk kera Borneo dibentang. Taburan geografi periuk kera adalah terhad kepada kawasan tropika sahaja. Periuk kera tumbuh dari paras laut hingga ke 3400m di atas paras laut. Jenis ini mengemari lingkungan yang kurang subur dan terdedah. Terdapatnya periuk kera di lingkungan ini disebabkan sifat magingnya. Secara umumnya jenis yang endemik pada Borneo ini mempunyai taburan yang terhad, dalam keadaan tertentu, hanya terdapat disatu puncak gunung sahaja. Taburan jenis terhad ini mungkin disebabkan oleh faktor tanah, masa yang tidak mencukupi untuk jenis tersebut berkembang atau mungkin disebabkan kurangnya explorasi keatas jenis tersebut terutama sekali di kawasan Kalimantan. Kajian ini menunjukkan bahawa *N. reinwardtiana* adalah terhad pada Borneo dan Sumatra.

Introduction

The distribution of *Nepenthes* is restricted to but scattered throughout the tropics, with the centre of distribution in Borneo, Sumatra, Peninsular Malaysia, Philippines and New Guinea. It extends eastwards to New Caledonia and Isles of Pines, westwards to the Seychelles and Madagascar, southwards to the York Peninsula, and northwards to an isolated location on Khasia Hill in India, Indo-China but is absent from Burma.

Nepenthes grows from sea level (even within the spray zone of the sea) to about 3400 m. The species can be arbitrarily categorised in two groups, viz the lowland group and the highland group. The former group consists of species which commonly grow below 100 m above sea level (only occasionally growing to above 1000 m). The latter group grows commonly on high mountains at elevations above 1000 m but occasionally growing down to about 500 m, with no records below 100 m.

Generally, the lowland species grow in open habitats such as secondary bushes associated with *Gleichenia* ferns, road side embankments, edges of the forest, swampy area, heath forest, peat swamp forest and gaps in lowland dipterocarp forest.

The highland species are common and most conspicuous in montane rain forest. They are rare in submontane rain forest or oak forest but some species such as *N. tentaculata* grow within the gap or in open areas of the forest. They commonly grow between 800 and 2700 m.

***Nepenthes* occurring outside Borneo**

N. albomarginata

The species is fairly widely distributed, reported to be found in Borneo, Peninsular Malaysia and Sumatra (Adam *et al.* 1989). In Borneo, it has been widely collected along the coastal area, on the western part of the island. Phillipps and Lamb (1988) mentioned that the species grows along sandy coasts and in areas of white sandy podsol soils, and on rocky sandstone outcrops and cliff, but rarely in peat swamp forest. It grows in heath forest, scrub vegetation (Ashton 1971), in limestone vegetation (Anderson 1965), and occasionally in Padang Alan forest (Smythies 1965). In Sabah, it is recorded in Beaufort-Sipitang area only, growing at an altitude of 0 to 100 m above sea level. It grows in heath forest, secondary scrub and tall canopy lowland dipterocarp forest. In Sarawak, the species has been commonly encountered on the western part, particularly around Kuching area, Bukit Braang and Mount Bungoh. It grows commonly at an altitude of below 100 m (but can be found sometimes up to 1200 m above sea level), in tropical heath forest, along the coast on rock faces well within the spray zone of sea water, on open vegetation in limestone vegetation, and secondary scrub. Danser (1928) mentioned the occurrence at western, and southeastern division of Kalimantan. The rare occurrence of the species can be attributed to the lack of botanical exploration of this part of the island.

N. gracilis

The species is geographically widely distributed, found in Borneo, Sumatra, Peninsular Malaysia and Celebes. It grows on exposed sites such as roadside clearings, secondary bush and low canopy heath forest, commonly at below 100 m and only rarely at higher altitudes up to 1200 m.

