

*DELIMITATION OF THE
NEPENTHES MACFARLANEI GROUP
WITH TWO SPECIES DESCRIBED AS NEW*



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This paper was printed in the appendix of the third volume of *Nepenthes - The Tropical Pitcher Plants* (published by Redfern Natural History Productions in April, 2023).

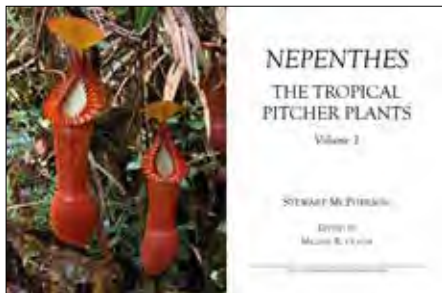
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Date of online publication: 13 April, 2023

ISBN of *Nepenthes - The Tropical Pitcher Plants Volume 3*: 978-1-908787-49-1

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APPENDIX A

Delimitation of the *Nepenthes macfarlanei* Group with Two Species Described as New

Gideon Lim¹, Michal R. Golos², François Sockhom Mey³, Andreas Wistuba⁴, Stewart R. McPherson⁵ & Alastair S. Robinson⁶

¹ B-07-03, Tower B, Epic Residence, Jalan BP 7/12 Bandar Bukit Puchong 2, 47120 Puchong, Selangor, Malaysia; malaysiacarnivorousplants@gmail.com

² School of Biological Sciences, University of Bristol, 24 Tyndall Avenue, Bristol, BS8 1TQ, UK; michal.golos@bristol.ac.uk

³ 9 rue René Lothon, 27110 Epéguard, France; meyfr@yahoo.fr

⁴ Friedhofweg 4, 88437 Maselheim, Germany; andreas@wistuba.com

⁵ Redfern Natural History Productions, 61 Lake Drive, Hamworthy, Poole, Dorset, BH15 4LR, UK; stewart@redfernnaturalhistory.com

⁶ National Herbarium of Victoria, Royal Botanic Gardens Victoria, Melbourne, VIC 3004, Australia; alastair.robinson@rbg.vic.gov.au

Abstract

Studies of *Nepenthes macfarlanei* at its type locality, along with supporting examinations of reference herbarium materials and field observations of allied taxa throughout Peninsular Malaysia made over two decades, have resulted in a better understanding of the group of closely related taxa formerly treated as *N. macfarlanei sensu lato*. This group includes three previously undescribed species, two of which are described at species rank here. The interpretations presented within this work are supported by thorough examinations of the majority of known voucher materials from this region held in herbaria in Southeast Asia and Western Europe. The newly named taxa are described and illustrated and a revised key to the informally named *N. macfarlanei* complex provided.

Figure A1 (facing page): A lower pitcher of *Nepenthes macfarlanei* observed at the type locality on Gunung Bubu in August 2022, during the expedition undertaken to resolve the taxonomy of this species (Greg Palena).

Introduction

Peninsular Malaysia has long been considered a region with little to offer in terms of pitcher plant novelties, but the last few years have seen renewed interest in the taxonomy of its *Nepenthes* (Ghazalli *et al.*, 2019, 2020, 2021; Tamizi *et al.*, 2020a, b; Tan *et al.*, 2023).

Until recently, all Peninsular Malaysian *Nepenthes* with conspicuous hairs under the lid were treated as *N. macfarlanei*. Clarke & Lee (2012) pointed out that similar though shorter hairs are also found in *N. alba* and *N. gracillima* (as already noted by Danser, 1928, but largely overlooked thereafter). Prior to this, the close affinities between these species had not been fully appreciated. However, until now, the type population of *N. macfarlanei* in the Bintang Range had not been studied *in situ* by *Nepenthes* taxonomists, and descriptions of the species were based largely on the commonly encountered populations from the Titiwangsa Range (Main Range), particularly those of the Cameron Highlands and Genting Highlands. As such, the distinctive lower lid hairs of *N. macfarlanei* were said to be only up to 2 mm long (Clarke, 2001), even though the type material, type description, and original illustrations of this species all clearly indicate coarse bristles measuring up to 10 mm or more. Field studies carried out in 2022 of the type population of *N. macfarlanei* in the Bintang Range (Fig. A1), as well as of taxa from the Titiwangsa Range previously referred to this species, identified a number of additional morphological differences between them. This led to the description of *N. berbulu* by Tan *et al.* (2023). Building on this work, two further taxa previously lumped under *N. macfarlanei* are here described as new species: *N. sericea* and *N. ulukaliana*, chiefly known from the Cameron Highlands and Genting Highlands, respectively. The *N. macfarlanei* group is circumscribed on morphological grounds and a dichotomous key is provided.

Botanical History of *Nepenthes macfarlanei* s.lat.

Nepenthes macfarlanei was first brought to the attention of the wider scientific community on April 6th, 1905, in a talk given by William Botting Hemsley (1843–1924), Keeper of the Herbarium at Kew, at a general meeting of the Linnean Society of London. Hemsley presented specimens and drawings of a variety of *Nepenthes* pitchers and their associated glandular structures. These were supplemented by 25 magic lantern slides prepared by L. Farmar^[1], including one of *N. macfarlanei* (Anon., 1905). Summaries of this talk, of varying length and detail, were published in a number of British periodicals over the following weeks and months^[2] (Hemsley, 1905a–e; Anon., 1905), the earliest known to us being that in the horticultural magazine *The Garden*, dated April 15th, which related: “Mr. Hemsley first exhibited a new species, *Nepenthes Macfarlanei*, which differs from all other known species, except *N. Lowii*, in the under side of the lid being thickly beset with stiff bristles, interspersed with large honey-glands. The function of the bristles in this position is not obvious, but their rôle would seem to be preventive to flying insects, though ants might creep among them and drink the honey.” (Hemsley, 1905a). This represents the earliest known appearance of the binomial *N. macfarlanei* in print. However, the most detailed account, based on an extended abstract of Hemsley’s remarks, appeared a week later in *The Gardeners’ Chronicle*, and included a description

of both the lower and upper pitchers of *N. macfarlanei*, as well as the microstructure of its abaxial lid nectar glands and the digestive glands of the pitcher interior (Hemsley, 1905c).

Hemsley wrote that the species was brought to his attention the previous year by fellow botanist John Muirhead Macfarlane (1855–1943), then based in Philadelphia, during the latter’s visit to the Royal Botanic Gardens, Kew^[3], where a single herbarium specimen from Gunung Bubo (=Gunung Bubu, 1657 m) in the Bintang Range^[4] was preserved. Hemsley agreed to describe the species and decided to name it in Macfarlane’s honour. When Hemsley discussed his work with David Prain (1857–1944), then superintendent of the Calcutta Botanic Garden, Prain offered to send all of the *Nepenthes* herbarium material at his disposal on loan to Kew to support Hemsley’s studies. The material arrived in early 1905 and included “upwards of a dozen specimens [of *N. macfarlanei*] from the same locality” (see Figs. A2–5), allowing Hemsley to make “an almost complete description” of the species (Hemsley, 1905c). This description appeared the following year in *Icones Plantarum*, where *N. macfarlanei* was depicted for the first time (Hemsley, 1906). The two illustrations^[5] (Figs. A6–7) very clearly show the long bristles of the lower lid surface, which had already been mentioned in the talk abstract, where it was stated: “the longest bristles are half an inch [ca. 13 mm]” (Hemsley, 1905c).

The description in *Icones Plantarum* was notably the first to extend the species concept of *Nepenthes macfarlanei* beyond Gunung Bubu, as it included material from the Titiwangsa Range (*Wray* 339, SING!) that is now recognised as belonging to *N. berbulu*, the only other Peninsular Malaysian species with similarly long lid bristles (Tan *et al.*, 2023). The description also cited the original Kew specimen shown to Hemsley by Macfarlane (*Murton* 36, K n.v.) and the material on loan from Calcutta (see “Notes on specimens examined” under *N. macfarlanei*).

Over the next two decades, information on *Nepenthes macfarlanei* accrued chiefly in the publications of two authors: eponymous *Nepenthes* specialist Macfarlane, then professor of botany at the University of Pennsylvania, and Henry Nicholas Ridley (1855–1956), first director of the Singapore Botanic Gardens. Macfarlane’s 1908 treatment of the genus for *Das Pflanzenreich* provided a revised description of *N. macfarlanei* but did not cite any new herbarium material (Macfarlane, 1908).^[6] The following year, Ridley (1909) expanded the known range of *N. macfarlanei* to include Gunung Berumban (=Gunung Berembun, 1840 m) in the Cameron Highlands (cf. *Ridley s.n.*, SING!; =*N. sericea*; not to be confused with other Peninsular Malaysian mountains of the same name) and the peaks above Semangko Pass (cf. *Burn-Murdoch s.n.* & *Ridley s.n.*, all SING! [2 sheets each]; =*N. ulukaliana*), both from the Titiwangsa Range. Ridley (1915a) further added a record from Gunung Kerbau (=Gunung Korbu, 2183 m), the highest mountain in the Titiwangsa Range and Peninsular Malaysia’s second-highest overall (cf. *Robinson s.n.*, MO; =*N. sericea*), and Ridley (1915b) added one from Gunung Tahan (2187 m) in the Timur Range^[7], the highest peak in the Malay Peninsula. The plants from Gunung Tahan, “common in the damp mossy woods of the Padang [a high plateau consisting primarily of elfin scrub]”, were described as having pitchers varying in colour “from apple-green with red-brown slashes to entirely red with darker spots” and referable to *N. macfarlanei* by the “pubescent lid” (Ridley, 1915b:168). These were almost certainly lower pitchers of *N. gracillima* (cf. *Ridley* 16096, SING! [3 sheets]).



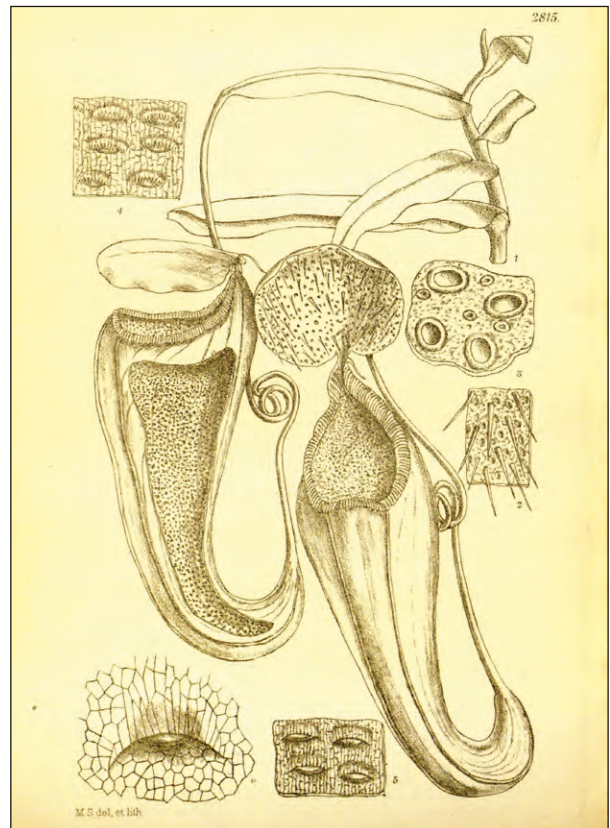
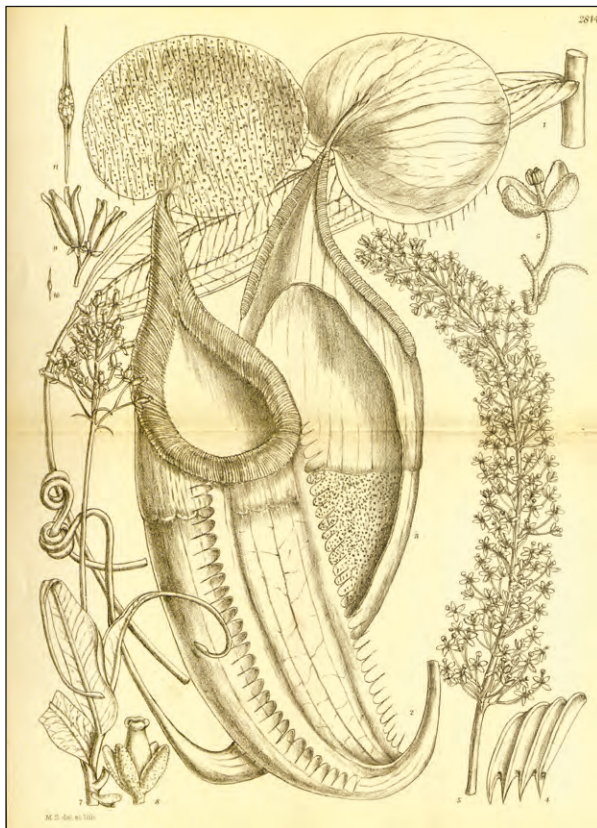
Figures A2 (above left), A3 (above right), A4 (below left), and A5 (below right): The lectotype (above left) and three isolectotypes of *Nepenthes macfarlanei* designated by Jebb & Cheek (1997). Held at Kew Herbarium, they constitute the collection number *Dr. King's Collector* 7421. These specimens presumably arrived at Kew from Calcutta in 1905 and informed the original description and botanical illustrations of the species. The lectotype itself has a pencil annotation that reads "*Nepenthes Macfarlanei* Hemsl." followed by the initials "W.B.H.", presumably in Hemsley's own hand (Jebb & Cheek, 1997:57) (© copyright of the Board of Trustees of the Royal Botanic Gardens, Kew).



Macfarlane's (1919) popular treatment of the genus for *The Standard Cyclopaedia of Horticulture* gave the following summary for *Nepenthes macfarlanei*: "A Malayan species with oval or funnel-shaped pitchers that are green, with extensive deep claret areolations. The lid bears long hirsute bristles within.—Not yet in cult., but a promising species for hybridization."

Ridley (1924), for his five-volume *The Flora of the Malay Peninsula*, provided a simplified illustration of *Nepenthes macfarlanei* clearly based on the two from Hemsley (1906). Once again, the long bristles on the lower lid are clearly visible.^[8] The recognised range of *N. macfarlanei* now encompassed peaks across the Bintang, Timur, and Titiwangsa ranges (based on material of *N. berbulu*, *N. gracillima*, *N. macfarlanei*, *N. sericea*, and *N. ulukaliana*). Ridley described it as "[a] beautiful species, easily recognised by its hairy lid" (Ridley, 1924).

In 1927, Murray Ross Henderson (1899–1982), then curator of the Singapore herbarium, provided the first records of *Nepenthes macfarlanei* s.lat. from Rhododendron Hill (=Bukit Mentigi, 1538 m; see Scrivenor, 1931:7) in the Cameron Highlands (Henderson, 1927; *Henderson S.17874 & 17878*, both SING!; =*N. sericea*).



Figures A6 (above left) and A7 (above right): The first published illustrations of *Nepenthes macfarlanei*, from Hemsley (1906). Tabula 2814 (left) is based on the material loaned from Calcutta in 1905, which was the first to include female floral material (see Hemsley, 1905c). Tabula 2815 (right) is based on *Murton 36*, a specimen received at Kew in 1878 as perhaps the first known example of its species, and was lithographed prior to the arrival of the Calcutta material (Hemsley, 1906).

In his influential 1928 monograph on *Nepenthes*, Benedictus Hubertus Danser (1891–1943) provided a revised description of *N. macfarlanei* based on a combination of new and old herbarium material from the Bogor and Singapore herbaria (Danser, 1928). This material encompassed specimens from Gunung Bubu, Gunung Tahan, Semangko Pass, Gunung Ulu Semangko (1394 m), and Rhododendron Hill, here recognised as a mix of *N. gracillima*, *N. macfarlanei*, *N. sericea*, and *N. ulukaliana*. This resulted in a broadened species concept and a correspondingly vague description, in which the climbing stem leaves were described as “very differently shaped” and the pitchers said to “vary extraordinarily”, the lids having “very differently long and thick bristles” (Danser, 1928:299, 323, 324). In a later section he added: “The very striking hairs on the lower side of the lid of *N. Macfarlanei* are very different in length and in number in different specimens, and short hairs on the underside of the lid occur also often in *N. gracillima* and *N. sanguinea*. Also the upper pitchers of *N. Macfarlanei* are not always widely infundibuliform [...]” (Danser, 1928:410).

Danser considered the boundaries between these species to be blurred by hybrid material. He tentatively identified *Wray 339* (SING!; now regarded as *Nepenthes berbulu*) and *Ridley 16174* (SING!; now regarded as *N. gracillima*) as natural hybrids between *N. gracillima* and *N. macfarlanei*. He correctly noted that the former “bears the typical [i.e. long] bristles of *N. Macfarlanei*” and the latter “much more dense and delicate hairs”. Danser identified a number of specimens that he considered to differ from typical *N. sanguinea* only in the presence of hairs on the lower lid surface, and treated these as true representatives of that species. Other specimens, from Gunung Berembun, Gunung [Ulu?] Semangko, Gunung Sitong (=Gunung Stong, 1422 m), and Gunung Tahan, considered by him to show additional affinities with *N. macfarlanei*, were tentatively identified as *N. macfarlanei* × *N. sanguinea*. We regard this last group as constituting a mix of *N. gracillima*, *N. sericea*, and *N. ulukaliana*. Danser’s treatment was followed by that of Hermann Harms (1870–1942) for *Die Natürlichen Pflanzenfamilien* (Harms, 1936), but this only very briefly mentioned *N. macfarlanei* and merely summarised Danser’s findings.

An early article on Peninsular Malaysian *Nepenthes* by Richard Eric Holttum (1895–1990), then director of the Singapore Botanic Gardens, stated that “typical” *N. macfarlanei* could be found on a peak in the south-central Titiwangsa Range (= *N. berbulu*) and included a photograph by Danish planter Frederic C. Fogh (?–1945) of a lower pitcher with very long (*ca.* 1 cm) lid bristles (Holttum, 1940). Though the provenance of this image is unknown, it must show either *N. berbulu* or *N. macfarlanei*, and is likely the first photograph ever published of either taxon.

Little was written about *Nepenthes* during the Second World War and in the two decades that followed. This finally began to change with the ‘*Nepenthes* renaissance’ of the 1960s and ‘70s, led primarily by the Japanese botanical and enthusiast communities^[9] (see esp. Kurata, 1976), which spurred renewed global interest in the genus. From this time until the present, the name *N. macfarlanei* has been routinely, and often erroneously, applied to all Peninsular Malaysian *Nepenthes* bearing conspicuous lid hairs. In particular, it has been consistently applied to plants from across the Titiwangsa Range, especially the much-visited Cameron Highlands and Genting Highlands^[10] (Henderson, 1959; Anderson, 1973; Soepadmo, 1977; Stone, 1981; Yong, 1981:162; Shivas, 1983a, b, 1984; Polunin, 1988; Hopkins *et*

al., 1990; Chua, 1995, 2000a, b, 2001; Yeo, 1996; Robinson, 1997; Schmid-Hollinger, 1997; Chua & Henshaw, 1999; Bourke, 2003; Untung, 2006; McPherson, 2009a, 2010; Thorogood, 2010; Tsuchihashi, 2013). The late 1960s saw the development of the Genting Highlands complex on the summit of Gunung Ulu Kali (1772 m), which made the populations of *N. ulukaliana* therein accessible for the first time and resulted in the first collections from that mountain. This site would eventually become the best known and most visited of any species of the *N. macfarlanei* group.

Nepenthes macfarlanei has also been reported from Gunung Tahan by some sources (e.g. Rubeli, 1986:196; Uchida, 1996; Bowden, 2000; Ong, 2016), largely owing to confusion with *N. gracillima*, whose lower pitchers may be quite similar. Therefore, *N. macfarlanei* has generally been considered a species widespread across the mountains of Pahang, Perak, and Selangor, much as it was by Danser (Turner, 1995). One notable exception was a 1965 work by Bertram Evelyn Smythies (1912–1999), in which the name was applied to the lower pitchers (previously undescribed) of the otherwise entirely dissimilar *N. lowii* of Borneo, owing to the fleshy bristles borne on the lower lids of that species (Smythies, 1965; see Clarke, 1997:139). Another misidentification appeared in *Carnivorous Plants of the World in Color* by Katsuhiko and Masahiro Kondo (1983:107), where *N. macfarlanei s.lat.* was illustrated with a plant resembling *N. gracilis*, an error fixed in the second edition (Kondo & Kondo, 2006:117).

In the 1984 work *Pitcher Plants of Peninsular Malaysia & Singapore*, one of the earliest popular books on *Nepenthes*, Roger Shivas illustrated his concept of *N. macfarlanei* solely with images of *N. sericea* and *N. ulukaliana*, though he noted that the lid hairs could reach 5 mm (Shivas, 1984).

The distribution, conservation, and reproductive biology of *Nepenthes macfarlanei s.lat.* were the focus of the doctoral studies of forest botanist Lillian S.L. Chua (1995). Chua studied the taxon *in situ* across a number of peaks in the Titiwangsa Range and on Gunung Tahan in the Timur Range, but also at its type locality on Gunung Bubu in the Bintang Range, where she recorded “large numbers of plants” (Chua, 1995:37–39, 49–51). Chua also comprehensively reviewed herbarium material referred to this taxon (see Chua, 1995:187) and determined Gunung Korbu to be its northernmost recorded locality, with its range extending to the southern limit of the Titiwangsa Range (Chua, 1995:49, 52). As part of this work, a conservation study of *N. macfarlanei s.lat.* was undertaken as a collaboration between the University of Bath and the Forest Research Institute Malaysia (FRIM). It represented a notable effort in this regard, at a time when little was known of the population size, structure, and distribution of *Nepenthes* species generally (Simpson, 1995:116–117). The results of Chua’s Ph.D. work, based primarily on studies carried out in the Genting Highlands (= *N. ulukaliana*) but also the Cameron Highlands (= *N. sericea*), were published in a series of papers over the following years (Chua & Henshaw, 1999; Chua, 2000a, b, 2001).

