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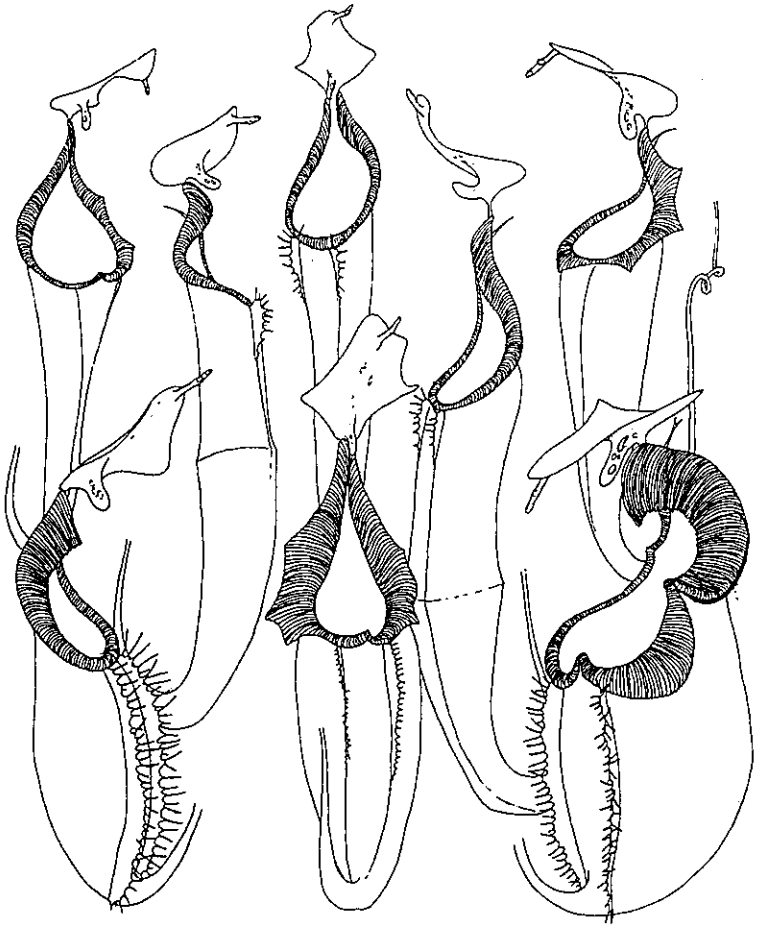

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AN ACCOUNT OF *NEPENTHES* IN NEW GUINEA

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ABSTRACT

The carnivorous nature of Nepenthes, *its ecology, architecture, morphology and taxonomy of New Guinea species are discussed. The unique architecture of* N. ampullaria *is described for the first time. A taxonomic summary with descriptions and drawings of all eleven species known to occur in New Guinea is presented. For each species the synonymy in New Guinea only is given and one undescribed species is outlined. All collections from New Guinea seen by the author are listed and assigned to species, and distribution maps are given. A collector index is also provided.*

INTRODUCTION

Nepenthes was last revised for New Guinea by Danser in 1928. His work covered the 51 species found in Indochina, Malaysia, Indonesia, the Philippines and New Guinea, but omitted a further 15 species which lay outside the political boundary of the then Dutch East Indies. Harms' monograph in Engler & Prantl (1936) included the entire genus, but made no taxonomic changes to Danser's work, other than resurrecting a single species which Danser had synonymised. Since then 9 species have been added, piecemeal, to the genus. No new species have been described from New Guinea, although the herbarium material has more than quadrupled.

Danser illustrated six of the New Guinea species but, illustrations of others are widely scattered in the literature. With the exception of Kurata's book 'The *Nepenthes* of Mt.Kinabalu' (1976) there are currently no regional guides to the genus.

This paper presents a complete taxonomic guide to the species in New Guinea, with discussions on their biology and ecology, as well as illustrations of all the species.

There are four genera of carnivorous plants in New Guinea; *Byblis* (Byblidaceae), *Drosera* (Droseraceae), *Nepenthes* (Nepenthaceae) and *Utricularia* (Lentibulariaceae). Of these *Nepenthes*, the 'Pitcher Plant', is undoubtedly the most spectacular, with its large, rigid, water-filled pitchers. Ten species have been recorded from New Guinea, five of which are endemic. All ten species are found in Irian Jaya, but only four species occur in Papua New Guinea. One undescribed species is present on Waigeo Island, off the western tip of Irian Jaya.

Nepenthes are short, erect shrubs or climbers with a highly specialised leaf structure (Figure 1). The apparent 'lamina' bears at its tip a tendril from which arises a sharply upturned and hollow pitcher with a more or less oblique mouth overhung by a lid, from the base of the lid arises a short spur. Venation suggests that this spur is the true leaf apex (Lloyd, 1942) and strict morphological distinctions of petiole and lamina cannot be sensibly applied to the *Nepenthes* leaf. Whatever the derivations of the leaf

blade, tendril, pitcher and its lid may be, in this paper the blade is referred to as the leaf blade, and a narrowing at its base as the petiole. The pitchers are variable in size and shape, from globose to cylindrical, and are almost invariably half-filled with water and the remains of numerous insects and other organisms.

EVOLUTIONARY ORIGIN OF *NEPENTHES*

There is no concensus on the natural affinities of the genus. It is the only member of the family Nepenthaceae, and although demonstrating remarkable similarities to the New World pitcher plants *Sarracenia*, *Darlingtonia* and *Heliamphora* (Sarraceniaceae) in its pitchered leaves, there is no good reason to suggest a relationship (Cronquist, 1981). All the species of *Nepenthes* show a remarkably uniform structure, specific differences are generally slight. Thus although isolated as a genus, *Nepenthes* is a very discrete grouping. The remarkable morphology of the pitchered leaves, and the small generic variability suggests a rapid and revolutionary origin for the genus, necessarily obscuring its affinities.

PITCHER STRUCTURE AND FUNCTION

The pitcher of *Nepenthes* acts as a pitfall trap for a wide range of invertebrates. The wall of the pitcher is thin but of great strength, attributable chiefly to the thick-walled epidermis both within and without and supported by the veins which have a generous supply of sclerenchyma (Lloyd, 1942). The pitcher fluid is made up from water and enzymes secreted by the pitcher glands. Invariably these pitchers contain the remains of trapped organisms such as ants, flies, wasps, cockroaches and others. An account of prey organisms found in pitchers of *Nepenthes mirabilis* is given in Appendix A.

During development the mouth of the pitcher is hermetically sealed by the lid which only opens when the definitive size and shape of the pitcher has been attained. The lid is not fused to the pitcher mouth, but is both tightly applied, and has a dense growth of branching hairs which clothe the outer face of the pitcher mouth and the edge of the lid (Lloyd, 1942). Once open the lid is usually held a short way above the mouth, and it is probably an efficient bar to the entry of rain. An exception to this is *N. ampullaria* where the lid is turned completely back, and lacks nectar glands.

The edge of the pitcher mouth bears an unusual, finely ribbed structure - the peristome (Figure 1). In section the peristome is more or less T-shaped, with the arms of the T curving downwards and inwards. On the inner edge of the peristome the corrugations end in minute teeth, and between each of these teeth lies a nectar gland.

The upper one third or so of the inner pitcher wall is the waxy zone (or pruinose zone of some authors) and below this lies the glandular zone. Under the electron microscope the waxy zone is seen to be composed of a dense coating of minute ($< 1\mu m$), readily detachable wax scales, which prevent any organism from clinging to the wall (Juniper et. al., 1989). These scales function by attaching to the suction pads or tarsi of insects, temporarily destroying their ability to grip any surface, even after removal from the pitcher (Lloyd, 1942).

Prey is probably attracted to the pitcher by a combination of its colouration and the presence of nectar secreted by glands on the underside of the pitcher lid, the inner edge of the peristome, and on the outer surface of the pitcher (Joel, 1988). The prey drops into the fluid, which contains a wetting agent preventing escape. The combination of

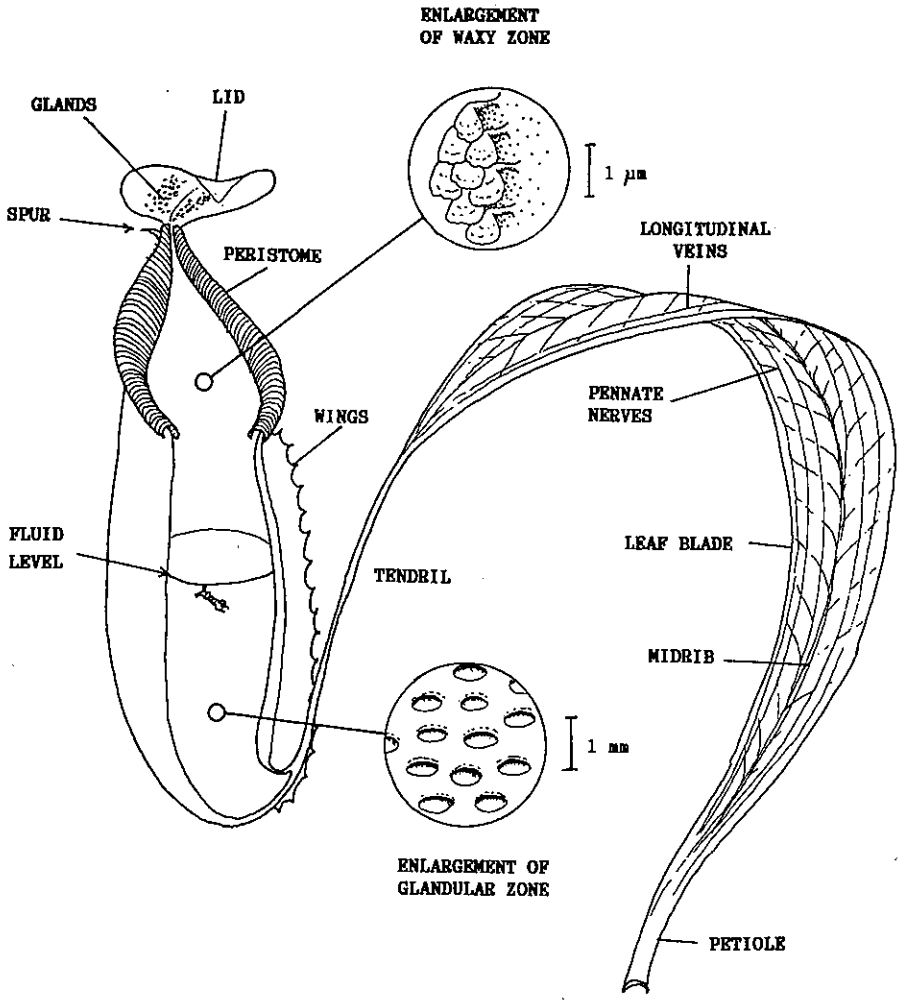


Figure 1. The Nepenthes leaf, showing the features mentioned in the text and showing enlargements of the inner pitcher surface.

proteolytic enzymes secreted by the glands in the lower part of the pitcher, and bacteria living in the pitcher fluid, leads to the breakdown of the prey followed by absorption of the products by these same glands (Lloyd, 1942).

The pitcher may also contain a number of organisms which are capable of living above, or within, the fluid without being trapped or digested. These include spiders and water mites, mosquito larvae (*Tripteroides* and *Toxorhynchites*), and the larvae of many other dipterans (Phoridae, Chironomidae), crustaceans (copepods and ostracods), protists, desmids, diatoms, bacteria and fungi may also be present (Lloyd, 1942).

ECOLOGY

In New Guinea, *Nepenthes* spp. are to be found from sea-level to 3,500 m, but most commonly between 1,500 to 2,500 m. They can be found in practically every vegetation type but especially on thin or nutrient-poor soils or other thin-canopied sites, and least commonly in seasonal savanna, and closed forest. They are often encountered along river banks, on abrupt, open, or rocky ridge tops, and in dry or swampy grassland. They are absent from large areas of the north coast of Papua New Guinea, and have not been found on the islands of the Bismarck archipelago with the exception of Manus Island. This may be explained by the rich volcanic soils and the incidence of the El Niño Southern Oscillation (McAlpine et. al., 1983), as the periodic droughts brought about by this climatic effect are most strongly felt on the north coast (Johns, 1986).

A high light requirement is characteristic of all carnivorous plants, and this is attributed to their higher respiratory rates. All carnivorous plants have cells rich in mitochondria, and cell chemistry is dominated by the products of their carnivorous habits, with more protein and fat metabolism than the more usual carbohydrates of plant cells (Lloyd, 1942, Juniper, 1989). The occurrence of *Nepenthes* in nutrient-poor sites is probably as much a measure of the poorly developed canopy, and consequent high light levels of such habitats, as it is of carnivory supplementing low mineral levels. Thus in cultivation many *Nepenthes* will thrive in a rich soil.

The most widely distributed and common species, *N. mirabilis*, is occasionally found in apparently nutrient rich situations, notably disturbed rain forest and grassland (Danser, 1928 and my personal observations). *Nepenthes ampullaria* is unusual in that it may be found in dense forest, including *Araucaria* stands, although it is equally common in open vegetation. It has tall, climbing stems which reach up to 15 m in length. While other species may also climb in vegetation, they are apparently less tolerant of shade.

Nepenthes maxima is found in the greatest range of habitats and associated with this shows more morphological variation than any other species in New Guinea, with slender, dwarfed forms growing epiphytically in moss cushions, thick robust climbers on ridge tops, and short erect plants in montane swamp grassland. Some other species are also found in a range of of habitats; *N. neoguineensis* for example is found on river gravel bars at sea level in Morobe Province and on limestone ridge tops at 2000 m in the Southern Highlands of Papua New Guinea. *Nepenthes vieillardii* may grow as a slender epiphyte in moss forest or as a compact, erect shrub above the treeline.

PITCHER MORPHOLOGY AND PLANT ARCHITECTURE

Young *Nepenthes* plants will produce their first pitchers while still minute, and these may be only 2 to 3 mm long. As the plant develops, so successive pitchers become larger, and begin to acquire their specific characters. At the point when the plant first flowers, a remarkable change occurs in the structure of the leaves. While the stems of the young plant are highly condensed, and produce rosettes of leaves with straight tendrils and incurving globose pitchers, in older plants the stems are slender, with long internodes, the tendrils are coiled and the pitchers face outwards from the tendril.

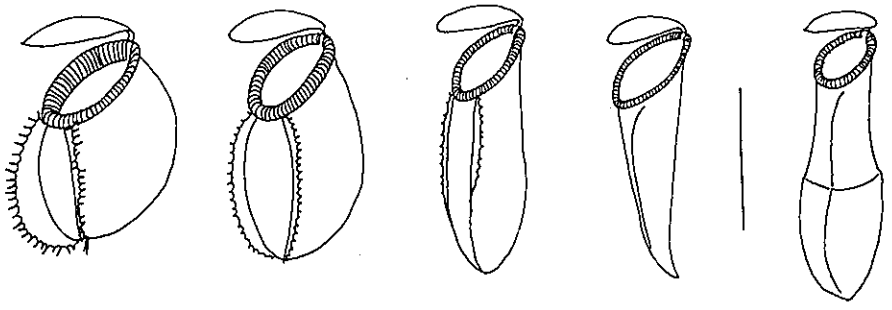
Although this dimorphism has been reported previously (Veitch, 1897; Danser, 1928; Kurata, 1976), the full extent to which this phenomenon exists has not been emphasized. The dimorphy of the pitchers and leaves often leads to confusion as to how many species are present at a site.

The pitcher has a dorsal, or back, surface from which arises the lid, while the ventral, or front, surface leads to the mouth. Along the ventral side there are two parallel, longitudinal ridges, which in many species bear fimbriate or entire wings. In

the majority of species these wings are more pronounced in the lower pitchers. In lower pitchers the pitcher's ventral surface faces the tendril, while in upper pitchers the dorsal surface faces the tendril.

Danser (1928) noted these differences as well as the change in pitcher shape, becoming more infundibulate, and less urceolate (Figure 2), and the reduction of the wings of the pitcher from the rosette to the climbing leaves. He did not appreciate that the change in pitcher shape was accompanied by the plant becoming fertile but regarded the phenomenon in terms of strict morphological stem types of 'rosettes', 'short stems' and 'elongated' or 'climbing stems'. This was no doubt due to his lack of field knowledge of the genus, his revision being very much an herbarium study based at Bogor. Kurata (1976) recognised the change as a gradual feature of the *Nepenthes* plant's growth.

Although most pitchers may be described by the general forms illustrated in Figure 2, some species have pitchers which are a combination of forms, and others may develop an abrupt hipped appearance.



URCEOLATE OVOID CYLINDRICAL INFUNDIBULATE HIPPED

Figure 2. Terms describing pitcher shape.

The dimorphy of the pitchers apparently follows the same pattern in all species. Figure 3 shows a young plant (A) and an older plant (B) of *N. mirabilis* to illustrate these changes.

At the point of transition a single, intermediate pitcher may be produced, which arises sideways to the tendril, and shows intermediate characters. In some *N. maxima* populations all the upper pitchers may arise sideways in this manner (Fig 14c). These pitchers show characters more usually associated with the lower pitchers, such as large ventral wings and a more ovoid to cylindrical shape, suggesting that the phenomenon is a neotonous development in these populations.

The morphological 'switch' associated with this change appears to be reversible as cuttings of upper stems revert to producing lower pitcher type leaves. Martin Cheek tells me that side shoots from the climbing stem may also show characteristics of the rosette shoots in *N. ampullaria.*

The change in pitcher form appears to be accompanied by a change in the trapping spectra. A survey of pitcher contents in a population of *N. mirabilis* on Misima Island, (Appendix A) shows that the lower pitchers contain a greater number of ants, cockroaches, myriopods and spiders, while the aerial pitchers have proportionately greater numbers of flying prey such as dipteran flies, hymenopterans and moths. Although the physical position of the pitcher is clearly a major factor influencing the trapped fauna (whether the pitcher touches the ground or is suspended), it would appear from the limited amount of information available, that the pitcher morphology - large fringed wings, a broad peristome and a wide mouth for crawling creatures, as opposed to

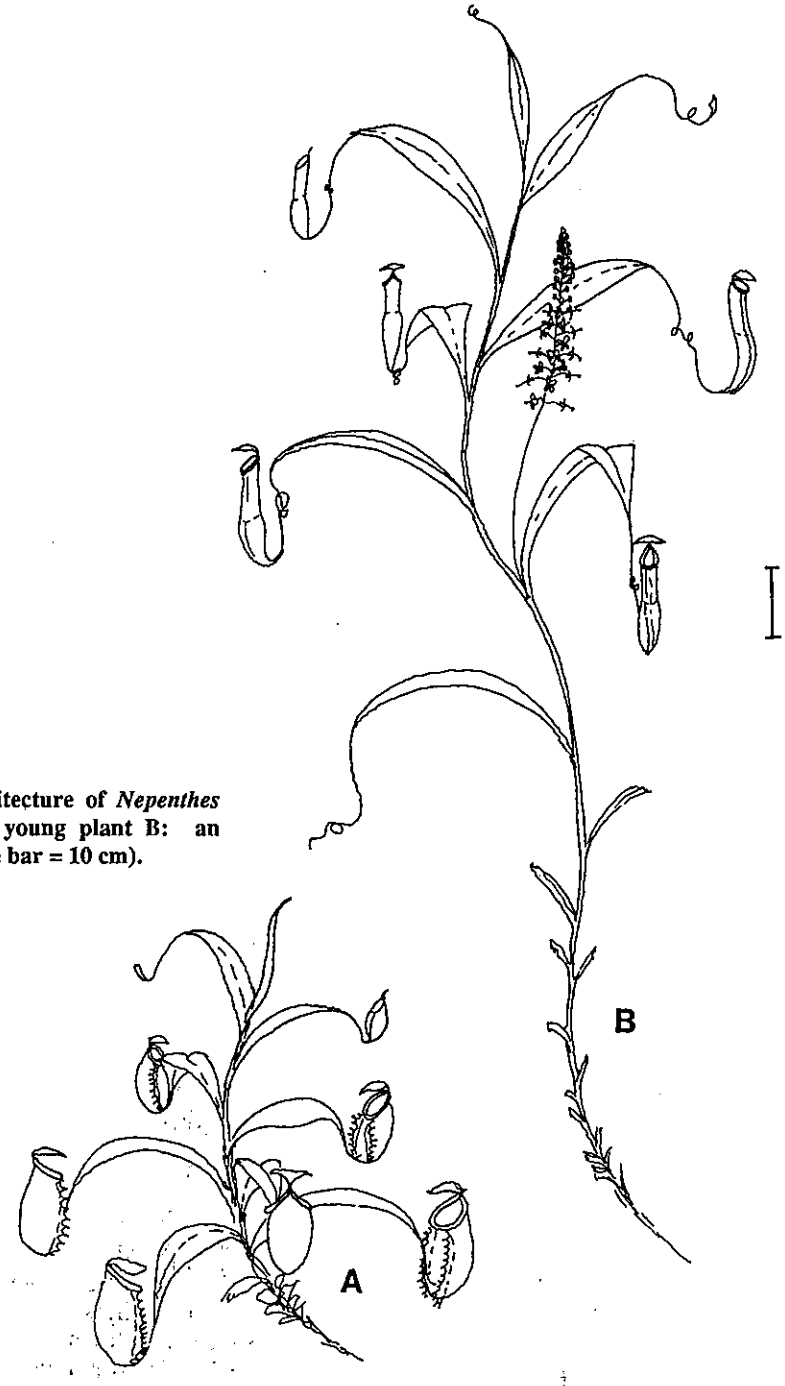


Figure 3. Architecture of *Nepenthes mirabilis*. A: a young plant B: an older plant (Scale bar = 10 cm).

much reduced wings, a slender peristome and narrow mouth for flying insects - is probably of equal significance.