It is widely distributed in Borneo. In Sabah and Sarawak, it is a common roadside plant, scrambling or climbing among *Gleichenia* bush, secondary scrub and heath forest. Phillipps and Lamb (1988) reported the growth of the plant on the podsolic soil of *Baekia* heath scrub of the interior plain of Sabah, and at the edge of swamps in association with *N. mirabilis* and *N. rafflesiana*; Smythies (1965) mentioned that the species can also be found in Padang Alan forest (dipterocarp forest of pure stands of *Shorea albida*), and Padang Keruntum forest (peat swamp forest dominated by *Combretocarpus rotundatus*). Its altitudinal distribution ranges from 0 to 1700 m but is commonly found at low altitude, usually below 100 m, rarely at an altitude above 1000 m.

N. mirabilis

It is geographically the most widespread species, occurring in Borneo, Peninsular Malaysia, Java, Sumatra, Thailand, Indo-China, Southern China, Moluccas, Philippines, Celebes, New Guinea and Australia (Danser 1928, Kurata 1976, Som 1988, Adam *et al.* 1989). The plants commonly grow in damp habitats, swampy areas, secondary vegetation and are found usually below 100 m.

It is a widespread species in Borneo and has been most commonly collected from the western and northern parts of the island. It grows from 0 to 1100 m, but most of the habitats are found below 100 m. The plants grow extensively in swampy areas but can also be found occasionally in drier areas or fringes of swampy areas, secondary scrub or roadside clearings.

N. reinwardtiana

The species has restricted distribution and is found in Borneo and Sumatra (Adam *et al.* 1989). There are reports that the species is found in Peninsular Malaysia (Macfarlane 1908, Danser 1928, Holttum 1940, Kurata 1976, Shivas 1984, Phillipps & Lamb 1988, Som 1988).

The occurrence of the species in Peninsular Malaysia was reported by Macfarlane (1908) based on Wallich specimens no. 2244 and a specimen collected by Hullet deposited at the Singapore Botanic Gardens Herbarium (SING). The microfiche of Wallich's specimen no.2244 at the Edinburgh Royal Botanic Garden Herbarium (E) consists of two different species, *N. gracilis* and *N. albomarginata*. The specimen of Hullet at the SING has an ambiguous label, particularly with reference to the locality where it was collected, written as "Luiggi in Pahang". This specimen was collected in 1893. According to Danser (1928) this specimen was collected from Lingga in Pahang.

We believe that this specimen of Hullet was collected from Mount Dai in Lingga, off the east coast of Sumatra. Steenis (1950) mentioned that Hullet went on an orchid collecting trip for Ridley to Mount Dai in Lingga in 1893 which agrees with the label on the specimen. Therefore, the report by Macfarlane (1908) and Danser (1928) on the occurrence of this species in Peninsular Malaysia has been erroneously followed or adopted by other authors in later years. Holttum (1940)

mentioned the doubtful occurrence of it in Peninsular Malaysia but he did not see any specimens of the species at the SING. Shivas (1984) and Som (1988), like Holttum, did not see any specimens of the species collected from Peninsular Malaysia. Green (1967) reported the absence of the species from Singapore Island, but according to her, its presence in the past has been reported on the island. Danser (1928) mentioned with uncertainty the occurrence of *N. reinwardtiana* in Celebes.

It is a fairly widespread species in Borneo, and has been collected from the northern, western, eastern and southern parts of the island. It grows commonly on exposed roadside bushes or bare ground on gentle or steep slopes, or oil dumping sites. It can be found at altitudes from sea level to 1200 m above sea level but most of the habitats are found at low altitudes. Phillipps and Lamb (1988) noted that the species is widespread in Borneo and can be found from sea level to 1200 m above sea level often growing epiphytically. Smythies (1965) reported its growing on montane rain forest, on coastal rock surfaces and epiphytically on *Dipterocarpus oblongifolius* trees overhanging the streams.

N. trichocarpa

The species is found in Peninsular Malaysia, Borneo and Sumatra (Adam *et al.* 1989). In Borneo, the plant commonly grows on exposed habitats such as roadside clearings scrambling and climbing among the *Gleichenia* bushes and in undisturbed or disturbed heath forests. It is a lowland species commonly found below 100 m. It often grows with the three common lowland species, *N. ampullaria*, *N. gracilis* and *N. rafflesiana*.