Matthew Jebb and Martin Cheek, in their “skeletal revision” of 1997 (the first major revision of the genus since Danser’s almost 70 years earlier), lectotypified *Nepenthes macfarlanei* with *Dr. King’s Collector 7421* (Figs. A2–5), thought to be one of the collection numbers (originally from the Calcutta herbarium) on which Hemsley based his description of the species (Jebb & Cheek, 1997). Their

concept of *N. macfarlanei* also encompassed herbarium material of *N. berbulu*, *N. gracillima*, *N. sericea*, and *N. ulukaliana*. This circumscription was maintained in their 2001 revision of *Nepenthes* for *Flora Malesiana* (which additionally included a detailed description of the species), where they wrote: “*Nepenthes macfarlanei* is immediately recognisable by the presence of bristles on the underside of the lid, seen in no other species of Peninsular Malaysia” (Cheek & Jebb, 2001), and in their later treatment for *Flora of Peninsular Malaysia* (Cheek & Jebb, 2012).

Charles Clarke’s (2001) treatment of *Nepenthes macfarlanei* for his monograph *Nepenthes of Sumatra and Peninsular Malaysia* was based on his field studies of populations from the Cameron Highlands and Genting Highlands (and illustrated with photographs thereof), which we here recognise as *N. sericea* and *N. ulukaliana*, respectively. However, the distribution given for the species (see Clarke, 2001:304, map 6A) suggests a more expansive species concept similar to that of Jebb and Cheek.^[11] Clarke described *N. macfarlanei* as “very variable throughout its range”, noting that plants from the Genting Highlands have infundibular lower and upper pitchers, whereas those from the Cameron Highlands tend to be more cylindrical. The species was similarly treated in Clarke’s subsequent book, *A Guide to the Pitcher Plants of Peninsular Malaysia* (Clarke, 2002).

Stewart McPherson’s two-volume *Pitcher Plants of the Old World*, published in 2009, documented all species of *Nepenthes* known at the time (McPherson, 2009a). Like Clarke, McPherson illustrated and based his concept of *N. macfarlanei* on plants from the Cameron Highlands and Genting Highlands (specifically Gunung Brinchang and Gunung Ulu Kali).^[12] This concept was maintained in *Field Guide to the Pitcher Plants of Peninsular Malaysia and Indochina* (McPherson & Robinson, 2012).

In 2012, Clarke co-authored with Chien Lee a revision of the *Nepenthes* of Gunung Tahan (Clarke & Lee, 2012). The authors pointed out that both *N. alba* and *N. gracillima* possess lid hairs (a fact already noted by Danser, 1928, but largely overlooked thereafter) and conclusively showed for the first time the close affinities between these species and *N. macfarlanei* s.lat. Clarke and Lee concluded that *N. macfarlanei* was absent from Gunung Tahan (and the eastern ranges in general), with prior records representing misidentified *N. gracillima*, a species producing similar lower pitchers.

This remained the taxonomic understanding for the following decade, until detailed studies of the type population of *Nepenthes macfarlanei* and related taxa in 2022 allowed for a reappraisal of the taxonomic situation. *Nepenthes berbulu* was separated from *N. macfarlanei* by Tan *et al.* (2023). The present paper builds on this work and further recognises the taxa chiefly known from the Cameron Highlands and Genting Highlands as two distinct species, here described as *N. sericea* and *N. ulukaliana*, respectively. An emended description of *N. macfarlanei*, apparently the first since Hemsley’s 1905 articles to deal with this taxon *sensu stricto*, is also provided. Remarkably, it appears that no *Nepenthes* taxonomists had climbed Gunung Bubu to study the type population of *N. macfarlanei* prior to our August 2022 expedition. Consequently, the habitat photographs of *N. macfarlanei* presented here and in Tan *et al.* (2023) are, to the best of our knowledge, the first to appear in the literature, despite the species having been first collected at least 145 years ago.

^[1]This must have been botanist Leopold ‘Leo’ Farmar (1878–1907), who was employed on the herbarium staff at Kew in 1903–1906 and again in 1907, and was recognised as an “expert photographer” (Anon., 1907; Farmar, N.d.). Farmar tragically took his own life at the age of 29, two years to the day after Hemsley’s talk.

^[2]In chronological order, summaries of Hemsley’s talk appeared in: *The Garden* on 15 April (Hemsley, 1905a); both *Nature* and *The GardeningWorld* on 20 April (Hemsley, 1905b; Anon., 1905; the latter dated 22 April – see p. 323 of the relevant issue for the contemporaneous publication schedule); *The Gardeners’ Chronicle* on 22 April (Hemsley, 1905c); *The Journal of Botany: British and Foreign* in May (Hemsley, 1905d); and *Proceedings of the Linnean Society of London* in October (Hemsley, 1905e). Macfarlane, for his part, presented his eponymous species during a talk to the annual general meeting of the American Philosophical Society on 13 April 1905, which was summarised in the 26 May issue of *Science* (Macfarlane, 1905). Additionally, a brief German-language summary of Hemsley’s article in *The Gardeners’ Chronicle* was provided by Schneider (1907).

^[3]Previously based in Edinburgh, Macfarlane moved to the United States in 1893 to become professor of botany at the University of Pennsylvania, a position he held until his retirement in 1920 (Steckbeck, 1943). Hemsley wrote that Macfarlane came upon Kew’s lone herbarium specimen of *Nepenthes macfarlanei* “when he was on the very point of leaving” (Hemsley, 1905c), presumably referring to his visit in 1904. This might explain why he did not describe the species himself and instead asked Hemsley.

^[4]Not to be confused with the higher peak of the same name near GunungYongYap in the Titiwangsa Range (see Quinn, 2020).

^[5]Both illustrations are signed “M.S. del. et lith.”, indicating that they were prepared by Matilda Smith (1854–1926). Smith became the sole artist and lithographer for *Icones Plantarum* beginning with tabula 1354 in 1881, and she continued in this role until her retirement in 1921, preparing virtually all plates during this time (Anon., 1921, 1927). Hemsley wrote of her work for *Icones Plantarum*: “The excellence of these drawings with very full floral analyses is generally acknowledged, and they present a permanent record of Miss Smith’s skill in re-animating dried, flattened specimens, often of an imperfect character.” (Hemsley, 1915).

^[6]Macfarlane (1908) erroneously gave the collection locality of two specimen numbers (*Wray 339*, SING!; *Wray 1643*, n.v.) as Gunung Bubu, when they were actually collected from the Titiwangsa Range; this was corrected in Macfarlane (1914), which included an English translation of the original Latin description.

^[7]We use ‘Timur Range’ to refer collectively to the major mountain complexes east of the Titiwangsa Range (with the exception of the isolated Benom massif), spanning the states of Kelantan, Pahang, and Terengganu (see e.g. Grismer *et al.*, 2010; Chan *et al.*, 2019). It should be noted that this Timur Range *sensu lato* is sometimes treated as two distinct ranges: the Tahan Range, often but not always restricted to the Tahan massif and its immediate surroundings, and the Timur Range *sensu stricto* to the east of it.

^[8]To the best of our knowledge, this would be the last published image to show the enlarged bristles of the type population of *Nepenthes macfarlanei* until Tan *et al.* (2023) and the present work (though see Holttum, 1940).

^[9]Though often overlooked in the Anglosphere, there exists an extensive and long-spanning Japanese-language literature on *Nepenthes*, including that dealing specifically with the species of the Malay Peninsula (e.g. Shimizu, 1975; Yamamoto, 1982; Tanabe, 1998a, b, c, 1999a, b; Tsuchihashi, 2013).

^[10]This species concept even entered the philatelic realm: a Malaysian stamp ostensibly depicting *Nepenthes macfarlanei*—part of a quartet of *Nepenthes* stamps released on April 6th, 1996 (Khang, 1996; see Souben, 1996, 2009; Ellis, 2000)—appears to show both a lower pitcher of *N. ulukaliana* and an upper pitcher of *N. sericea*.

^[11]As does the suggestion that *Nepenthes macfarlanei* co-occurs and hybridises with *N. gracillima s.lat.* on Gunung Tahan (Clarke, 2001:133), though this was not based on first-hand field observations (see also localities discussed in Chua, 2001:48, part of the same work).

^[12]Though mention of its presence in Taman Negara (a national park covering the eastern ranges, including the Tahan massif) hints at confusion with *Nepenthes gracillima* (see Clarke & Lee, 2012).

Botanical History of *Nepenthes alba* and *N. gracillima*

Nepenthes alba and *N. gracillima* have a convoluted taxonomic history. The former was originally identified by Ridley (1908) as *N. bongso*, a species endemic to Sumatra, based on a collection from Gunung Tahan (*Wray & Robinson 5411*, SING!; Fig. A8). This was followed in the same paper by Ridley's formal description of *N. gracillima*, based on a specimen collected at a lower elevation during the same 1905 expedition^[13] (*Wray & Robinson 5309*, SING!; Fig. A9). Its pitchers were said to be "pale green, tinted in places with dull crimson, and mottled with dull purple; lid of cup brighter green lined with dull crimson", and the "neck and lamina" of the pitcher lid were rather cryptically described as pubescent ("*Operculum [...] cervice et lamina pubescentibus*"; Ridley, 1908:320).

Macfarlane (1908) provided a detailed new description of *Nepenthes gracillima*, again based solely on *Wray & Robinson 5309*. He described the pitchers as monomorphic (implying that the available upper pitchers were the only type produced; Clarke & Lee, 2012) with a lid that is "sparsely pubescent outside and inside" ("*extus et intus sparse pubescens*"; Macfarlane, 1908:39). Curiously, he considered *N. gracillima* very similar ("*valde affinis*") to *N. albomarginata*—a species that, excepting superficial similarities in upper pitcher shape, is highly divergent—numbering it as subordinate to the latter and distinguished the two in his key only by the number of longitudinal veins of the lamina (Macfarlane, 1908:27, 39). Macfarlane disagreed with Ridley in that he treated the *N. alba* specimen *Wray & Robinson 5411* not as *N. bongso* but as the closely related *N. singalana*, likewise a Sumatran endemic.

Ridley (1909) was the first to extend the recognised range of *Nepenthes gracillima* when he recorded it from Telom in the vicinity of the Cameron Highlands; the relevant material (*Ridley 13704* & *s.n.*, both SING!) appears to represent a narrow-pitched variant of *N. sanguinea* with ramified spurs. The morphologically similar *N. ramispina*, which would become inextricably linked to the taxonomic history of both *N. alba* and *N. gracillima*, was described in the same paper, based on plants from Telom Ridge and the top of the Semangko Hills (*Ridley 12064*, K!, SING! [2 sheets]). This species lacks lid hairs; it was distinguished on the basis of the branched pitcher spur (versus simple in *N. gracillima*) that is the source of its name. Ridley (1913) reported collecting "[a]pparently a large-sized form" of *N. gracillima* on Gunung Menuang Gasing (=Gunung Nuang, 1493 m), which lies some 20 km south of today's Genting Highlands. Based on its location, this is very likely to have been *N. ramispina* (cf. *Symington 51798* & *51814*, both KEP!).

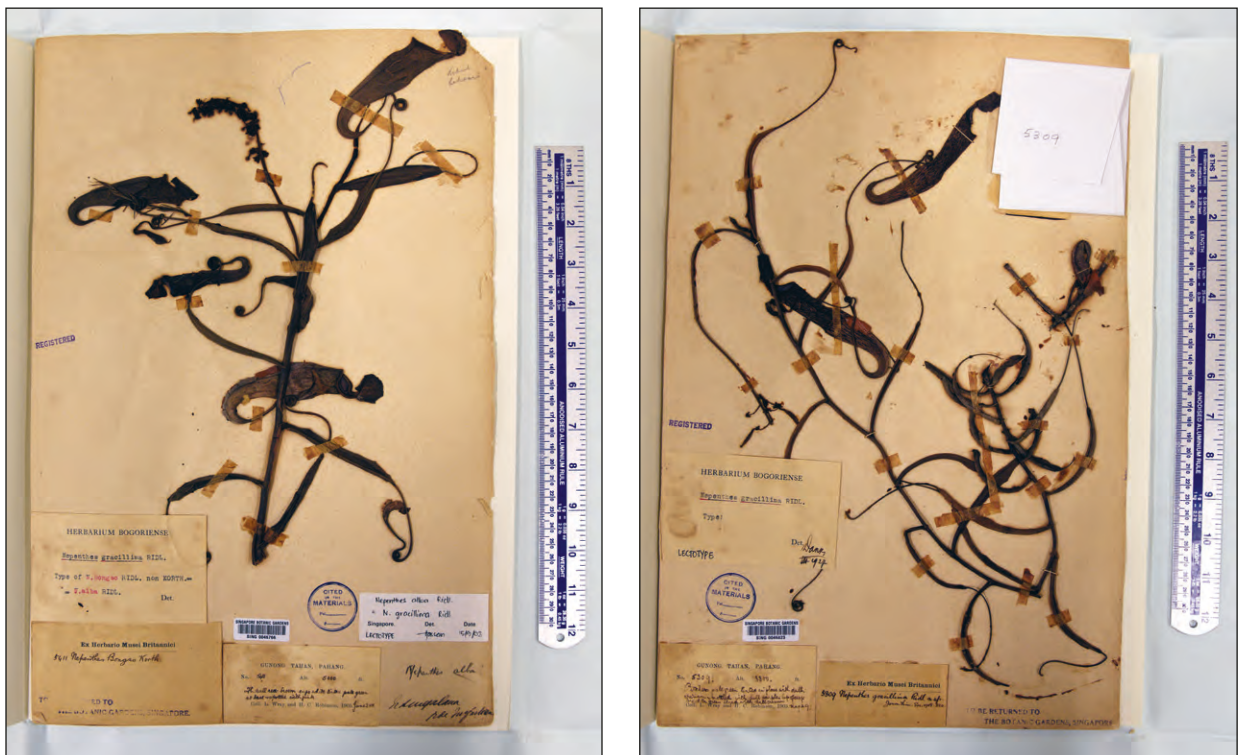
Macfarlane (1914) maintained the *Nepenthes alba* material *Wray & Robinson 5411* as *N. singalana*. Following Ridley, his treatment of *N. gracillima* encompassed also the Telom material (*Ridley 13704*, SING!; =*N. cf. sanguinea*), in addition to the type specimen from Gunung Tahan, but was otherwise merely an English translation of the Latin description provided six years earlier.

Ridley's (1915b) extensive paper on the botany of Gunung Tahan, based on his 1911 expedition there, described *Nepenthes gracillima* as having red to dark purple foliage and very dark pitchers, with a stem that "when broken exudes a violet-purple stain". He observed examples of this species with

“a distinct white ring round the mouth as in *N. albomarginata*”, apparently corroborating the affinity proposed by Macfarlane. Following Macfarlane, Ridley placed *N. alba* under *N. singalana*, though for the first time he described it under a unique name: *N. singalana* var. *alba*, a basionym that appears to have been entirely overlooked in subsequent literature. He described the pitchers as usually “an ivory-white colour tinted with green at the base”, and always very small, “about the size of those of *N. gracilis*”, though still “rather larger than those of *N. gracillima*” (Ridley, 1915b:169).

Ridley (1924) formally introduced two new taxa within the *Nepenthes macfarlanei* group. He described what he considered a large variant of *N. gracillima* as var. *major* (later Latinised as ‘*maior*’ by Danser, 1928), to which he referred the material from the Titiwangsa Range (viz. Gunung Nuang, Gunung [Ulu?] Semangko, and Telom; = *N. ramispina* and *N. cf. sanguinea*), restricting the nominate variety to Gunung Tahan. The large variety was said to have laminae 4 inches (ca. 10 cm) long and pitchers 4.5 inches (ca. 11.5 cm) tall, versus 2 inches (ca. 5 cm) and 3 inches (ca. 7.5 cm), respectively, in plants from Tahan. Notably, *N. ramispina*, whose pitchers were reported to measure 6–8 inches (ca. 15–20 cm), was also said to occur at the three aforementioned localities in the Titiwangsa Range.

Ridley’s second taxonomic novelty involved elevating *Nepenthes singalana* var. *alba* to species level as *N. alba*. It was said to have pitchers up to 3.5 inches (ca. 9 cm) tall and to be restricted to the upper reaches of Gunung Tahan. Pitcher colouration was described as “ivory white sometimes spotted with rose pink in the mouth and lid, rarely canary yellow” (Ridley, 1924:22). Ridley cited only his own



Figures A8 (above left) and A9 (above right): The lectotypes and earliest known specimens of *Nepenthes alba* (left; Wray & Robinson 5411) and *N. gracillima* (right; Wray & Robinson 5309), both of which were collected during the first botanical expedition to Gunung Tahan in 1905 and are deposited at the Singapore herbarium (Michal Golos).

herbarium material, collected on Gunung Tahan at 5000–7000 ft (ca. 1520–2130 m); presumably this refers to *Ridley 16097*, though this is a mixed collection that also includes *N. benstonei* (see below).

Ridley's descriptions of *Nepenthes alba* and *N. gracillima* are short on detail and were based on incomplete material notably lacking lower pitchers, which partly explains the taxonomic confusion they would later engender (McPherson, 2009a; Clarke & Lee, 2012).

Danser (1928) sank both *Nepenthes alba* and *N. ramispina* in synonymy with *N. gracillima*, writing: "I can not distinguish Ridley's *N. ramispina* and *N. alba*, the type specimens of which I have seen, from *N. gracillima*, of which too I have seen the type. The differences given by Ridley are of very little importance." (Danser, 1928:299). He illustrated his concept of *N. gracillima* with a drawing of the type material of *N. ramispina* (*Ridley 12064*). Macfarlane's suggestion of a close relationship between *N. gracillima* and *N. albomarginata* was correctly characterised by Danser as "certainly wrong". Of Ridley's *N. gracillima* var. *maior*, Danser opined that it is "only a large form, as may be distinguished in most other species, and it has no taxonomic value" (Danser, 1928:299).

Though he did not emphasise the point, Danser—like Ridley and Macfarlane before him—mentioned the (occasional, due to the inclusion of *Nepenthes ramispina* material) presence of lid hairs in his concept of *N. gracillima*, writing: "the inferior [lid] surface [...] with delicate or coarser spreading bristles or not" (Danser, 1928:298).

Surprisingly, none of the aforementioned authors discussed the shared presence of lid hairs in *Nepenthes gracillima* and *N. macfarlanei*. Moreover, none explicitly noted their presence in *N. alba*, as this species was generally treated as a synonym.

No more taxonomic work would be done on these species for several decades. The first botanical expedition to Gunung Tapis (1512 m), made in 1934 by Colin Fraser Symington (1905–1943), F.H. Landon (1909–1956), and Kiah bin Haji Mohamed Salleh (1902–1982), revealed the presence of a plant appearing to match the description of *Nepenthes gracillima* at ca. 4600 ft (ca. 1400 m), where it was found to be common in dwarf scrub (Symington, 1936; *Symington & Kiah S.28877*, KEP!, SING!). In an account of their 1936 ascent of Gunung Tahan, Edmund Jardine Strugnell (1903–1975) and John Phillips Mead (1886–1951) wrote: "Orchids and pitcher plants are numerous and one of the latter, *Nepenthes alba*, is very conspicuous with its white pitchers." (Strugnell & Mead, 1937)—a rare example of this binomial's continued use following Danser's synonymisation.

Holttum (1940:42) recorded that *Nepenthes gracillima* grew on Gunung Tahan and Pine Tree Hill, though he wrote that it "seems to be the least well defined species of the [Peninsular Malaysian] group, and needs further study". Smythies (1965) mistakenly applied the name *N. gracillima* to the dark-coloured and ostensibly similar pitchers of the Bornean endemic *N. muluensis*. The latter would only be formally described the following year by Mitsuru Hotta (1966), who considered it "closely related to *N. gracillima* of Malaya" based on superficial similarities in vegetative and floral morphology.

A notable outlier was Engkik Soepadmo (1977), who continued to use *Nepenthes alba* in line with Ridley's original species concept of it as a small, white-pitched plant from Gunung Tahan^[14] (as Strugnell and Mead had done). He illustrated his concept of *N. gracillima* with *N. ramispina*, and included a photo of what appears to be *N. gracillima* s.str. from Gunung Rabong (1538 m), just north of Gunung Tahan, as an unidentified species. Curiously, Soepadmo wrote that *N. macfarlanei* (which he illustrated with specimens of *N. ulukaliana*) was a suspected hybrid between *N. gracillima* and *N. sanguinea*, though he added: "How far this suspicion is true remains to be confirmed experimentally." (Soepadmo, 1977:43). William Null (1972) was perhaps the only other author during this time to use the name *N. alba*, which he applied to plants from Gunung Gedung (2066 m) in the Tahan massif.

Following Danser, many authors illustrated *Nepenthes gracillima* with images of *N. ramispina*, often from the area on Gunung Ulu Kali that became accessible with the construction of the Genting Highlands complex beginning in the late 1960s (e.g. Yong, 1981:164; Shivas, 1983b, 1984). Ruth Kiew (1985) wrote that *N. gracillima* was known from Gunung Brinchang, Gunung Tahan, Gunung Ulu Kali, and Fraser's Hill, adding that it was "abundant on Gunung Ulu Kali where variety *major* with black pitchers is found" (echoing the views of Stone, 1981 and Shivas, 1983b on this latter taxon). Her article was illustrated with a photograph of *N. ramispina*.