All the species of *Nepenthes* whose pitchers I have been able to examine in the field (*N. ampullaria, N. maxima, N. mirabilis, N. neoguineensis* and *N. papuana.*) have a catch dominated by ants. In New Guinea, at least, ants would appear to be the single most important prey item though my observations of ant behaviour on *Nepenthes* plants show that a large number of the ants visiting extrafloral nectaries on the pitcher, peristome and underside of the lid, do not get captured. The advantage to the plant lies in the recruitment of further prey from the ant colony, the relationship between plant and prey can therefore been seen as partly mutualistic (Joel, 1988).

Danser (1928) has noted that the inner surface of upper pitchers in many species has a far larger glandular zone, and in some species may be almost wholly glandular, whilst the lower pitchers have a larger waxy zone. This suggests that there may indeed be important functional differences between the upper and lower pitchers. Possibly the degree of wax scaling is reduced in these upper pitchers, due to the relative importance of trapping 'flyers' as opposed to 'walkers'.

In the North American pitcher plant genus *Sarracenia*, there appears to be an ecological exclusion of similar species groups from *Sphagnum* bogs. In each bog, the community tends to be dominated by one long-pitchered species and one short-pitchered species of *Sarracenia* (Gibson, 1983). This has been attributed to competitive exclusion between the plants, through feeding upon prey at different levels above the ground (Gibson, 1983). That such effects can occur over a matter of tens of centimetres, suggests that a similar type of 'competition' may occur between *Nepenthes* pitcher types, as well as in multiple-species assemblages of *Nepenthes*. The results presented in Appendix A go some way to confirming this.

A type of architecture distinct from all other species is found in the widespread *N. ampullaria* which occurs from Malaysia to New Guinea. In this species the upper pitchers are entirely absent, being reduced to mere swellings of the tendril tip. The lower pitchers on the other hand have spherical or urceolate form (Figure 8). These pitchers arise from compact, small-leaved rosettes and are often sunken in the leaf litter or in moss cushions, up to the level of the peristome. The lid is reflexed, and reduced to a narrow oblong. Although this lid form is found in a few other species of *Nepenthes* outside New Guinea, it is unusual, since the lid in the majority of species is apparently placed so as to prevent excessive rain from entering the pitcher.

Plants of this species branch often, and the numerous pitcher-bearing rosettes crowd the ground where it grows (Figure 4). As the plant begins to enter its climbing phase, larger leaves with coiled tendril tips are produced. While the leaf blades of the rosette plant may be as small as 2 x 0.5 cm, and dwarfed by the size of the pitcher, those of the climbing stem reach as much as 25 x 6 cm and do not bear pitchers. Side shoots from this climbing stem vary according to the light regime in which they grow. In shade they are of the rosette type, and bear small leaves with large pitchers, while in sunnier locations they have large leaf blades, and the first 2 to 3 leaves bear attenuate lower pitchers. This type of architecture is unique amongst the New Guinea species. Although Danser (1928) and earlier authors refer to the lack of upper pitchers in this species, its significance in terms of a distinct architectural type with important ecological implications has not been noted.

Nepenthes ampullaria is one of the larger climbers in the genus, and regularly exceeds 10 m in length in New Guinea. Its pitchers usually carpet the shady ground where it grows, sometimes in dense forest. As previously mentioned, carnivory in plants requires high light levels. By producing all but leafless lower pitchers, and large upper leaves without pitchers, *N. ampullaria* appears to be capable of exploiting a densely shaded site with its pitchers, and at the same time having a large photosynthetic area in

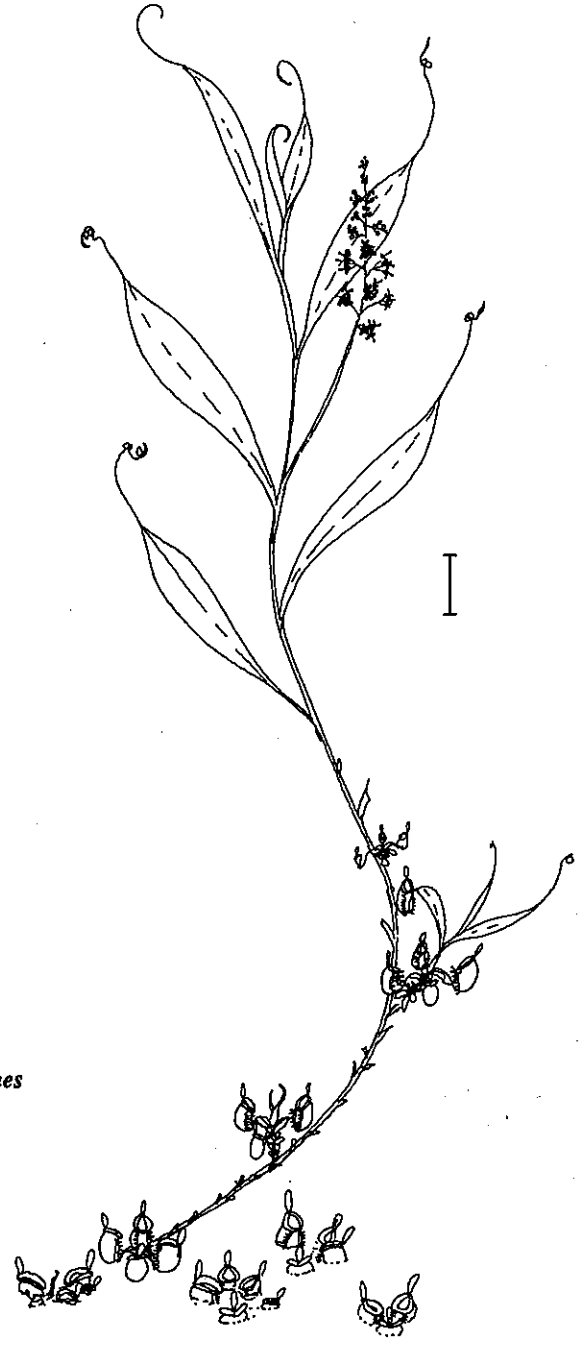


Figure 4. Architecture of *Nepenthes ampullaria* (Scale bar = 10 cm).

full sunlight. Undoubtedly the unique combination of small blade size in pitchered leaves and the large blades of pitcherless leaves suggests an extreme in division of function in this species.

A species of *Nepenthes* from Borneo, *N. mollis*, shares with *N. ampullaria* the habit of being a climber with large leaves with a dense indumentum below and on the midribs. The only herbarium specimen which I have seen (Bogor) has numerous leaves with coiled and swollen tendril tips which lack pitchers (Danser, 1928). A failure to collect pitchers, if they had been present in the canopy, would seem unlikely, unless they were inconspicuous and far removed from the leaves. This species was collected in 'dense forest'.

MORPHOLOGY OF THE LEAF BLADE

The blade of the leaf may be decurrent or petiolate to the main stem, decurrent meaning that the apparent blade tapers to the base of the leaf and from there continues down the sides of the stem for some distance (Figure 5A & G). *Nepenthes insignis* and *N. vieillardii* show this form of leaf, while the remaining species are more or less petiolate, although the petioles are often winged and in some species these wings run down the sides of the stem. *Nepenthes klossii* and *N. maxima* have such petioles, and these can be distinguished from truly decurrent leaves, by the fact that the blade is considerably narrowed at the petiole, before running down the stem. The leaves of climbing stems tend to be more petiolate than those of the rosette stems in all species.

In *Nepenthes ampullaria* and *N. maxima* the leaf blade shows great variation in size on the one plant; in *N. ampullaria* the blades of the rosette leaves are smaller, while in *N. maxima* the converse is true, and the upper leaves often have smaller blades than the lower ones. *Nepenthes mirabilis* is the only Papuasian species in which the leaf blade margin is finely fimbriate and then only in the lower leaves. The leaf blade margins of *N. maxima* and *N. treubiana* may be densely hairy. Leaf venation in the New Guinea species is illustrated in Figure 5. The relative numbers, distribution and dominance of the longitudinal veins and the pennate nerves is characteristic of the species and the leaves, in this figure, are arranged by the increasing degree to which the longitudinal veins occupy the blade. Venation patterns may prove to have considerable application in the remainder of the genus.

THE INFLORESCENCE

Nepenthes are dioecious. Male and female inflorescences are much the same in overall structure although the female spike is usually shorter, somewhat more robust, and in the paniculate species the partial peduncles may bear fewer flowers.

The inflorescence ranges from racemose to paniculate (Figure 6). *Nepenthes mirabilis, N. papuana* and *N. vieillardii* have a simple raceme (A). *N. insignis, N. klossii, N. maxima* and *N. treubiana* have a raceme with largely two-flowered partial peduncles (B), although these are often one-flowered towards the apex of the inflorescence. The remaining species are all paniculate, with 3 to 7 flowered partial peduncles. The branching of the partial peduncles is somewhat characteristic of the species. *N. paniculata* has umbel-like partial peduncles (C), although some are racemose (D), as are those of the undescribed species from Waigeo island. *N. neoguineensis* has corymbiform partial peduncles (E), while *N. ampullaria* has partial peduncles with 1 or more narrow bracts (F). Such bracts are only rarely encountered in other species. In all the species there is a tendency for the lower partial peduncles to bear more flowers than those near the apex, a feature alluded to in the composite figure.

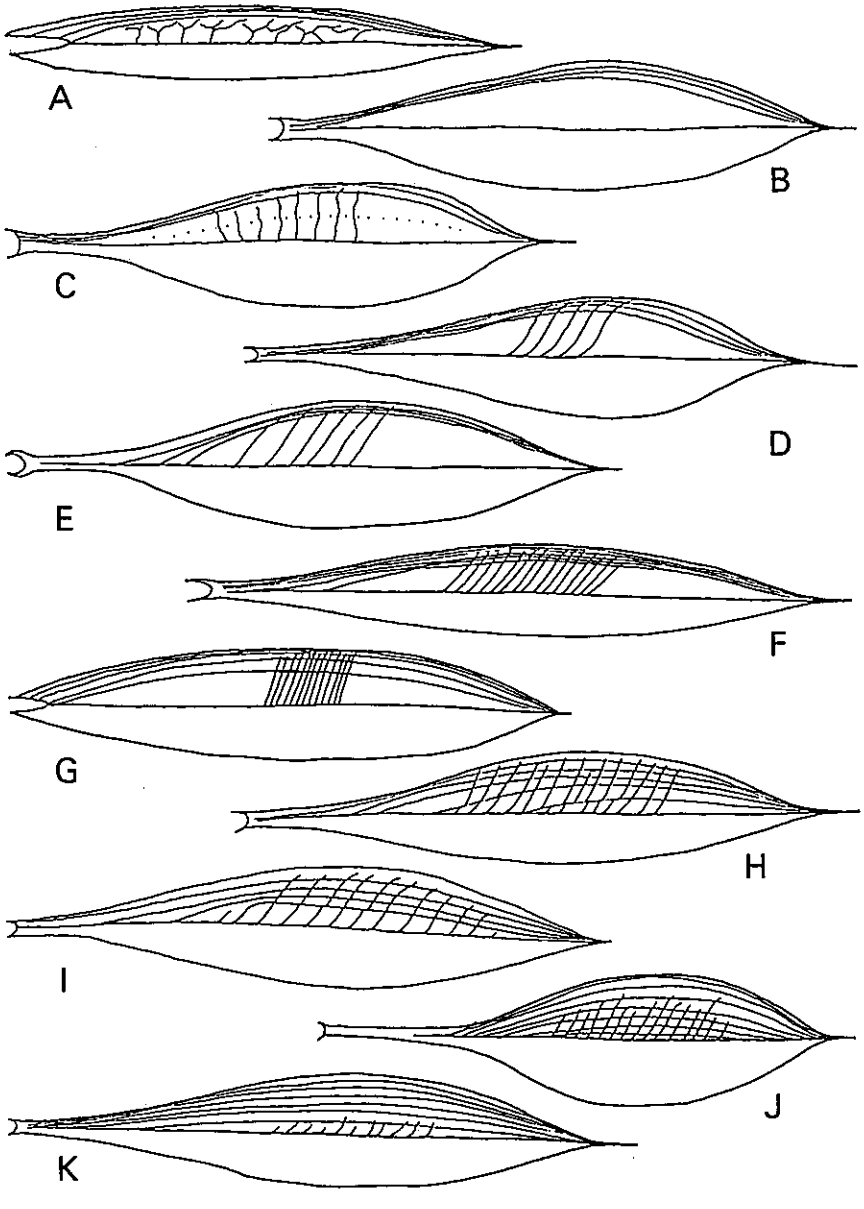


Figure 5. Venation patterns of leaves of Papuasian *Nepenthes*. A. *N. vieillardii*; B. *N. klossii;* C. *N. maxima;* D. *N. ampullaria;* E. *N. paniculata;* F. *N. neoguineensis;* G. *N. insignis;* H. *N. mirabilis;* I. *N. treubiana;* J. *N.* sp.; K. *N. papuana.*

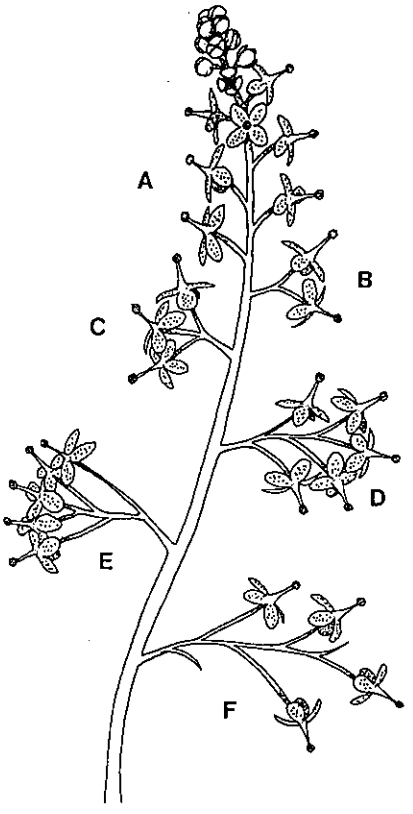


Figure 6. A composite inflorescence to show structural variation in *Nepenthes*.

DISTRIBUTION AND TAXONOMY

Five of the species of *Nepenthes* found in New Guinea are also found elsewhere. Of these, *N. mirabilis* is the most widespread species of the genus; its range virtually encompasses the whole southeast Asia region (Danser, 1928). *N. ampullaria* is a morphologically constant species throughout its range, from Malaysia to New Guinea although three varieties, based on minor inflorescence characters, have been described from New Guinea. *N. maxima*, which has the same distribution, is more variable, particularly so within New Guinea, where two varieties and a synonym have been described. *N. vieillardii* has a peculiar disjunct distribution pattern, being found in New Caledonia and in the mountains of Irian Jaya. Danser (1928) believed that *N. treubiana* was found on the coast of Sumatra, in addition to its localities at the extreme West of New Guinea but the material from Sumatra however cannot be credibly linked with this species. The remaining species are endemic to New Guinea.

No taxonomic changes have been made to Danser's interpretation of the New Guinea *Nepenthes*. Over half the species are confined to Irian Jaya, and are poorly known. Of these *N. klossii*, and *N. papuana* show close affinities to *N. maxima* and *N. mirabilis* respectively. One species, represented by a few fragmentary collections from Waigeo Island, must await adequate collection for its formal description.

Much of the herbarium material of *Nepenthes* is sterile. However, leaf characters are diagnostic. The lid demonstrates important characters in certain species.

Hybrids are readily formed between species in cultivation but none of the New Guinea material I examined appeared to be of hybrid origin, as it could be readily assigned to one species or another.

COLLECTING *NEPENTHES*

It is important to be aware of the dimorphy of the pitchers when collecting *Nepenthes*. Collections of both upper and lower pitchers are of interest (although not essential), particularly in the more variable species *N. maxima* and *N. mirabilis*. Likewise the fact that *Nepenthes* is a dioecious genus means that collections of male and female plants from the same locality are desirable. Leaf bases are important. Particular care should be taken when pressing and mounting the pitcher so that the wings on the ventral surface, the peristome and, most important of all, the underside of the lid, are clearly visible.

IDENTIFICATION

1. Key to the New Guinea species of *Nepenthes*

1. Lower pitchers urceolate, lid narrowly oblong-linear; upper pitchers rudimentary
N. ampullaria
1. Lower pitchers tubular to ovoid, lid rounded to ovate; upper pitchers always present in mature plants.
    2. Lid with 2 appendages on lower surface, axillary buds spike- like.
        3. Mouth of pitcher markedly hooded, with dorsal surface curving forwards over mouth
N. klossii
        3. Mouth oblique, the dorsal pitcher surface vertical, not curving forwards over mouth
N. maxima
    2. Lid with no appendages on lower surface, axillary buds never spike-like
        4. Leaf blade decurrent to 1/2 way down the internode.
            5. Peristome over 0.8 cm in width, pennate nerves parallel
N. insignis
            5. Peristome less than 0.5 cm in width, pennate nerves irregular
N. vieillardii
        4. Leaf distinctly petiolate, never decurrent.
            6. Margin of lower leaf blades fimbriate, upper pitchers not winged
N. mirabilis
            6. Margin of lower leaf blades entire, upper pitchers ± winged.
                7. Inflorescence a raceme.
                8. Leaves with 5-7 pairs of longitudinal veins throughout blade, pennate nerves obscure; pedicels 1-flowered
N. papuana
                8. Leaves with 2-4 pairs of longitudinal veins in outer two-thirds of the blade, some arising from the midrib; pedicels mostly 2-flowered
N. treubiana
                7. Inflorescence a panicle.

9. Longitudinal veins in 4-7 pairs, evenly spaced throughout blade

N. sp. Waigeo

9. Longitudinal veins in 3-4 pairs, in outer 1/3 of the leaf blade.

10. Upper pitcher widest at mouth, wholly infundibulate, leaf base semi-amplexicaul

N. paniculata

10. Upper pitchers narrowing to mouth, leaf base ± decurrent to stem

N. neoguineensis

2. Spot characters:

The following characters permit rapid identification of the four Papua New Guinea species:

N. ampullaria	-	Lower pitchers urceolate, no upper pitchers.
N. maxima	-	2-appendages on pitcher lids.
N. mirabilis	-	Lower leaf blades with fimbriate margins.
N. neoguineensis	-	Partial peduncles 4-5 flowered corymbs.