N. tentaculata

This species is reported to be found in Borneo and Celebes (Danser 1928, Kurata 1976). It was also reported to occur in Borneo only (Macfarlane 1908, Phillipps & Lamb 1988, Adam *et al.* 1989).

Recently, we confirmed Danser's (1928) identification of one herbarium specimen of *N. tentaculata* (BO, Rachmat 900) collected from Gunong Sinadji in Celebes. We believe the plants named as *N. adnata nomen nudum* by Hotta and Tamin (1986) from Sumatra are referable to *N. tentaculata*. The plants collected from Sumatra and Celebes resemble var. *imberbis* of Beccari and differ from the normal variety by the absence of groups of simple to branched appendages on either side of the pitcher spur, and also in the absence of hairs or bristles on the margin of the upper side of the lid of the pitcher.

It is a common species on the mountains of Borneo between an altitude of 700 to 2400 m. The species commonly grows in semi-shaded areas or within the gaps of submontane mossy forest. According to Phillipps and Lamb (1988), the species can grow at lower altitudes due to the effect of coastal climate, such as on Mount Silam and Mount Santubong, which encourages the formation of mossy forest with peaty soil.

N. rafflesiana

N. rafflesiana occurs in Borneo, Sumatra, Peninsular Malaysia and New Guinea (Danser 1928, Adam *et al.* 1989).

It is widespread in Borneo, having been collected frequently from the western and northern parts of the island. Its altitudinal distribution varies from 0 to 1500 m.

The species grows in heath forest, secondary thicket on roadside or waste ground, secondary bush, low altitude submontane mossy forest and rarely within the gaps of high canopy lowland dipterocarp forest; it grows in open habitats such as degraded, dry and waterlogged laterite and podsols and in deep shaded forest of ultrabasic and swampy areas (Phillipps & Lamb 1988). Smythies (1965) reported its occurrence in heath forest, Padang Alan forest (dipterocarp forest with pure stands of *Shorea albida*), Padang Keruntum forest (peat swamp forest dominated by *Combretocarpus rotundatus*), Alan forest (dominated by large trees of *S. albida*) and rarely in mixed peat swamp forest.

N. gymnamphora

The geographical distribution of the species differs from that of all other species. It occurs in Sumatra, Java and Borneo, although reported to be absent from Borneo. It is found on an isolated habitat in Banjarmasin in the southernmost part of Borneo (Kurata 1976). Its altitudinal distribution and habitat in Borneo is unknown.

N. maxima

This species occurs in Borneo, Celebes, Moluccas and New Guinea (Danser 1928, Kurata 1976, Phillipps & Lamb 1988, Adam *et al.* 1989). Macfarlane (1908) reported it to be found in Borneo, Celebes and New Guinea but made no mention of the occurrence of the species in Moluccas.

It is a fairly widespread species in Borneo but is absent from the southernmost part of the island. There has been a controversial opinion on the presence of the species in Sabah. Kurata (1976) and Phillipps and Lamb (1988) reported its absence in Sabah but others have reported its presence there (Corner 1978, Turnbull & Middleton 1981). We have noted several herbarium specimens referable to *N. maxima sensu lato* which have been collected from Sabah. The species is commonly found to grow in submontane mossy forest, at an elevation of 560 to 2000 m but Corner (1978) recorded it at 1500 to 2700 m. It is often found at this elevation growing on roadside clearings, disturbed mossy forest, and oil dumping sites.

It is also fairly widespread in Celebes, Moluccas and New Guinea (Danser 1928), and grows at an altitude ranging from 600 to 1550, 800 to 1900, 1200 to 2100 m respectively. It grows commonly on mountain summits in submontane forests.

Recently we noted one specimen collected by Iboet from Pulau Siberoet in Sumatra not previously reported by Danser (1928), and Hotta and Tamin (1986).

N. ampullaria

This species occurs in Borneo, Peninsular Malaysia, Sumatra and New Guinea (Danser 1928, Kurata 1976, Adam *et al.* 1989). It commonly grows at low altitudes usually below 100 *m*. It grows in disturbed habitats, heath forest, secondary thickets and within the gaps of lowland primary forests.