Kiew (1990), in her review of the *Nepenthes* flora of Gunung Tahan, concluded that three species grew there: the "common" *N. gracillima* and *N. macfarlanei*, and the more scarce *N. sanguinea*. She was notably the first author since Ridley to base her determinations on a combination of field and herbarium studies of Gunung Tahan (Clarke & Lee, 2012). Kiew distinguished what she called *N. macfarlanei* by the presence of "coarse hairs" on the lower lid surface and the distinctly toothed inner peristome margin; these observations were likely based on lower pitchers of *N. gracillima*. Conversely, what Kiew referred to as *N. gracillima*, a dwarf species with "small ivory-white [upper] pitchers, which from afar look like candles" doubtless represented *N. alba*. She correctly observed that plants with white upper pitchers also bore purple-black lower pitchers but concluded that Ridley's *N. alba* and *N. gracillima* corresponded to these two pitcher forms and were therefore synonyms. *Nepenthes alata*, previously recorded from the mountain by Danser (1928) on the basis of a single contentious specimen (*Ridley 16097*, SING!; see Shivas, 1984:pl. 7), was excluded from Gunung Tahan by Kiew, who instead assigned *Ridley 16097* to *N. gracillima*. This specimen was subsequently shown to represent *N. benstonei* (Clarke, 2001, 2006; Clarke & Lee, 2012), a Peninsular Malaysian endemic described by Clarke (1999).^[15]

In addition to Gunung Tahan, Kiew (1990) considered *Nepenthes gracillima* to grow on Gunung Padang (1315 m), Gunung Stong, Gunung Tapis, Gunung Ulu Kali, the Cameron Highlands, and Fraser's Hill, but noted that plants from Gunung Tahan were considerably smaller in all respects and differed markedly in pitcher colouration. The "rice green or black" pitchers described by Kiew from Gunung Ulu Kali must certainly have represented *N. ramispina*.

In a major taxonomic change likely influenced by Kiew, Jebb & Cheek (1997) restored *Nepenthes ramispina*, recognising *N. gracillima* as an endemic of the eastern ranges encompassing Gunung Tahan and Gunung Tapis^[16], but retained *N. alba* as a synonym of the latter and assigned Ridley 16097 (= *N. benstonei*) to *N. gracillima* as Kiew had done. They lectotypified all three taxa: *N. alba* and *N. gracillima* with Wray & Robinson 5411 and 5309 from Gunung Tahan (both SING!), respectively, and *N. ramispina* with material from Gunung Ulu Semangko (Ridley 12064, SING!). These species concepts remained essentially unchanged in the authors' subsequent works dealing with Peninsular Malaysian *Nepenthes* (Cheek & Jebb, 2001, 2012), though their treatment for *Flora Malesiana* notably included a revised description of *N. gracillima* and was the first to illustrate the species correctly, including its lid hairs and lower pitchers (see Cheek & Jebb, 2001:71, fig. 8; republished as Cheek & Jebb, 2012:262, fig. 1).

However, the taxonomy of the group remained confused. Clarke (2006) was of the opinion that Danser (1928) had erred in noting lid hairs in *Nepenthes gracillima* and that his specimens must have been hybrids with *N. macfarlanei*, as “these hairs are never present on the pitcher lids of other species from the Malay Peninsula”. Even Cheek & Jebb (2012) wrote of *N. gracillima* upper pitchers as having a “lower surface lacking hairs”, though these were clearly shown in the accompanying illustration.

Clarke's (2001, 2002) concept of *Nepenthes gracillima*, which was not seen by him in the field at that time, followed that of Jebb & Cheek (1997) in also encompassing *N. alba*, and was illustrated exclusively with photographs of that species (though it was supplemented with a discussion of authentic voucher specimens of *N. gracillima*). The species was recognised as occurring only on the Tahan massif and Gunung Tapis (Clarke, 2001:132–133, 302, map 4C). The accompanying description clearly accords with *N. alba*, particularly in terms of pitcher colouration and size.

McPherson (2009a, b) made important progress in clarifying some of the differences between *Nepenthes alba* and *N. gracillima*, and explicitly resurrected the former for the first time since Danser's revision. Both species were said to be known with certainty only from Gunung Tahan, with herbarium material suggesting their possible presence also on Gunung Tapis, though both were incorrectly stated to lack lid hairs. McPherson regarded *N. alba* as a dainty species with light-coloured (often white) upper pitchers, reflecting the original species concept of Ridley. Contrastingly, *N. gracillima* was treated as a robust plant with lower pitchers reminiscent of *N. macfarlanei* and dark upper pitchers that were much larger than those of *N. alba* at up to 26 cm tall.

Clarke & Lee (2012) pointed out that McPherson's description of *Nepenthes gracillima* was at odds with the lectotype of that species, which has small, gracile upper pitchers (Fig. A9), quite unlike the large, angular aerial trap illustrated in McPherson (2009:585, fig. 317; image reproduced here as Fig. A49). Clarke and Lee determined, based on field work conducted on Gunung Tahan and an extensive review of herbarium material, that *N. gracillima* is unusual within the genus for producing truly trimorphic pitchers.^[17] Rosettes and short-stemmed plants produce large, ovoid to broadly cylindrical lower pitchers resembling those of *N. macfarlanei*. These are followed by the first aerial

pitchers, produced in the early vining stage when the stem is some 1–3 m long, which agree with the upper pitcher figured by McPherson and which are well represented by the pair of *ca.* 20 cm tall pitchers on one of Ridley’s specimens (*Ridley 16174*, K!). Only in the final climbing stage, when the stem is 3–5 m long, are the small, slender upper pitchers of the lectotype produced (Clarke & Lee, 2012). Clarke and Lee termed the early aerial traps, which they described as the predominant form, “intermediate” pitchers, though it is important to note that these differ from the typical intermediate pitchers seen across the rest of the genus in that they are produced for an extended period of time (not limited to one or a few traps) and morphologically fit the conventional definition of true upper pitchers (*viz.* a dorsal tendril attachment, corresponding tendril coils, and a complete lack of ventral wings). Unfortunately, Clarke and Lee did not include any figures in their paper, which could have helped to clarify the differences between the two types of aerial traps.

Clarke & Lee (2012) were the first to explicitly point out the presence of lid hairs in *Nepenthes alba*, hinting at its close affinities to the other taxa of the *N. macfarlanei* group. They concluded that Gunung Tahan harboured four *Nepenthes* species: *N. alba*, *N. benstonei*, *N. gracillima*, and *N. sanguinea*.

Nepenthes × *setiuensis* was described by Tamizi *et al.* (2020a) as a natural hybrid between *N. gracilis* and *N. macfarlanei*, based on plants from Setiu district, Terengganu, but was considered a synonym of *N. gracillima* by Tan *et al.* (2023), a position that is maintained herein. We are of the opinion that the sympatric plants identified by Tamizi *et al.* (2020a) as *N. macfarlanei* were likely lower-pitched examples of *N. gracillima* (*cf.* Fig. 7B therein); owing to their shape, size, and conspicuous lid hairs, the lower pitchers of *N. gracillima* have often been mistaken for those of *N. macfarlanei s.lat.*

^[13]Led by zoologist Herbert Christopher Robinson (1874–1929) and botanist Leonard Wray, Jr. (1853–1942), this was the first expedition of a botanical nature to reach the mountain’s summit (see Briggs, 1988:9; Lin, 2004).

^[14]However, in a 1971 work by the same author, *Nepenthes alba* was illustrated without specific identification and the upper reaches of Gunung Tahan were said to harbour only *N. gracillima* and *N. singalala (sic)* (Soepadmo, 1971:123, pl. 39a), the latter apparently following Macfarlane’s original identification of *N. alba* as *N. singalana*, which was briefly adopted also by Ridley.

^[15]It was later concluded by both A.S. Robinson and A.S. Fleischmann (quoted in McPherson, 2009a:558) and Clarke & Lee (2012) that one of the two duplicates of *Ridley 16097* at Kew Herbarium (#651564) represents *N. alba*; the remaining Kew specimen (#651565), like that deposited in Singapore, belongs to *N. benstonei*.

^[16]Though Jebb and Cheek otherwise only cited herbarium material from these two peaks, reflecting their biogeographical understanding of *Nepenthes gracillima*, they mistakenly included *Ridley 13704 (SING!)*, a specimen of *N. cf. sanguinea* from Telom.

^[17]*Nepenthes sumatrana* is the only other *Nepenthes* species widely recognised as having distinctly trimorphic pitchers (in that case: rosette, lower, and upper; Clarke, 2001). *Nepenthes pudica*, which in its mature form produces subterranean pitchers in addition to more conventional (though rare) lower and upper traps, could also be said to fall into this category (see Dančák *et al.*, 2022). See also “Upper Pitcher Dimorphism” in the Discussion section for more on this phenomenon in *N. sericea* and other species.

Materials and Methods

Field observations were made in August 2022 of four species of the *Nepenthes macfarlanei* complex: *N. berbulu* on two undisclosed peaks of the Titiwangsa Range, *N. macfarlanei* on Gunung Bubu (its type locality in the Bintang Range), *N. sericea* on Gunung Brinchang and Gunung Warpu in the Cameron Highlands (Titiwangsa Range), and *N. ulukaliana* on Gunung Ulu Kali in the Genting Highlands (Titiwangsa Range). These were preceded by an expedition in February 2020 by G. Lim and others that successfully located *N. berbulu* on one of the two aforementioned peaks harbouring this species. For further details on these expeditions, see Tan *et al.* (2023). Additionally, A. Robinson and S. McPherson observed *N. alba* and *N. gracillima* on Gunung Tahan (Timur Range) in 1996 and March 2008, respectively, and several of the authors have observed *N. sericea* and *N. ulukaliana* in the Cameron Highlands and Genting Highlands, respectively, on multiple occasions. In the course of preparing the manuscript, the authors reviewed all relevant material pertaining to the *N. macfarlanei* group that is deposited at KEP, L, and SING herbaria, with further specimens studied at BO, K, and P (acronyms follow Thiers, 2023). Additionally, online scans were consulted of material at A, MO, MPU, NLU, NY, RSA, TEX, US, and WIS.

New herbarium material was collected by G. Lim under permit ref. JH/100 Jld. 33(35) issued by the Forest Department of Peninsular Malaysia, and subsequently deposited at KEP and KLU. Fine measurements of live material were made using Vernier callipers and a tape measure. Measurements on herbarium material of small-scale structures such as hairs were made using a stereomicroscope.

Locality data for the distribution map was taken from herbarium records and information gathered from field observations, and plotted using SimpleMappr (Shorthouse, 2010).

Results

Comprehensive field and herbarium studies by the authors have developed a significantly improved understanding of the morphological variation across the range of *Nepenthes macfarlanei s.lat.*, hitherto regarded as a highly variable taxon in works on the genus (Jebb & Cheek, 1997, 2001; McPherson, 2009a; Clarke & Lee, 2012; McPherson & Robinson, 2012). As a consequence, we re-circumscribe *N. macfarlanei* Hemsl. in a stricter sense that reflects both the type description and the newly appreciated narrower geographical range of this species, whilst recognising two unnamed taxa previously regarded as *N. macfarlanei s.lat.* as *N. sericea* Golos, Wistuba, G.Lim, Mey, S.McPherson & A.S.Rob. and *N. ulukaliana* A.S.Rob., Wistuba, Mey, Golos, G.Lim & S.McPherson, respectively. This refined concept of *N. macfarlanei* also led to the recent publication of *N. berbulu* H.L.Tan, G.Lim, Mey, Golos, Wistuba, S.McPherson & A.S.Rob. (Tan *et al.*, 2023), once regarded by Danser as a possible hybrid between *N. gracillima* and *N. macfarlanei* (Danser, 1928). Also considered are the morphologically allied but geographically disparate *N. alba* (Ridl.) Ridl. and *N. gracillima* Ridl., both from the eastern Timur Range (see Fig. A10).

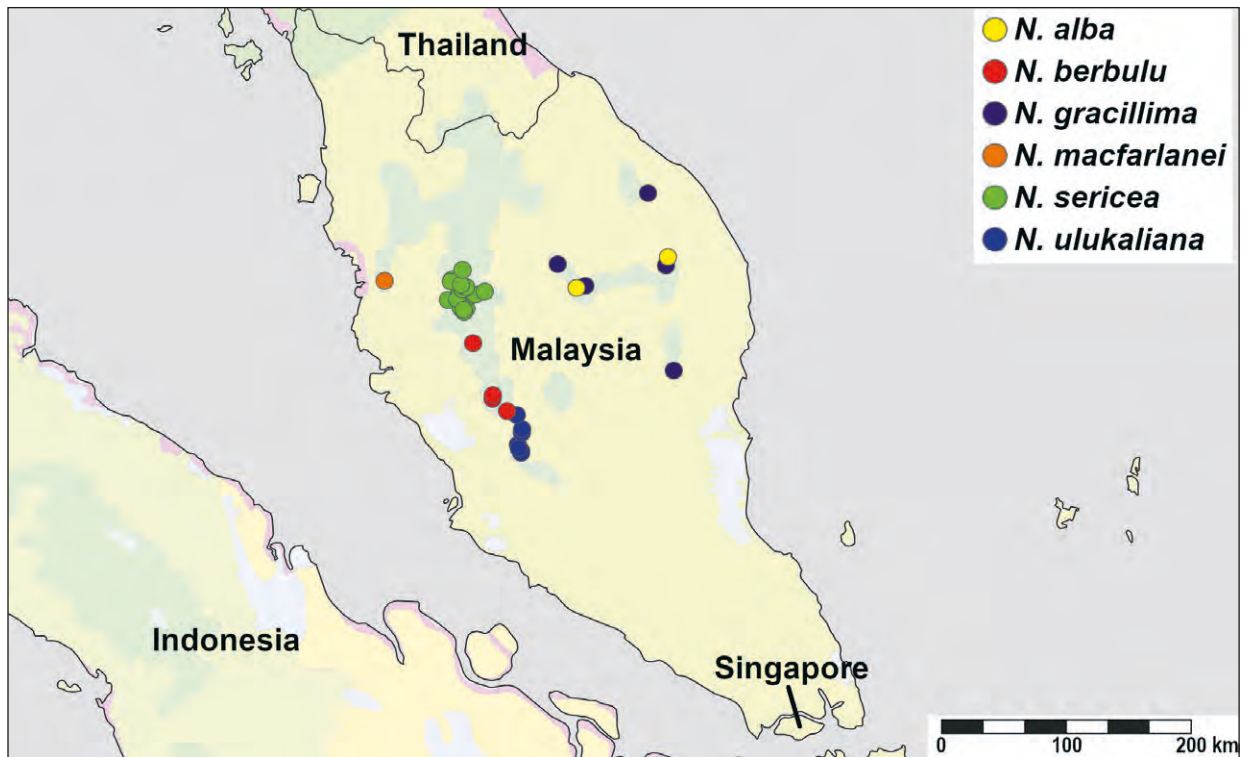


Figure A10 (above): Known distributions of the six members of the *Nepenthes macfarlanei* group, based on field observations and voucher specimens. The coloured areas show ecoregions defined by the World Wide Fund for Nature (WWF); note that all known species of this group are confined to the ‘Peninsular Malaysian montane rain forests’ ecoregion, which roughly corresponds to areas above 1000 m in elevation. This map supersedes that appearing in Tan *et al* (2023), incorporating corrections and newly acquired locality data. Created by Michal Golos.

Delimitation of the *Nepenthes macfarlanei* Group

Nepenthes macfarlanei and the herein described *N. sericea* and *N. ulukaliana* appear to be very closely related and are morphologically similar to three other species known from Peninsular Malaysia: *N. alba*, *N. berbulu*, and *N. gracillima*. We regard these six species as forming a group that we name the *Nepenthes macfarlanei* group, after its earliest described taxon. This group so far includes taxa from the highlands of Peninsular Malaysia that all share the following combination of characteristics: 1) the presence of hairs beneath the lid that are developed to varying degrees, from short filamentous hairs (*N. alba*, *N. gracillima*, *N. sericea*, and *N. ulukaliana*) to coarse bristles (*N. berbulu* and *N. macfarlanei*); 2) round to ovate crateriform nectar glands \pm evenly distributed across the lower surface of the lid but largely absent from the margins; 3) a distinct, finely toothed peristome that flattens and widens into a short column towards the rear; and 4) sessile, lanceolate to oblong leaves. Given favourable environmental conditions, the species of the *N. macfarlanei* group climb readily and, with the exception of *N. berbulu* and *N. gracillima*, produce upper pitchers which very often lack significant pigmentation such that they can appear predominantly white or creamy yellow, often with a yellowish green base. The inflorescence comprises mostly 2-flowered partial peduncles, each usually with a bract.

Key to the species of the *Nepenthes macfarlanei* group (adapted from Clarke & Lee, 2012 and Tan *et al.*, 2023)

- 1a** Pitchers with thickened lid hairs ≥ 5 mm long.....2
1b Pitchers with filamentous lid hairs ≤ 3 mm long.....3
- 2a** Upper pitchers wholly infundibular, typically white, base green—Bintang Range... *N. macfarlanei*
2b Upper pitchers broadly cylindrical, white with dark speckling, base green—Titiwangsa Range
 *N. berbulu*
- 3a** Lower pitchers wholly ovoid, amphora-shaped—Titiwangsa Range.....*N. ulukaliana*
3b Lower pitchers infundibular to ovoid in the lower part, cylindrical or slightly infundibular above
 the hip.....4
- 4a** Upper pitchers of \pm uniform size and form with respect to individual plants.....5
4b Upper pitchers of two distinct forms, being up to 26 cm tall on shorter climbing stems, but
 reduced to ≤ 10 cm tall on established climbing stems, distinctly slender, very narrowly infundibular
 below hip, cylindrical above, predominantly mottled with black or red speckling, hip at or more
 typically below the midsection; pitcher lid ovate, not strongly cordate at the base; spur up to 12
 mm long on mature plants; peristome teeth distinct, 0.5–5.0 mm—Timur Range....*N. gracillima*
- 5a** Upper pitchers small, < 13 cm tall, usually conspicuously white and often with red speckling,
 hip at or above the midsection; pitcher lid circular, strongly cordate at the base; spur < 5 mm long
 on mature plants; peristome teeth indistinct or very short, < 0.2 mm—Timur Range....*N. alba*
5b Upper pitchers large, often > 20 cm tall, broadly infundibular or broadly cylindrical, white,
 base green, hip at midsection to immediately below the peristome—Titiwangsa Range...*N. sericea*

The members of the *Nepenthes macfarlanei* group that occur in the Titiwangsa Range do not form a gradient of continuous variation from north to south, as some workers have suspected. Instead, they appear to fall into distinct morphotypes corresponding to the species recognised herein, with little if any overlap in their distributions (Fig. A10). Interestingly, the western species with short lid hairs (*Nepenthes sericea* and *N. ulukaliana*) do not grow near to each other, nor do those with long bristles (*N. berbulu* and *N. macfarlanei*). The presence of both *N. alba* and the likewise short-haired *N. gracillima* in the eastern Tahan massif (and apparently also in the even more easterly Gunung Padang–Gunung Sembilu complex) is the only known example of sympatry in the group, though *N. gracillima* generally grows at lower elevations than does the more strictly highland *N. alba* (900–1700 m versus 1400–2187 m). On most mountains within their range, species of the *N. macfarlanei* group appear to co-occur with the widespread *N. sanguinea*, which generally occupies a lower (though often overlapping) elevational range. On a minority of peaks in the southern Titiwangsa Range, such as Gunung Ulu Kali, a third species—*N. ramispina*—is also present.

Table A1: A comparison of *Nepenthes macfarlanei*, *N. sericea*, and *N. ulukaliana*. Morphological characters of the three taxa are based on herbarium material supplemented with field observations made in the Bintang Range (Gunung Bubu) and Titiwangsa Range (Gunung Brinchang and Gunung Warpu in the Cameron Highlands, and Gunung Ulu Kali in the Genting Highlands).

	<i>N. macfarlanei</i>	<i>N. sericea</i>	<i>N. ulukaliana</i>
Geographical range	Bintang Range (southern, only known from Gunung Bubu)	Titiwangsa Range (north-central, mainly known from Cameron Highlands)	Titiwangsa Range (southern, mainly known from Genting Highlands)
Elevational range (m)	1500–1657	(?900–)1300–2183	(?900–)1200–1772
Leaves	Lanceolate to oblong, apex acute to rounded	Oblanceolate to spatulate or oblong, apex acute to rounded	Oblanceolate to oblong, apex acute to rounded
Lid hairs	Thick, coarse bristles 5–12 mm long, \pm evenly distributed	Fine, to 2 mm long, \pm evenly distributed	Fine, to 1 mm long, evenly distributed
Peristome	\pm Curved throughout in lateral aspect, column arising gradually	\pm Curved throughout in lateral aspect, column arising gradually	Planar at front, with well-defined column arising abruptly and perpendicularly at rear
Lower pitchers	Ovoid (rarely infundibular) in basal portion, with medial hip, cylindrical above	Ovoid to infundibular in basal portion, with medial hip, cylindrical above	Amphora-shaped to urceolate, with distal hip close to peristome
Size of lower pitchers	To 22 cm tall and 7 cm wide	To 28 cm tall and 9 cm wide	To 25 cm tall and 8.5 cm wide
Colour of lower pitchers	Yellowish green to tan, heavily speckled dark red to purple; peristome red to dark purple, sometimes with faint banding	Yellowish green to red, heavily speckled dark red to purple; peristome red to dark purple, usually without banding	Yellowish green to red, heavily speckled dark red to purple; peristome yellow to dark red, often with banding
Lid of lower pitchers	Sub-orbicular to orbicular	Sub-orbicular to ovate	Sub-orbicular to orbicular
Upper pitchers	Wholly infundibular with hip located just below peristome or absent	Wholly infundibular with hip located just below peristome or with hip located at mid-point and cylindrical to slightly infundibular above	Wholly infundibular with hip located just below peristome or absent
Size of upper pitcher	To 24 cm tall and 7 cm wide	To 26 cm tall and 7 cm wide	To 18 cm tall and 7 cm wide
Colour of upper pitchers	Yellowish green basally, creamy white with faint red speckling above; peristome white with reddish banding	Yellowish green basally, creamy white above, with variable degree of red speckling; peristome white to light pink, often with reddish banding	Yellowish green basally, creamy white to yellow above, sometimes with faint red speckling; peristome white to yellow with reddish banding
Lid of upper pitchers	Sub-orbicular	Sub-orbicular to ovate	Sub-orbicular

Taxonomic Treatment

The six species of the *Nepenthes macfarlanei* group are outlined below, with two—*N. sericea* and *N. ulukaliana*—described as new, and one—*N. macfarlanei*—subject to an emended description. The remaining species entries—for *N. alba*, *N. berbulu*, and *N. gracillima*—are presented in an abbreviated form, as comprehensive and up-to-date descriptions of these species are available in Clarke & Lee (2012) and Tan *et al.* (2023). Two further nomenclatural changes of note are made: the authority citation of *N. alba* is emended to account for the long-overlooked basionym *N. singalana* var. *alba*, and that of *N. macfarlanei* is changed to refer to a recently uncovered earlier publication introducing the name.