The following characters are of importance in identifying field or herbarium material:

Leaves

Axillary buds spike-like: *N. klossii* and *N. maxima.*
Leaf bases decurrent: *N. insignis* and *N. vieillardii.*
Lower leaf blades with minutely fimbriate margin: *N. mirabilis.*
Newest leaf blades with longitudinal folds *N. maxima.*

Venation (Figure 5).

Venation patterns are diagnostic. Care should be taken to look at actual veins as opposed to leaf folds (viz. *N. maxima*). In dried specimens the veins will be visible as raised lines. In fresh leaves the venation may be obscure, but is readily seen as translucent lines against a light source.

Pitchers

No upper pitchers: *N. ampullaria.*

Pitcher spur branched: *N. ampullaria*, but sometimes not, all others simple, except *N. mirabilis*, in which it may have a flattened, fringed end.

Pitcher lids; folded back beyond vertical: *N. ampullaria.* with two processes below: *N. klossii* and *N. maxima.*

Upper pitchers with 2 ridges: *N. insignis, N. klossii, N. maxima, N. paniculata,* and *N. treubiana*; with entire wings running the whole length of the pitcher: *N. papuana*; with fringed wings: *N. neoguineensis, N. paniculata* and *N. papuana*; with wings running only a partial length of the pitcher: *N. maxima*; or pitchers with very slight ridges: *N. mirabilis* and *N. vieillardii.*

Inflorescence (Figure 6)

Partial peduncles:

all single-flowered:	*N. mirabilis, N. papuana* and *N. vieillardii.*
largely double-flowered:	*N. insignis, N. klossii, N. maxima,* and *N. treubiana.*
3 or more flowered:	*N. paniculata, N.* sp. Waigeo, *N. neoguineensis* (corymbiform), *N. ampullaria* (with a bract).

SYSTEMATIC ACCOUNT

For each species the nomenclature for New Guinea only is given. After the type specimen the geographical range for those species found outside New Guinea is given. Leaf dimensions refer to the blade alone, pitcher sizes are the greatest dimensions of height and width.

Ecological information is derived from a combination of herbarium labels and my own observations. Distribution summarises ocurrence in the districts of Irian Jaya, the provinces of Papua New Guinea and islands on which the species has been recorded. Notes include a general discussion of variation, biology and distinguishing characters.

The collection data are arranged by country and follow as near as possible a north-west to south-east arrangement. Herbarium material was consulted at Bogor (BO), Bulolo Forestry College (Bulolo), The Royal Botanic Gardens, Kew (K); The National Herbarium, Lae (LAE); Universitas Cenderawasih; Manokwari; the University of Papua New Guinea (UPNG), and Singapore Botanic Gardens (SING).

The 'material examined' section only includes those specimens which I have seen, and not all those in the literature, nor those at the Arnold Arboretum, Berlin Museum, Canberra Botanic Gardens, Rijksherbarium at Leiden, or Queensland herbarium unless duplicates have been deposited at Bogor, Kew or Lae. Unless otherwise indicated ("*non vide*"), I have seen all specimens cited. For some records no collections were made, and these are indicated by *vide Jebb* and the year of the observation.

Illustrations were prepared from colour slides and/or herbarium material. All the species have been previously illustrated, but interpretation of herbarium material was often poor and the three-dimensional structure of *N. klossii* pitchers in particular has been reassessed. Scale bars of 5 cm for the whole plant (and 1 cm for the inflorescence, where this is drawn to a different scale) are given.

Nepenthaceae Dumortier 1829

Nepenthes Linn. Syst. ed. I. (1735); Gen. ed. I 273 (1737)

Dioecious, carnivorous shrubs or lianes, occasionally epiphytes. Stems to 15 m in length; climbing, sometimes prostrate, or short and erect. Leaves spirally arranged, highly modified, with a petiole, expanded blade, a tendril, pitcher and lid, the pitcher fluid-filled and capable of digesting trapped organisms. Leaf blade to 45 x 15 cm; thin to leathery; midrib robust and prominent; veins both longitudinal and pennate. Tendrils slender, cylindrical, about as long as leaf blade, straight in lower leaves, coiling in upper leaves.

Pitchers dimorphic; lower or rosette pitchers urceolate to ovoid, incurved with ventral, or front, surface facing tendril, with two ventral ridges or wings, these wings often with fimbriate margin. Upper pitchers produced at, or shortly before, the onset of flowering, cylindrical to infundibulate, outwardly-curved with dorsal surface facing tendril, with two ribs or much reduced wings on the ventral surface; rarely absent. Inner surface of pitcher glandular in the lower part, glandless and pruinose in the upper. Mouth of pitcher ringed by a peristome of finely-ridged tissue, which is generally finer and narrower in upper pitchers. Lid glandular or not, sometimes with appendages on lower surface. Spur inserted close to the lid, on the dorsal surface of the pitcher.

Inflorescence a raceme or panicle, the branches bearing 1-2 flowers if a raceme, and 3-10 flowers if a panicle, these generally shorter and with fewer flowers towards the apex; sometimes with 1 or more narrow bracts. Flowers with 4 sepals, imbricate, with

nectar glands within, petals absent; male flowers with stamens united into a column, anthers crowded into a single whorl, gynoecium absent; female flowers with stamens absent the ovary ellipsoid, superior, 4 loculae with axile placentation. Fruit a dry, loculicidal capsule producing 100-500 minute, filiform, wind-dispersed seeds.

Indumentum variable, generally greatest in younger parts, usually most marked on the stem, midribs and inflorescence. Colour of stem and leaf blade pale or dark green overall, pitchers variously marked with deep red or yellow spots, flecks or blotches; sometimes deep maroon or yellow throughout.

The genus comprises about 70 species, mostly in southeast Asia, with outlying species in Madagascar, Seychelles, Sri Lanka and India New Caledonia, one species extends to northern Australia. I recognise eleven species in New Guinea, one of which is outlined here for the first time. Six of these species are endemic to New Guinea. The origin of all specimens I have examined is shown in Figure 7.

Figure 7. Collections of all *Nepenthes* examined.

1. *Nepenthes ampullaria* Jack

(Figures 4 & 8)

Nepenthes ampullaria Jack, in Desc. Malay. Pl. iii (1823) 23.

N. ampullaria var. *geelvinkiana* Becc. in Malesia III, p.8 (1886).
N. ampullaria var. *longicarpa* Becc. ibid.
N. ampullaria var. *microsepala* Macf. in Nova Guinea VIII,1,p.339 (1911).

Type: unknown, presumed lost, probably Jack ex. Singapore.

Malaysia to New Guinea.

Description

Stem cylindrical, 1 to 1.5 cm; climbing to 15 m, with many terrestrial and some aerial rosettes. Leaf blade lanceolate to spathulate, rosette leaves 2-5 x 0.5 cm, climbing leaves up to 25 x 6 cm, sessile or with short petiole clasping stem. Longitudinal veins 3 to 5 on each side, in outer third or half of leaf blade. Pennate nerves numerous, running obliquely and forming a rectangular network with the longitudinal veins (Figure 5D).

Pitchers: lower pitchers obliquely urceolate, laterally flattened, semi-circular on dorsal side, almost straight ventrally, 2-10 cm high, to 10 x 9 cm, with two fringed wings to 1.5 cm broad, the fringe elements to 1 cm; mouth oval, almost horizontal;

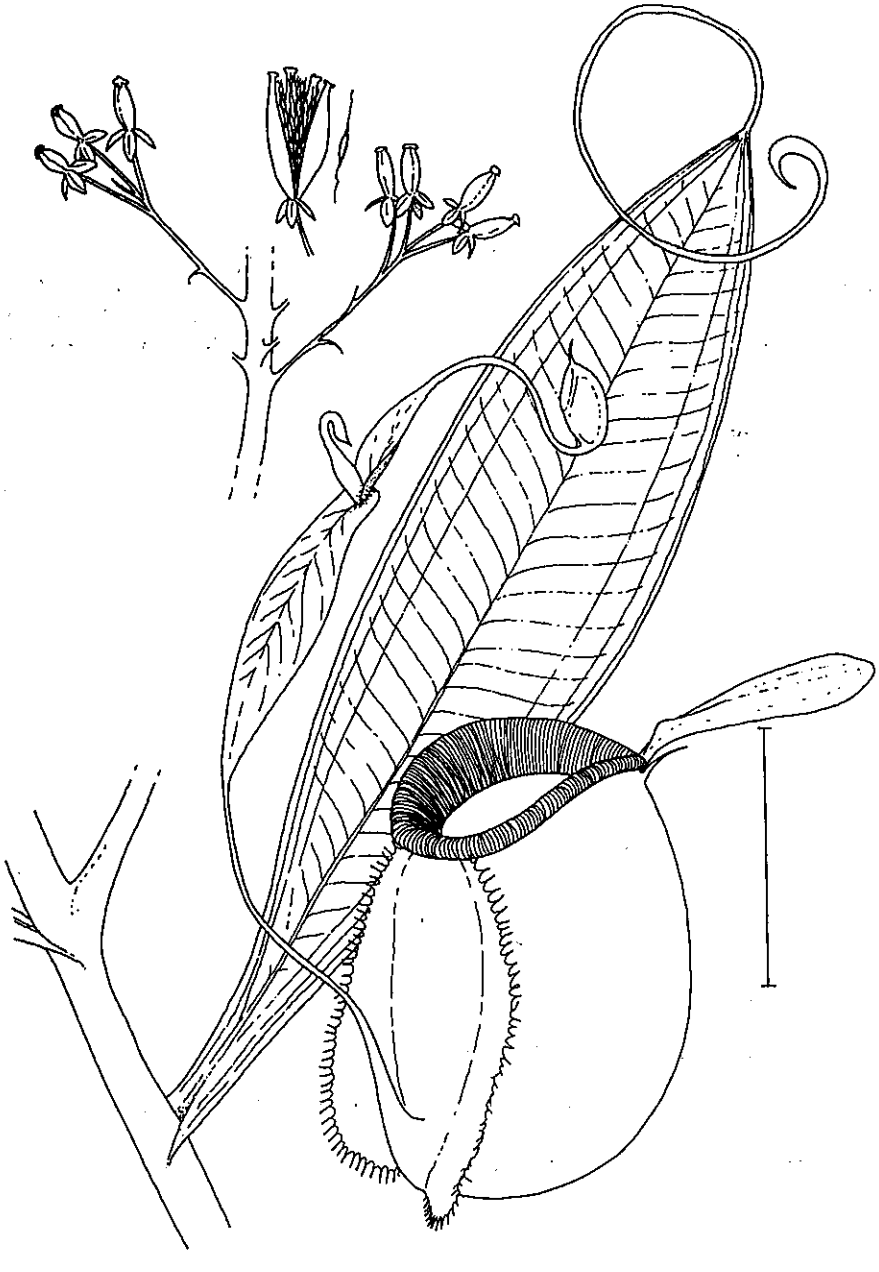


Figure 8. ***Nepenthes ampullaria*; Lake Kutubu, Southern Highlands. *Jebb CRI 783*, and photographs.**

peristome flattened to 1.5 cm, and sloping steeply inwards; inner walls almost wholly glandular; lid narrowly cuneate, rounded at the apex, tapering towards the base, to 4 x 1.5 cm, glandless; spur simple or branched to 1 cm; upper rudimentary, the tendril tip coiling, and slightly swollen.

Inflorescence a panicle to 40 cm long, partial peduncles to 5 cm, 3 to 6 (- 10) flowered, with one or more (rarely absent) acuminate bracts to 1 cm long.

Indumentum densely velvety in young parts, under leaf blades, esp. margins, on young pitchers and on the inflorescence. Colour dark green, pitchers usually green, and deeply flecked with maroon, but some almost whitish yellow, with pale pink flecks, likewise the leaves of these pitchers may be a pale yellow-pink if buried beneath leaf litter; sepals green to yellow; indumentum deep red.

Ecology: rain forest, especially *Araucaria* forests, secondary forests, open microphyllous vegetation, or swamp forest, from 25 to 2,100 m.

Distribution: throughout Irian Jaya; in Papua New Guinea in West Sepik, Western, Northern and Southern Highlands Provinces. Figure 9 shows origin of collections examined.

Notes: a very distinctive species, unique in its lack of upper pitchers. The habit of this species is to develop numerous short rosettes, with small spathulate blades, and large inward facing pitchers, which are often sunken in moss or leaf litter. These rosettes arise from creeping stems, which may become climbing. These continue to bear occasional aerial rosettes with pitchers, although their development appears to be dependent upon the light regime. In shady sites the rosettes are identical to the terrestrial ones, having minute leaf blades and large pitchers, while in more open conditions the leaf blades are large, and the first two to three also bear small pitchers, in later leaves the pitchers do not develop. The climbing stem bears large lanceolate, and pitcherless leaves with apical tendrils that are slightly swollen at their apex.

The architecture of *N. ampullaria* is distinct from that of other species, and I have already suggested that it has evolved a means of exploiting heavily-shaded sites with its pitchers; unusual for *Nepenthes* and carnivorous plants in general.

The varieties described by Beccari and Macfarlane were based upon single, morphologically distinct collections and are of no taxonomic consequence.

Figure 9. Collections of *N. ampullaria* examined.

Material Examined

IRIAN JAYA: MANOKWARI: Meos Waar, Ransiki sub-dist., *Kalkman BW 3568* (LAE); Arfak Mts, Monswoon Bein, Pratt s.n. (K). **BIAK:** Japen-Biak, *Aet & Idjan 258* (BO), *489* (BO, K),

Soemberbata, nr. Serui, *Aet & Idjan 831* (K), *Agathis* Complex, Aisau, *Vink BW 11288* (BO, LAE, SING); Dalman, 45 kms from Nabire, *Kanehira & Hatusima 12174* (BO), *ibid 12175* (BO) **JAYAPURA:** Bernhard Biv, Mamberamo R., *Meijer Drees 503* (K); Idenburg R., *Feuilletau de Bruyn 112* (BO); Legar R., *Janowsky 42* (BO); Rouffaer R., *Docters van Leeuwen 9814* (BO, K), *ibid 9822* (BO), border of affluent "C", *Docters van Leeuwen 10258* (p.p.) (BO); E slopes of Cyclop Mts, *Brass 8942* (BO, LAE); Above Jayapura, *Kostermans 361* (BO); Tablasoefoe village, *van Royen & Sleumer 6461* (K). **JAYAWIJAYA:** Sibil Valley, *Kalkman 4019* (LAE). **MERAUKE:** Nord River, sago swamp near Van-Weelskamp, *Versteeg 1214* (BO, K), *ibid 1229* (BO, K); Camp III-IV, *Kloss s.n., 2/1913* (K). Swamp on the Nord R., *Versteeg 1047* (BO); On Nord R. in the plain, *von Römer 46* (BO), *ibid 47* (BO), *ibid 449* (BO); Ingembit to Opka, *Reksodihardjo 388* (BO, K).

PAPUA NEW GUINEA: WEST SEPIK: Wootung *Araucaria* stand, Vanimo sub-district, *Howcroft LAE 64024* (LAE), along edge of Sepik River, *Howcroft LAE 64052* (LAE, UPNG); 3 miles SE of Frieda airstrip, Telefomin sub-district, *Kerenga & Lelean LAE 73971* (LAE, UPNG); Frieda R., *Unkau WLL 4* (LAE, UPNG). **EAST SEPIK:** Ambunti sub-district, along Yappa (Hunstein) R., *Hoogland & Craven 10550* (K, LAE). **WESTERN:** 528 mile camp, Fly R., *Brass 6618* (BO), *Brass 6802* (BO, K, LAE); 20 kms NE of Nomad, *Paijmans 1436* (LAE); Fly River, 1 mile north of Kiunga, *Pullen 7256* (K, LAE); Kiunga sub. dist. nr. Ingembit village, *Ridsdale & Galore NGF 31757* (LAE); Kiunga, *Streimann & Womersly LAE 51839* (K, LAE); W. of airstrip at Kiunga, *Streimann & Lilian NGF 34149* (K, LAE). **SOUTHERN HIGHLANDS:** Lake Kutubu, *Jebb CRI 783* (CRI); W. end of Lake Kutubu, *Ericho UPNG 18243* (UPNG); Mt. Bosavi, Northern side, *Jacobs 8964* (BO, LAE). **NORTHERN:** Vanape valley, Yodda junction with Mambare R., *Giulianetti & English 25* (K); Ioma, Popondetta, *Ridsdale NGF 31726* (K, LAE, SING).

2. *Nepenthes insignis* Dans.

(Figure 10)

Nepenthes insignis Dans., Bull. Jard. Bot. Buitenz., Ser III, Vol IX, Liv. 3-4 p.314 (1928).

Type: *Pulle 277* (B+?) *non vide.*, Beaufort River, Irian Jaya.

Endemic to New Guinea.

Description

Stem triangular, 0.5-1 cm thick. Leaf blade linear-lanceolate to slightly spathulate, 10x3 to 30x6 cm; apex acute, base attenuate, decurrent into 2 wings on stem. Longitudinal veins distinct, 3 to 5 on each side, in outer half of leaf blade, innermost vein more widely spaced from others. Pennate nerves numerous, running obliquely to margin. In dry state, only longitudinal veins visible on underside (Figure 5G).

Pitchers: lower pitchers ovoid in lower half, gradually becoming cylindrical in upper half, to 16 x 5 cm, with two narrow, sparsely denticulate wings; peristome expanded, crinkled 0.6-2 cm broad; upper pitchers infundibulate, sharply triangular in section at base, almost cylindrical above, to 25 x 8 cm, with two prominent ribs over the whole length, peristome expanded, crinkled, 0.8-3.5 cm broad. Lid suborbicular-ovate, rounded at the apex, rounded to cordate at the base, to 7 cm long, with a distinct midrib and 2 prominent lateral veins with many, large, rimmed glands clustered about these. Spur simple, to 0.5 cm.

Inflorescence a raceme, to 50 cm long, peduncle angular and grooved, partial peduncles without bracts, nearly all 2-flowered, the lower ones 2-2.5 cm long.

Indumentum sparse. Colour not known.

Ecology: river banks, rainforest, 80 to 850 m.

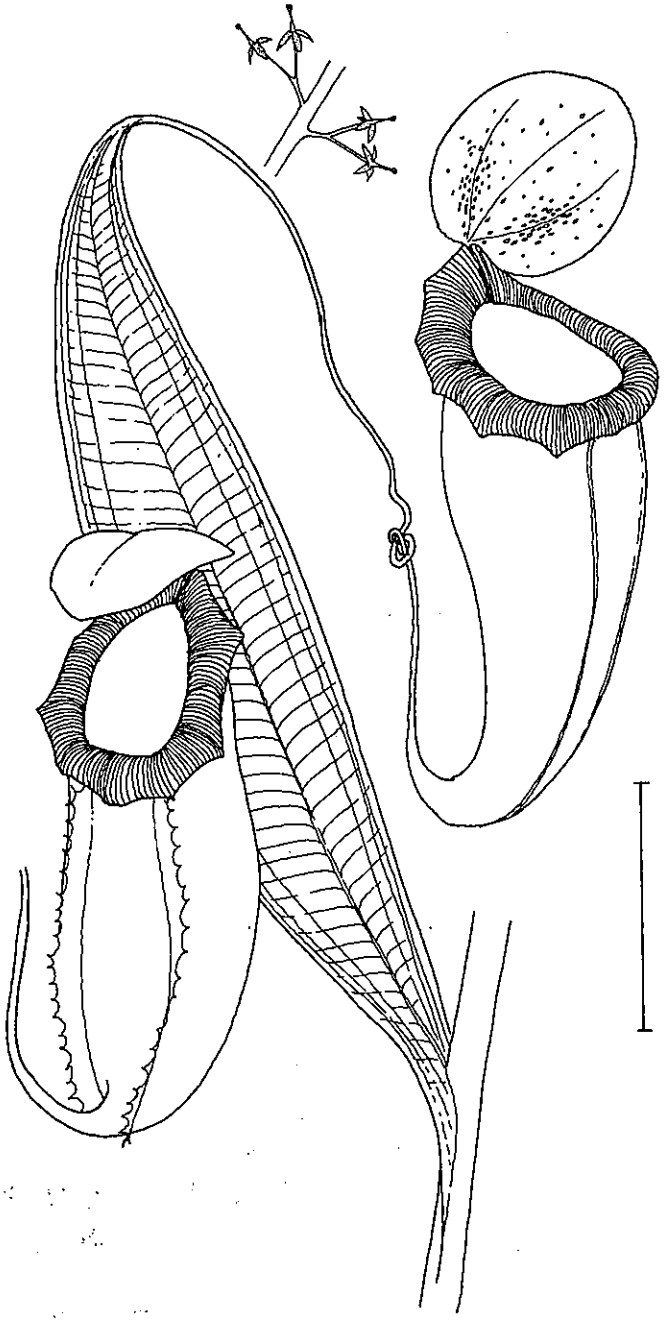


Figure 10. ***Nepenthes insignis; Pulle 277,*** **Beaufort River, Irian Jaya.**

Distribution: Jayapura and Merauke districts of Irian Jaya. (Figure 11)

Notes: a little known species, but the four collections I examined are distributed to the north and south of the central mountains of Irian Jaya, and the species could well occur in Papua New Guinea. The combination of large pitchers, decurrent leaf bases, lack of glandular processes on the lid, the venation pattern and 2-flowered partial peduncles distinguish it from all other species in New Guinea.