It is a common species in Borneo most often collected in the north (Sabah) and west (Sarawak), and occasionally in Kalimantan, but it has not so far been recorded from the central part of the island. It usually grows below 100 *m* and is occasionally found up to 1000 *m*. It can be found in lowland high canopy dipterocarp forest, occasionally on exposed roadside clearings, on the edges or in permanently or seasonally flooded habitats. It grows in damper areas that rarely dry out (Phillipps & Lamb 1988); in heath forest and scrubland (Ashton 1971); in semi-shaded and peat swampy forest or sterile ground such as peat moor, sometimes exposed sites by the stream (Kurata 1976); in heath, peat swamp and Alan forests (Smythies 1965).

N. hookeriana

The species is present in Borneo, Peninsular Malaysia and Sumatra. The elevation in which it is found ranges from 0 to 450 *m*, and commonly grows in secondary vegetation.

In Borneo it has been reported from a few areas in Sabah, Sarawak and Kalimantan. It is found between 0 to 300 *m* above sea level. Kurata (1976) reported a wider altitudinal distribution (0 to 1000 *m*), but most of the habitats are situated below 100 *m*. It is found commonly in exposed habitats such as scrub vegetation, climbing among *Gleichenia* bushes on roadsides and regenerating waste ground and heath forest. Kurata (1976) noted it in semi-shaded and swampy forests, or sterile ground such as peat moors, and sometimes in exposed sites by streams.

Species endemic to Borneo

N. bicalcarata

It is a fairly widespread species in Borneo, frequently encountered in the northern and western parts of the island. It has not been reported from the southern and eastern parts of the island. It grows in primary peat swamp forests of Borneo at 0 to 1600 *m*, but most of the habitats are found below 100 *m*. Ashton (1971) collected this species on Mount Periok in Brunei at an elevation of *circa* 1600 *m* above sea level. It is found in the remnant peat swamp forests of Sabah. The species is common in Alan Bunga peat swamp forest dominated by pure stands of *Shorea albida*, occasionally in Alan forest, Padang Alan forest and Padang

Keruntum forest (Smythies 1965). It was found in swamps or forest margins in the lowland of Sarawak and Brunei together with other lowland species such as *N. ampullaria*, *N. gracilis* and *N. rafflesiana* (Kurata 1976).

N. hirsuta

It is a fairly widespread species in Borneo. It is commonly found on the northern and western parts but is absent from the southern half part of the island. It grows in habitats such as heath forest, submontane or montane heath forest and edges of forests between 150 to 1500 *m*. Danser (1928) noted the distributional area of the species to be limited to the mountains of northwestern Borneo. Phillipps and Lamb (1988) noted the distribution of the species to include Brunei, Sarawak, West Kalimantan, and Central Sabah. It grows in habitats such as heath forest, submontane or montane heath forest and edges of the forest. Smythies (1965) noted the habitats as montane rain forest, and tropical heath forest. Phillipps and Lamb (1988) noted that the species on Mount Lotong was found in an unusual type of mixed casuarina-conifer forest growing in thick peat over sandstone under shade.

N. macrovulgaris

This species has an unusual pattern of distribution, fairly widespread but limited to Sabah (Adam *et al.* 1989). The habitats are found between 250 and 1000 *m*. It grows in open habitats such as bare ground, roadside bushes climbing among *Gleichenia linearis* and in mossy forests within natural and man-made disturbed forest gaps between 250 to 1000 *m*.

N. boschiana

This species has only been recorded from the summit of Mount Sakoembang, in southeastern part of Borneo, at an altitude of 950 *m* (Danser 1928). The habitat is unknown but Smythies (1965) noted that the species occurred in montane rain forest.

N. burbridgeae

The species is confined to ultrabasic soil on Mount Kinabalu and Mount Tambuyukon (Adam *et al.* 1989). It has been frequently collected on three separate localities on Mount Kinabalu, *viz* Pig Hill, Marai Parai and Mamut Hill in Mamut Copper Mine in Ranau. It grows on submontane mossy forest, occasionally on exposed sites at an altitude of 1100 to 2300 *m*.