Species synonymies have been thoroughly revised following consultation of the relevant literature and corresponding herbarium material. The *Carnivorous Plant Database* of Schlauer (2015) proved particularly useful in tracing some of the more obscure misidentifications. All synonyms and heterochronyms are listed chronologically in ascending order, as are herbarium specimens (by date of collection).

The species distributions presented are derived from field observations and examination of the listed voucher specimens, and are further informed by citizen science sources (e.g. habitat photographs uploaded online; cf. Blanco *et al.*, 2019; Isenberg *et al.*, 2022).

Herbarium material has not been arranged by state or other subnational administrative unit, as is often the convention. This has been done in order to avoid giving a misleading picture of distribution, as many of the peaks from which the listed specimens were collected straddle state boundaries. Thus, material collected on either side of a single mountain could be attributed to different states, obscuring the specimens' close geographical proximity. At the same time, if such a system were followed, geographically disparate collections might be grouped together in a highly artificial manner.

Due to bad weather on the summit of Gunung Bubu, our observations of type *Nepenthes macfarlanei* were limited. The species was observed at two sub-populations in the summit area, with approximately 12 plants studied at the first sub-population. The second sub-population harboured significantly more plants than the first, but heavy downpours coupled with limited time made additional observations of the taxon there impossible. The following emended description of *N. macfarlanei* is based on the lectotype and its duplicates, additional herbarium material (see “Additional specimens examined”), and observations and measurements made *in situ* at the first sub-population encountered at the type locality.

The descriptions of *Nepenthes sericea* and *N. ulukaliana* are based on their respective type materials, a substantial number of additional herbarium accessions (see “Additional specimens examined”), and field observations carried out on Gunung Brinchang and Gunung Warpu (of the former species), and on Gunung Ulu Kali (of the latter).

Nepenthes alba (Ridl.) Ridl. (1924:22) ≡ *Nepenthes singalana* var. *alba* Ridl. (1915b:169) (Figs. A11–21)

Lectotype (designated by Jebb & Cheek, 1997:44): Pahang, Gunung Tahan, 5000 ft [≈1520 m], 3 June 1905, *Wray & Robinson 5411* (SING! [#46766], isolecto- BO! [#1300378]) [stem with four upper pitchers and male inflorescence (lecto-); pitcherless stem with male inflorescence (isolecto-); “Fl.[owers] dull red-brown, cups white tinted pale green at base & spotted with pink.”; both sheets labelled “Type of *N. Bongso* Ridl. non Korth. = *N. alba* Ridl.” by B.H. Danser (isolecto- in August 1927), who identified them as *N. gracillima*].

- *N. bongso* sensu Ridley (1908:320)
- *N. singalana* sensu Macfarlane (1908:47) & Macfarlane (1914:282) = *N. alba* & *N. singalana*
- “*N. trifolium*” *ined.* (annotated by H.N. Ridley on *Ridley 16097*, K! [2 sheets], SING!; collected July 1911) = *N. alba* & *N. benstonei*
- *N. singalana* var. *alba* Ridl. (1915b:169) — **Type** (per Ridley, 1908:320, cited in Ridley, 1915b:169): *Wray & Robinson 5411* (see lectotype above).
- *N. gracillima* sensu Danser (1928:296), Kiew (1990:34), Jebb & Cheek (1997:43), Cheek & Jebb (2001:69), Clarke (2001:131), Clarke (2002:19) & Cheek & Jebb (2012:261), *partim* (see *N. gracillima*)

For a detailed morphological description of *Nepenthes alba*, see the species entry in the present work or that in Clarke & Lee (2012). For a description of leaf anatomy, see Ghazalli *et al.* (2021).

Distribution, ecology, and conservation: *Nepenthes alba* is known with certainty only from the upper reaches of the Tahan massif in the Timur Range, on the border between Kelantan and Pahang—including Gunung Tahan itself and neighbouring Gunung Gedung (2066 m)—where it occurs from around 1400 m to the summit of Gunung Tahan at 2187 m. It forms a conspicuous element of the *padang* (open grassland and scrub) of the mountain’s undulating plateau (Fig. A12), itself called the Padang (Ng, 1982; Lim *et al.*, 2012). Clarke (2018a) reported that it may also occur on the summit of Gunung Tapis, some 100 km to the south-east, but this requires confirmation.

A single herbarium specimen (*Hislop s.n.*, SING! [#93950]) points to this species’ presence on the distant and little-botanised peak of Gunung Padang (1315 m) in the Terengganu Hills of western Terengganu (see Ummul-Nazrah *et al.*, 2011). This mountain is notably connected by a high ridge to neighbouring Gunung Sembilu (1355 m), from which herbarium material apparently attributable to *Nepenthes gracillima* was collected on the same expedition (*Hislop s.n.*, SING! [#93986]). If these records are confirmed, then it is likely one or both of these species also occur on the higher peaks in the *ca.* 70 km that separate Gunung Padang–Gunung Sembilu from the Tahan massif (see Fig. A10), such as Gunung Badong (1249 m), Gunung Gagau (1379 m), and Gunung Perlis (1263 m).



Figure A11 (above): *Nepenthes alba* (Gunung Tahan). Stunted plants with entirely white upper pitchers; note canary-yellow developing pitcher (Kenneth Hiew).



Figure A12 (above): *Nepenthes alba* (Gunung Tahan). Female flowering plant growing in exposed summit scrub habitat (often termed *padang*, after a Malay word broadly meaning 'field') (Kenneth Hiew).

Ridley (1915b) wrote that on Gunung Tahan the species grew in the “driest and rockiest” areas of the Padang, the pitchers usually containing “little or no water”. Most pitchers were empty, but where fluid was present, Ridley recorded finding ants and small dipterans as prey, with one trap containing a small, live rutelid beetle.

The IUCN Red List entry for *Nepenthe alba*, in which it is assessed as *Least Concern* (Clarke, 2018a), is up-to-date and accurately reflects the conservation status of this species as currently understood. The population on Gunung Tahan is sizeable, consisting of an estimated several thousand mature plants (Clarke, 2018a) and both the Tahan massif and Gunung Padang lie within Taman Negara, a well-managed national park.

Natural hybrids: *Nepenthes benstonei*, *N. gracillima*, and *N. sanguinea* are also found on the Tahan massif, but no natural hybrids have been recorded with certainty, despite *N. alba* and *N. gracillima* sometimes co-occurring (though see Figs. A22, A47–48). Clarke & Lee (2012) suspected that these two species may be reproductively isolated, possibly as a result of discrete flowering times.

Additional specimens examined: Gunung Tahan, no elevation data, July 1911, *Ridley 16090* (K!) [stem with upper pitchers and male inflorescence, stem with upper pitchers, infructescence, and inflorescence; identified as *N. gracillima* by H.N. Ridley; NB: mixed collection—plant with male inflorescence belongs to *N. gracillima*]; Gunung Tahan, no elevation data, July 1911, *Ridley 16097* (K! [2 sheets], SING!) [stem with upper pitchers and female inflorescence (K sheet 1); pitcherless stem with female inflorescence (K sheet 2); stem with upper pitchers, female inflorescence, and infructescence (SING); K sheet 1 labelled “*N. singalana* Becc. Hitherto reported only from Sumatra.” by J.M. Macfarlane, ?1924, and “Type of *N. alba* Ridl[e]y” by unknown hand, and identified as *N. gracillima* by B.H. Danser, 1930; K sheet 2 and SING labelled “*Nepenthes trifolium*” by H.N. Ridley; SING identified as *N. alata* by B.H. Danser, ?July 1927; NB: mixed collection—K sheet 2 and SING belong to *N. benstonei*]; Gunung Tahan, no elevation data, July 1911, *Ridley 16098* (SING!) [rosette with pitchers and male inflorescence, stem with upper pitchers; identified as *N. gracillima* by H.N. Ridley; labelled “*Nepenthes gracillima* Ridl. Authentic specimens.” by B.H. Danser, August 1927]; Gunung Tahan, 5500–7000 ft [≈1680–2130 m], 12 June 1922, *Haniff & Nur S.7890* (SING!), *S.7891* (SING!) [stems with upper pitchers and male inflorescences (both sheets); both sheets identified as *N. gracillima* by B.H. Danser, August 1927]; Gunung Tahan, ridge forest, 3500–4500 ft [≈1070–1370 m], 28 August 1928, *Holtum S.20644* (SING!) [stem with lower pitcher, stems with upper pitchers, male inflorescence, and infructescences; NB: mixed collection—large stem fragment with lower pitcher belongs to *N. gracillima*]; Gunung Tahan, tops of ridges, 4500–5000 ft [≈1370–1520 m], 30 August 1928, *Holtum S.20666* (SING!) [stems with upper pitchers and male and female inflorescences]; Gunung Tahan, 7000 ft [≈2130 m], 26 July 1936, *Strugnell & Sow 42878* (KEP!) [stem with intermediate-upper pitchers and male inflorescence, separate infructescence; NB: complete stem shows rapid transition between rosette and vining stages]; Gunung Tahan, common in *Leptospermum* scrub, 5000 ft [≈1520 m], 14 September 1937, *Corner s.n.* (L!) [stem with upper pitchers and infructescence]; Gunung Tahan, common in *Leptospermum* scrub, 5500 ft [≈1680 m],



Figure A13 (above left): *Nepenthes alba* (Gunung Tahan). Plant growing in a more sheltered location and consequently exhibiting larger foliage and longer internodes (Stewart McPherson). **Figure A14 (above right):** *Nepenthes alba* (Gunung Tahan). Typical rosette pitcher (Kenneth Hiew).



Figure A15 (above left): *Nepenthes alba* (Gunung Tahan). Maroon lower pitcher (Stewart McPherson). **Figure A16 (above right):** *Nepenthes alba* (Gunung Tahan). Intermediate pitcher largely retaining dark colouration of lower pitchers but interspersed with irregular streaks of yellow; note dwarfed foliage in background (Stewart McPherson).

14 September 1937, *Corner s.n.* (L! [4 sheets]) [stem with upper pitchers and infructescence(s) (all sheets)]; Gunung Tahan, common in *Leptospermum* scrub, no elevation data, 14 September 1937, *Corner s.n.* (L!) [stem with upper pitchers and infructescence]; Gunung Padang, no elevation data, July 1952, *Hislop s.n.* (SING!) [stem with upper pitchers]; Gunung Tahan, ascent of, no elevation data, February 1961, *Wong & Wyatt-Smith W58* (KEP!), *W61* (KEP!), *W62* (KEP!), *W63* (KEP!) [numerous stems with upper pitchers and male inflorescences (*W58*); complete plant with roots, two growth points, and upper pitchers (*W61*); very small rosettes with pitchers (*W62*); branched stem with upper pitchers and male inflorescence (*W63*)]; Gunung Tahan, mountain plateau, padang, very stunted shrubby forest, 5000 ft [≈1520 m], 15 August 1966, *Ng FRI 1478* (KEP!, L!, SING!) [stem with upper pitchers (all sheets)]; Gunung Tahan, padang, rocky ground, 5200 ft [≈1580 m], 1 March 1973, *Ng FRI 20915* (KEP!, L!) [stem with upper pitchers (both sheets)]; Gunung Tahan, padang, on base rocks, 5200 ft [≈1580 m], 1 March 1973, *Ng FRI 20954* (KEP!) [stem with upper pitchers and male inflorescence]; Gunung Tahan, padang, no elevation data, 1 September 1984, *Muslim s.n.* (KEP! [2 sheets]) [stem with intermediate pitchers and male inflorescence (sheet 1); stem with upper pitchers and male inflorescence (sheet 2); labelled “black form”]; NB: mixed collection—sheet 1



Figure A17 (above left): *Nepenthes alba* (Gunung Tahan). Pure white upper pitcher (Kenneth Hiew).
Figure A18 (above right): *Nepenthes alba* (Gunung Tahan). A minority of upper pitchers are conspicuously mottled with various shades of red on the interior or exterior to variable extents (Stewart McPherson).



Figure A19 (above left): *Nepenthes alba* (cultivated plant). Lid in lateral aspect, showing minute hairs of lower surface (Andreas Wistuba). **Figure A20 (above right):** *Nepenthes alba* (cultivated plant). Close-up of lid apex of same specimen; note dense covering of hairs (Andreas Wistuba).



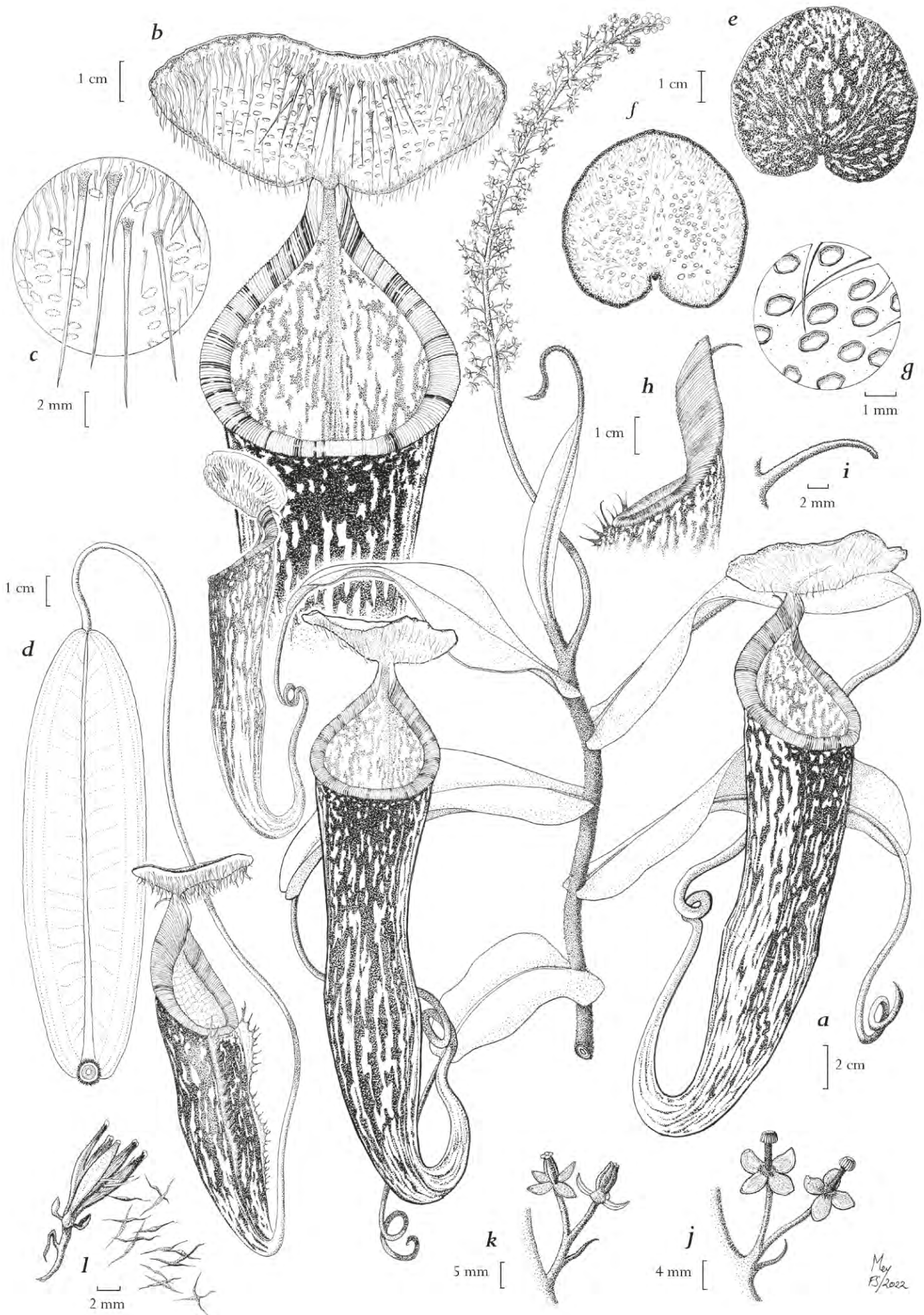
Figure A21 (above left): *Nepenthes alba* (Gunung Tahan). Intensely rose-coloured upper pitcher (Stewart McPherson). **Figure A22 (above right):** Atypical lower pitcher from Gunung Tahan, possibly representing a hybrid between *Nepenthes alba* and *N. gracillima* (Kenneth Hiew).

belongs to *N. gracillima*]; Gunung Tahan, padang, no elevation data, 1 September 1984, *Muslim s.n.* (KEP! [2 sheets]) [stem with upper pitchers and infructescence, stem with upper pitchers only (sheet 1); stem with upper pitchers (sheet 2); labelled “white form”]; Gunung Tahan, padang, 1530 m, 25 March 1987, *Kiew RK 2450* (KEP!, SING! [2 sheets]) [stem with upper pitchers (KEP)]; stems with upper pitchers and female inflorescences (both SING sheets)]; Gunung Tahan, padang just below summit, 4°38'N 102°14'E, 2180 m, 5 August 1996, *Chua FRI 41539* (KEP!) [stem with upper pitchers and infructescence]; Gunung Tahan, padang on west slopes, 4°37'N 102°15'E, 2265 m [sic!], 5 August 1996, *Kiew RK 4064* (KEP!) [stem with upper pitchers and male inflorescence, stem with upper pitchers and infructescence]; Gunung Tahan, padang on west slopes, growing in thicket, 4°37'N 102°15'E, 2265 m [sic!], 5 August 1996, *Kiew RK 4072* (KEP!) [stem with upper pitchers]; Gunung Tahan, peak of Bukit Bonsai, montane forest, quartzite, 4°37.74'N 102°13.03'E, 1691 m, 3 February 2007, *Lim FRI 56340* (KEP!) [stem with upper pitcher]; Gunung Tahan, quartz ridge from Gunung Bonsai to Gunung Botak, montane forest, 4°37.68'N 102°13.19'E, 1731 m, 3 February 2007, *Lim FRI 56344* (KEP!, SING!) [stem with upper pitchers, infructescence, and developing inflorescence (KEP); stem with upper pitchers and male inflorescence (SING)]; Gunung Tahan, Kem Bonsai, campsite, 4°37'N 102°13'E, 1690 m, 8 May 2008, *Chew FRI 65306* (KEP!, SING!) [stem with upper pitchers and male inflorescence (KEP); stem with upper pitchers (SING)].

Notes on specimens examined: *Ridley 16098* (SING!) was assigned to *Nepenthes gracillima* by Clarke & Lee (2012:48) and labelled as authentic material of that species by B.H. Danser on account of it having been collected and identified as such by describing author H.N. Ridley. However, we have tentatively referred it to *N. alba* due it including a distally infundibular upper pitcher, lower pitchers that are strongly contracted above the hip, and a small flowering plant barely out of the rosette stage.

Strugnell & Sow 42878 (KEP!) was regarded by Clarke & Lee (2012:39) as a specimen of *Nepenthes alba*, despite having long, narrow, dark-speckled intermediate or early-stage upper pitchers closely resembling those of *N. gracillima*, highlighting that not even aerial pitcher form and colouration are necessarily a reliable means of distinguishing these species. In the same vein, the following specimens are tentatively placed under *N. alba* herein, though in many respects they appear intermediate between that species and *N. gracillima*: *Corner s.n.* (L! [#886017, 886018, 886024 & 886025]), *Haniff & Nur S.7890* (SING!), *Kiew RK 2450 & 4072* (both KEP!), *Muslim s.n.* “white form” (KEP! [sheet 2]), *Ng FRI 20954* (KEP!), and *Wong & Wyatt-Smith W63* (KEP!).

The stated collection locality of *Hislop s.n.* (SING! [#93950])—Gunung Padang in Terengganu—is genuine and not to be confused with the often-recorded *padang* habitat of *Nepenthes alba* on Gunung Tahan, consisting of rocky grassland, scrub, and dwarfed, open-canopied woodland (see Whitmore, 1975:131), or the mountain’s famous high plateau, itself called the Padang, on which the species is often observed in the aforementioned habitat (see Ng, 1982).