Figure 11. Collections of *N.insignis* examined.

Material Examined

IRIAN JAYA: JAYAPURA: Idenburg R., 4 kms S of Bernhard camp, *Brass 13379* (BO); 2 kms SW of Bernhard camp, *Brass 13669* (BO); border of affluent "C" of the Rouffaer R., *Docters van Leeuwen 10258* (p.p.)(BO, K). **MERAUKE:** border of the Beaufort R., *Pulle 277* (BO).

3. *Nepenthes klossii* Ridl.

(Figure 12)

Nepenthes klossii Ridl., Transact. Linn. Soc., ser 2, bot., IX, p. 140 (1916).

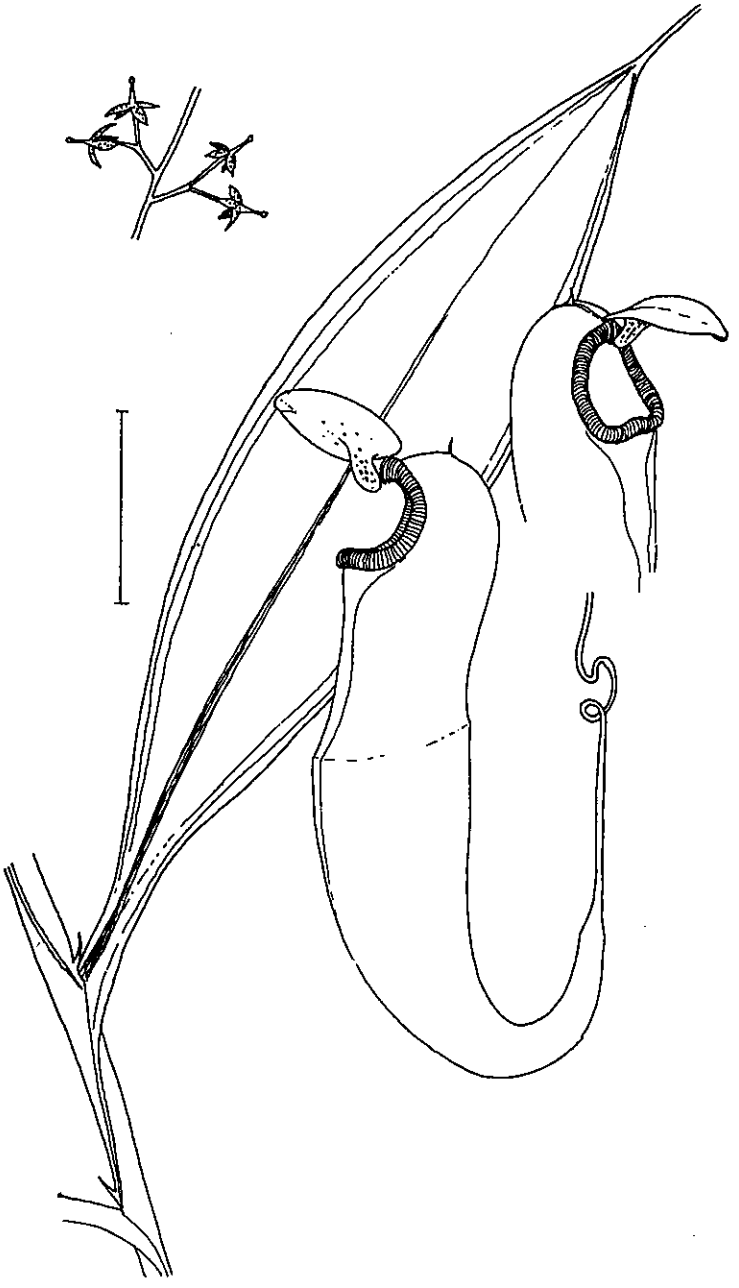
Type: *Kloss s.n., 26/1/1913* (SING), Mimika, Irian Jaya.

Endemic to New Guinea.

Description

Stem triangular with two slight ridges from leaf bases, to 1 cm thick. Leaf blade lanceolate to oblong-lanceolate, 6 x 18 to 9 x 25 cm; apex acute; gradually or abruptly tapering into winged petiole, clasping stem, decurrent to half way on internode. Midrib drying ribbed above; densely hairy, especially towards base. Axillary buds prominent, spike-like. Longitudinal veins obscure, 2 or more on each side, running parallel in outer 1/3 or 1/4 of leaf blade. Pennate nerves totally obscured (Figure 5B).

Pitchers: lower pitchers unknown; upper pitchers abruptly originating from tendril, infundibulate in lower part, cylindrical above, slightly hipped; to 20 x 5 cm, with two prominent ribs on ventral surface; mouth oblique to vertical, facing forward, more or less cordate in outline, acuminate and nearly horizontal towards lid, acutely pointed on ventral side; peristome curved, 0.3-0.5 cm, to 1.5 cm near lid; spur to 1 cm long, blunt, inserted 1 cm from the lid. Lid suborbicular, to 5 cm long, slightly cordate at base, with two appendages on under side; larger appendage a laterally flattened crest near the junction with pitcher, and recurved towards pitcher, about 1 cm long, wholly glandular;



12. *Nepenthes klossii; Emya 4893,* Wissel Lakes, Irian Jaya.

other appendage, at apex, a less well defined swelling without glands; midrib with large glands along its length.

Inflorescence a raceme, the lower partial peduncles to 3 cm long, 2- flowered.

Indumentum dense on growing parts, underside of leaf blade, above and below midrib, pitcher, upper surface of lid, spur and inflorescence. Colour of lid deep purple, remainder probably reddish.

Ecology: habitat unknown, probably grassland at 1000 to 2000 m, where it is apparently sympatric with *N. maxima.*

Distribution: Paniai and Merauke districts of Irian Jaya (Figure 13).

Notes: *Eyma 4893* is undoubtedly a good match for the Kloss specimens cited by Danser (1928), which were then the only known specimens of the species. This collection shows features which are obscure on the Kloss specimens, due the manner in which they have been pressed and mounted, notably the distinctive 'hooded' appearance of the pitcher mouth, and the presence of 2 crests on the underside of the lid. Danser, referring to *Kloss s.n.* (*SING*) mentions only one. Comparison of the Kloss specimen with Danser's illustration suggests that the artist did not interpret the pressed specimen correctly. The remarkable hooded mouth of this species is reminiscent of the insectivorous New World pitcher plants *Sarracenia minor* or *Darlingtonia californica* (Sarraceniaceae).

The lid appendages, leaf venation and 2-flowered partial peduncles of *N. klossii* suggests that it is probably closely related to *N. maxima*, a very variable species. Eyma's collections from the Wissel Lakes area, however, indicate that *N. klossii* and *N. maxima* may well grow together [*Eyma 4894* = *N. maxima*; *Eyma 4893* = *N. klossii*]. The distinction between the two species is slight, and lies in the greater pubescence, thicker leaf blade, and the forward-directed mouth of the former, and the evidence of their growing in close proximity in the Wissel Lakes area, is also significant. Only three collections of *N. klossii* have been made.

Figure 13. Collections of *N. klossii* examined.

Material Examined

IRIAN JAYA: MERAUKE: Camp VIa, Wollaston expedition, *Kloss s.n.* (K); Camp VIb, *Kloss s.n, 26/1/1913* (SING). **PANIAI:** Enarotali, Lake Tigi, *Eyma 4893* (BO, K, SING).

4. *Nepenthes maxima* Nees

(Figure 14)

Nepenthes maxima Nees, Ann. Sc. Nat., III, p.369, (1824).

N. boschiana Becc., Mal., 1, p.214 (1878); non Korth., Verh. Nat. Gesch., p.25, t.2 & 4, f.39-54 (1839); Macf., J. Linn. Soc., Bot., XLII, p.126 (1914).

N. oblanceolata Ridl., Transact. Linn. Soc., ser. 2, bot.,IX, p.140 (1916); Danser, Bull. Jard. Bot. Buitenz., Serie III, Vol. XVI, p.469 (1940).

N. maxima var. *minor* Macf. in Gibbs, Contributions to the phytogeography and flora of the Arfak Mountains. p.141 (1917).

Type: *Reinwardt 1537* (BO), Sulawesi.

Malaysia to New Guinea.

Description

Stems climbing, to 6 m or more, 0.3-1 cm thick, cylindrical to triangular, often winged from leaf bases, occasionally with four wings from adjacent leaves; sometimes strongly plagiotropic. Terrestrial to epiphytic.

Leaf blade obovate to lanceolate, 10 x 3 to 20 x 6 cm; apex blunt to acute; base attenuate to a narrowly winged petiole to 7 cm long, dilated at base into decurrent wings, which may run for 1 cm or up to 2 internodes down the stem. Axillary buds prominent, spike-like. Longitudinal veins 1 to 3 on each side, in outer 1/3 to 1/4 of blade, indistinct (leaf blade often strongly furrowed on its upper surface, from being folded in bud, giving impression of veins at regular spacing, the veins themselves more apparent in dried specimens or when the leaf is held against the light). Pennate nerves numerous, not parallel, often branched, perpendicular near midrib, but irregular towards margin, and running towards the base in lower third of blade, indistinct (Figure 5C).

Pitchers: lower pitchers narrowly ovoid, becoming cylindrical above, occasionally hipped, or whole pitcher ellipsoidal, widest in middle; to 18 x 5 cm; with 2 fringed wings to 0.8 cm broad with hairs to 0.6 cm; peristome rounded, 0.2-0.5 cm; spur simple, small, inserted close to lid; upper pitchers abruptly or gradually originating from tendril, not always truly outfacing; infundibulate to cylindrical, to 20 x 5 cm, occasionally hipped; with two prominent ribs, occasionally with a small fringed wing near mouth, or rarely like lower pitchers; peristome flattened, up to 2 cm broad near lid, often with irregular folds towards outer margin, sometimes with an acute peak on front edge, acuminate and elongate towards lid. Lid orbicular to triangular, 2-5 cm long, apex obtuse, more or less cordate at base, with a laterally flattened crest up to 0.8 cm long on basal part of midrib also a filiform or dorsally flattened appendage near tip; with numerous large glands on underside, especially on the two appendages. Spur simple, to 0.5 cm.

Inflorescence a loose raceme, to 40 cm long, partial peduncles mostly 2-flowered, to 2.5 cm; rarely with bracts.

Indumentum variable, glabrous to densely pubescent on stems, petioles, midrib, leaf margin, tendril and inflorescence. Colour variable, leaves dark green, midrib and tendril red, pitcher usually flecked red or maroon, rarely pale green throughout; sepals red, stigma pale green; indumentum reddish brown.

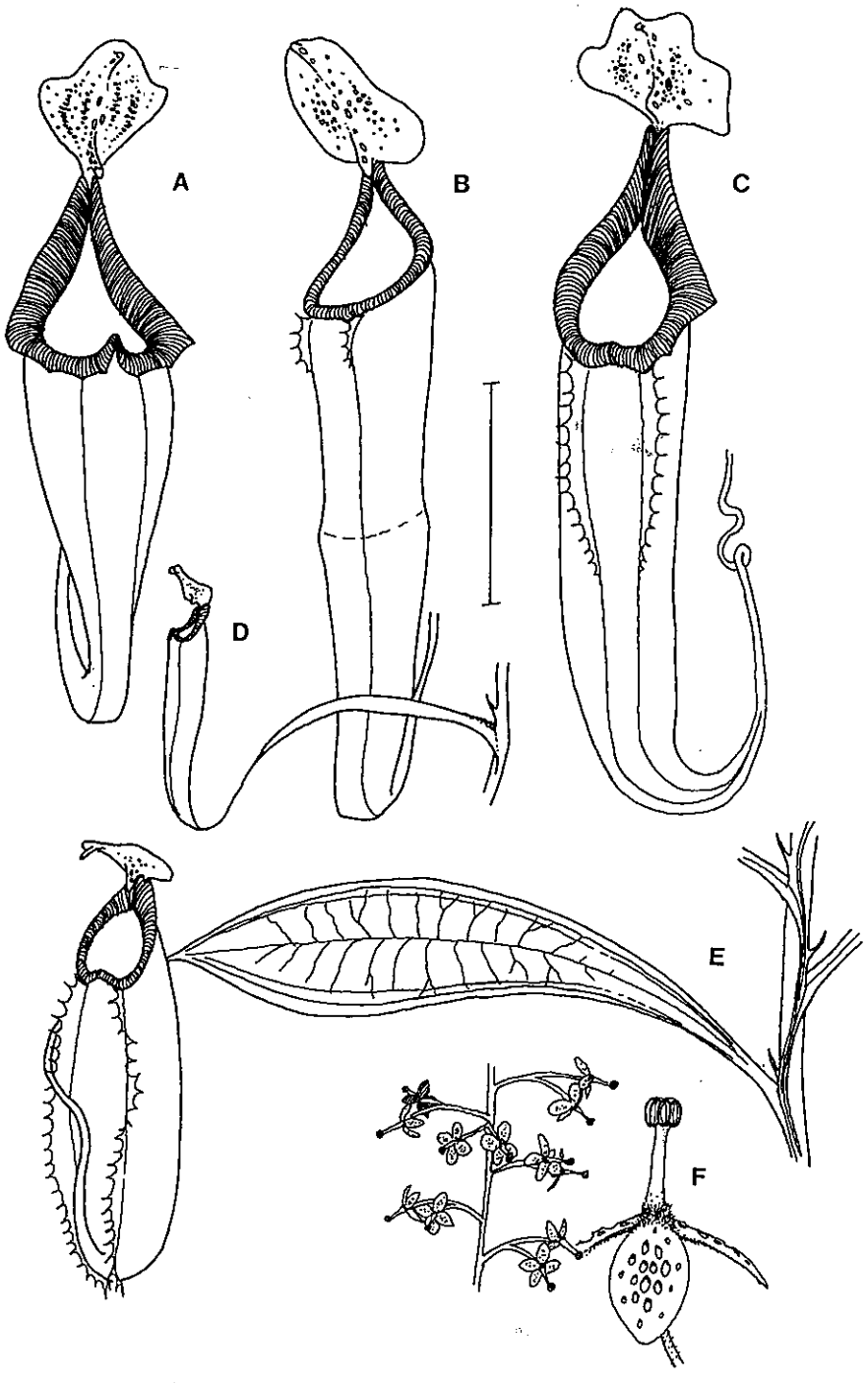


Figure 14: ***Nepenthes maxima.*** **A-upper pitcher; Holuwon, Balim Valley, IJ, Jebb photograph. B-upper pitcher; Telefomin, PNG;** ***Jebb 238*** **and photograph. C-upper pitcher; Baiyer River, PNG, Jebb photograph. D-upper pitcher;** ***Hutton NGF 4998,*** **Tari, PNG. E-lower pitcher;** ***Ridsdale & Henty NGF 33105,*** **Star Mts., PNG. F-male inflorescence; Telefomin, PNG; Jebb photograph.**

Ecology: epiphytic in mossy forest, or terrestrial in swamp grassland, on ridge tops, in open forest on white sand, and in thin soils over rock. From 1200 to 2500 m above sea level.

Distribution: throughout New Guinea from Arfak Mountains to the d'Entrecasteaux Islands but not yet collected in Northern, Central or Eastern Highlands Provinces of Papua New Guinea (Figure 15).

Notes: *Nepenthes maxima* is a widespread and highly variable species. The upper pitchers rangé greatly in form, from narrowly cylindrical to strongly infundibulate. Four examples from different areas of New Guinea are illustrated in Figure 14, and the cover drawing shows some of the variation on one mountain within the Anggi Lakes region of Irian Jaya. *Nepenthes oblanceolata* is a small form of *N. maxima*. One former variety, reduced by Danser, *N. maxima* var. *minor*, is minute in all parts, with narrow, linear leaves this is a widespread and common morphological form (*Brass 11836, Schram BW 13400, Sleumer & Vink BW 14011, ibid. BW 14189, Gjellerup 1130, Mayr 10*, and *Hutton NGF 49980* (Fig. 14D). In some collections the upper pitchers are winged along their entire length, resembling the rosette pitchers (*Barker s.n., Kostermans 2345, Lam 2156, Pulle 1137, van Royen 3864, van Royen & Sleumer 6887*, and *Versteeg BW 12719*). In others the lower pitchers are ovoid throughout (*Ridsdale et al. NGF 33105*), while the upper pitchers vary from slender and cylindrical (*Ridsdale et al. NGF 33105, Barker LAE 66820*), to markedly infundibulate (*Schram BW 13380, Graf s.n.*).

In some populations the upper pitchers are not outfacing, but originate sideways from the tendril (Figure 14C). It is common in these individuals to have large-winged upper pitchers, which are more similar to lower pitchers.

The two lid appendages, the irregular pennate nerves, the spike-like axillary buds, and the 2-flowered partial peduncles are diagnostic, and indicate its relationship to *N. klossii*.

Figure 15. Collections of *N. maxima* examined.

Material Examined

IRIAN JAYA: SORONG: Ije R. valley, Tamaru R., *Royen & Sleumer 7719* (BO, K); Kebar Valley, on crest of Nettoti Range, N of valley, *van Royen 3864* (BO, LAE); Mt. Nettoti, *van Royen & Sleumer 7934* (K), *ibid. 7952* (BO, K), *ibid. 8027* (BO, K); on path to Andjai, *ibid. 8234* (K), *ibid. 8235* (K); Aifat R. valley, Tohkiri Mts, path to Sururemtimtum, *van Royen & Sleumer 6887* (K, LAE). **MANOKWARI:** Witsche, *Mayr 58* (BO); Mt. Antap nr. Minjanbau, *Versteeg BW 12719* (BO); Anggi Lakes, *Gibbs 5502* (K), *ibid. 5937* (K), *Kanehira & Hatusima 13736* (BO), *vide Jebb 1990*; Angi R., *Gjellerup 1130* (BO); Anggi Gita lake, *Kostermans 2123* (BO), *ibid. 2165* (BO, K), *ibid. 2178* (BO), *ibid. 2345* (BO), *ibid. 2383* (BO); Anggi-Gigi Lake, Bivouac Noord-Pool, *Sleumer & Vink BW 14011* (LAE); Mt. Sensenemes, *Sleumer & Vink BW 14189* (BO, LAE). ?, Beng Moendi, *Mayr 10* (BO); Wandamen

Peninsula, nr. Wondiri, *Mayr 268* (BO); Wandiwoi Mts, *Schram BW 13380* (LAE); *ibid 13400* (LAE). **PANIAI:** Biv XIV - Biv XVI, *Eyma 4266* (BO); ?, *Eyma 4393* (BO); *Eyma 4435* (BO, K); Kemandora valley, *Eyma 4592* (BO); Enarotali, *Eyma 4819* (BO, K), *Eyma 4826* (BO), *Rifai 6533* (BO), *ibid. 6705* (BO); Lake Tigi, *Eyma 4894* (BO, K); Perai lookout, *Eyma 5276* (BO, K); Araboebivak, *Eyma 5391* (BO), *Eyma 5393* (BO). **JAYAPURA:** 15 kms SW of Bernhard Camp, *Brass 11900* (BO); 15 kms SW of Idenburg Camp, *Brass 12430* (BO); 4 kms SW of Bernhard Camp, *Brass 13232* (BO); Cyclops Mts, *van Royen & Sleumer 5928* (BO, K). **JAYAWIJAYA:** G. Boetak, ridge to Doorman Top, *Lam 2156* (BO); Nassau Mts, *Docters van Leeuwen 10995* (BO); Balim Valley, *Brass 11494* (BO), *Brass 11833* (BO), *Brass 11836* (BO); above Wellesey, *Kostermans & Soegeng 610* (BO, K), *ibid. 781* (BO, K). **MERAUKE:** Noord R., Bijenkorpf bivac, *Pulle 659* (BO), *ibid. 710* (BO, K); Eastern part of Oru valley, *Pulle 1137* (BO); Hellwig Mts, *Pulle 843* (p.p.)(BO); *von Römer 1156* (BO); *ibid. 1192* (BO); Camp VIa, *Kloss s.n., 17/2/1913* (K); Camp VIb *ibid. 1/13* (K); Camp VIc, *ibid., 2/13* (K); Camp III- VIII, *ibid., 12/12* (K); Camp IX-X, *ibid. 26/1/13* (K); Camp XI-IX, *ibid. 2/13* (K).