N. clipeata

It has been collected once by Hallier from Mount Kelam in Kalimantan (Danser 1928, Adam *et al.* 1989). The habitat and altitudinal distribution of this species is unknown.

N. ehippiata

This species is very restricted in distribution. It was first collected by Hallier in 1899 from Bukit Batoe Loesoeng in southeastern Borneo, and later collected by Winkler in 1924 from Bukit Raja (Raya) in the western part of Borneo, at an altitude of 1900 *m* (Danser 1928, Adam *et al.* 1989). It has been collected very recently by Nootboom from the same locality at an altitude of 2000 to 2270 *m*. Nootboom (1987) noted the habitats as montane forest with very steep slopes.

N. fusca

The distribution of the species in Borneo is very restricted. It is found growing on Mount Komoel (Adam *et al.* 1989). A few authors (Kurata 1976, Corner 1978, Phillipps & Lamb 1988) have recorded its presence in Sabah, but these specimens should be referred to as *N. maxima* Reinwardt ex. Nees *sensu lato*. In addition, we have discovered two new localities for the species in Borneo from herbarium material, *viz* Mount Njapa at an altitude of 1000 *m* and the summit of Mount Apo Dari (1500 *m*). The species grows in the forest on narrow, stony mountain ridges covered with humus and is common (Danser 1928).

N. lowii

Danser (1928) noted that its distribution is confined to Mount Kinabalu (1500 to 2500 *m*), Bukit Lawai and Bukit Batoe Tiban. In this survey the species has been found to be fairly widespread in Borneo. In North Borneo, it is found on some other mountain summits: Mount Monkobo, Mount Alab, Mount Trusmadi and Mount Tambuyukon. In northwestern Borneo the species occurs on Mount Mulu, Gunung Api, Bukit Lawai and Mount Murud. It has also been collected on Bukit Temedu in western Borneo and Gunung Rakik in eastern Borneo. It is a montane species occurring an altitude of about 900 to 3400 *m*. The plant can be a climber later becoming epiphytic on tall trees of submontane mossy forest. It can also be found scrambling in open short scrub vegetation dominated by Ericaceae.

N. mapuluensis

According to the collector, Kostermans, this species grows commonly on the limestone mountain of Ilas Mapulu in East Borneo at an altitude of 800 *m* (Adam & Wilcock 1990).

N. mollis

This species was first described by Danser (1928) but its ecological preferences are poorly known. This species is known from one locality, Mount Komoel, at an altitude of 1880 *m* (Danser 1928, Adam *et al.* 1989). The species grows on a steep slope covered with dense forest and it has been collected once.

N. pilosa

This species is limited to north and east Borneo. In north Borneo it has been collected from Mount Alab, Long Pasia and Bukit Buli. In east Borneo it has been recorded from Bukit Batoe Losoeng and Bukit Batoe Tiban. The plants grow in mossy forest between 1700 to 1900 *m* (Adam *et al.* 1989). Phillipps and Lamb (1988) noted that this species occurs in scattered localities in Borneo between 1200 to 1800 *m*.

N. rajah

This species is found on Mount Kinabalu and Mount Tambuyukon between 1600 to 2650 *m* (Adam *et al.* 1989). It is found in east Mesilau Valley at *circa* 2000 *m* and Marai Parai at 1800 *m* on Mount Kinabalu. In east Mesilau the species grows on an exposed area at the edge of mossy forest. Kurata (1976) noted that the species can also be found on upper Kolopis River and Mount Kinabalu in sunny and wet places of the mossy forest.

N. veitchii

This species is fairly widespread in Borneo. It can be found in north, northwestern, east and west Borneo between 0 to 1600 *m* above sea level (Adam *et al.* 1989). It is the only species of the genus which is a true epiphyte. It is totally absent from the western half of north Borneo and absent from Mount Kinabalu but commonly grows on Bukit Tawai at *circa* 800 to 1000 *m* on ultrabasic soil.