Nepenthes berbulu H.L. Tan, G. Lim, Mey, Golos, Wistuba, S. McPherson & A.S. Rob. (2023:16, figs. 1–10, 13–15, 17, 18A–C) (Figs. A23–39)

Holotype: Perak, Titiwangsa Range (exact location withheld for conservation reasons), above 1900 m, 23 August 2022 *Lim 4* (KEP!, isotypes KEP! [7 sheets] & KLU! [2 sheets]) [stem with three upper pitchers, female inflorescence, and infructescence (holo-); stem with two lower pitchers (iso- KEP sheet 1); stem with two upper pitchers (iso- KEP sheets 2 & 3); stem with lower to intermediate pitcher, separate lower to intermediate pitcher (iso- KEP sheet 4); stem with intermediate pitcher (iso- KEP sheet 5); stem with two infructescences (iso- KEP sheet 6); stem with male inflorescence (iso- KEP sheet 7); stem with upper pitcher and infructescence (iso- KLU sheet 1); stem with two lower pitchers (iso- KLU sheet 2)].

- *N. macfarlanei* sensu Hemsley (1906:1), Macfarlane (1908:77), Macfarlane (1914:284), Ridley (1924:24), Jebb & Cheek (1997:57), Cheek & Jebb (2001:91) & Cheek & Jebb (2012:263), *partim* (see *N. macfarlanei*)
- *N. gracillima* × *N. macfarlanei* sensu Danser (1928:299) = *N. berbulu* & *N. gracillima*

For a detailed morphological description of *Nepenthes berbulu*, see the species entry in the present work or that in Tan *et al.* (2023).

Distribution, ecology, and conservation: *Nepenthes berbulu* is known from seven peaks in the south-central Titiwangsa Range, the identities of which have been withheld for conservation reasons (see Tan *et al.*, 2023). Curiously, the species' known range lies exactly between that of *N. sericea* to the north and *N. ulukaliana* to the south (see Fig. A10). The conspicuous gap of almost 50 km in the known distribution of this species is likely to reflect a gap in knowledge rather than a true geographical disjunction, though comparative field studies between these disparate populations are warranted. *Nepenthes berbulu* has been documented from an elevational range of approximately 1400–2100 m. It grows terrestrially in stunted ericaceous summit forest (Fig. A24) and either terrestrially or epiphytically in mossy forest (Fig. A25).

Tan *et al.* (2023) assessed the conservation status of *Nepenthes berbulu* as *Endangered* against the IUCN Red List criteria on account of its limited extent of occurrence (<5000 km²) and area of occupancy (<500 km²), and small number of known localities (five at the time), with projected declines in area

Figure A23 (facing page): *Nepenthes berbulu* H.L. Tan, G. Lim, Mey, Golos, Wistuba, S. McPherson & A.S. Rob (a) Habit with upper pitchers and male inflorescence (b) Close-up of upper pitcher showing lid underside and mouth (c) Detail of thickened bristles near lid apex (d) Rosette leaf with lower pitcher (e) Upper surface of lower pitcher lid (f) Lower surface of lower pitcher lid (g) Detail of lower pitcher lid glands (h) Peristome of lower pitcher in lateral aspect, showing pronounced column (i) Spur (j) Male flowers (k) Female flowers (l) Seedpod with dispersing seeds. Based on the type material, additional voucher specimens, as well as photographs and measurements made *in situ* at the type locality. Illustration by François Mey.



Figure A24 (above left): *Nepenthes berbulu* (type locality). Female flowering plant with upper pitchers growing among stunted summit scrub; note dried infructescence to left (François Mey). **Figure A25 (above right):** *Nepenthes berbulu* (type locality). Plant with lower pitchers growing in mossy forest just below summit; note large size of foliage and long internodes as compared to summit plants (Stewart McPherson).



Figure A26 (above left): *Nepenthes berbulu* (type locality). Climbing stem with upper pitchers (centre) and rosette with lower pitcher (top left), both growing epiphytically (Michal Golos). **Figure A27 (above right):** *Nepenthes berbulu* (type locality). Typical lower pitchers borne on long tendrils (Andreas Wistuba).

of occupancy, quality of habitat, and number of mature individuals, resulting from poaching for the horticultural trade. Poaching of sought-after *Nepenthes* species is an ongoing problem in the region (McPherson, 2022a, b). However, the conservation status of *N. berbulu* may need to be reassessed in the likely event that the species is found to have a wider range than currently appreciated; two additional localities have been identified since its description on the basis of citizen science photos, though these both lie close to previously known sites.

Natural hybrids: A single putative hybrid with *Nepenthes sanguinea* was recorded at ca. 1700 m at the type locality (Fig. A40) and a putative cross with an undescribed species was observed at a second locality (Tan *et al.*, 2023).

Additional specimens examined: Titiwangsa Range (exact location withheld for conservation reasons), summit, 6700 ft [≈2040 m], no date [presumably 1888, per van Steenis-Kruseman, 2017b; see Wray, 1890], *Wray 339* (SING!) [stem with upper pitchers; tentatively identified as *N. gracillima* × *N. macfarlanei* by B.H. Danser, August 1927; “Flower reddish brown, cup white marked with crimson”]; Titiwangsa Range (exact location withheld for conservation reasons), ca. 4600 ft [≈1400 m], June 1933, *Banfield s.n.* (SING! [2 sheets]) [stem(s) with lower pitchers (both sheets)]; Titiwangsa Range (exact location withheld for conservation reasons), near summit, 4800 ft [≈1460 m], 30 December 1939, *Holttum S.36511* (SING! [2 sheets]) [rosette with pitchers and stem with lower pitcher (sheet 1); separate lower pitcher and lamina (sheet 2)]; Titiwangsa Range (exact location withheld for conservation reasons), 4800 ft [≈1460 m], 30 December 1939, *Holttum 36512* (SING!) [stem with upper pitcher]; Titiwangsa Range (exact location withheld for conservation reasons), summit, ca. 4500 ft [≈1370 m], 23 September 1940, *Addison S.37379* (SING!) [stem with upper pitchers and infructescence]; Titiwangsa Range (exact location withheld for conservation reasons), heath forest at summit plateau, 6600 ft [≈2020 m], 22 September 1994, *Chua et al. FRI 39045* (KEP!) [stem with upper pitchers and infructescence]; Titiwangsa Range (exact location withheld for conservation reasons), heath forest at summit plateau, 4700 ft [≈1430 m], 23 September 1994, *Chua et al. FRI 39048* (KEP! [4 sheets], L!, SING!) [stem with upper pitcher(s) and female floral material (all sheets)].

? *N. berbulu* × *N. sanguinea*: Titiwangsa Range (exact location withheld for conservation reasons), heath forest at summit plateau, 4700 ft [≈1430 m], 23 September 1994, *Chua et al. FRI 39049* (KEP!) [stem with upper pitchers].

Indeterminate material: Titiwangsa Range (exact location withheld for conservation reasons), path to [mountain], ±4800 ft [≈1460 m], 21 March 1929, *Holttum S.21554* (SING!) [stem with upper pitchers and male inflorescence, stem with lower pitcher; tentatively identified as *N. macfarlanei* by B.H. Danser, 1929, though described by him as “[r]ather an intermediate between this and *N. sanguinea*”]; Titiwangsa Range (exact location withheld for conservation reasons), summit, exposed rocky scrub, 4750 ft [≈1450 m], 18 August 1960, *Burkill, Shah & Noor HMB 2382* (SING!) [stem with upper pitcher].

Notes on specimens examined: *Nepenthes berbulu*, with its dark-speckled, distally cylindrical upper pitchers and long (*ca.* 10 mm) lid bristles, is a striking and highly distinctive species. Prior to its publication by Tan *et al.* (2023), this unique combination of characters had never been explicitly remarked upon in the literature (though herbarium material of this species had been included under *N. macfarlanei* or its putative hybrids by several authors), presumably because none of the previous *Nepenthes* workers had studied live plants.

Specimens from the southern part of the species' range appear to sometimes have wholly infundibular lower pitchers (e.g. *Banfield s.n.* [sheet 2], SING! [#93995]), though the typical long bristles and distally cylindrical upper pitchers are also present. It is uncertain whether this is partly an artefact of specimen pressing or perhaps reflects introgression with *Nepenthes ulukaliana*, whose northern limit is known to almost reach the southern limit of *N. berbulu*, though the two are not known to overlap.



Figure A28 (above left): *Nepenthes berbulu* (type locality). Large, dark-speckled lower to intermediate pitchers (Andreas Wistuba). **Figure A29 (above right):** *Nepenthes berbulu* (type locality). Intermediate pitcher; note wing remnants in upper half of pitcher body (Andreas Wistuba).

Chua et al. FRI 39049 (KEP!) is considered by us to likely be a natural hybrid with *Nepenthes sanguinea*; though the foliage of this specimen agrees with *N. berbulu*, the form of the upper pitchers (which lack lid bristles) recalls *N. sanguinea*.

Burkill, Shah & Noor HMB 2382 (SING!) and *Holttum S.21554* (SING!) are unusual in having wholly infundibular upper pitchers; the identity of this material is uncertain.



Figure A30 (above): *Nepenthes berbulu* (type locality). Upper pitchers with contrasting crimson body pigmentation and near-white peristomes and lids (Michal Golos).



Figure A31 (above left): *Nepenthes berbulu* (type locality). Lower lid of rosette pitcher bearing small number of rudimentary bristles interspersed by nectar glands (Gideon Lim). **Figure A32 (above right):** *Nepenthes berbulu* (type locality). Lower lid of mature pitcher; note distribution of nectar glands in two lateral groups and largely circumferential placement of lid bristles (Gideon Lim).



Figure A33 (above left): *Nepenthes berbulu* (type locality). Exceptionally long lid bristles forming a formidable barrier around the periphery of the lid, particularly in the apical region. A small snail is visible in one of the lateral 'bald patches' (Michal Golos). **Figure A34 (above right):** *Nepenthes berbulu* (type locality). Upper pitcher lid with an atypical distribution of bristles, lacking lateral 'bald patches' and bristles near the margins (Andreas Wistuba).



Figure A35 (above left): *Nepenthes berbulu* (type locality). Ants feeding under and between lid bristles of lower pitcher (Gideon Lim). **Figure A36 (above right):** *Nepenthes berbulu* (second locality). Lid bristles of large upper pitcher (Benjamin Hagger).



Figure A37 (above left): *Nepenthes berbulu* (type locality). Dark-coloured upper pitcher with climbing stem; note clasp leaf bases (Stewart McPherson). **Figure A38 (above right):** *Nepenthes berbulu* (second locality). Upper pitcher growing among *Dipteris conjugata* ferns (Andreas Wistuba).



Figure A39 (above left): *Nepenthes berbulu* (second locality). Long lid bristles of upper pitcher (François Mey). **Figure A40 (above right):** Putative hybrid between *Nepenthes berbulu* and *N. sanguinea* growing at ca. 1700 m, at the type locality of the former (Michal Golos).

Nepenthes gracillima Ridl. (1908:320) (Figs. A41–52)

Lectotype (designated by Jebb & Cheek, 1997:43): Pahang, Gunung Tahan, 3300 ft [≈1010 m], 29 May 1905, *Wray & Robinson 5309* (SING! [#46823], isolecto- BO! [#1298761]) [stem with three upper pitchers and badly damaged infructescence (lecto-); stem with three upper pitchers (two missing distal portions) and two badly damaged male inflorescences (isolecto-); lecto- sheet labelled “Pitchers pale green, tinted in place with dull crimson, mottled with dull purple, lip of cup brighter green lined with dull crimson”; both sheets labelled “*Nepenthes gracillima* Ridl. Type!” by B.H. Danser, August 1927].

- *N. macfarlanei* sensu Ridley (1924:24), Danser (1928:323), Jebb & Cheek (1997:57), Cheek & Jebb (2001:91) & Cheek & Jebb (2012:263), *partim* (see *N. macfarlanei*)
- *N. gracillima* × *N. macfarlanei* sensu Danser (1928:299) = *N. berbulu* & *N. gracillima*
- *N. macfarlanei* × *N. sanguinea* sensu Danser (1928:324) = *N. gracillima*, *N. sericea* & *N. ulukaliana*
- *N.* × *setiuensis* A.Amin, M.N.Faizal & Dome in Tamizi *et al.* (2020a:29, figs. 1–3, 4B & 5A, D [= *N. gracillima*]) — **Holotype**: Terengganu, Setiu, no elevation data, 30 April 2019, *Amin et al. MDI 12419* (MARDI n.v.).

- Non *N. gracillima* sensu Macfarlane (1914:282) = *N. gracillima* & *N. sanguinea*
- Non *N. gracillima* sensu Ridley (1924:22) = *N. gracillima*, *N. ramispina* & *N. sanguinea*
- Non *N. gracillima* var. *maior* Ridl. (1924:22) [published as ‘*major*’; corrected in Danser, 1928:299] = *N. ramispina* — **Type** (per Danser, 1928:299): Selangor, Gunung Semangko, 4000 ft [≈1200 m], April 1911, *Ridley 15563* (SING! [#94073]) [stem with upper pitcher, separate leaf with upper pitcher; labelled “*Nepenthes gracillima* Ridl. Authentic specimens of the var. *maior* Ridl.” by B.H. Danser, August 1927].
- Non *N. gracillima* sensu Danser (1928:296, fig. 7 [= *N. ramispina*]) = *N. alba*, *N. gracillima* & *N. ramispina*
- Non *N. gracillima* sensu Smythies (1965:170) = *N. muluensis*
- Non *N. gracillima* sensu Shivas (1984:31, pls. 14–15 [= *N. ramispina*]) = *N. gracillima* & *N. ramispina*
- Non *N. gracillima* sensu Kiew (1990:34) = *N. alba*, *N. benstonei*, *N. gracillima* & *N. ramispina*
- Non *N. gracillima* sensu Jebb & Cheek (1997:43), Cheek & Jebb (2001:69, fig. 8a, d–g [= *N. gracillima*], fig. 8b–c, h [= ?*N. alba*]) & Cheek & Jebb (2012:261, map 3, fig. 1A, D–G [= *N. gracillima*], fig. 1B–C, H [= ?*N. alba*]) = *N. alba*, *N. benstonei* & *N. gracillima*
- Non *N. gracillima* f. *ramispina* (Ridl.) U. Westphal (2000:25) *nom. nud.* = *N. ramispina*
- Non *N. gracillima* sensu Clarke (2001:131, map 4C, figs. 71–72 & 151 [= *N. alba*]) & Clarke (2002:19, 3 figs. on p. 19 [= *N. alba*]) = *N. alba* & *N. gracillima*

For a detailed morphological description of *Nepenthes gracillima*, see the species entry in the present work or that in Clarke & Lee (2012). For a description of wood anatomy, see Schwallier *et al.* (2017), where this species is treated under the name *N. macfarlanei* (based on *Corner s.n.*, L! [#885965, a.k.a. 1852532]).



Figure A41 (above left): *Nepenthes gracillima* (Gunung Tahan). Rosette plant with pitcher (Kenneth Hiew). **Figure A42 (above right):** *Nepenthes gracillima* (Gunung Tahan). Lower pitcher with typical, brown-speckled pitcher body and banded green peristome (Stewart McPherson).



Figure A43 (above left): *Nepenthes gracillima* (Gunung Tahan). Close-up of mouth and lid; note hairs on lower lid surface (Chien Lee). **Figure A44 (above right):** *Nepenthes gracillima* (Gunung Tahan). Lower pitcher with typical brown-speckled cup but darker, maroon peristome (Chien Lee).

Distribution, ecology, and conservation: This species is known with confidence only from the Tahan massif and neighbouring Gunung Rabong^[18] but may also occur on Gunung Tapis. *Nepenthes* × *setiuensis*, here considered a synonym of this species, extends the range of *N. gracillima* to Setiu district, Terengganu. The species is apparently also found on Gunung Sembilu of the Terengganu Hills (*Hislop s.n.*, SING! [#93986]) and is therefore likely to occur on the higher terrains between that mountain and Gunung Tahan (see Fig. A10 and discussion under *N. alba*). Further studies are needed to ascertain the full extent of its distribution in the eastern mountain ranges of Peninsular Malaysia. It has a known elevational range of at least 900–1700 m (Clarke & Lee, 2012), and possibly up to 2000 m (McPherson & Robinson, 2012). It occurs terrestrially or as an epiphyte in closed upper montane forest (Clarke & Lee, 2012).

The IUCN Red List entry for *Nepenthes gracillima*, where it is assessed as *Least Concern* (Clarke, 2018b), is up-to-date and accurately reflects the conservation status of this species as currently understood. The Tahan massif, Gunung Rabong, and Gunung Sembilu all lie within Taman Negara, a well-managed national park, and the Gunung Tahan population alone has been estimated to comprise thousands of mature plants (Clarke, 2018b).

Natural hybrids: *Nepenthes alba*, *N. benstonei*, and *N. sanguinea* are also found on Gunung Tahan, but no natural hybrids with *N. gracillima* have been reliably recorded there to date (Clarke & Lee, 2012; but see Figs. A22, A47–48), though photographs from the field seem to show a cross between sympatric *N. gracillima* and *N. sanguinea* on nearby Gunung Rabong (G. Lim, pers. observ.). In Terengganu, Tamizi *et al.* (2020b) reported finding several putative hybrids between *N. malayensis* and what they identified as sympatric *N. macfarlanei*, the latter likely representing *N. gracillima*.

Additional specimens examined: Gunung Tahan, no elevation data, July 1911, *Ridley 16090* (K!) [stem with upper pitchers and male inflorescence, stem with upper pitchers, infructescence, and inflorescence; identified as *N. gracillima* by H.N. Ridley; NB: mixed collection—plant with infructescence belongs to *N. alba*]; Gunung Tahan, no elevation data, July 1911, *Ridley 16096* (SING! [3 sheets]) [stem with lower pitcher (sheet 1); stem with lower pitcher, separate leaf with lower pitcher (sheet 2); separate leaves with lower pitchers (sheet 3); identified as *N. macfarlanei* by H.N. Ridley; sheets 1 and 3 tentatively identified as *N. macfarlanei* × *N. sanguinea* by B.H. Danser, August 1927]; [Gunung] Tahan, Wray’s Camp, no elevation data, July 1911, *Ridley 16174* (K!, SING!) [stem with large upper pitchers (K); stem with lower pitcher (SING); identified simply as “*Nepenthes*” by H.N. Ridley; identified by B.H. Danser as *N. gracillima* in 1930 (K) and (tentatively) as *N. gracillima* × *N. macfarlanei* in August 1927 (SING)]; Gunung Tahan, top, no elevation data, July 1911, *Ridley s.n.* (SING!) [separate leaves with lower pitchers; identified simply as “*Nepenthes*” by H.N. Ridley; tentatively identified as *N. macfarlanei* × *N. sanguinea* by B.H. Danser, August 1927]; Gunung Tahan, no elevation data, July 1911, *Ridley s.n.* (SING!) [stem with lower pitcher; identified as *N. sanguinea* by H.N. Ridley]; Gunung Tahan, 4000–6000 ft [≈1220–1830 m], 22 June 1922, *Haniff & Nur 8306* (SING!) [leaf with lower pitcher only; tentatively identified as *N. macfarlanei* × *N. sanguinea* by B.H. Danser, August 1927]; Gunung Tahan, padang luas, ca. 5000 ft [≈1520 m], 26 May 1923 [*sic*; presumably 26 June], *Kloss FMS 12212* (L!) [branching stem with intermediate to upper pitchers; identified as *N. gracillima* by B.H. Danser, February 1929]; [Gunung Tahan], 5000 ft [≈1520 m], 25 June 1923, *Kloss FMS 12211* (L!) [leaf with upper pitcher only]; Gunung Tahan, padang luas, no elevation data, 29 June



Figure A45 (above left): *Nepenthes gracillima* (Gunung Tahan). Typical brown-speckled lower pitcher; note resemblance to traps of *N. sericea* (Stewart McPherson). **Figure A46 (above right):** *Nepenthes gracillima* (Gunung Tahan). Lower pitchers with particularly dark peristomes and lilac interiors (Kenneth Hiew).



Figures A47 (above left) and A48 (above right): *Nepenthes gracillima* (Gunung Tahan). Lower pitchers exhibiting exceptionally dark colouration, domed lids, and hips situated high on the pitcher body, an unusual combination of characters hinting at possible hybrid influence (Stewart McPherson).

[1923], *Kloss FMS 12259* (SING!) [stem with lower pitchers]; Gunung Tahan, ridge forest, 3500–4500 ft [\approx 1070–1370 m], 28 August 1928, *Holttum S.20644* (SING!) [stem with lower pitcher, stems with upper pitchers, male inflorescence, and infructescences; NB: mixed collection—small stem fragments with upper pitchers and floral material belong to *N. alba*]; Gunung Tahan, Tangga Duabelas [=Gunung Tangga Dua Belas or ‘Gunung Tangga 12’; 1679 m], 5000 ft [\approx 1520 m], 15 September 1937, *Corner s.n.* (L! [3 sheets]) [stem with lower pitcher (all sheets); sheets 2 and 3 lacking provenance information on sheet beyond “Malaysia”; wood anatomy of sheet 3 (#885965, a.k.a. 1852532) studied by Schwallier *et al.* (2017) under the name *N. macfarlanei*]; Gunung Sembilu, no elevation data, July 1952, *Hislop s.n.* (SING!) [stem and separate leaves with lower pitcher; identified as *N. macfarlanei* by J.A. Hislop]; Gunung Tahan, ascent of, no elevation data, February 1961, *Wong & Wyatt-Smith W60* (KEP!) [stem with lower pitchers]; Gunung Rabong, path to, 2500–3300 ft [\approx 760–1010 m], 12 March 1972, *Shah MS 2523* (A!, KEP!, SING!) [stem with lower pitchers (A); two stems with lower pitchers, stem with male inflorescence (KEP); stem with upper pitchers and male inflorescence (SING)]; Gunung Tahan, trail to, ridge, 5000 ft [\approx 1520 m], 2 March 1973, *Ng FRI 20961* (KEP!) [stem with lower pitchers]; Gunung Tahan, padang, no elevation data, 1 September 1984, *Muslim s.n.* (KEP! [2 sheets]) [stem with intermediate pitchers and male inflorescence (sheet 1); stem with upper pitchers and male inflorescence (sheet 2); labelled “black form”; NB: mixed collection—sheet 2 belongs to *N. alba*]; Gunung Tahan, padang, around Gunung Padang [*sic*] campsite, montane forest, exposed quartz slope, 4°35.88’N 102°14.87’E, 1666 m, 6 February 2007, *Lim FRI 56363* (KEP!) [stem with upper pitchers, infructescence, and developing inflorescence]; [Gunung Tahan], Kem Bonsai, campsite, unshaded, 4°37’N 102°13’E, 1690 m, 8 May 2008, *Chew FRI 65305* (KEP!) [stem with lower pitchers]; [Gunung Tahan], valley behind Kem Padang, unshaded, 4°35’N 102°14’E, 1600 m, 10 May 2008, *Yao FRI 65338* (KEP!) [stem with upper pitchers and developing inflorescence].