PAPUA NEW GUINEA: WEST SEPIK: Okwalimkan R. headwaters, *Ridsdale & Henty NGF 33105* (LAE); ridge across the Din from Busilmin, 1km. N of Busilmin, *Barker s.n.* (LAE); Above Busilmin Airstrip. Telefomin sub-district, *Barker LAE 66820* (LAE), on track to Telefomin, *Barker LAE 67625* (LAE); on upper part of ridge between Busilmin Airstrip and Bielga River, Telefomin, *Barker & Lelean LAE 66811* (LAE); 200 m. to the west of Telefomin airstrip, *Jebb 238* (CRI); between Feramin and Telefomin, Hindenburg Range, *Kalkman 5323* (LAE); Victor Emmanuel range, track from Feramin to Bolfen camp, *van Royen 11480* (LAE, UPNG); Telefomin, *Womersley NGF 9386* (LAE); Torricelli Mts, *Schlechter 20337* (K). **WESTERN:** 40 kms. NE of Ningerum, Kiunga sub-district, *Hyn 173* (LAE); Ok Tedi, *Lloyd Hamilton UPNG s.n.* (UPNG, Bulolo). **SOUTHERN HIGHLANDS:** Binaru Range, Tari sub-district, *Hutton NGF 49980* (LAE); Kalalo, on Erave-Kagua road, *Jebb 414* (CRI); near Telefomin, *Lisowski 53164* (K); Hedemari area, Koroba sub-district, *Powell UPNG 2448* (LAE, UPNG); 4 miles from Kopiago on Koroba road, *Womersley NGF 37301* (LAE); nr. Ebenda, Anga Valley, *Schodde 1658* (K, LAE). **ENGA:** Porgera valley, c. 3 miles from Porgera, *Ingemann 10* (LAE). **WESTERN HIGHLANDS:** Near Karap village, Jimi Valley, *Womersley & Millar NGF 7635* (LAE); Ambra swamp, Mt.Hagen, *Kwapena WLL 169* (Bulolo). **MADANG:** Adelbert Mts., Menginap, *Hopkins UPNG 13265* (UPNG); 2 kms E of Bundi, *Jebb s.n.* (CRI), *Bal UPNG 18360* (UPNG), *Hiaso UPNG 18356* (UPNG), *Kumbia UPNG 18358* (UPNG), *ibid. 18359* (UPNG), *Mana UPNG 18357* (UPNG); *Mandeakali UPNG 18355* (UPNG); *Orapa UPNG 18354* (UPNG); 3 kms S. of Simbai, *vide Jebb 1990*. **MOROBE:** Yinzaing vicinity, *Clemens 3604* (K); Kikiepa village, Wantoat sub-district, *Graf s.n.* (LAE); ridge of headwaters of Buhem River, Mt. Rawlinson, Huon Peninsula, *Hoogland 9299* (BO, K, LAE); Vicinity of Kikiepa village, nr. Wantoat patrol post, slopes of Finnisterre Mts, *Womersley & Thorne NGF 12696* (LAE). **MILNE BAY:** Normanby Is., Mt. Pabinama, *Brass 25662* (*non vide*), *ibid. 25663* (K, LAE); Fergusson Is., Mts. between Agamoia and Ailuluai, *Brass 27057* (LAE).

5. *Nepenthes mirabilis* (Lour.) Druce

(Figure 16)

Nepenthes mirabilis (Lour.) Druce, Rep. Exch. Cl. Br. Isl., 1916, p.637 (1917).

Phyllamphora mirabilis Lour., Fl. coch., ii, p.606 (1790).
Nepenthes phyllamphora Willd., Sp.pl.,IV,2,p.874 (1805).

Type unknown.

Malaysia to the Solomon Islands.

Description

Stems cylindrical, shrubby, erect or occasionally climbing to 6 m, 0.6-1 cm thick. Lower leaves lanceolate, apex acuminate, margin fimbriate, upper leaves broader, obovate, apex acute; 20x4 to 40x10 cm; petiole slightly winged, 3-20 cm long, forming

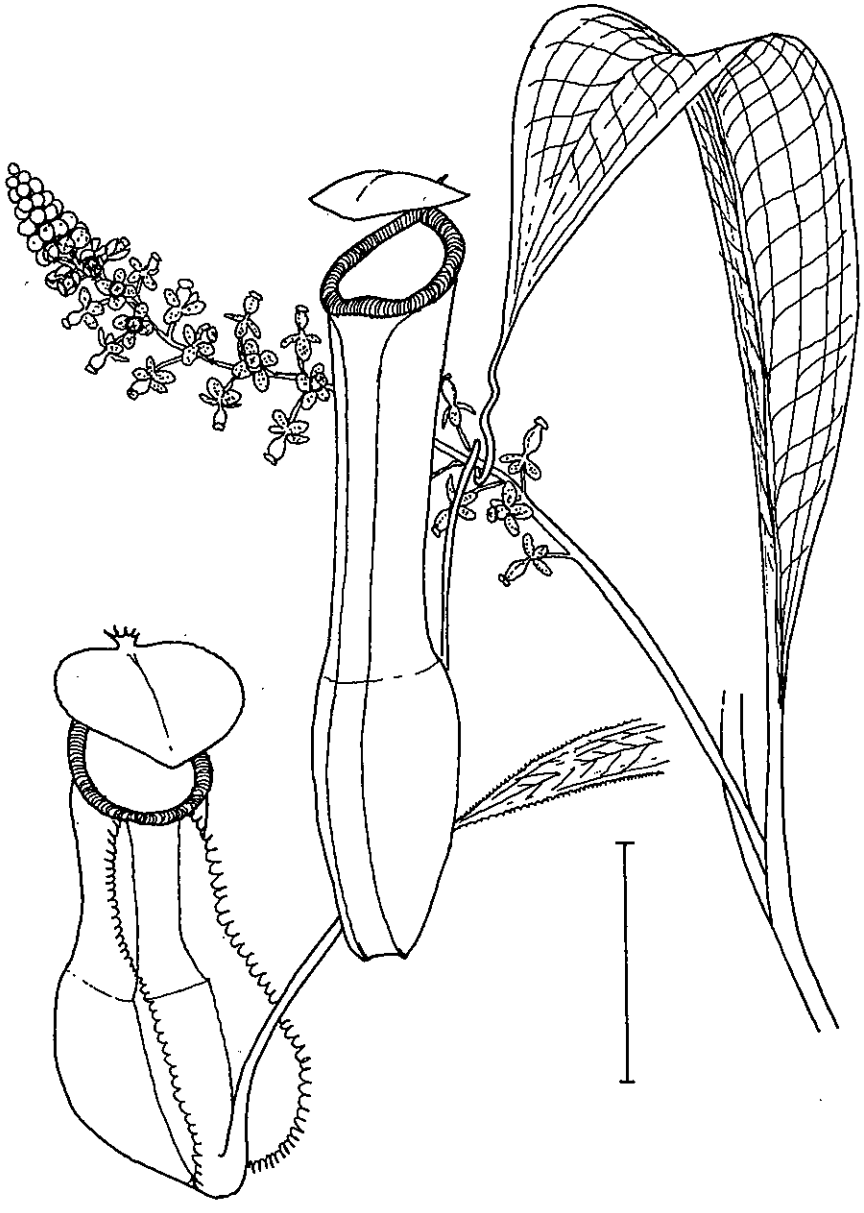


Figure 16. ***Nepenthes mirabilis*; *Jebb 404*, Misima Is, PNG.**

a short sheath at base. Longitudinal veins 4 to 8 on each side, all from base, or some originating from along midrib; throughout leaf blade. Pennate nerves numerous, curving towards margin, forming distinct rectangles with longitudinal veins (Fig. 5H).

Pitchers: lower pitchers ovoid in lower part, cylindrical towards mouth, usually hipped; to 20 x 5 cm, with two fimbriate wings; mouth oblique; peristome rounded 0.5-1.2 cm; spur flattened, with two or more attenuations, confluent with lid; upper pitchers gradually originating from tendril, infundibulate at base, cylindrical above, distinctly hipped, to 20 x 3 cm, with two, more or less prominent ridges; mouth slightly oblique, peristome flattened, 0.2-0.8 cm broad; spur simple, inserted close to lid, to 0.5 cm. Lid orbicular, sometimes convex above.

Inflorescence a dense raceme, peduncle to 15 cm in length, pedicels without bracts, rarely with, to 1.5 cm long; the whole nearly cylindrical.

Indumentum sparse, on growing parts only. Colour usually pale green to yellowish, sometimes flushed red in upper part of pitchers, rarely with red flecks; sepals red.

Ecology: dry grasslands or woodlands, swamp grassland, ultrabasic soils with sparse forest, occasionally rainforest clearings, from sea level to 1500 m, mostly below 200 m.

Distribution: throughout New Guinea, especially common in grasslands/woodlands of Morobe and Central Provinces (Fig. 17).

Notes: a widespread and variable species, especially outside New Guinea; very common occupying more habitats than any other species, it is one of the few species which appears to be capable of living on apparently nutrient-rich soils in forest clearings or edges. Fringed upper pitchers are not uncommon. This species can be distinguished by the fimbriate margin of the rosette leaves, the hipped pitcher, and the regular net-like venation pattern (Figure 5H). A single specimen (*Voyage of Rattlesnake Bot 463*) has large pedicel bracts, otherwise absent in this species. Eleven species were described from northern Queensland, Australia by Bailey, but these were all reduced by Danser (1928) to *N. mirabilis*. No synonyms have been described in New Guinea.

Figure 17. Collections of *N. mirabilis* examined.

Material Examined

NEW GUINEA: ?, *Branderhorst 94* (K); ?, *Anta [Wentholt] 29* (BO); ?, NE of Kuruvitu village, towards Mwatawa, track in swamp forest, *Frodin UPNG 4073* (LAE, UPNG, K); ?, Kamasi, *Wenthold 199* (BO); ?, *Pringo 94* (BO).

IRIAN JAYA: SORONG: Sorong, *Stelleman 15* (BO); Kebar valley, *van Royen 3809* (K, LAE); east of Andjai, *van Royen 3968* (K, LAE); Nertoi, opposite Andjai, *van Royen & Sleumer 6767* (BO, K);

Seta, NE of Lake Ajamaru, *Vink BW 15326* (K); Babo, McCluer gulf, *Aet [Lundquist] 644* (BO); *ibid. 731* (BO). **MANOKWARI:** Waren 60 miles south of Manokwari, *Kanehira & Hatusima 13011* (BO); Arfak Mts, Monswoon Bein, *Pratt s.n.* (K). **BIAK:** Job Island, *Schram BW 14964* (LAE). **FAKFAK:** Esania, Borowai district, *Stefels BW 3160* (LAE). **JAYAPURA:** Ifar, Jayapura, *Assem 23* (K); Jayapura, *Gjellerup 172* (BO); Cyclops Mts, *Gjellerup 493* (BO), *Iwanggin BW 5225* (LAE, SING); *Kostermans BW 4313* (LAE), *Meijer Drees 136* (BO, K); Lake Sentani, *Reksodihardjo 26* (BO); E of Koejaboe R., Lake Sentani, *van Royen 4515* (BO, LAE); Jayapura to Sentani, *van Royen & Sleumer 5644* (BO); *Jebb, vide 1980*. **MERAUKE:** Merauke, N bank of Koembe R., 15 kms NE of Koembe, *van Royen 4897* (BO, LAE). **ARU ISLAND:** P. Kobror, *Buwalda 5105* (BO); P.Tringan, K.p. Ngaibor, *Buwalda 5341* (BO, SING).

PAPUA NEW GUINEA: WEST SEPIK: Ossima, Pule Lake, Vanimo, *Streimann & Kairo NGF 39297* (K, LAE). **EAST SEPIK:** Yambi, *Hinson 46* (K, LAE). **WESTERN:** Wuroi, Oriomo R., *Brass 5749* (BO); Lake Daviumbu, *Brass 7798* (LAE); Wassi Kussa R., *Brass 8481* (BO, K), Tarara; *Brass 8573* (K, LAE), *Brass 8725* (K, LAE); Morehead-Arufi road, *Henty & Foreman NGF 49409* (LAE); Arufi, Wassi-Kussa R., *Henty & Katik NGF 38672* (LAE); 1 mile S of Moorhead, *Pullen 7156* (K, LAE); near Weam, *Ridsdale NGF 33567* (K, LAE); Oriomo Creek, mouth of Yakup Creek 40 miles from sea, *Womersley NGF 17740* (LAE). **SOUTHERN HIGHLANDS:** Lake Kutubu, *Ericho UPNG 18245* (UPNG), *Jebb vide 1989*. **WESTERN HIGHLANDS:** Ambra swamp, near Kuk Tea Research Station, Mt. Hagen, *Kwapena WLL 169* (LAE); Nondugl, *Mason 79* (K); Wurup area 10 miles SE of Mt. Hagen, *Wheeler ANU 6204* (LAE). **MANUS:** Mt. Dremsel, *Kerenga LAE 77541* (LAE), *Sands 986* (LAE); S of Buyang, *Kerenga & Croft LAE 77366* (LAE); Bulihan village, *Rooney UPNG 29* (UPNG). **MOROBE:** Labu nr. Lae, *Womersley NGF 3231* (LAE); Markham Point, *Floyd NGF 5671* (LAE), *Ridsdale & Frodin NGF 30352* (K, LAE); Oomsis, *Beamish 3* (LAE), *Floyd NGF 5564* (K, LAE), *Kairo & Streimann NGF 30714* (Bulolo, K, LAE); Gabensis, *Millar NGF 9721* (K, LAE); Patep, *Womersley NGF 3085* (K, LAE); Wagau, *Sayers NGF 21639* (LAE); Lake Wanum, *Frodin UPNG 7043* (UPNG), *Garret & Jones ANU 21076* (LAE); Red Hill, c.15 miles W of Lae, *Hartley 9757* (LAE), *Moi & Inu NGF 25984* (Bulolo, K, LAE), *van Royen NGF 20082* (LAE), *Womersley NGF 3264* (LAE); Kapoba sub-district, *Gillison & Kairo NGF 25723* (Bulolo, LAE), *ibid. 25724* (LAE); Dengalu, *Kairo NGF 27565* (Bulolo, K, LAE), *Millar NGF 23005* (K, LAE); Manki, *Blackwood 204* (K); valley between Wau and Bulolo, *Fallen 622* (LAE); Mankley nr. Bulolo, *Foreman LAE 60338* (LAE); Kaisenik, nr. Wau, *Kerenga LAE 76421* (LAE); Garaina, *Millar NGF 22690* (LAE); Drome logging area, Wau, *Streimann et. al. NGF 27875* (K, LAE); **CENTRAL:** Sogeri plateau, *Bell UPNG 20* (UPNG), Mageri, *Barrett NGF 4181* (K, LAE), *Graf s.n.* (LAE), *Ibali UPNG 3* (UPNG), *Womersley & Thorne NGF 12518* (K, LAE); Berebei village, *Pullen 3464* (LAE); Varirata plateau, *Frodin UPNG 4378* (UPNG), *Tanis UPNG 63* (UPNG); Mt. Marinata, *Brass 558* (BO); Kerima Pass, *Brass 1208* (BO); Owen Stanley Range, *Burke s.n.* (K); Koitaki, *Carr 12278* (SING, K); Rouna 3, *Gebo UPNG 416* (UPNG); Laloki R., c. 3 miles S of Sogeri, *Hartley 10608* (LAE), Rouna, *Brass 3667* (BO); Sirinumu area, *Schodde 2815* (K, LAE), E of Tupuseleia, Astrolabe Range, *Kanis 1348* (K, LAE); coastal scarp of Astrolabe Range, *Stevens LAE 50396* (K, LAE); Bisiatabu, *White 363* (BO). **NORTHERN:** 5 miles N of Moro, Tufi sub-district, *Darbyshire 1212* (LAE); c. 2 miles S of Toma Barigi-Managolase, *Pullen 5920* (LAE). **MILNE BAY:** ?, *Voyage of the Rattlesnake, 27/6/1849, Bot 463* (K); Qapuara Ridge, *Cruttwell 108* (K); Fergusson Is., Aimelele No.1, *Brass 25997* (K, LAE), *Brass 25998* (K, LAE); Deiei, Gomwa Bay, *Brass 27352* (LAE); nr. Deidei, *Croft in NGF 49907* (K, LAE); Normanby Is., Mt. Pabinama, *Brass 25689* (LAE); NE of Bwasiaiai, *Croft LAE 71205* (LAE); Waikaiuna Bay, *Galore & Gray NGF 8685* (LAE); Mt. Bwebwesu, *Jebb 391* (CRI); Sewa bay, *Lelean & Streimann LAE 52526* (LAE); Kiriwina Is., nr. Losuia, *Gillison NGF 25260* (LAE); Misima Is., Pana Tinani, Panmuti Point, *Mann NGF 43351* (LAE); 2 kms NE of Bwagoia, Misima Is., *Jebb 404* (CRI), *Henty NGF 27010* (LAE); Sudest Island, Joe Landing, *Brass 27753* (LAE); Rossel Is., Abaleti, *Brass 28365* (LAE); Woodlark Is., *Brass 28765* (K, LAE).

6. *Nepenthes neoguineensis* Macf.

(Figure 19)

Nepenthes neoguineensis Macf., Nova Guin., VIII,1,p.340, t.LXVII (1911).
non N.neoguineensis Ridley, Trans. Linn. Soc., ser. 2, Bot., IX, p.139 (1916) (=*N. papuana*).

Type: *Versteeg 1746* (BO, K), Sabang, Irian Jaya.

Endemic to New Guinea

Description

Stems climbing or scrambling, to 10 m or more, angular below internodes, otherwise rounded, to 1 cm thick. Leaf blade lanceolate, to 35 x 8 cm; apex acute; base tapering to winged petiole 3-7 cm long, this slightly decurrent. Longitudinal veins 3 to 4 on each side, running in outer 1/3 of leaf blade. Pennate nerves numerous, ascending obliquely and curving towards margin; irregularly reticulate in outer 1/2 of leaf blade (Fig. 5F).

Pitchers: lower pitchers ovoid, becoming cylindrical towards mouth, but narrowest there, to 14 x 4.5 cm; with prominent fringed wings up to 1 cm broad, fringe elements to 0.3 cm; peristome flattened, to 0.8 cm broad, sloping inwards; upper pitchers gradually originating from tendril, finely infundibulate in lower part, becoming swollen at 2/5 its length, then slightly narrowed and barely widened again towards mouth, to 24 x 5 cm; with fringed wings throughout basal curve, to 2 cm broad, reaching to tendril; peristome curved, 0.2-0.5 cm broad. Spur simple to 0.5 cm. Lid suborbicular, to 6 cm, apex truncate to emarginate, base occasionally cordate; with numerous small glands.

Inflorescence a loose panicle, to 40 cm, partial peduncles (2-) 4-5 flowered corymbs to 5 cm.

Indumentum very sparse, only on new leaves which soon become glabrous; lower leaves occasionally pubescent at margin and on midrib. Colour: green, pitchers occasionally flecked with small amounts of red.