N. campanulata

This species is found only on Mount Ilas Bungaan at an altitude of 300 *m*. The species, according to Kurata (1973), cannot spread from this locality owing to its habitat. The collector, Kostermans, noted the species growing on sand and on the sheer limestone wall of Ilas Bungaan.

N. muluensis

This species was first described by Hotta in 1966 and ever since has only been recorded on Mount Mulu, situated in the northern part of Borneo. The species grows sympatrically with *N. tentaculata*, preferring exposed short scrub vegetation on the summit at an altitude of 1800 to 2320 *m*.

N. borneensis

This species, which is very closely related to *N. boschiana*, is known from a single mountain, Gunung Besar, in Southern Kalimantan between 1300 to 1880 *m* (Adam & Wilcock 1989). The habitat of the species is unknown.

N. edwardsiana

This species is found on three mountain summits in north Borneo: Mount Kinabalu, Mount Tambuyukon and Mount Trusmadi between 1500 and 2700 m (Adam *et al.* 1989).

N. villosa

The species is confined to a single mountain, Mount Kinabalu, between 1800 and 3400 m, on the southern slope. It grows on montane mossy forest and is confined to the ultrabasic rock zone. The failure of the species to spread to tall canopy submontane oak forest may be due to shade and soil factors. Phillipps and Lamb (1988) noted that the species has been found occasionally in areas where the soil is of granitic origin rather than ultrabasic origin.

N. northiana

This species has been reported from western Borneo on limestone hills in Bau near Kuching, between 30 and 100 m above sea level (Anderson 1965, Smythies 1965, Adam *et al.* 1989). The occurrence of this species in the Baram area, noted by Macfarlane (1925) as *N. decurrens* (a synonym), is doubtful. There is no other report of this species from Baram. It grows in limestone crevices commonly overhanging semi-shaded vertical walls of limestone, and on gentle slopes in damp habitats.

Natural hybrids

Three natural hybrids have been recognised in this study. There are *N. alisaputraiana*, *N. ghazallyiana* and *N. sarawakiensis*. The field studies show that these hybrids grow sympatrically with their respectively putative parental species. *N. alisaputraiana* (1930 to 1950 m) grows together on Pig Hill (Mount Kinabalu) with *N. burbridgeae* (1900 to 1950 m) and *N. rajah* (1950 to 2320 m). *N. ghazallyiana* grows together with *N. gracilis* and *N. mirabilis* in Telupid. *N. sarawakiensis* grows together with *N. tentaculata* and *N. muluensis* on Mount Mulu in Sarawak.

Discussion

The genus *Nepenthes* has a wide altitudinal distribution ranging from sea level up to circa 3400 m. Regardless of altitude, *Nepenthes* spp. tend to grow in exposed habitats and nutrient poor soils, localised in special habitats such as limestone hills, ultrabasic area.

Nepenthes plants grow well in open or exposed habitats such as roadside embankments among the shrub or *Gleichenia* bush and only rarely occur within lowland dipterocarp forest and montane oak preferring gaps within the forest. Holttum (1940) reported that *Nepenthes* plants are only found in open places, never

(at least in Malaysia) in shady "primitive forest"; some species are adapted to the conditions found on high exposed mountain ridges. Chai and Radcliffe (1984) found *Nepenthes* in Sarawak growing most commonly in peat swamp and kerangas forests but almost absent from the lowland mixed dipterocarp forest. Hotta and Tamin (1986) found that Sumatran *Nepenthes* in lowland and montane areas grow in exposed habitats such as secondary scrub or bush, roadside clearing and montane mossy forest. Green (1967) observed a similar situation for *Nepenthes* in Singapore.