Indeterminate material: Gunung Tapis, *ca.* 4600 ft [\approx 1400 m], 14 June 1934, *Symington & Kiah S.28877* (KEP!, SING!) [stem with upper pitchers and male inflorescence (KEP); stems with upper pitchers and male and female inflorescences (SING)]; Gunung Sembilu, no elevation data, July 1952, *Hislop s.n.* (SING! [2 sheets]) [stems with upper pitcher and separate male inflorescence (sheet 1); small rosettes with pitchers (sheet 2); identified as *N. gracillima* by J.A. Hislop (sheet 2 tentatively so)]; Gunung Tapis, summit padang, open heath, 4600 ft [\approx 1400 m], 11 September 1968, *Cockburn FRI 11021* (KEP!, L!) [stem(s) with upper pitchers and female floral material (both sheets)].

Notes on specimens examined: The specimen from Gunung Sembilu bearing a single lower pitcher and originally identified as *Nepenthes macfarlanei* (*Hislop s.n.*, SING! [#93986]) appears to represent a genuine specimen of *N. gracillima*; the identities of the two other specimens of this collection series (bearing rosette and upper pitchers) are less certain. The material from Gunung Tapis (*Cockburn FRI 11021*, KEP!, L!; *Symington & Kiah S.28877*, KEP!, SING!) may also belong to this species, but this requires confirmation. The following specimens are unusual in having upper pitchers lacking the typical dark speckling of this species: *Lim FRI 56363* (KEP!), *Muslim s.n.* “black form” (KEP! [sheet 1]), and *Yao FRI 65338* (KEP!). They are tentatively placed under *Nepenthes gracillima* on account of general pitcher form.

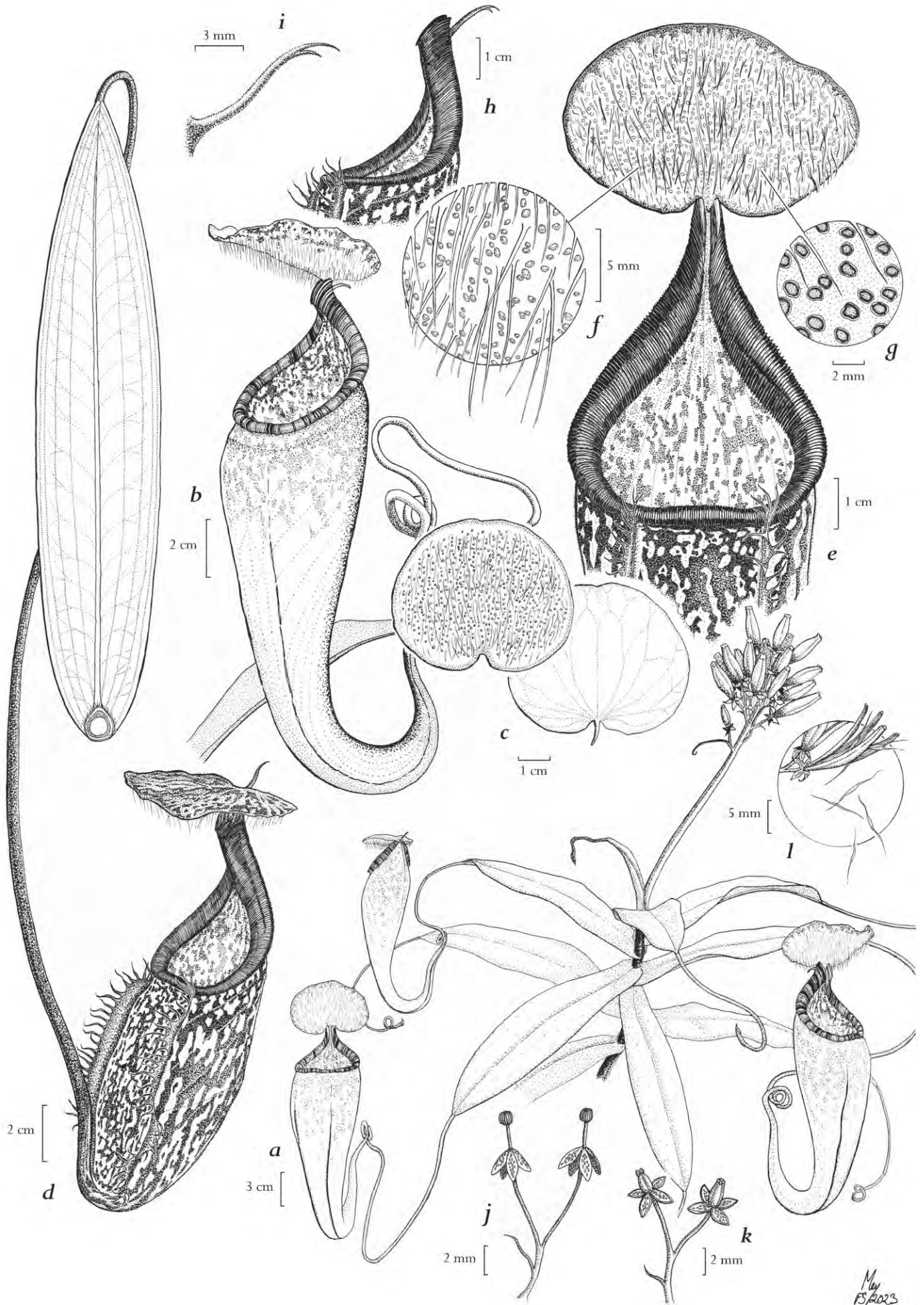
^[18] See Soepadmo (1977:42) for a habitat photo of putative *Nepenthes gracillima* from ridge-tops leading to Gunung Rabong at *ca.* 1800 m; a similar wild plant is shown on p. 39, from 2100 m on a “moist mountain top” at an unspecified locality, presumably Gunung Tahan.



Figure A49 (above left): *Nepenthes gracillima* (Gunung Tahan). Large, early-stage ('intermediate') aerial pitcher (Stewart McPherson). **Figure A50 (above right):** *Nepenthes gracillima* (Gunung Tahan). Detail of freshly opened aerial pitcher (Chien Lee).



Figure A51 (above left): *Nepenthes gracillima* (Gunung Tahan). Small, late-stage ('true' upper) aerial pitcher with spent male inflorescence in background (Chien Lee). **Figure A52 (above right):** *Nepenthes gracillima* (Gunung Tahan). Detail of leaf attachment to stem; note sub-decurrent angling of laminar bases (Stewart McPherson).



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***Nepenthes macfarlanei* Hemsl. (1905a:x)^[19] descr. emend. Mey, Golos, G.Lim, Wistuba, S.McPherson & A.S.Rob. (Figs. A53–74)**

Lectotype (designated by Jebb & Cheek, 1997:57): Perak, Gunung Bubu, 4800–5300 ft [≈1460–1620 m], March 1885, *Dr. King's Collector 7421* (K! [#651560], isolecto- K! [3 sheets: #651561–651563]^[20]) [separate single lower, intermediate, and upper pitchers (lecto-); stem with upper pitcher and two male inflorescences (isolecto- sheet 1); stem with two poorly preserved upper pitchers (isolecto- sheet 2); stem with intermediate pitcher and separate lower pitcher, both dissected (isolecto- sheet 3); “A fine *Nepentis* [sic] 10 to 15 ft long, leaves rich dark green, flower waxy brown, pitcher and lid mottled with pale green & dark claret, in young plants towards top they are of a light green mottled with red. Dense and open jun.[gle]. Near and on top of G. B.”; lecto- and isolecto- sheet 3 labelled “*Nepenthes Macfarlanei* Hemsl.” by W.B. Hemsley].

- Non *N. macfarlanei* sensu Hemsley (1906:1, tabs. 2814–2815 [= *N. macfarlanei*]), Macfarlane (1908:77) & Macfarlane (1914:284) = *N. berbulu* & *N. macfarlanei*
- Non *N. macfarlanei* sensu Ridley (1924:24, fig. 138 [= *N. macfarlanei*]), Jebb & Cheek (1997:57), Cheek & Jebb (2001:91) & Cheek & Jebb (2012:263, map 5) = *N. berbulu*, *N. gracillima*, *N. macfarlanei*, *N. sericea* & *N. ulukaliana*
- Non *N. macfarlanei* sensu Danser (1928:323) = *N. gracillima*, *N. macfarlanei*, *N. sericea* & *N. ulukaliana*
- Non *N. macfarlanei* sensu Smythies (1965:170) = *N. lowii*
- Non *N. macfarlanei* sensu Shivas (1984:35, fig. on cover & pl. 21 [= *N. ulukaliana*], pls. 18–20 & 22 [= *N. sericea*]), Clarke (2001:158, map 6A, fig. on p. viii & fig. 90 [= *N. sericea*], figs. 26 & 89 [= *N. ulukaliana*]), Clarke (2002:21, fig. on cover, fig. on p. 20 & bottom 2 figs. on p. 21 [= *N. sericea*], top fig. on p. 21 [= *N. ulukaliana*]), McPherson (2009a:599, figs. 323–324 [= *N. ulukaliana*], figs. 325–326 [= *N. sericea*]) & McPherson & Robinson (2012:35, figs. 49–51 [= *N. ulukaliana*]) = *N. macfarlanei*, *N. sericea* & *N. ulukaliana*

Description: Terrestrial or epiphytic, erect, subscandent or climbing shrub, to at least *ca.* 5 m tall. *Stems* terete to subangular, branched, 4–7 mm in diameter. Internodal length 21–37 mm in rosettes, 18–52 mm in climbing stems. *Leaves* sessile, ±spirally arranged. Laminae coriaceous, lanceolate in rosettes with acute apex, narrowly elliptic-ob lanceolate to oblong in short and climbing stems with acute to rounded apex, 18–23 cm long by 3–3.4 cm wide in rosette leaves,

Figure A53 (facing page): *Nepenthes macfarlanei* Hemsl (a) Habit with upper pitchers and infructescence (b) Upper pitcher (c) Lower surface (left) and upper surface of lower pitcher lid (d) Rosette leaf with lower pitcher (e) Close-up of lower pitcher showing lid underside and mouth (f) Detail of lid underside showing bristles and interspersed glands (g) Detail of lower pitcher lid glands (h) Peristome of lower pitcher in lateral aspect, showing pronounced column (i) Spur (j) Male flowers (k) Female flowers (l) Seedpod with dispersing seeds. Based on the type material, additional voucher specimens, as well as photographs and measurements made *in situ* on Gunung Bubu. Illustration by François Mey.

8–13 cm long by 2.5–3.5 cm wide in leaves of climbing stem, margins entire, clasping stem for $\frac{1}{2}$ to $\frac{3}{4}$ of its circumference, not decurrent, vernation convolute. Longitudinal veins 4 on either side of midrib in the marginal $\frac{2}{3}$ of lamina, barely discernible in living specimens, conspicuous in herbarium material, pinnate veins numerous, at $50\text{--}90^\circ$ from the midrib, overlapping the longitudinal nerves. Tendrils of lower pitchers uncoiled, *ca.* 38 cm long, 3 mm wide, tendril length to pitcher height ratio 2:1 to 3:1; of upper pitchers coiling once or twice, 14–17 cm long, 1–4 mm wide, generally of ratio 1:1 to 1:2. *Rosette pitchers* infundibular in basal third and sub-cylindrical above. Lid with small number of rudimentary bristles on lower surface. *Lower to intermediate pitchers* ovoid or rarely infundibular in lower half, slightly constricted at midpoint to form a hip, cylindrical above, 14.3–22 cm tall, 5–7 cm wide, tendril ventrally or laterally attached, wings 5–7 mm wide with fringe elements 5–7 mm long, mouth ovate to triangular, oblique, raised towards rear to form a recurved neck, peristome sub-cylindric in section, 2–5 mm wide at front, broadening and flattening towards rear of pitcher, reaching 8–12 mm at column, ribs fine but pronounced, teeth triangular-acuminate. Lid sub-orbicular to orbicular, 4–5.5 cm long, 5–7 cm wide, apex rounded, occasionally retuse, base cordate, lower surface except for margins evenly covered with tens to several hundred coarse white acicular bristles ≤ 12 mm long, pointing downward, more or less numerous in fresh pitchers, sparse in old pitchers suggesting caducous habit, interspersed with numerous nectar glands *ca.* 1 mm in diameter, round to elliptic, crateriform, rimmed with a low, thin margin, \pm evenly distributed throughout. Pitcher interior densely glandular in basal 60–70%, remaining part waxy. Spur flattened, inserted near base of lid, simple or divided into 2 or 3 short lobes, 10–16 mm long, apex acute, often slightly curved downwards. *Upper pitchers* wholly infundibular, hip located just below peristome or absent, 11–24 cm tall, 4.2–7 cm wide, tendril dorsally attached, wings reduced to ridges, prominent except below mouth where inconspicuous, ventral face flattened at base, becoming gibbous above. Mouth ovate to rounded-triangular, oblique, ascending at an angle of $50\text{--}60^\circ$ towards back of pitcher, gradually becoming vertical at column, peristome sub-cylindric in section, 1–2 mm wide at front, and 4–6 mm at column, teeth conspicuous, fine, triangular-acuminate. Lid sub-orbicular, 2.5–4 cm long, 3.6–5 cm wide, apex rounded to obtuse, base cordate, lower lid surface as per lower pitchers, bristles 4–6 mm long. Pitcher interior densely glandular in basal 80–90%, remaining part waxy. Spur as per lower pitchers, 4–5 mm long. *Inflorescence* a racemoid panicle. Male inflorescence mostly two-flowered throughout, *ca.* 60 flowers in total, peduncle *ca.* 16–20 cm long, 2 mm wide, rachis *ca.* 14–18 cm long, bracts prominent, situated close to ramification of partial peduncle, simple, filiform, consistently produced. Tepals broadly elliptic, *ca.* 2 mm long, 1 mm wide, apex obtuse to rounded, adaxially concave with nectar glands. Female inflorescence mostly two-flowered throughout, *ca.* 50 flowers in total, peduncle 17–18 cm long, 3 mm wide, rachis 6–7 cm long, bracts as in male flowers but basalmost partial peduncle with a longer bract of 10–28 mm. Tepals broadly elliptic, *ca.* 1 mm long, 0.5 mm wide, apex acute. Seeds fusiform, *ca.* 10 mm long, centrally rugose, with well-developed wings. *Indumentum* of orange-brown caducous hairs, < 1 mm long, present on emerging tendrils and tendrils of rosette leaves, and on lower pitchers; short, fine brown hairs present on leaf axils and silver hairs on tendrils of climbing



Figure A54 (above left): *Nepenthes macfarlanei* (Gunung Bubu). Short-stemmed plant bearing lower pitchers; note acute laminar apices (Michal Golos). **Figure A55 (above right):** *Nepenthes macfarlanei* (Gunung Bubu). Rosette pitcher; note apically branched spur (François Mey).



Figure A56 (above left): *Nepenthes macfarlanei* (Gunung Bubu). Small, elongated lower pitcher (Michal Golos). **Figure A57 (above right):** *Nepenthes macfarlanei* (Gunung Bubu). Typical, basally ovoid lower pitcher (François Mey).



Figure A58 (above left): *Nepenthes macfarlanei* (Gunung Bubu). Typical, basally ovoid lower pitcher (Stewart McPherson). **Figure A59 (above right):** *Nepenthes macfarlanei* (Gunung Bubu). Lower to intermediate pitcher; note damage caused by leaf miner (François Mey).



Figure A60 (above left): *Nepenthes macfarlanei* (Gunung Bubu). Upper pitcher with atypical, dark-speckled colouration (Stewart McPherson). **Figure A61 (above right):** *Nepenthes macfarlanei* (Gunung Bubu). Upper pitcher with typical whitish colouration (Andreas Wistuba).



Figure A62 (above): *Nepenthes macfarlanei* (Gunung Bubu). Upper pitcher with climbing stem; note laminar bases that clasp stem for at least half of its circumference (Greg Palena).

stem; other parts of stem, upper pitchers, and laminae of rosette leaves and climbing stem leaves glabrescent on adaxial and abaxial surfaces; inflorescences appearing glabrous. *Colour* of mature stems dark brown, dark purple, or nearly black. Leaves bright green, midrib dark red or dark purple both adaxially and abaxially. Lower pitchers yellow, orange, pink, or pale green, mottled with dark red, dark brown, or purple. Peristome red to dark purple, darkening markedly with age, sometimes with marginally darker stripes. Lower pitcher lid as per the pitcher body on the upper surface, yellowish green heavily speckled with red to dark red on lower surface. Upper pitchers pale green or yellowish green at the base, becoming progressively creamy to bright white above, with internal red speckling apparent externally owing to pitcher translucency. Peristome predominantly white to creamy white with numerous red stripes. Lid mostly white above but heavily marked with red to dark red speckles on lower surface. One plant was observed bearing an upper pitcher with heavy speckles as in the lower pitchers. Bristles bright white to creamy white on young pitchers, darkening as pitchers age.

Etymology: The specific epithet commemorates Scottish botanist John Muirhead Macfarlane (1855–1943), who brought the species to the attention of describing author Hemsley in 1904 (see Hemsley, 1905c). Macfarlane published numerous scholarly papers on *Nepenthes* beginning in the 1880s and revised the entire genus for *Das Pflanzenreich* in 1908, an important work that included eight new species descriptions.



Figure A63 (above left): *Nepenthes macfarlanei* (Gunung Bubu). Flowering female plant with upper pitcher (Stewart McPherson). **Figure A64 (above right):** *Nepenthes macfarlanei* (Gunung Bubu). Upper pitcher growing among *Gleichenia truncata* ferns (Michal Golos).



Figure A65 (above left): *Nepenthes macfarlanei* (Gunung Bubu). Lower lid of rosette pitcher showing rudimentary bristles (François Mey). **Figure A66 (above right):** *Nepenthes macfarlanei* (Gunung Bubu). Lower lid of mature lower pitcher with long (ca. 10 mm) bristles (Andreas Wistuba).



Figure A67 (above left): *Nepenthes macfarlanei* (Gunung Bubu). Detail of lid bristles and surrounding nectar glands (Andreas Wistuba). **Figure A68 (above right):** *Nepenthes macfarlanei* (Gunung Bubu). Upper pitcher with long lid bristles (Andreas Wistuba).

Phenology: Both male and female inflorescences of *Nepenthes macfarlanei* were observed on Gunung Bubu in August 2022. The latter were developing seed pods, but these were a few weeks from being ripe. Herbarium material known to us includes male inflorescences from March and April, female inflorescences from January and March, and infructescences from March, April, and June. However, the total number of specimens is too small to draw any firm conclusions about flowering phenology.

Distribution and ecology: *Nepenthes macfarlanei* is known with certainty only from the summit area of Gunung Bubu (Fig. A10), the highest peak of a semi-isolated massif that constitutes the southernmost extent of the Bintang Range, the upper regions of which are granitic (Wong, 1966; Grismer *et al.*, 2010). The species has been recorded from a relatively narrow elevational range of 1500 m to the summit of Gunung Bubu at 1657 m.

Nepenthes macfarlanei may prove to be highly localised. Notably, it appears to be absent from Gunung Hijau (1448 m), which lies only 20 km to the north of Gunung Bubu, in the Taiping Hills, and where a form of *N. sanguinea* (similar to that found on the summit of Gunung Bubu) is common. It has been suggested that the failure of *N. macfarlanei* to colonise Gunung Hijau may be due to the species' limited potential for long-distance seed dispersal (Chua, 1995:50, 2001), but equally it may be explained by the relatively low elevation of that mountain and its associated massif, of which it is the highest peak.

Nepenthes macfarlanei was observed by the authors in two sub-populations in the summit area of Gunung Bubu at about 1600 m elevation. The two sub-populations are about 15 minutes apart on foot. At the first, *N. macfarlanei* grows in stunted ericaceous forest mostly as a terrestrial, with plants climbing readily among trees, while at the second, it is found in typical mossy forest habitat. Dozens of plants were observed on *Sphagnum*-covered earthen banks and others were seen vining up trees.

Lower pitchers of *Nepenthes macfarlanei* were observed to produce a whitish exudate reminiscent of that produced by the Bornean species *N. lowii* and *N. ehippiata*, though in much lower quantities. It is possible that this exudate is regularly consumed by associated fauna.

Natural hybrids: *Nepenthes macfarlanei* is only known to be sympatric with *N. sanguinea*; a specimen of *N. sanguinea* producing large, slender upper pitchers grew alongside the second sub-population. A single, putative hybrid between the two species was recorded on the summit of Gunung Bubu (Figs. A75–76), growing a few meters from *N. macfarlanei* plants in the first sub-population. *Nepenthes mirabilis* was found along a stream at 310 m elevation on Gunung Bubu (F. Mey, pers. observ.), but this species is unlikely to hybridise with *N. macfarlanei* owing to significant elevational separation.