Ecology: river edge and river gravel bars, ridge crests, rarely open grassland or disturbed forest. From sea level to 900 m, occasionally to 1400 m.

Distribution: from Jayapura to the d'Entrecasteaux islands, chiefly on the north coast, but also south to Lake Kutubu and Erave in the Southern Highlands, and on the south fall of the Carstenz Range. Common along the Buso River south of Lae, and in other parts of Morobe province, and once collected on Fergusson Island (Fig. 18).

Figure 18. Collections of *N. neoguineensis* examined.

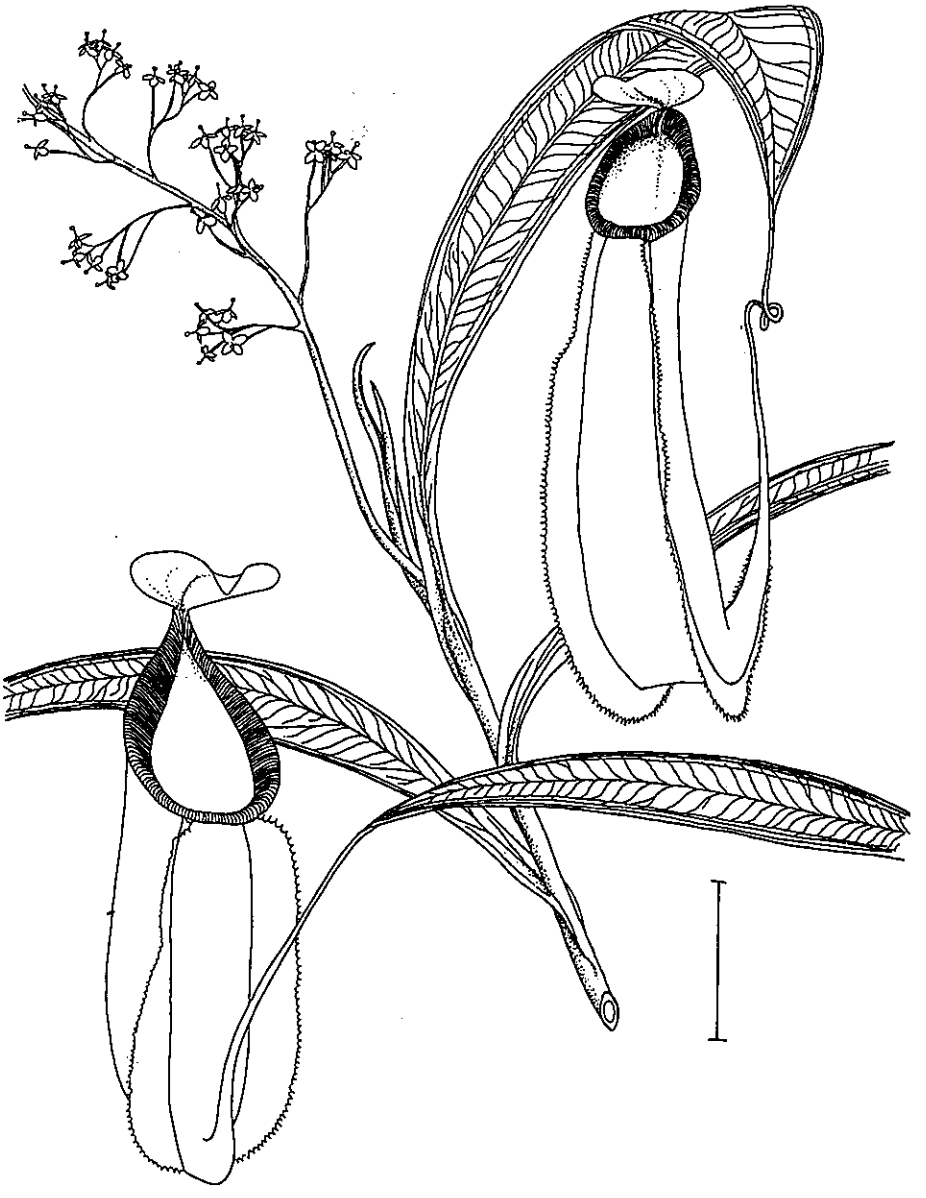


Figure 19. ***Nepenthes neoguineensis*; *Jebb 434*, Erave, PNG.**

Notes: the heavily fringed upper and lower pitchers, and corymbiform partial peduncles are diagnostic. It has not been collected from many Highland areas, nor in Madang Province. The type specimen at Kew has a poorly developed inflorescence in which the partial peduncles are only 2-flowered.

Material Examined

IRIAN JAYA: JAYAPURA: Jayapura, *Brass 8808* (BO), *Brass 8890* (BO), *Gjellerup 122* (BO), *Kostermans & Soegeng 133* (BO), *Meijer Drees 228* (BO, K); Cape Tanah Merah, *van Royen & Sleumer 6493* (BO, K). **MERAUKE:** ? first *Nepenthes* hill nr. Sabang, *Versteeg 1268* (BO), *ibid. 1746* (BO, K); Camp I-III, *Kloss s.n., 22/11/12* (K); Camp VIa, *ibid.* (K); Camp VIb, *ibid., 1/13* (K); Camp Vic, *ibid., 2/13* (K); Camp III-VIII, *ibid., 12/12* (K).

PAPUA NEW GUINEA: WEST SEPIK: Prospect Creek nr. Frieda R., Telefomin SD, *Henty & Foreman NGF 42582* (LAE). **EAST SEPIK:** Nr. Wantipi village (on Bliri R.) Aitape, *Darbyshire & Hoogland 8347* (LAE), *ibid. 8357* (K, LAE); Mt. Turu, nr. Yangoru Patrol Post, Maprik, *Pullen 1491* (LAE). **SOUTHERN HIGHLANDS:** 7kms WNW of Samberigi, *Jebb 421* (CRI); 5 kms W of Erave, *Jebb 434* (CRI); Sorotage, Lake Kutubu, *Anon LAE 69103* (Bulolo, LAE); Lake Kutubu, *Ericho UPNG 18244* (UPNG), *Jebb CRI 784* (CRI). **MOROBE:** SE of Lae on the coast opposite Lasanga Island, *Jacobs 9651* (LAE), *Jacobs 9658* (LAE); Buso R., *Rau 571* (Bulolo, LAE), *Streimann NGF 24461* (LAE), *ibid. 24463* (LAE), *Watt 31* (LAE), *Foreman LAE 52313* (LAE); 10 miles east of, Garaina, *Womersley NGF 46416* (K, LAE), creek near Saru R., *Gillison & Seruvatu NGF 25742* (Bulolo, LAE). **NORTHERN:** Arumu R. south of Botue Village, *Hoogland 3968* (LAE). **MILNE BAY:** Mts. between Angimoia and Ailuluai, Fergusson Is., *Brass 27194* (LAE).

7. *Nepenthes paniculata* Dans.

(Figure 20

Nepenthes paniculata Dans., Bull. Jard. Bot. Buitenz., Ser III, Vol IX, Liv 3- 4 p.344 (1928).

Type: *Lam 1569* (BO), Doorman Top, Irian Jaya.

Endemic to New Guinea.

Description

Stem climbing, to 7m long, 0.5-1 cm thick. Leaf blade broadly lanceolate, 20 x 4 to 30 x 7 cm; apex acuminate; base gradually attenuate into a narrowly winged petiole to 9 cm long, and forming a semi-amplexicaul sheath. Longitudinal veins 3 to 4 on each side, in outer 1/3 of leaf blade. Pennate nerves numerous, running obliquely to margin and forming an irregular network (Fig. 5E).

Pitchers: lower pitchers unknown; upper pitchers gradually originating from tendril, wholly infundibulate, to 11x5 cm, with two prominent ribs, sometimes with narrow fringed wings; peristome flattened 0.4-1 cm broad; lid suborbicular, cordate at base to 5 cm, small glands throughout; spur simple, small.

Inflorescence a panicle, to 30 cm long, angular, partial peduncles up to 5-flowered at base, to 3 cm long.

Indumentum sparse. Colour unknown.

Ecology: mossy forest on ridge top at 1460 m.

Distribution: only known from the single, type collection from Doorman Top (Fig. 21).

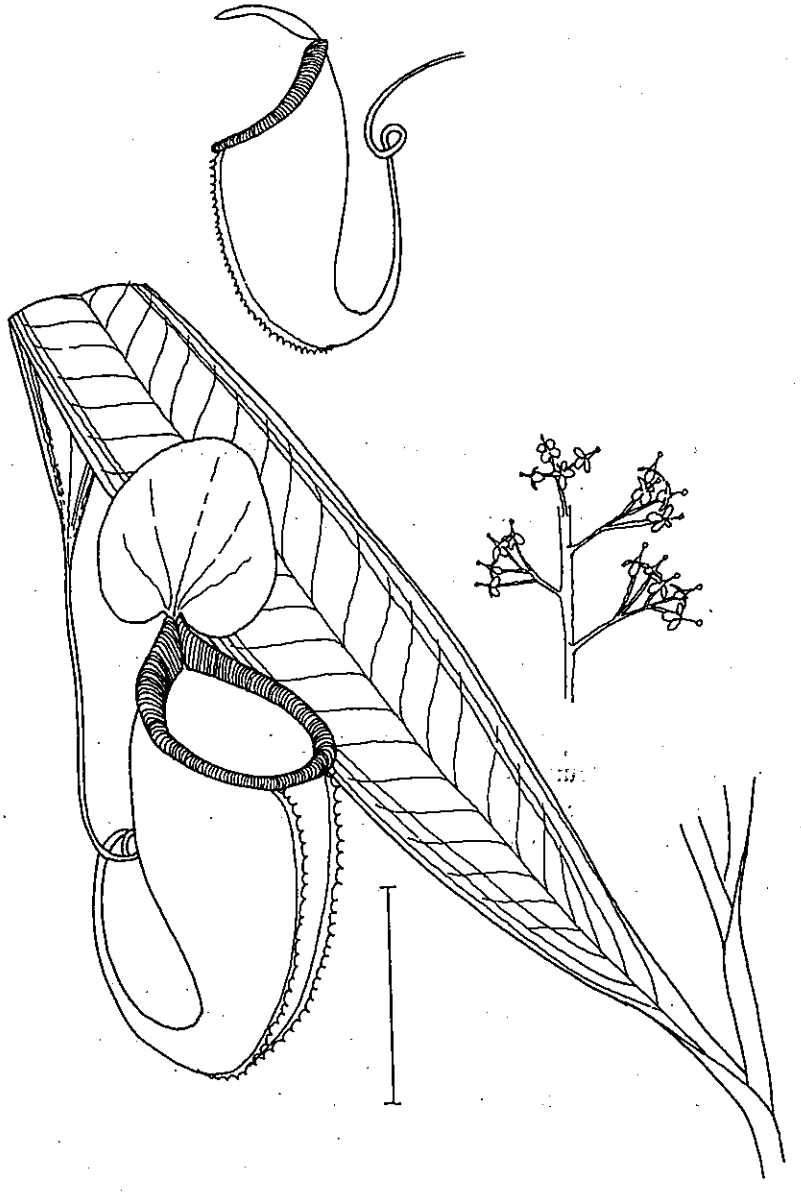


Figure 20. ***Nepenthes paniculata; Lam 1569*****, Doorman Top, IJ, and after Danser (1928).**

Notes: although the least known species in New Guinea, it is readily distinguished from the remaining paniculate species by its wholly infundibulate, and unwinged upper pitchers.

Figure 21. Collections of *N. paniculata* examined.

Material Examined

IRIAN JAYA: JAYAPURA: Ridge to Doorman Top, *Lam 1569* (BO).

8. *Nepenthes papuana* Dans.

(Figure 22)

Nepenthes papuana Dans., Bull. Jard. Bot. Buitenz., Ser III, Vol IX, Liv 3-4 p.346 (1928).

N. neoguineensis Ridl., Trans. Linn. Soc., ser.2, Bot., IX, p.139 (1916); non Macf., Nova. Guin., VIII, p.340 (1911).

Syntypes: *Docters van Leeuwen 10282* (BO), *ibid. 10340* (BO) & *ibid. 10341* (BO), Rouffaer River, Irian Jaya.

Endemic to New Guinea.

Description

Stem climbing, cylindrical, 0.5-0.7 cm thick. Leaf blade lanceolate, to 30 x 5 cm; apex acute; base attenuate, barely petioled, with a semi-amplexicaul sheath to stem. Longitudinal veins 4 to 6 on each side, in outer 2/3 of the leaf blade; more distinct on lower surface than above. Pennate nerves less distinct, numerous, running obliquely towards margin, and forming an irregular network (Fig. 5K).

Pitchers: lower pitchers obliquely ovoid in lower part, gradually narrowed towards mouth, 6 x 2.5 cm, with 2 wings, fringed or not, over whole length, to 0.6 cm broad; peristome to 0.2 cm wide; upper pitchers shortly infundibulate in basal part, ovoid to 1/3 its length, then wholly cylindrical or slightly attenuate and dilated at mouth, to 15 x 4 cm, with 2 narrow wings which may or may not be fringed, to 0.6 cm broad; peristome to 0.3 cm wide. Lid orbicular, cordate at base, to 3 cm, glands densely set near base of midrib. Spur simple, flattened.

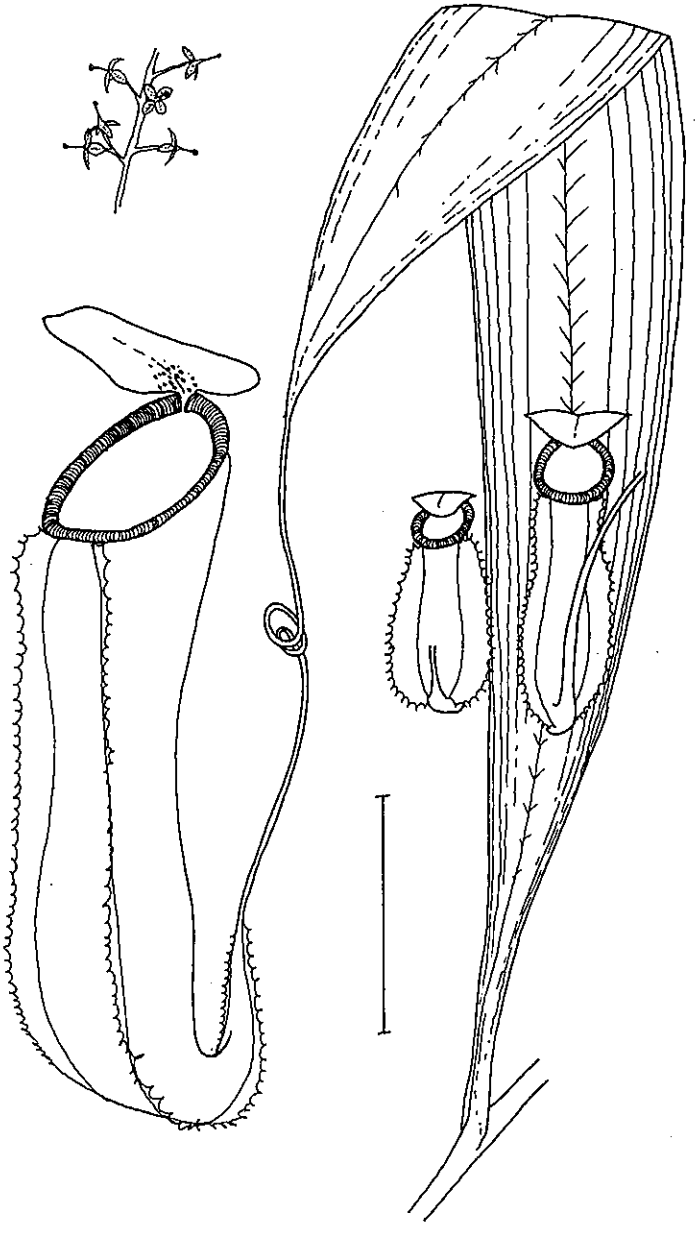


Figure 22. ***Nepenthes papuana;*** **upper and lower pitchers from Holuwon, IJ, Jebb photograph; venation and flowers after** ***van Leeuwen 1034*** **and** ***10431,*** **Rouffaer R., IJ.**

Inflorescence a raceme, 25 cm long, lower partial peduncles to 1.5 cm, 1-flowered, occasionally 2-flowered towards base.

Indumentum sparse, but sometimes dense beneath blade margin. Colour: pitchers pale green externally, with few pale red flecks, but more darkly pigmented within.

Ecology: rain forest, open grassland, 30 to 1,000 m.

Distribution: Jayapura and Merauke districts of Irian Jaya (Figure 23).

Notes: initially described as *N.neoguineensis* by Ridley some 5 years after Macfarlane had used the name, this was rectified by Danser who used the next most appropriate geographical epithet but unfortunately it is not known from Papua New Guinea. One of the types - *Docters van Leeuwen 10340* - has no fimbriate hairs on the pitcher wings, while the other types do. It is distinguished from *N. mirabilis* by its unhipped pitchers, the presence of wings on the upper pitchers, which may or may not extend some distance along the tendril, and the short-petioled leaf with less distinct pennate nerves; the mouths of the upper pitchers are larger, and more funnel-like, and the peristomes narrower. Several collections of *N. mirabilis* from Western Province (*Brass 7798, 8573* and *8725, Pullen 7156* and *Ridsdale NGF 33567*) are very similar to this species. More complete collections from Western Province are needed to solve this anomaly. I hesitate to nominate a lectotype from the syntypes, until a formal revision of the entire genus is undertaken.

Figure 23. Collections of *N. papuana* examined.

Material Examined

IRIAN JAYA: JAYAPURA: Border of affluent "C" of the Rouffaer R., *Docters van Leeuwen 10258* (p.p.)(BO), *ibid. 10282* (BO), *ibid. 10340* (BO), *ibid. 10341* (BO). **MERAUKE:** Camp VIa, *Kloss s.n., 5/1/13* (SING); northern part of the Noord R., *von Römer 454* (BO), *ibid. 900* (BO); Balim valley, Holuwon, *Jebb vide 1980.*

9. *Nepenthes treubiana* Warb.

(Figure 25)

Nepenthes treubiana Warb., in Engl., Bot. Jarb., XIII, p.318 (1891).

Type: *Warburg 20581* (B). McCluer Gulf, Irian Jaya.

Sumatra and Irian Jaya.

Description

Stem climbing, angular to 1.3 cm in diameter. Leaf blade lanceolate, to 35 x 7 cm; apex acute; gradually attenuate to base, petiole short, or to 7 cm, winged, these ±running down stem, to 0.3 cm broad. Longitudinal veins 3 to 7, some arising from midrib, running in outer 2/3 of blade. Pennate nerves numerous, running obliquely towards margin, reticulate in outer part of blade (Fig. 5I).

Pitchers: lower pitchers urceolate-globose, to 20x10 cm, with fringed wings to 1 cm broad; peristome rounded to 1.5 cm; lid orbicular, to 8 cm, slightly cordate; spur simple; upper pitchers infundibulate below, widest at 3/4 length, and narrowed towards the mouth; 20 x 6 cm, with two ridges, peristome rounded to 0.9 cm.

Inflorescence a dense raceme to 40 cm long, 0.7 cm thick, partial peduncles nearly all 2-flowered, to 2.5 cm long.

Indumentum generally sparse, but dense beneath blade margin. Colour not known.

Ecology: coastal, growing on the rocky foreshore, also in forest (?).

Distribution: Sorong District of Irian Jaya (Fig. 24).

Notes: only known from a small region of the Sumatran coast and the western most tip of New Guinea. Danser has united these two populations, although it seems highly unlikely that they can be derived from the same stock. The Sumatran collections were formerly regarded as a variety of *N. boschiana*. The very large urceolate pitchers, and 2-flowered partial peduncles give these geographically isolated populations unique features in common. Warburg did not illustrate this species and the type is presumed lost (although I have not attempted a search at Berlin) but material from Misool is a good match to the original description. No upper pitchers are known from New Guinea. Danser's illustration (1928) is based on Sumatran material.

Figure 24. Collections of *N. treubiana* examined.