In this study it was noted that *N. ampullaria*, when growing in exposed area, is a short climber and flowers when reaching the length of *circa* 1 m long. The same species, when growing in lowland dipterocarp forest, is a tall climber and flowers only when the plant succeeds in reaching the canopy top which is about 15 to 30 m. A similar pattern of growth has also been observed on *N. macrovulgaris*, where on bare soil the plant is a scrambler, bushy and flowering when it is less than 1 m long, whereas in secondary bushes the plant is a climber among *Gleichenia* bush flowering when reaching 1 m long. In mossy forest the plant is a tall climber succeeding in flowering when the plant reaches the top of the tree, *circa* 5 to 6 m tall. The growth pattern and flower production of these species seem to be related to light exposure or intensity. Similar observations have also been reported by previous workers. Smythies (1965) pointed out that exclusion of *Nepenthes* in dipterocarp forest is related to light intensity and nutrient requirements. He found that all species of *Nepenthes* seemed to flourish in full sunlight but failed to produce flowers under fairly heavy shade. Secondly, no *Nepenthes* seedlings were found in cleared areas of dipterocarp forest. He speculated that nitrogen may be a requisite for the growth of *Nepenthes* under natural conditions but this needs experimental confirmation. Mazrimas (1979) observed that different light intensities influence the growth rate and pitcher production in *Nepenthes*. Green (1967) also found that shade can influence the development of pitchers and tendril formation in *Nepenthes*. Lavarack (1981) observed that *N. mirabilis* in York Peninsula in Australia is a small compact shrub with numerous pitchers in exposed habitats, whilst it grows into a tall climber up to 10 m long with fewer pitchers in wet shady swamps.

The common occurrence of *Nepenthes* in nutrient poor soils such peat swamp, heath forest, sandyfield, limestone vegetation, on bare rocks is attributed to its carnivorous habit. The evidence of tolerance, if not preference, of *Nepenthes* for nutrient poor soils has also been reported by previous workers. Chapman (1947, cited in Juniper *et al.* 1989) observed *Nepenthes* growing in the 'patana', of nutrient poor grassland in Sri Lanka. Juniper (cited in Juniper *et al.* 1989) found that *N. destillatoria* and *N. pervillei* could be observed growing on exposed granite rocks often beside new road cuttings, rooting into crevices.

The serpentine or ultrabasic endemics according to Kruckerberg (1954) are characterised by being able to obtain sufficient calcium even at the low concentration characteristics of this site. The heavy metal ions concentrations such as cobalt, nickel and chromium may serve only to keep away opposition, not to provide any specific need of the endemics. *N. northiana*, *N. campanulata*, *N. clipeata* and *N. mapuluensis* are limestone endemics only known, from Bau, Ilas Bungaan,

Mount Kelam and Ilas Mapulu respectively. The tolerance, preference or restricted distribution of these species growing in this limestone habitat is still not understood.

The restricted distribution of species in the Kalimantan part of Indonesia, which may be more widespread than presently known, is attributed to lack of botanical exploration and the lack of the floristic knowledge of the area.

Acknowledgements

We wish to thank the Universiti Kebangsaan Malaysia, the University of Aberdeen and the Sabah National Parks for financing this project, and Julaihi Adam and Aliosman Mahdi for their assistance in the field.