Figure A69 (above): *Nepenthes macfarlanei* (Gunung Bubu). Lid of old lower pitcher missing most of its bristles, which have been broken at their bases; note milky globules of exudate hanging from glands (Andreas Wistuba).



Figure A70 (above): *Nepenthes macfarlanei* (Gunung Bubu). Recently opened (left) and near-senescent lower pitchers, showing differences in colouration and presence of intact bristles (François Mey).

Prey, infauna, and other associated organisms: We are not aware of any records of prey or other organisms associated with the pitchers of this species.

Conservation status: The current assessment of *Nepenthes macfarlanei* for the IUCN Red list categorises this species as *Least Concern* (Clarke, 2018c). However, this assessment relates to the species concept *sensu lato*, making it inaccurate with respect to *N. macfarlanei* as circumscribed herein.

Field work and herbarium studies show that *Nepenthes macfarlanei* is known with certainty only from Gunung Bubu, its type locality. Neighbouring peaks with suitable habitat might reveal additional populations of this species, but further research is required to ascertain its presence on them. The bad weather that hampered our August 2022 expedition meant that it was not possible to estimate the total number of individuals present.

Gunung Bubu lies in the centre of Bubu Permanent Forest Reserve (18,213 ha), the southernmost part of Bintang Hijau Forest Reserve (Ibrahim *et al.*, 2011), and as such is afforded a certain level of protection. However, fires caused by human activities and logging within the boundaries of the park have occurred in recent years, leaving significant damage in the protected area, including cleared terrain and silted streams (G. Lim, pers. observ.). Gunung Bubu is relatively accessible to experienced hikers and, given the fact that *N. macfarlanei* has significant horticultural value, the species may be subject to unscrupulous collection. Poaching of rare *Nepenthes* like *N. clipeata*, *N. ephippiata*, and *N. rigidifolia* has occurred at significant levels recently (McPherson, 2022a, b), and in some cases undescribed species are threatened before they are even properly documented and described, as was the case with *N. berbulu* (Tan *et al.*, 2023).

Observations of *Nepenthes macfarlanei* made *in situ*, together with information gleaned from voucher specimens, satisfy the IUCN 3.1 Red List EN (*Endangered*) criteria B1ab(ii,iii,v)+2ab(ii,iii,v) (IUCN, 2012), as the species has an extent of occurrence (EOO) of <5000 km², an area of occupancy (AOO) of <500 km², and is known only from one location, with projected declines in area of occupancy, quality of habitat, and number of mature individuals. The only known population of *N. macfarlanei* occurs in an area that is unlikely to be impacted by land development in the foreseeable future. Habitat degradation and population decline are anticipated as a result of fire, logging, and poaching for the horticultural trade; the latter has already significantly impacted a number of *Nepenthes* and is estimated to threaten almost a third of known species (Cross *et al.*, 2020). Though *N. macfarlanei* grows in a forest reserve, this reserve has seen logging and attendant ecological problems in recent years (Anon., 2007). Given its apparently limited geographical and elevational range and status as a summit endemic, *N. macfarlanei* is likely to be particularly vulnerable to the effects of climate change owing to progressive loss of suitable habitat (see Schwallier *et al.*, 2016).



Figure A71 (above): *Nepenthes macfarlanei* (Gunung Bubu). Beading of water on lid bristles of lower pitcher (Gideon Lim).



Figure A72 (above): *Nepenthes macfarlanei* (Gunung Bubu). Ants among lid bristles of upper pitcher (Stewart McPherson).

Additional specimens examined: Gunung Bubu, 5000–5300 ft [\approx 1520–1620 m], March 1885, *Dr. King's Collector 7395* (SING!) [bifurcated stem with upper pitcher and male inflorescence; “A *Nepentis* [sic] 6 to 8 ft long, half parasite [?], leaves light green, pitcher towards top of lid light yellow with bright red spots inside, flower pale green with bright yellow stamens. Grows on trees, open jun.[gle]. Top of Gunung Boobo.”; identified as *N. macfarlanei* by B.H. Danser, August 1927, who wrote: “The same number in Herb. Bogoriensi has typical *Macfarlanei*-pitchers. *Locus classicus*.”]; Gunung Bubu, 5000 ft [\approx 1520 m], March 1890, *Wray 3849* (P!) [stem with upper pitchers, infructescence, and female inflorescence; “♂ and ♀ fl.[owers] pale yellowish green”]; Gunung Bubu, summit, no elevation data, 8 April 1933, *Symington FMS 30848* (KEP!) [stem with upper pitchers]; Gunung Bubu, summit, 5434 ft [=1656 m], 31 January 1938, *Ladow FMS 45159* (KEP!) [stems with upper pitchers and female inflorescences]; Gunung Bubu, summit via Manong, 5400 ft [\approx 1650 m], 10 June 1978, *Shah & Mahmud MS 3986* (KEP!, SING!) [stem with upper pitcher (KEP); stem with upper pitchers and infructescence (SING)]; Gunung Bubu Besar [main summit], summit trail to Gunung Bubu Kecil [minor summit], 1600 m, 20 April 1995, *Chua FRI 39091* (KEP!, L!) [stem with upper pitcher and infructescence (KEP); stem with upper pitchers and male inflorescence (L)]; Gunung Bubu, summit, exposed montane forest, 1657 m, 20 December 2006, *Lim FRI 52833* (KEP!) [stem with upper pitcher]; Gunung Bubu, summit, mossy shaded montane forest, 1653 m, 20 December 2006, *Lim FRI 52835* (KEP!) [stem with lower pitchers]; Gunung Bubu, 1615 m, 17 August 2022, *Lim 2* (KEP! [3 sheets]) [stem with upper pitchers and infructescence (sheet 1); stem with lower pitchers (sheet 2); stem with upper pitchers and male inflorescence (sheet 3)].

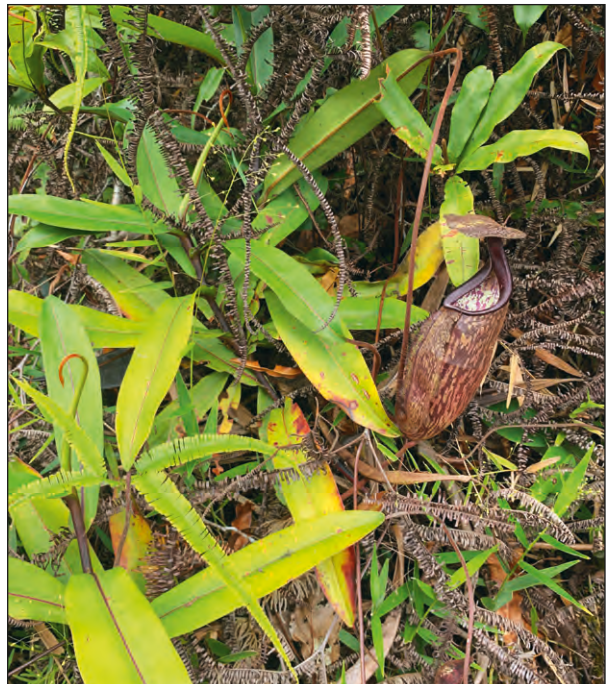


Figure A73 (above left): *Nepenthes macfarlanei* (Gunung Bubu). Sub-orbicular lid of upper pitcher (Greg Palena).
Figure A74 (above right): *Nepenthes macfarlanei* (Gunung Bubu). Several growth points bearing lower pitchers; note distinctive shape of laminae and sympatric ferns of the genus *Oleandra* (François Mey).

Indeterminate material: Perak, no further location data, no elevation data, no date [presumably 1884–1886; see Stafleu & Cowan, 1985:456], *Scortechini s.n.* (SING! [2 sheets]) [stem with lidless upper pitcher (sheet 1); pitcherless stem with infructescence (sheet 2); both sheets tentatively identified as *N. macfarlanei* by B.H. Danser, August 1927].

Notes on specimens examined: Hemsley based his concept of *Nepenthes macfarlanei* on material from four collectors (Hemsley, 1906). The oldest of these specimens, *Murton 36* (K n.v.), was collected on Gunung Bubu at approximately 5000 ft (ca. 1520 m) by Henry James Murton (1853–1882), then superintendent of the Singapore Botanic Gardens, and had been at Kew since 1878 (Hemsley, 1906). Described as consisting of “one small pitcher and three or four small leaves” (Hemsley, 1905c), it formed the basis for the second *Icones Plantarum* illustration (Fig. A7) and was the specimen originally shown to Hemsley by Macfarlane.

Also cited by Hemsley were the specimens transferred from Calcutta, including *Dr. King’s Collector 7395* (SING!) and the lectotype series *7421* (K! [4 sheets]; Figs. A2–5). The King in question was British botanist Sir George King (1840–1909). This material was very likely collected by German explorer Hermann Kunstler (1837–1887), one of the main collectors employed by King, who used abbreviated place names (cf. “G. B.” for Gunung Bubu seen in the aforementioned material), and climbed Gunung Bubu at least three times, including in March 1885, when the material was collected (see Stafleu & Cowan, 1979:545; van Steenis-Kruseman, 2017a).

The Calcutta material also included specimens collected by Leonard Wray, Jr. (1853–1942), then curator of the Perak State Museum. Hemsley cited three numbers: *Wray 339* (SING!), *1643* (n.v.), and *3849* (P!). The first of these is a specimen of *Nepenthes berbula* from the Titiwangsa Range (see under that species), but the last is a genuine *N. macfarlanei* specimen from Gunung Bubu.



Figure A75 (above): Upper pitcher of putative *Nepenthes macfarlanei* × *N. sanguinea* (François Mey).



Figure A76 (above): Putative hybrid between *Nepenthes macfarlanei* and *N. sanguinea* growing near the summit of Gunung Bubu; note climbing stem with upper pitcher in background (François Mey).

Finally, Hemsley mentioned an unnumbered collection by Italian clergyman and botanist Benedetto Scortechini (1845–1886), likely equivalent to that currently deposited in Singapore and labelled as *Nepenthes macfarlanei* (*Scortechini s.n.*, SING! [2 sheets: #93956 & 93984]). This material is difficult to identify, as the only extant pitcher is lidless and the locality is unknown beyond “Perak”. Unfortunately, though a diligent collector, Scortechini was known to have “considerably neglected to label his specimens” (Burkill, 1927:131).

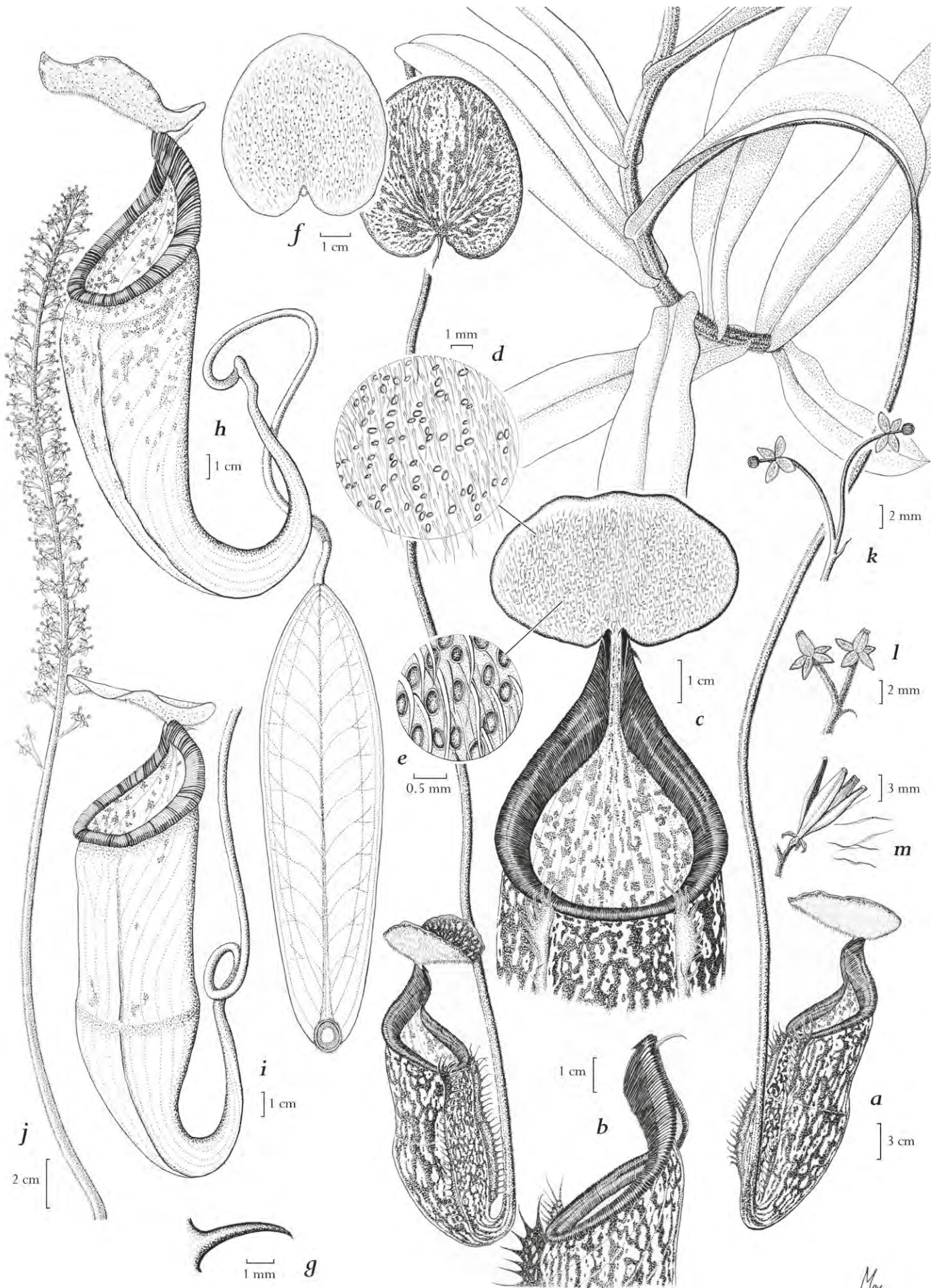
Over the years, herbarium material from more than twenty peaks has been attributed to *Nepenthes macfarlanei*, covering the Bintang, Timur, and Titiwangsa ranges (see Chua, 1995:187), the vast majority representing other members of the *N. macfarlanei* complex. Though much progress has been made over the last two decades in clarifying the taxonomic relationships within the *N. macfarlanei* group, it is remarkable that until now the true nature of the eponymous species had not been properly elucidated.

Even Clarke & Lee (2012), who pointed out that plants from Gunung Bubu had longer and coarser lid bristles than those from other regions, only gave a maximum length of 5 mm for these structures (as did Cheek & Jebb, 2012), when in the available herbarium material they commonly reach double that length.^[21]

^[19]The description of *Nepenthes macfarlanei* for *Icones Plantarum* (Hemsley, 1906) was clearly Hemsley’s definitive treatment of the species. However, it was certainly not the earliest, and rules pertaining to the establishment of new plant species had not yet been formalised at the time (the first code to declare itself binding was published in 1906, but was not universally accepted; see Nicolson, 1991). The question therefore arises as to which publication established the binomial *N. macfarlanei*. Hemsley’s treatment for *Icones Plantarum* cited the summaries of his 6 April 1905 talk appearing in *Proceedings of the Linnean Society of London* (in October 1905; Hemsley, 1905e) and *The Gardeners’ Chronicle* (on 22 April 1905; Hemsley, 1905c), in that order, noting that they were “without a complete description” (“*absque descriptione plena*”) (Hemsley, 1906). The former has usually been cited as the type description of *N. macfarlanei* (see e.g. Ridley, 1924; Danser, 1928; Jebb & Cheek, 1997; Cheek & Jebb, 2001, 2012; Clarke, 2001; McPherson, 2009a), sometimes on equal terms with the earlier (and more comprehensive) article from *The Gardeners’ Chronicle* (see e.g. IPNI, 2023, which until recently followed the citation given in Prain, 1908, itself taken from Hemsley, 1906). However, since there exist equivalent and unambiguously earlier published accounts of Hemsley’s talk (apparently overlooked until now), we have chosen to cite as the type description the earliest such account known to us: that appearing in *The Garden*, dated April 15th (Hemsley, 1905a).

^[20]Persistent identifiers: <http://specimens.kew.org/herbarium/K000651560> (lecto-), <http://specimens.kew.org/herbarium/K000651561> (isolecto- sheet 1), <http://specimens.kew.org/herbarium/K000651562> (isolecto- sheet 2), and <http://specimens.kew.org/herbarium/K000651563> (isolecto- sheet 3).

^[21]The books of McPherson (2009a) and McPherson & Robinson (2012), which state that the lid hairs of *Nepenthes macfarlanei s.lat.* reach up to 10 mm, are the only major recent works to correctly reflect the development of these structures in the type population.



M
 FS/2023

Nepenthes sericea Golos, Wistuba, G.Lim, Mey, S.McPherson & A.S.Rob.,
spec. nov. (Figs. A77–116)

Holotype: Kelantan, Gunung Warpu, 1745 m, 19 August 2022, *Lim 3* (KEP!, isotypes KEP! [3 sheets]) [stem with two upper pitchers and two male inflorescences (holo-); stem with lower pitcher (iso- sheet 1); stem with two upper pitchers and two infructescences (iso- sheet 2); stem with two upper pitchers (iso- sheet 3)].

- *N. macfarlanei* sensu Ridley (1924:24), Danser (1928:323), Shivas (1984:35), Jebb & Cheek (1997:57), Cheek & Jebb (2001:91), Clarke (2001:158), Clarke (2002:21), McPherson (2009a:599), Cheek & Jebb (2012:263) & McPherson & Robinson (2012:35), *partim* (see *N. macfarlanei*)
- *N. macfarlanei* × *N. sanguinea* sensu Danser (1928:324) = *N. gracillima*, *N. sericea* & *N. ulukaliana*

Diagnosis: *Nepenthes sericea* differs from *N. macfarlanei* in having (differences in parentheses) pitchers with dense indumentum of filamentous lid hairs ≤ 2 mm long (vs. pitchers with numerous thickened lid hairs 5–12 mm long), and upper pitchers that may be wholly infundibular with a hip just below the peristome, or with a hip located at the mid-point and cylindrical to sub-infundibular above (vs. wholly infundibular with or without a hip present just below the peristome).

Description: Terrestrial or epiphytic, erect, subscandent or climbing shrub, up to several metres tall. *Stems* terete to slightly angular, 3–8 mm in diameter. Internodal length 22–25 mm in rosettes, *ca.* 23–100 mm in climbing stems. *Leaves* sessile, coriaceous. Lamina oblanceolate, sometimes spatulate in rosettes or obovate-oblong in climbing stems, 5.7–18.5 cm long, 2.0–4.1 cm wide, apex acute to obtuse, often rounded in laminae of climbing stems growing in exposed sites, base usually clasping stem for at least $\frac{3}{4}$ of its circumference, 3 longitudinal veins on either side of midrib, tendrils supporting rosette or lower pitchers 27–61(–90) cm long, 2–5 mm wide, uncoiled; those supporting upper pitchers 12–17 cm long, 1–4 mm wide, coiled several times. *Rosette pitchers* variable in shape, ovoid or infundibular in basal third and sub-cylindrical above or sub-cylindrical throughout. Lid with fine hairs on lower surface. *Lower to intermediate pitchers* ovoid to broadly infundibular in basal half to two-thirds and cylindrical above, the two parts demarcated by a distinct or faint hip, and contracted slightly immediately below mouth, 19.5–28 cm tall, 6.2–9.0 cm wide, wings generally extending length of ventral surface, sometimes present only in upper half of pitcher,

Figure A77 (facing page): *Nepenthes sericea* Golos, Wistuba, Lim, Mey, S.McPherson & A.S.Rob (a) Habit with lower pitchers (b) Peristome of lower pitcher in lateral aspect, showing pronounced column (c) Close-up of lower pitcher showing lid underside and mouth (d) Detail of lid underside showing hair density and interspersed minute glands (e) Detail of lower pitcher lid glands (f) Lower surface (left) and upper surface of lower pitcher lid (g) Spur (h) Infundibular upper pitcher (i) Cylindrical upper pitcher (j) Male inflorescence (k) Male flowers (l) Female flowers (m) Seedpod with dispersing seeds. Based on the type material, additional voucher specimens, as well as photographs and measurements made *in situ* on Gunung Warpu and Gunung Brinchang (density of lid hairs reduced for clarity). Illustration by François Mey.

2–4 mm wide, with long, widely spaced fringe elements. Mouth ovate, peristome subcylindrical to distinctly flattened, particularly at column, 5–6 mm wide at front, 15–18 mm wide at column where opposing parts sometimes diverge near lid, ribs *ca.* 0.5 mm high, teeth *ca.* 1 mm long. Lid sub-orbicular to ovate, 50–65 mm long, 52–62 mm wide, usually held at *ca.* +20–30° from horizontal, lower surface lacking appendages or prominent medial ridge, with fine hairs up to *ca.* 2 mm long, sometimes denser medially and especially near apex, minute crateriform glands up to 0.3–0.7 mm in diameter densely but \pm evenly distributed across entire lower surface with exception of margins and sometimes also midline ridge. Pitcher interior glandular in basal 40–50%. Spur filiform, simple or apically branched, *ca.* 3–10 mm long. *Upper pitchers* wholly infundibular with hip immediately below mouth or infundibular in basal part and cylindrical to slightly infundibular above medial hip, usually contracted immediately above hip, 9.2–26 cm tall, 3.4–7.0 cm wide, wings reduced to prominent ridges except just below mouth where ridges often inconspicuous, ventral face flattened at base and often becoming gibbous in upper part in wholly infundibular pitchers, ventrally flattened throughout in cylindrical pitchers. Mouth ovate, peristome subcylindrical to distinctly flattened, elongated at rear into column of variable height, *ca.* 2–5 mm wide at front, *ca.* 4–15 mm wide at column, ribs conspicuous, striate, teeth minute, sharp. Lid sub-orbicular to ovate, 30–38 mm long, 28–48 mm wide, apex rounded, base cordate, held at *ca.* +20–30° degrees from horizontal, lower surface lacking appendages or prominent medial ridge, with fine hairs 1–1.5 mm long densely distributed throughout, except near margins where becoming minute, pitted glands concentrated medially and particularly towards apex. Pitcher interior glandular in basal 70–85%



Figure A78 (above left): *Nepenthes sericea* (Gunung Brinchang). Young epiphytic plant with lower pitcher (François Mey). **Figure A79 (above right):** *Nepenthes sericea* (Gunung Warpu). Short-stemmed terrestrial plant with lower pitcher (Stewart McPherson).