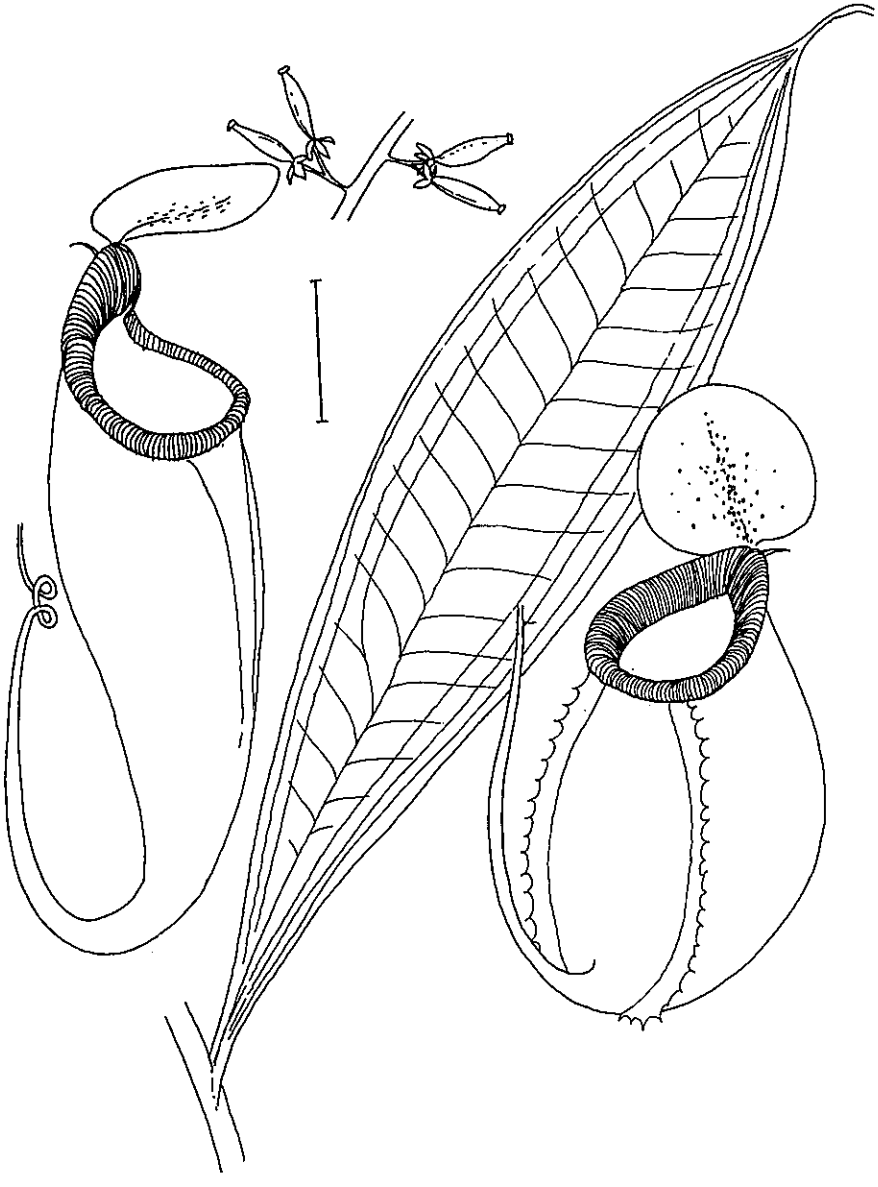


Figure 25. ***Nepenthes treubiana; Pleyte 813*****, Misool Is., IJ.**

Material Examined

IRIAN JAYA: SORONG: Misool Is., *Pleyte 813* (BO, K); Misool Is., *Pleyte 976* (BO); coast of McCluer Gulf, near Sigar, *Warburg 20581* (B+?).

10. *Nepenthes vieillardii* Hook, F.

(Figure 27)

Nepenthes vieillardii Hook, F., in D.C., Prodr., XVII, p.104 (1873).

Type: *Vieillard 1121* (K). New Caledonia.

Irian Jaya and New Caledonia.

Description

Stems climbing or erect, often greatly contracted, to 0.6 cm thick. Occasionally an epiphyte. Leaf blade lanceolate, 7 x 2 to 20 x 4 cm; apex acute; base decurrent, to 2 cm down stem. Tendril of upper pitchers sometimes not coiled in alpine plants. Longitudinal veins 3 to 4 (0-5) running in outer 1/3 to 1/4 of leaf blade. Pennate nerves distinct or indistinct, running obliquely from midrib and branching sinuously and irregularly, forming an irregular network in outer 1/2 of blade (Fig. 5A).

Pitchers: lower pitchers ovoid to campanulate, to 11x4 cm, with two fringed wings to 0.8 cm broad, fringe segments to 0.4 cm long; peristome to 0.5 cm broad; upper pitchers infundibulate in lower part, becoming ventricose, somewhat narrowed in middle and infundibulate towards mouth; to 12 x 5 cm; wings lacking; peristome to 0.4 cm. Lid orbicular to elliptical, to 4 cm, with many small glands. Spur simple to 0.5 cm.

Inflorescence a raceme, to 20 cm long, but often much contracted and dense; pedicels to 1.5 cm long.

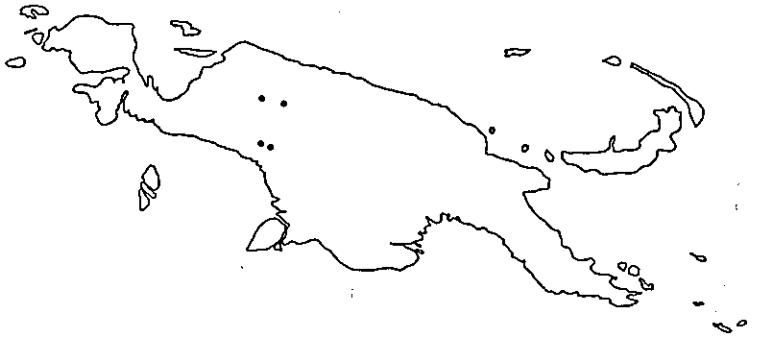
Indumentum variable, sparse to frequent on new growth and inflorescence. Colour unknown.

Ecology: epiphyte in mossy forest, or amongst scrub and grass above tree-line, from 1460 to 3520 m.

Distribution: chiefly Jayawijaya District and adjacent areas of Irian Jaya (Fig. 26).

Notes: At its extreme upper altitudinal level it becomes dwarfed and stunted (*Lam 1637 & 1654*). Pulle's collections from Erica Top (*802 & 803*) are very small delicate plants, which Danser remarks upon as being included here only on account of the degree of variety shown by this species in New Caledonia. The small, narrow leaves with decurrent bases are diagnostic.

Figure 26. Collections of *N. vieillardii* examined.



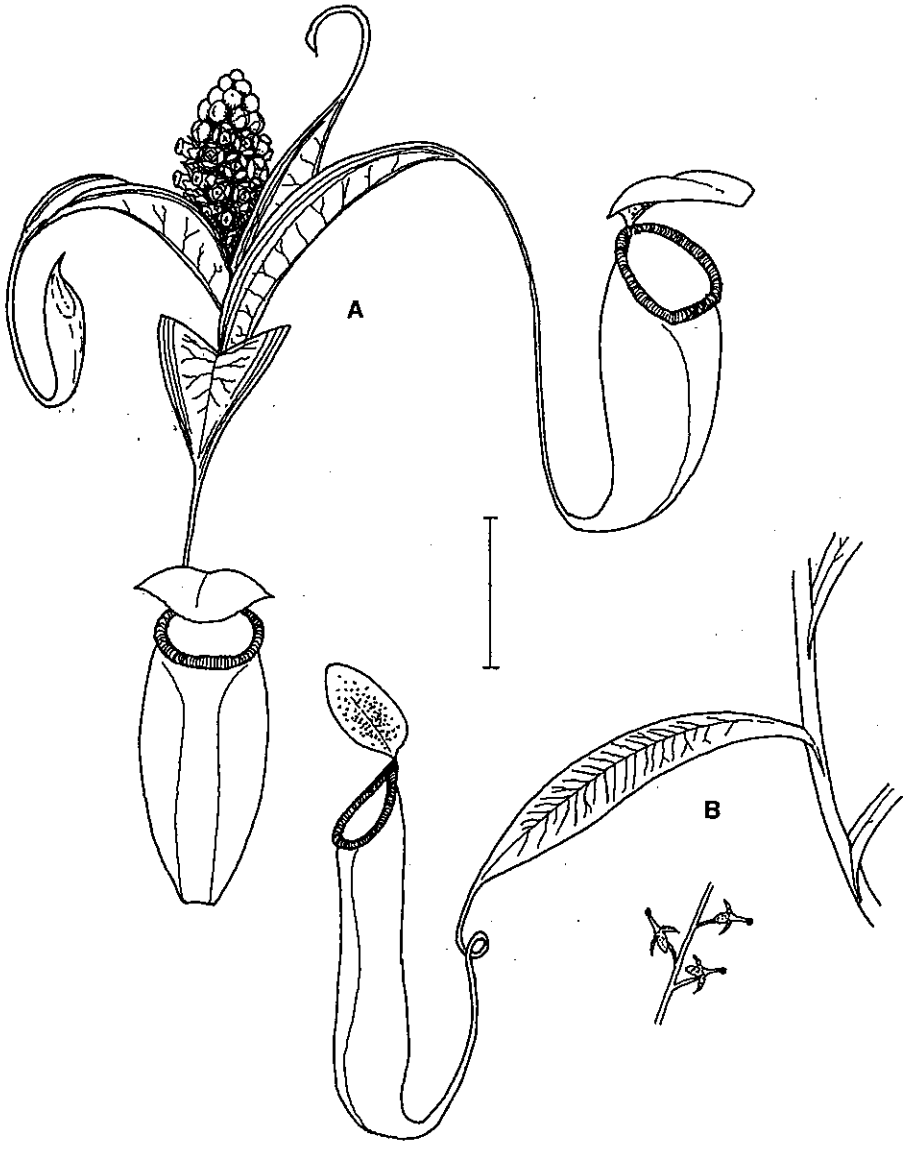


Figure 27. ***Nepenthes viellardii;*** **A) upper pitcher,** ***Lam 1654,*** **a shrub on Doorman Top, IJ, at 3,500 m. B) upper pitcher;** ***Brass 12189,*** **an epiphyte, SW. Bernard Camp, IJ, at 2,100 m.**

Material Examined

IRIAN JAYA: JAYAPURA: 18 km SW of Bernhard Camp, Idenburg R., *Brass 12189* (BO, K, LAE). **JAYAWIJAYA:** Erica Top, *Pulle 802* (BO), *Pulle 803* (BO); Hellwig Mts, *Pulle 843* (BO;p.p.); Nassau Mts, *Docters van Leeuwen 10834* (BO, K); foot of Doorman Top, *Lam 1637* (BO), *Lam 1654* (BO). **MERAUKE:** Noord R., *von Römer 1037* (BO), *ibid. 1038* (BO), *ibid. 1052* (BO).

11. *Nepenthes* sp.

(Figure 29)

Nepenthes sp..

Endemic to New Guinea

Description

Stem climbing, slender, rounded, to 0.5 cm thick. Leaf blade broadly lanceolate, to 22 x 7.5 cm; apex and base acute; petiole not winged, to 8 cm, forming a semiamplexicaul sheath to stem. Longitudinal veins 4 to 7 on each side, most arising from base, sometimes 1-2 arising from midrib, running throughout leaf blade, usually more distinct than pennate nerves which are numerous and arise obliquely (Fig. 5J).

Pitchers: lower pitchers ovate, to 8 x 2.5 cm, peristome rounded to 0.5 cm; with fringed wings to 0.7 cm broad, lid orbicular; upper pitchers cylindrical, to 17 x 3 cm, with 2 slight ridges, peristome rounded to 0.4 cm.

Inflorescence a panicle, to 20 cm; partial peduncles 4 to 5 flowered; to 2.5 cm long.

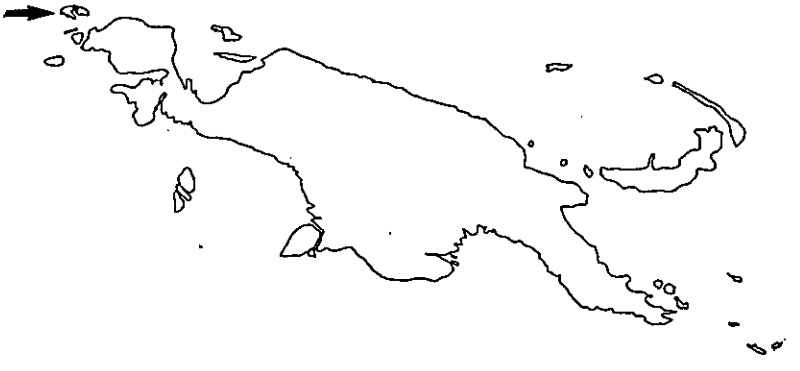
Indumentum absent. Colour yellowish green, midrib red, pitchers green, lid red.

Ecology: open grassland on ultrabasic soil at 200 m.

Distribution: Waigeo Island, Irian Jaya (Fig. 27).

Notes: This description is based on fragmentary van Royen collections, which almost certainly represent an undescribed species. It can be readily distinguished from all other paniculate species of *Nepenthes* that grow in New Guinea or southeast Asia. *N. ampullaria* and *N. tomoriana* (Sulawesi) have partial peduncle bracts. *N. neoguineensis* has distinct corymb-like pedicels. *N. bicalcarata* (northwest Borneo) has 3-flowered partial peduncles, and a distinctive peristome. *N. paniculata* differs in habitat leaf venation and its infundibulate upper pitchers. There is, unfortunately, insufficient material to provide an adequate description.

Figure 28. Collections of *Nepenthes* sp. examined:



Material Examined

IRIAN JAYA: SORONG: Waigeo Island, Go Isthmus, summit of Poean Hill, *van Royen 5541* (K, L, LAE), Kambele hills, *van Royen 5418* (L).

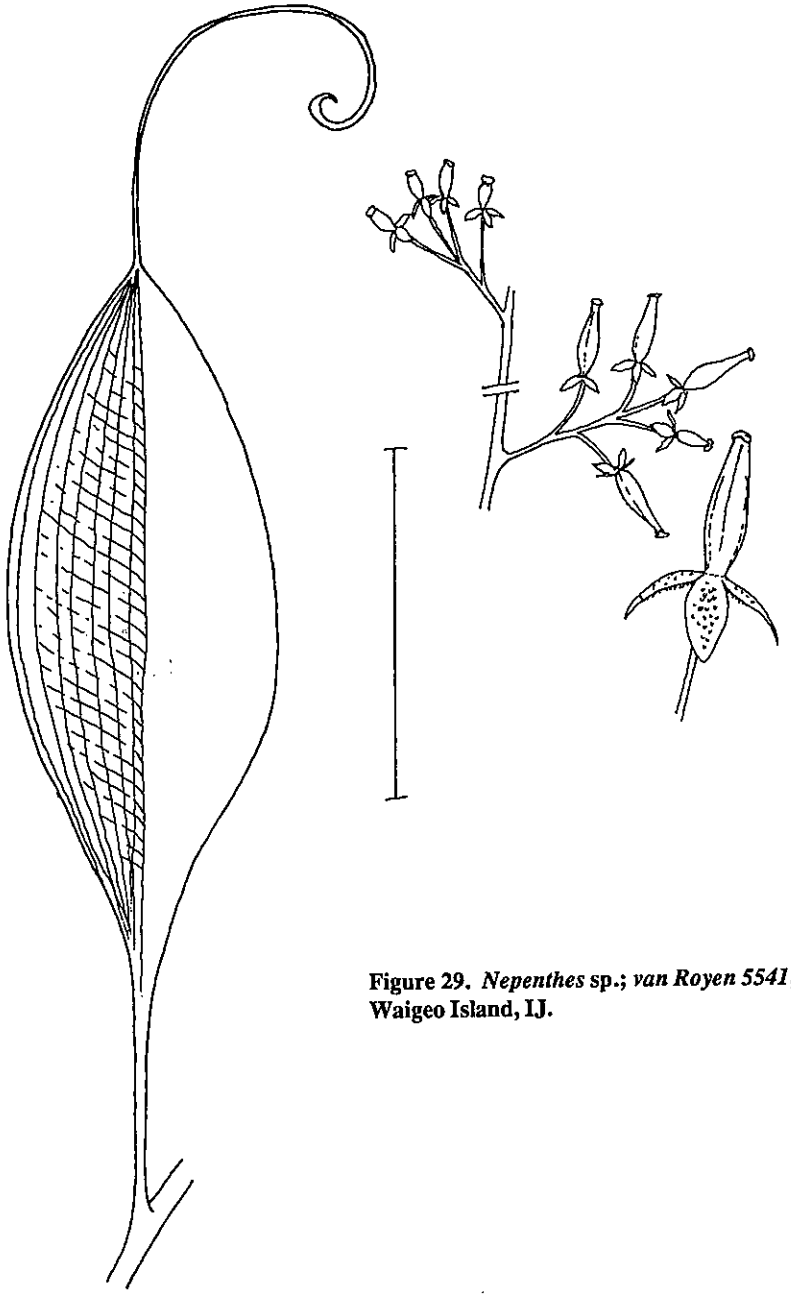


Figure 29. ***Nepenthes*** **sp.;** ***van Royen 5541*****, Waigeo Island, IJ.**

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REFERENCES

Cronquist, A. (1981). *An integrated system of classification of flowering plants*, Columbia University Press, New York.

Danser, B. H. (1928). The Nepenthaceae of the Netherlands Indies. *Bulletin du Jardin botanique de Buitenzorg*, Ser. 3, 9, Liv.3-4, 249-438.

Gibson, T.C. (1983). *Competition, disturbance, and the carnivorous plant community in the southeastern United States.* Ph.D. Dissertation, University of Utah.

Harms, H. (1936). *Nepenthaceae*; in: A.Engler & K.Prantl, *Die Natürlichen Pflanzenfamilien*, 2 aufl. band 17b.

Joel, D.M. (1988). Mimicry and mutualism in carnivorous pitcher plants. *Biological Journal of the Linnean Society*, **35**, 185-197.

Johns, R.J. (1986). The instability of the tropical ecosystem in New Guinea. *Blumea* **31**, 341-371.

Juniper, B.E., Robins, R.J. & Joel, D.M. (1989). *The Carnivorous Plants.* Academic Press, London.

Kurata, S. (1976). *The Nepenthes of Mt. Kinabalu. Sabah National Parks Publication No.1.*, Sabah.

Lloyd, F. E. (1942). *The Carnivorous Plants.* Chronica Botanica, Waltham, Mass., U.S.A.

McAlpine, J.R., Keig, G. & Falls, R. (1983). *The climate of Papua New Guinea.* CSIRO and Australian National University Press, Canberra.

Veitch, H.J. (1897). Nepenthes. *Journal of the Royal Horticultural Society*, **21**, 226-255.

APPENDIX A

Results of a survey of pitcher contents from a community of *Nepenthes mirabilis* growing in savanna woodland at approximately sea level near Bwagoia, Misima Island, Papua New Guinea, in September 1983. Table 1 shows the raw data, tables 2 and 3 summarise the catch in terms of flying and walking prey, and their distribution. The categories are those made in the field, and no attempt has been made to alter them to uniformity. A notable feature of freshly opened pitchers is the incidence of large centipedes, these appear to be caught prior to almost any other prey, while cockroaches are frequent in older pitchers, possibly attracted to the smell of decay.

These figures represent only the most recent catch, the older pitchers also contained a considerable quantity of unidentifiable remains.

Table 1. Contents of 52 pitchers from 20 plants. The pitchers are numbered sequentially from the apex of the plant downwards, number 1 being the youngest, open pitcher.