References

- ADAM, J.H. & WILCOCK, C.C. 1989. A new *Nepenthes* from Gunong Besar, Kalimantan Selatan, Borneo. *The Garden's Bulletin Singapore* 42(1): 25-28.
- ADAM, J.H. & WILCOCK, C.C. 1990. A new *Nepenthes* from Mount Ilas Mapulu in Borneo. *Blumea* 35: 265-267.
- ADAM, J.H., WILCOCK, C.C. & SWAINE, M.D. 1989. Ecology and taxonomy of Bornean *Nepenthes*. *University of Aberdeen Tropical Biology Newsletter* 56: 2-4.
- ANDERSON, J.A.R. 1965. Limestone habitat in Sarawak, Pp. 49-57 in *Proceedings of the Symposium on Ecological Research in Humid Tropics Vegetation*. July 1963. Kuching, Sarawak.
- ASHTON, P.S. 1971. The plants and vegetation of Bako National Park. *Malayan Nature Journal* 24: 151-162.
- CHAI, P. & RADCLIFFE, G. 1984. Ant plants and carnivorous plants of kerangas scrub vegetation in Bako National Park. *Nature Malaysiana* 9 (2): 18-27.
- CORNER, E.J.H. 1978. The plant life. Pp. 112-178 in Luping, Chin Weng & Dingley (Eds.) *Kinabalu Summit of Borneo*. Sabah Society Monograph.
- DANSER, B.H. 1928. The Nepenthaceae of the Netherlands Indies. *Bulletin Jardine Botanique Buitenzorg* 9(3), LIVR 3-4: 249-435.
- GREEN, S. 1967. Notes on the distribution of *Nepenthes* in Singapore. *The Gardens' Bulletin Singapore* 22: 53-65.
- HOLTUM, R.E. 1940. Malayan pitcher-plants. *Malayan Nature Journal* 1: 35-44.
- HOTTA, M. 1966. Notes on Bornean plants, I. *Acta Phytotaxonomica et Geobotanica* 22(1-2): 7-9.
- HOTTA, M. & TAMIN, R. 1986. *Nepenthes* di Sumatra. Pp. 75-113 in Hotta, M. (Ed.) *Diversity and Dynamics of Plant life in Sumatra. Forest Ecosystem and Speciation in Wet Tropical Environments. Part 1. Report and collection of papers*. Sumatra Nature Study (Botany). Kyoto University.
- JUNIPER, B.E., ROBINS, R.J. & JOEL, D.M. 1989. *The Carnivorous Plants*. Academic Press. 353 pp.
- KRUCKERBERG, A.R. 1954. Plant speciation in relation to serpentine soils. *Ecology* 25: 267-274.
- KURATA, S. 1973. *Nepenthes* from Borneo, Singapore & Sumatra. *The Garden's Bulletin Singapore* XXVI: 227-232.
- KURATA, S. 1976. *Nepenthes* of Mount Kinabalu. *Sabah National Parks Publication No. 2*. Sabah National Parks Trustees.
- LAVARACK, P.S. 1981. *Nepenthes mirabilis* in Australia. *Carnivorous Plant Newsletter* 10(3): 69-76.
- MACFARLANE, J.M. 1908. Nepenthaceae. In A. Engler, *Das Pflanzenreich Regni Vegetabilis Conspectus* 4(3) Heft 36: 1-91. Liepzig.
- MACFARLANE, J.M. 1925. A new species of *Nepenthes* from Borneo (*N. decurrens*). *Kew Bulletin*: 35-37.
- MAZRIMAS, J. 1979. *Nepenthes*. *Carnivorous Plant Newsletter* 8(1): 24-29.
- NOOTEBOOM, H.P. 1987. *Report of the 1982-1983 Bukit Raya Expedition*. Rijksherbarium, Leiden, The Netherlands. 93 pp.

- PHILLIPPS, A & LAMB, A. 1988. Pitcher-plants of East Malaysia and Brunei. *Nature Malaysiana* 13(4): 8-27.
- SHIVAS, R.G. 1984. *Pitcher-plants of Peninsular Malaysia and Singapore*. Maurizen Asia.
- SMYTHIES, B.E. 1965. The distribution and ecology of pitcher-plants (*Nepenthes*) in Sarawak. *UNESCO Humid Tropics Symposium*. July 1963. Kuching.
- SOM, R.M. 1988. *Systematic Studies on Nepenthes Species and Hybrids in the Malay Peninsula*. Ph.D. thesis. Universiti Kebangsaan Malaysia.
- STEENIS, C.G.J.V. 1950. Malaysian plant collectors and collection being a cyclopaedia of botanical exploration in Malaysia and a guide to the concerned literature up to year 1950. *Flora Malesiana* 1. Noordhoff-Kolff, Djakarta.
- STEENIS, C.G.J.V. 1969. Plant speciation in Malesia with special reference to the theory of non-adaptive saltatory evolution. *Biological Journal of the Linnean Society* 1: 97-133.
- TURNBULL, J. R. & MIDDLETON, A.T. 1981. A preliminary review of the Sabah species of *Nepenthes*, including a regional list and some selected localities. Report to the Sabah Parks Trustees. (Unpublished).