Pitcher No.	Type	Height above ground (cm)	Contents
Plant A: 6 pitchers, 3 leaves with unopened pitchers.			
1	Upper	6	8 centipedes, 17 ants, 3 flies.
2	Upper	12	c.30 ants, 6 cockroaches.
3	Inter	7	2-300 ants, 2 Trigonid bees, 2 centipedes, 10 cockroaches.
4	Inter	0	300+ ants.
5	Inter	0	300 ants.
6	Lower	0	200+ ants, 15 cockroaches.
Plant B: 4 pitchers, 3 leaves with unopened pitchers.			
1	Upper	8	1 centipede.
2	Upper	0	200+ ants.
3	Lower	0	1 cockroach, 1 beetle, 200+ ants.
4	Lower	0	200+ ants.
Plant C: 5 pitchers, 2 leaves with unopened pitchers.			
1	Upper	0	2 ants, 1 spider, 1 large fly, 6 Drosophilids, 1 centipede.
2	Lower	0	4 centipedes, 4 large ants, 1 Isopod, 8 small red ants.
3	Lower	0	3 cockroaches, 5 centipedes, 9 large black ants, 1 small Orthopteran, 50 red ants, 4 flies.
4	Lower	0	2 cockroaches, 300+ ants.
5	Lower	0	1 cockroach, 200+ ants.
Plant D: 4 pitchers, 3 leaves with unopened pitchers.			
1	Upper	30	1 Orthopteran, 2 centipedes.
2	Upper	20	2 small weevils, 1 cockroach, 2 flies, 2 large black ants, 6 Ichneumons, 1 caterpillar, 1 centipede.
3	Upper	20	1 centipede, 6 weevils, 6 small beetles, 1 large beetle, 2 big ants, 3 spiders, 3 small flies.
4	Upper	20	1 large beetle, 6 big ants, 1 weevil, 4 small beetles, numerous ants, 7 Ichneumons.
Plant E: 2 pitchers, 3 leaves with unopened pitchers.			
1	Lower	0	6 cockroaches, 1 Orthopteran, 60 ants, 12 Ichneumons, 3 flies.
2	Lower	0	150 ants, 1 cockroach, 1 snail, 1 Orthopteran.
Plant F: 3 pitchers, 2 leaves with unopened pitchers.			
1	Upper	10	2 centipedes, 2 flies, 2 ants, 2 midges.
2	Upper	40	1 midge.
3	Inter	0	300 ants, 4 beetles.

Pitcher No.	Type	Height above ground (cm)	Contents
Plant G: 2 pitchers, 2 leaves with unopened pitchers.			
1	Lower	0	1 large moth, 4 centipedes, 1 large ant, 6 small ants, 1 Orthopteran.
2	Lower	0	(damaged).
Plant H: 4 pitchers, 2 leaves with unopened pitchers.			
1	Upper	30	1 centipede, 1 ant.
2	Upper	30	1 beetle.
Plant I: 3 pitchers, 2 leaves with unopened pitchers.			
1	Upper	30	1 centipede, 2 flies.
Plant J: 6 pitchers, 2 leaves with unopened pitchers.			
1	Upper	30	1 Orthopteran, 15 midges.
2	Upper	15	150 ants, 2 cockroaches, 1 small beetle, 1 centipede.
3	Upper	20	3 big beetles, 5 small moths, 6 midges, 2 Orthopterans,
4	Centipedes	30 Ichneumons.	
Plant K: 1 pitcher, 4 leaves with unopened pitchers.			
1	Upper	0	200+ ants, 3 cockroaches, 1 moth, 1 Orthopteran, 3 centipedes, 4 midges.
Plant L: 3 pitchers, 2 leaves with unopened pitchers.			
1	Upper	20	1 centipede, 2 Orthopterans, 14 flies, 1 wasp, 6 ants.
2	Inter	0	5 millipedes, 150+ ants, 2 snails.
3	Inter	0	150+ ants.
Plant M: 4 pitchers, 3 leaves with unopened pitchers.			
1	Upper	10	1 spider, 1 beetle, 6 Ichneumon, 7 flies.
2	Upper	15	3 centipedes, 7 big black ants, 50 small ants, 2 weevils, 2 small beetles, 6 flies, 1 small moth.
3	Inter.	0	1 large wasp, 1 large beetle, 3 small beetles, 100 ants, 1 moth, 1 silverfish.
4	Lower	0	300+ ants, 1 millipede, 1 cockroach.
Plant N: 4 pitchers, 4 leaves with unopened pitchers.			
1	Upper	30	2 moths, 12 ants, 1 spider, 4 flies.
Plant O: 2 pitchers, 1 leaf with unopened pitcher.			
1	Lower	0	1 large Orthopteran, 1 beetle, 4 flies, 6 ants.
2	Lower	0	2 millipedes, 6 flies, 1 Orthopteran, 1 cockroach, 1 snail.
Plant P: 3 pitchers, 2 leaves with unopened pitchers.			
1	Lower	0	cockroach, 1 beetle, 75 ants, 1 centipede, 4 flies, 1 spider.
2	Lower	0	200 ants, 4 snails, 1 large spider, 1 moth.
Plant Q: 3 pitchers, 3 leaves with unopened pitchers.			
1	Upper	5	200+ ants, 2 cockroaches, 1 moth, 2 centipedes, 4 beetles.
Plant R: 2 pitchers, 2 leaves with unopened pitchers.			
1	Upper	15	1 centipede, 1 Orthopteran, 1 spider, 2 beetles, 6 flies, 5 ants.
Plant S: 4 pitchers, 2 leaves with unopened pitchers.			
1	Upper	3	1 beetle.
2	Lower	0	1 centipede, 5 beetles, 10 centipedes, 300+ ants, 2 flies.
Plant T: 3 pitchers, 3 leaves with unopened pitchers.			
1	Upper	0	3 centipedes, 4 flies, 20 small ants, 10 Ichneumons.
2	Upper	10	2 small Ichneumons.

Table 2. Distribution of prey by pitcher type.

Pitcher type: Prey:	lower (17) total	lower (17) av/pitcher	intermediate (7) total	intermediate (7) av/pitcher	upper (28) total	upper (28) av/pitcher
WALKERS						
Ants	2198	129.3	1450	183.4	890	32.3
Cockroaches	32	1.9	10	1.2	14	0.5
Myriopods	28	1.7	7	1.0	35	1.2
Snails	6		2		--	
Spiders	2		--		7	
Others	1		1		2	
	2267	133.3	1470	210.0	948	33.8
As % of contents	97.8%		99.2%		83.1%	
FLYERS						
Flies	23	1.3	-		94	3.4
Ichneumons	12	0.7	-		48	1.8
Beetles	8	0.5	8	1.0	32	1.2
Orthopterans	6		-		8	
Moths	2		1		10	
Wasps/Bees			3		1	
	51	3.0	12	1.7	193	6.9
As % of contents	2.2%		0.8%		16.9%	

Table 3. Distribution of prey by pitcher height.

Pitcher position: Prey:	Pitchers on ground (27) total	Pitchers on ground (27) av/pitcher	Pitchers suspended above ground (25) total	Pitchers suspended above ground (25) av/pitcher
WALKERS				
Ants	3770	139.6	768	30.7
Cockroaches	32	1.2	24	1.0
Myriopods	40	1.5	30	0.2
	3858	142.8	854	34.2
As % of contents	98.6%		87.4%	
FLYERS				
Flies	32	1.2	85	3.4
Ichneumon wasps	22	0.8	38	1.5
Beetles	16	0.6	32	1.3
As % of Pitcher	54	2.0	123	4.9
As % of contents	1.4%		12.6%	

APPENDIX B

SPECIMENS SEEN BY THE AUTHOR

Further information is to be found under the particular species listings. Species names are abbreviated to the first 3 letters; 'IJ' = Irian Jaya; 'PNG' = Papua New Guinea.

AET & IDJAN 258 (*amp*), 489 (*amp*), 831 (*amp*); Aet 731 (*mir*); Aet [Lundquist] 644 (*mir*); Anta [Wentholt] 29 (*mir*); Assem 23 (*mir*).

BAL UPNG 18360 (*max*); Barker s.n. (*max*), LAE 66820 (*max*), LAE 67625 (*max*); Barker & Lelean LAE 66811 (*max*); Barrett NGF 4181 (*mir*); Beamish 3 (*mir*); Bell UPNG 20 (*mir*); Blackwood 204 (*mir*); Branderhorst 94 (*mir*); Brass 558 (*mir*), 1208 (*mir*), 3667 (*mir*), 5749 (*mir*), 6618 (*amp*), 6802 (*amp*), 7798 (*mir*), 8481 (*mir*), 8573 (*mir*), 8725 (*mir*), 8808 (*neo*), 8890 (*neo*), 8942 (*amp*), 11494 (*max*), 11833 (*max*), 11836 (*max*), 11900 (*max*), 12189 (*vie*), 12430 (*max*), 13232 (*max*), 13379 (*ins*), 13669 (*ins*), 25662 (*max*), 25663 (*max*), 25689 (*mir*), 25997 (*mir*), 25998 (*mir*), 27057 (*max*), 27194 (*neo*), 27352 (*mir*), 27753 (*mir*), 28365 (*mir*), 28765 (*mir*); Burke s.n. (*mir*); Buwalda 5105 (*mir*), 5341 (*mir*).

CARR 12278 (*mir*); Clemens 3604 (*max*); Croft NGF 49907 (*mir*), LAE 71205 (*mir*); Cruttwell 108 (*mir*).

DARBYSHIRE 1212 (*mir*); Darbyshire & Hoogland 8347 (*neo*), 8357 (*neo*); Docters van Leeuwen 9814 (*amp*), 9822 (*amp*), *p.p.* [*BO*] 10258 (*amp*), *p.p.* (*BO*,*K*) 10258 (*ins*), *p.p.* (*BO*) 10258 (*pap*), 10282 (*pap*), 10340 (*pap*), 10341 (*pap*), 10834 (*vie*), 10995 (*max*).

ERICHO UPNG 18243 (*amp*); 18244 (*neo*), 18245 (*mir*); Eyma 4266 (*max*), 4393 (*max*), 4435 (*max*), 4592 (*max*), 4819 (*max*), 4826 (*max*), 4893 (*klo*), 4894 (*max*), 5276 (*max*), 5391 (*max*), 5393 (*max*).

FALLEN 622 (*mir*); Feuilletau de Bruyn 112 (*amp*); Floyd NGF 5564 (*mir*), NGF 5671 (*mir*); Foreman LAE 52313 (*neo*), LAE 60338 (*mir*); Frodin UPNG 4073 (*mir*), UPNG 4378 (*mir*), UPNG 7043 (*mir*).

GALORE & GRAY NGF 8685 (*mir*); Garret & Jones ANU 21076 (*mir*); Gebo UPNG 416 (*mir*); Gibbs 5502 (*max*), 5937 (*max*); Gillison NGF 25260 (*mir*); Gillison & Kairo NGF 25723 (*mir*), NGF 25724 (*mir*); Gillison & Seruvatu NGF 25742 (*neo*); Giuilianetti & English 25 (*amp*); Gjellerup 122 (*neo*), 172 (*mir*), 493 (*mir*), 1130 (*max*); Graf s.n. (*mir*), s.n. (*max*).

HARTLEY 9757 (*mir*), 10608 (*mir*); Henty NGF 27010 (*mir*); Henty & Foreman NGF 42582 (*neo*), NGF 49409 (*mir*); Henty & Katik NGF 38672 (*mir*); Hiaso UPNG 18356 (*max*); Hinson 46 (*mir*); Hoogland 3968 (*neo*), 9299 (*max*); Hoogland & Craven 10550 (*amp*); Hopkins UPNG 13265 (*max*); Howcroft LAE 64024 (*amp*), LAE 64052 (*amp*); Hutton NGF 49980 (*max*); Hyndman 173 (*max*).

IBALI UPNG 3 (*mir*); Ingemann 10 (*max*); Iwanggin BW 5225 (*mir*).

JACOBS 8964 (*amp*), 9651 (*neo*), 9658 (*neo*); Janowsky 42 (*amp*); Jebb 238 (*max*), 391 (*mir*), 404 (*mir*), 414 (*max*), 421 (*neo*), 434 (*neo*), CRI 783 (*amp*), CRI 784 (*neo*).

KAIRO NGF 27565 (*mir*); Kairo & Streimann NGF 30714 (*mir*); Kalkman BW 3568 (*amp*), 4019 (*amp*), 5323 (*max*); Kanehira & Hatusima 12174 (*amp*); 12175 (*amp*), 13011 (*mir*), 13736 (*max*); Kanis 1348 (*mir*); Kerenga LAE 76421 (*mir*), LAE 77541 (*mir*); Kerenga & Croft LAE 77366 (*mir*); Kerenga & Lelean LAE 73971 (*amp*); Kloss s.n., 22/11/12 (Camp I-III) (*neo*), 2/13 (Camp III-IV) (*amp*), 12/12 (Camp III-VIII) (*max*), 12/12 (Camp III-VIII) (*neo*), s.d. (Camp VIa @ K) (*klo*), 17/2/13 (Camp VIa @ K) (*max*), s.d. (Camp VIa @ K) (*max*), s.d. (Camp VIa @ K) (*neo*), 5/1/13 (Camp VIa

@ S) (*pap*), 26/1/13 (Camp VIb @ S) (*klo*), 1/13 (Camp VIb @ K) (*max*), 1/13 (Camp VIb @ K) (*neo*), 2/13 (Camp VIc) (*max*), 2/13 (Camp VIc) (*neo*), 26/1/13 (Camp IX-X) (*max*), 2/13 (Camp XI-IX) (*max*); Kostermans 361 (*amp*), 2123 (*max*), 2165 (*max*), 2178 (*max*), 2345 (*max*), 2383 (*max*), BW 4313 (*mir*); Kostermans & Soegeng 133 (*neo*), 610 (*max*), 781 (*max*); Kumbia UPNG 18358 (*max*), UPNG 18359 (*max*); Kwapena WLL 169 (*mir*).

LAM 1569 (*pan*), 1637 (*vie*), 1654 (*vie*), 2156 (*max*); Lelean & Streimann LAE 52526 (*mir*); Lisowski 53164 (*max*); Lloyd Hamilton UPNG s.n. (*max*).

MANA UPNG 18357 (*max*); Mandeakali UPNG 18355 (*max*); Mann NGF 43351 (*mir*); Mason 79 (*mir*); Mayr 10 (*max*), 58 (*max*), 268 (*max*); Meijer Drees 136 (*mir*), 228 (*neo*), 228 (*neo*), 503 (*amp*); Millar NGF 9721 (*mir*), NGF 22690 (*mir*), NGF 23005 (*mir*); Moi & Inu NGF 25984 (*mir*).

ORAPA UPNG 18354 (*max*).

PAIJMANS 1436 (*amp*); Pleyte 813 (*tre*), 976 (tre); Powell UPNG 2448 (*max*); 2448 (*max*); Pratt s.n. (*mir*), (*amp*); Pringo 94 (*mir*); Pulle 277 (*ins*), 659 (*max*), 710 (*max*), 802 (*vie*), 803 (*vie*), 843 (*max*), 843 (*vie*), 1137 (*max*); Pullen 1491 (*neo*), 3464 (*mir*), 5920 (*mir*), 7156 (*mir*), 7256 (*amp*).

RAU 571 (*neo*); Reksodihardjo 26 (*mir*), 388 (*amp*); Ridsdale NGF 33567 (*mir*), NGF 31726 (*amp*); Ridsdale & Frodin NGF 30352 (*mir*); Ridsdale & Galore NGF 31757 (*amp*); Ridsdale & Henty NGF 33105 (*max*); Rifai ? 6705 (*max*), {?} 6533 (*max*); von Römer 46 (*amp*), 47 (*amp*), 449 (*amp*), 454 (*pap*), 900 (*pap*), 1037 (*vie*), 1038 (*vie*), 1052 (*vie*), 1156 (*max*), 1192 (*max*); Rooney UPNG 29 (*mir*); van Royen 3809 (*mir*), 3864 (*max*), 3968 (*mir*), 4515 (*mir*), 4897 (*mir*), 11480 5541 (sp.nov.), NGF 20082 (*mir*); van Royen & Sleumer 5644 (*mir*), 5928 (*max*), 6461 (*amp*), 6493 (*neo*), 6767 (*mir*), 6887 (*max*), 7719 (*max*), 7934 (*max*), 7952 (*max*), 8027 (*max*), 8234 (max), 8235 (*max*), s.n. (*max*).

SANDS 986 (*mir*); Sayers NGF 21639 (*mir*); Schlechter 20337 (*max*); Schodde 1658 (*max*), 2815 (*mir*); Schram BW 13380 (*max*), BW 13400 (*max*), BW 14964 (*mir*); Sleumer & Vink BW 14011 (*max*), BW 14189 (*max*); Stefels BW 3160 (*mir*); Stelleman 15 (*mir*); Stevens LAE 50396 (*mir*); Streimann NGF 24461 (*neo*), NGF 24463 (*neo*); Streimann et. al. NGF 27875 (*mir*); Streimann & Kairo NGF 39297 (*mir*); Streimann and Lilian NGF 34149 (*amp*); Streimann & Womersly LAE 51839 (*amp*).

TANIS UPNG 63 (*mir*).

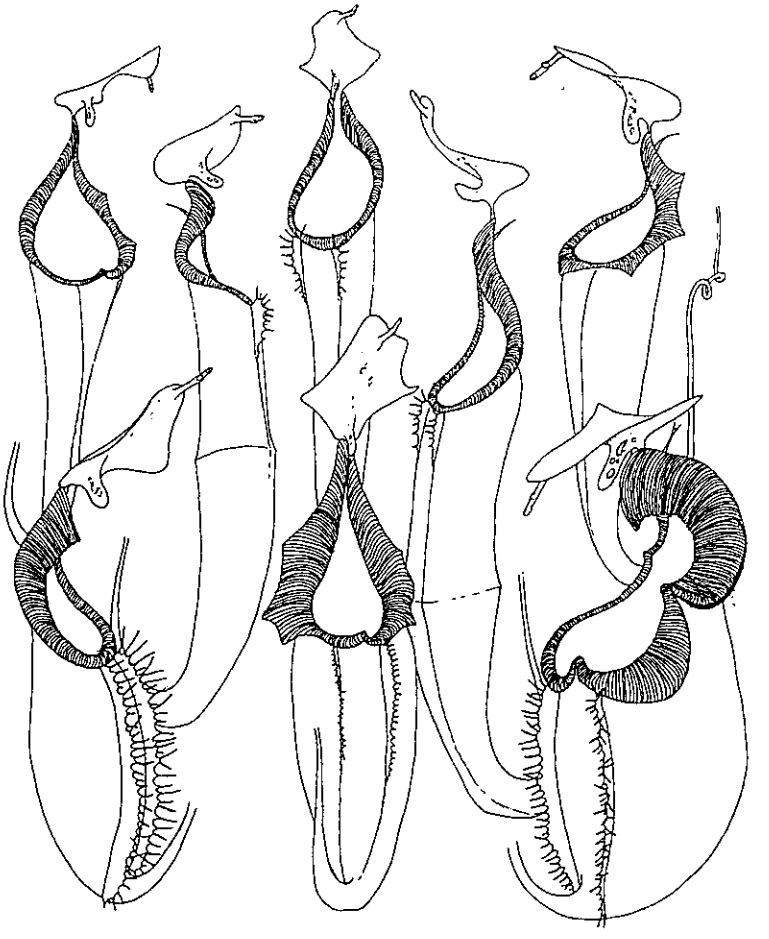
UNKAU W/L 4 (*amp*).

VERSTEEG 1047 (*amp*), 1214 (*amp*), 1229 (*amp*), 1268 (*neo*), 1746 (*neo*), BW 12719 (*max*); Vink BW 11288 (*amp*), BW 15326 (*mir*); Voyage of the Rattlesnake, Bot 463 (*mir*).

WARBURG 20581 (*tre*); Watt 31 (*neo*); Wenthold 199 (*mir*); Wheeler ANU 6204 (*mir*); White 363 (*mir*); Womersley NGF 3085 (*mir*), NGF 3231 (*mir*), NGF 3264 (*mir*), NGF 9386 (*max*), Womersley NGF 17740 (*mir*), NGF 37301 (*max*), NGF 46416 (*neo*); Womersley & Millar NGF 7635 (*max*); Womersley & Thorne NGF 12518 (*mir*), NGF 12696 (*max*).

Anon. LAE 69103 (*neo*).

Science in New Guinea



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