Figure A80 (above): *Nepenthes sericea* (Gunung Yong Belar). Plants with richly coloured cylindrical and infundibular upper pitchers emerging through surrounding vegetation (Christophe Maerten).



Figure A81 (above left): *Nepenthes sericea* (Gunung Warpu). Rosette pitcher (François Mey). **Figure A82 (above right):** *Nepenthes sericea* (Gunung Warpu). Hanging lower pitcher among *Lycopodiella cernua* (Michal Golos).



Figure A83 (above left): *Nepenthes sericea* (Gunung Brinchang). Typical lower pitcher (Alastair Robinson). **Figure A84 (above right):** *Nepenthes sericea* (Gunung Brinchang). Large lower pitcher; note shiny lid hairs (Alexey Yakovlev).

when pitcher wholly infundibular, otherwise considerably less so. Spur filiform, simple, *ca.* 3–10 mm long, apex acute. *Inflorescence* a racemoid panicle. Male inflorescence *ca.* 25 cm long, peduncle 6–13 cm long, *ca.* 3 mm wide, rachis 12–19 cm long, bearing *ca.* 90–180 flowers on predominantly 2-flowered partial peduncles, often becoming 1-flowered apically, bracts prominent, basal or situated close to ramification of partial peduncle, simple, filiform. Tepals *ca.* 2 mm long, 1 mm wide. Female inflorescence *ca.* 16 cm long, peduncle *ca.* 13 cm long, *ca.* 2 mm in diameter, rachis *ca.* 3 cm long, bearing *ca.* 20–30 flowers singly or in pairs, bracts variably expressed, often short, simple, filiform. Tepals ovate-elliptic, *ca.* 2 mm long, 1 mm wide, distal two-thirds of adaxial surface with minute nectar glands. *Indumentum* conspicuous, up to *ca.* 0.5 mm long, golden, velvety on stem, midribs, tendrils, and developing pitchers; that of pitchers largely caducous and only minute in mature pitchers, that of inflorescence generally restricted to peduncle. *Colour* of lower pitcher exterior yellow, green, purple, or red, heavily mottled with dark red, brown, or purple, lighter between wings. Peristome uniformly red, brown, or purple. Interior waxy zone off-white, often with red to purple blotches. Upper pitchers often entirely creamy white or nearly so in upper portion, grading into green or yellow in narrow basal section, occasionally with heavy red blotching, particularly in cylindrical upper pitchers. Peristome white or light pink, often with irregular reddish banding. Lower lid red speckled on cream background. Tepals maroon, fruits yellowish.

Etymology: The specific epithet *sericea* is Latin for ‘silken’ and refers to the fine hairs present on the lower surface of the lid of this species, which are notably softer to the touch than the coarse bristles of *Nepenthes macfarlanei*.

Phenology: *Nepenthes sericea* appears to flower throughout the year. Chua (1995:104) failed to find a pronounced periodicity to the timing of anthesis in a population of this species from the Cameron Highlands, contrary to her findings for *N. ulukaliana* in the Genting Highlands (see there).

Distribution and ecology: *Nepenthes sericea* has been recorded with certainty only from the north-central Titiwangsa Range and is best known from the Cameron Highlands. It ranges from at least Gunung Yong Yap (2168 m) in the north to the Cameron Highlands area (e.g. Gunung Berembun, Gunung Brinchang, Gunung Irau, Gunung Jasar, and Gunung Terbakar) in the south, a span of *ca.* 35 km, and has been documented from more than twenty peaks (Fig. A10). The northern extent of its range may be limited by the seasonal climate of the northern Titiwangsa Range, but its occurrence in this region is largely unknown due to a lack of botanising. The species is generally found above 1300 m and reaches the upper limit of its elevational range on the summit of Gunung Korbu (2183 m), the highest peak of the Titiwangsa Range.

This species grows terrestrially or as an epiphyte in mossy forest and summit scrub. Lower pitchers often developed embedded in a thick layer of *Sphagnum* moss (Fig. A110). During our visit to Gunung Brinchang (2032 m) and Gunung Warpu (1745 m) in August 2022, many dried pitchers were observed, possibly indicative of seasonality or a sensitivity to a dry spell prior to our visit. An earlier visit made by G. Lim to Gunung Brinchang in December 2014 found the same population of plants with healthy



Figures A85 (above left) and Figure A86 (above right): *Nepenthes sericea* (Gunung Warpu). Intermediate pitchers (above left by Andreas Wistuba, above right by Stewart McPherson).



Figure A87 (above left): *Nepenthes sericea* (Gunung Brinchang). Dark-coloured intermediate pitcher growing among *Sphagnum* moss (Andreas Wistuba). **Figure A88 (above right):** *Nepenthes sericea* (Gunung Yong Belar). Trio of intermediate pitchers (Christophe Maerten).



Figure A89 (above left): *Nepenthes sericea* (Gunung Warpu). Speckled early-stage upper pitcher (Andreas Wistuba).
Figure A90 (above right): *Nepenthes sericea* (Gunung Brinchang). Cylindrical and distinctly flared upper pitcher (Stewart McPherson).



Figures A91 (above left) and A92 (above right): *Nepenthes sericea* (Gunung Brinchang). Almost entirely white cylindrical upper pitchers (above left by Alexey Yakovlev, above right by Gideon Lim).



Figures A93 (above left) and A94 (above right): *Nepenthes sericea* (Gunung Yong Belar). Cylindrical upper pitchers exhibiting variable red pigmentation (above left by Kenneth Hiew, above right by Christophe Maerten).



Figure A95 (above left): *Nepenthes sericea* (Gunung Yong Belar). Upper pitchers somewhat intermediate between typical distally cylindrical and wholly infundibular aerial traps (Kenneth Hiew). **Figure A96 (above right):** *Nepenthes sericea* (Gunung Warpu). Broadly infundibular upper pitcher (Michal Golos).

upper pitchers, including numerous cylindrical upper pitchers, at the height of the rainy season. Yeo (1996) reported many dead plants in exposed areas during a visit to the Cameron Highlands.

The upper pitchers of this species are notably dimorphic, being either infundibular throughout or infundibular in the basal portion and cylindrical above (see “Upper Pitcher Dimorphism” in Discussion section).

Natural hybrids: This species is often sympatric with *Nepenthes sanguinea* and natural hybrids are not uncommon; several were documented as part of this research on Gunung Warpu (Figs. A117–119) and records from other localities can be found in the literature (e.g. Gunung Jasar; Clarke, 2002:22, fig.).

Prey, infauna, and other associated organisms: Ants were commonly observed on the underside of the lid, often walking on the lid hairs without making contact with the lid surface (Figs. A107–109). Their movement appeared to be slightly impeded by the hairs, but they did not appear to represent major prey at that time. Repeated striking of the lid from above to emulate raindrops failed to dislodge any ants from the lower surface, a test that was undertaken in light of observations made by Bauer *et al.* (2012b), which demonstrated how raindrops can ‘flick’ insects into the traps of *Nepenthes gracilis*.

Schmid-Hollinger (1997) documented prey found in the pitchers of *Nepenthes macfarlanei s.lat.* on Gunung Brinchang (= *N. sericea*). He found that in many lower pitchers ants were “by far” the dominant prey, though the diet of these terrestrial traps also included a notable number of larger prey items (all found multiple times): short- and long-legged centipedes (orders cf. Scolopendromorpha and Scutigleromorpha, respectively), cockroaches (genus cf. *Ectobius*), and unidentified beetles, mites, and spiders (though he noted that the last two might have been dead infauna). With the exception of ants, these findings mirror our own somewhat limited field observations. Prey from one partly senescent lower pitcher of *N. sericea* on Gunung Warpu included a centipede and the remains of two long-legged crickets (suborder Ensifera; Fig. A114); ants and small dipterans were found in other pitchers (M. Golos & F. Mey, pers. observ.). Similarly, we observed a number of sizeable prey items in the pitchers of *N. berbulu* at its type locality, including a beetle, a spider, a scutigleromorph centipede, and several dead Tenebrionidae larvae, the latter all found in a single pitcher (see Tan *et al.*, 2023).

The microhylid frog *Kalophrynus yongii* is reported to breed in the pitchers of *Nepenthes macfarlanei s.lat.* on Gunung Brinchang in the Cameron Highlands (Matsui, 2009); this record must presumably relate to *N. sericea*. Eggs and larvae were found in a large pitcher, the eggs attached to the inner surface above the fluid level.

Schmid-Hollinger (N.d.) observed a larva (possibly of a hoverfly) living in the digestive fluid of *Nepenthes macfarlanei s.lat.* on Gunung Brinchang (= *N. sericea*). Hoverflies have been observed visiting the flowers, particularly around noon (R. Schmid-Hollinger, pers. comm.). A similar infaunal larva was observed by us in an upper pitcher of *N. berbulu* (see Tan *et al.*, 2023:34, fig. 17B).

Schmid-Hollinger (2010) reported an example of an ‘ant garden’ in an old, largely dried upper pitcher of *Nepenthes macfarlanei* in the Cameron Highlands (= *N. sericea*). The small black ants (likely a species of *Crematogaster*) had built their nest inside, sealing off the top of the pitcher with a grey organic mass that appeared to consist of processed leaves overgrown with fungi, leaving only a small entrance hole. Additional holes had been cut into the base of the pitcher hollow, near the tendril. When disturbed, ant workers immediately brought their brood outside, carrying it on the outside of the dried pitcher. Similar ant gardens have been observed in dead or dying pitchers of *N. cornuta* in Mindanao, the Philippines, and *N. maxima* in West Papua, Indonesia (Gronemeyer *et al.*, 2014).

Conservation status: *Nepenthes sericea* has been documented from more than twenty peaks across a span of *ca.* 35 km in the north-central part of the Titiwangsa Range, centred on the border regions of Kelantan, Perak, and Pahang. It has a broad elevational distribution of at least 1300–2183 m and could be inferred to occur on any number of lesser peaks and ridges between its known strongholds. As such, the species is tentatively assessed as LC (*Least Concern*) against the IUCN 3.1 Red List criteria (IUCN, 2012).

This assessment is made with the caveat that ongoing development in Peninsular Malaysia’s highlands (see Leong, 1992; Razali *et al.*, 2018), coupled with a measurably warming climate and associated



Figure A97 (above left): *Nepenthes sericea* (Gunung Warpu). Upper pitcher with significant ventral gibbosity (Andreas Wistuba). **Figure A98 (above right):** *Nepenthes sericea* (Gunung Warpu). Unusually narrow upper pitcher (Andreas Wistuba).

changes in patterns of precipitation, may threaten the long-term survival of this species across the entirety of its range.

Certain populations of *Nepenthes sericea* are threatened with agricultural development, especially at the species' type locality on Gunung Warpu, Lojing Highlands, Kelantan, and other nearby peaks. The local guides call the entrance to this mountain *Pintu Kebun Sayur*, Malay for 'Vegetable Farm Gate', in reference to the vegetable patches leading to the trail head, which is just an hour's trek on foot from where the holotype was collected. Standing on the summit of Gunung Warpu during our expedition in August 2022, we observed large swathes of nearby land being clear cut in preparation for agricultural plantations. The Lojing Highlands and the neighbouring Cameron Highlands make ideal locations for the farming of high-value crops like white corn, strawberries, and other ornamentals that favour cool conditions and which cannot be grown in lowland Peninsular Malaysia. Erosion as a result of development causes frequent landslides, which can result in significant loss of habitat when slopes collapse above the areas closest to human activities (see Abdullah, 2022; SAI Malaysia, N.d.).

Additional specimens examined: Gunung Berembun, no elevation data, November 1908, Ridley *s.n.* (SING!) [stem with lower pitchers; tentatively identified as *N. macfarlanei* × *N. sanguinea* by B.H. Danser, August 1927]; Gunung Korbu, 6000 ft [≈1830 m], June 1913 [should be February–



Figure A99 (above left): *Nepenthes sericea* (Gunung Brinchang). Typical infundibular upper pitcher (Alastair Robinson). **Figure A100 (above right):** *Nepenthes sericea* (Gunung Warpu). Dwarfed upper pitcher (François Mey).



Figure A101 (above): *Nepenthes sericea* (Gunung Warpu). Climbing stem with upper pitcher (Stewart McPherson).



Figure A102 (above left): *Nepenthes sericea* (Gunung Warpu). Typical lower and upper pitchers from the same population (Gideon Lim). **Figure A103 (above right):** *Nepenthes sericea* (Gunung Warpu). Detail of upper pitcher showing lid hairs and finely toothed peristome (Andreas Wistuba).

March, per Ridley, 1915a:43], *Robinson s.n.* [collected by Dyak collectors of the Federated Malay States Museum, per Ridley, 1915a:43] (MO!) [stem with upper pitcher, stem with upper pitcher and male inflorescence; NB: lid hairs appear disproportionately long for species due to small size of pitchers, but measure only *ca.* 2 mm]; Gunung Terbakar, 4500 ft [≈1370 m], 9 June 1923, *Henderson FMS 10984* (SING! [2 sheets]) [stem with upper pitchers and female inflorescence (sheet 1); stem with upper pitcher (sheet 2)]; Rhododendron Hill [=Bukit Mentigi], 5100 ft [≈1550 m], 20 November 1925, *Henderson S.17874* (SING!), *S.17878* (SING!) [stem with lower pitchers (*S.17874*); stem with upper pitcher (*S.17878*)]; Rhododendron Hill [=Bukit Mentigi], 4500 ft [≈1370 m], 13 October 1929, *Symington 20927* (KEP!) [stem with upper pitchers]; Rhododendron Hill [=Bukit Mentigi], 5100 ft [≈1550 m], 2 April 1930, *Henderson S.23329* (BO!, NY!, SING!) [stem with upper pitcher, separate lidless lower pitcher (BO); stems with lower pitchers, stem with upper pitchers (NY); stem with lower pitchers (SING); NB: likely mixed collection—NY material is probably hybrid with *N. sanguinea*]; Gunung Berembun, 6000 ft [≈1830 m], 4 April 1930, *Holttum S.23404* (SING!) [stem with upper pitcher, pitcherless stem with infructescence, and separate leaf with intermediate pitcher]; Gunung Batu Gangan, 6250 ft [=1905 m], 20 May 1931, *Watson 11541* (KEP!, SING!) [stem with upper pitchers (KEP); stem with upper pitchers, separate leaf with upper pitcher (SING)]; Rhododendron Hill [=Bukit Mentigi], no elevation data, 24 May 1931, *Symington 20820* (KEP!) [stem with upper pitcher]; Batu Gaja [Gunung Brinchang?], no elevation data, 26 May 1931, *Symington 23885* (KEP!) [stem with lower pitchers]; [Gunung] Brinchang, mossy forest, no elevation data, 26 May 1931, *Symington 23896* (KEP!) [leaf with lower pitcher only; NB: lower pitcher very large at 28 cm tall (excluding lid)]; Gunung Batu Gangan, top [“*atas bukit*”], no elevation data, 10 August 1931, *Jaamat 25948* (KEP!, SING!), *27026* (KEP!) [stem with lower pitchers (*25948* KEP); rosettes with pitchers (*25948* SING); stem with upper pitchers, pitcherless stem with male inflorescence (*27026*)]; Gunung Korbu, “summit” [satellite peak given low elevation?], 5000 ft [≈1520 m], 22 July 1933, *Symington 32123* (KEP!) [two stems, each with upper pitcher and female inflorescence]; Gunung Korbu, ridge, *ca.* 5500 ft [≈1680 m], 22 July 1933, *Symington 32137* (KEP!) [stem with upper pitchers and male inflorescence]; Gunung Korbu, mossy forest, 6000 ft [≈1830 m], 22 July 1933, *Symington 32220* (KEP! [2 sheets]) [stem with upper pitcher and male inflorescence, separate leaf with intermediate pitcher (sheet 1); stem with intermediate pitcher, stem with upper pitchers (sheet 2)]; Gunung Korbu, open ridge, 6000 ft [≈1830 m], 22 July 1933, *Symington 32221* (KEP!) [stem with upper pitchers and developing inflorescence]; Gunung Terbakar, summit, no elevation data, 12 April 1934, *Symington 36226* (KEP!) [two stems, each with upper pitcher and infructescence]; Gunung Irau, no elevation data, 14 April 1934, *Symington 36546* (KEP!) [stem with upper pitcher and male inflorescences; “pitchers like candles set on the tops of gnarled trees around the summit”]; Gunung Brinchang, ridge forest, *ca.* 6500 ft [≈1980 m], 15 May 1936, *Holttum S.31275* (SING!) [stem with upper pitcher; NB: upper pitcher very large at 26 cm tall (excluding lid)—label states it was taken from “largest plants”]; Gunung Brinchang, summit, 6665 ft [=2031 m], 16 May 1936, *Holttum S.31274* (SING!) [stem with upper pitcher and male inflorescence, separate upper pitcher]; Gunung Korbu, 7160 ft [=2182 m], 1 February 1938, *Strugnell 45891* (KEP!) [stem with upper pitchers and male inflorescence]; Gunung Raya, top [“*atas bukit*”], no elevation data, 19 June 1938, *Sow 47175* (KEP!) [stems with upper pitchers and male inflorescences]; Gunung Perdah, slopes of, no elevation data, 26 February 1948, *Allen s.n.* (SING!) [pitcherless stem with infructescence,

separate leaf with lower pitcher]; Gunung Jasar[?], top, secondary growth of felled elfin forest, 5000 ft [\approx 1520 m], 24 December 1949, *Wyatt-Smith KEP 66582* (KEP!) [stem with upper pitchers and infructescence]; [Gunung] Brinchang, exposed summit ridge, 6660 ft [=2030 m], 1 September 1956, *Burkill HMB 787* (L!, SING!) [stem with lower pitchers (both sheets)]; G Brinchang, near summit, cloud forest, 1950 m, 21 July 1961, *Nicolson 1188* (US!, with attached habitat photo taken 27 July 1961) [stem with upper pitcher, separate upper pitcher, stem with male inflorescence]; Gunung Brinchang, near rain shelter adjacent to Telecom Station, near top, 4°31'N 101°17'E [*sic*], 6666 ft [=2032 m], 18 June 1962, *Abbe & Abbe 10296* (A!) [pitcherless stem]; Gunung Brinchang, 6000–6600 ft [\approx 1830–2010 m], 4 May 1964, [*collector not stated*] 8019 (NLU!) [stem with upper pitcher]; Gunung Brinchang, summit, mossy forest, 6500 ft [\approx 1980 m], May 1965, *Stone 5671* (SING!) [stems with upper pitcher, pitcherless stem with infructescence]; Gunung Brinchang, montane ericaceous forest, 6666 ft [=2032 m], 3 March 1968, *Ng FRI 5981* (L!) [stem with upper pitcher]; Gunung Brinchang, 6400 ft [\approx 1950 m], 19 February 1969, *Stone 8396* (L!, NLU! [2 sheets]) [two stems with upper pitcher(s), pitcherless stem with male inflorescence, separate leaf with lower pitcher (L); stem with upper pitchers and male inflorescence, pitcherless stem (NLU sheet 1); pitcherless stem (NLU sheet 2)]; Gunung Brinchang, near summit, heath forest, 1900 m, 17 January 1970, *Anderson 2936* (MO!, NLU!, RSA!) [stem with upper pitcher (MO); leaf with lower pitcher



Figure A104 (above): *Nepenthes sericea* (Gunung Warpu). Detail of lid hairs of lower pitcher (Andreas Wistuba).

(NLU); stem with lower pitcher, separate leaf with upper pitcher, separate infructescence (RSA)]; Gunung Brinchang, summit, ca. 6664 ft [=2031 m], 20 July 1973, *Carlquist 4433* (RSA!) [stem with upper pitchers and male inflorescence]; Gunung Jasar, path to, near top, no elevation data, 23 August 1977, *Kochummen FRI 19070* (L!) [stem with upper pitcher and male inflorescence]; Gunung Brinchang, 6000–6650 ft [≈1830–2030 m], 22 March 1987, *Worthington 12645* (L!, MO!, NY!) [stem with upper pitcher and male inflorescence (L); stem with upper pitcher and female inflorescence (MO); pitcherless stem with male inflorescence, separate leaf with upper pitcher (NY)]; Gunung Brinchang, peak, low vegetation, no elevation data, 2 May 1987, *Kiew RK 2598* (KEP!) [pitcherless stem with male inflorescence, separate leaf with upper pitcher]; Gunung Brinchang, ca. 6000 ft [≈1830 m], 18 November 1988, *Jackson s.n.* (RSA!) [stem with upper pitcher]; Gunung Brinchang, upper montane, 2800 m [*sic!*], 28 April 1993, *Chua FRI 38815* (KEP!) [stem with lower pitchers]; Gunung Jasar, open padang sandstone, amidst bamboo and rhododendron, 2000 m [*sic!*], 28 April 1993, *Chua FRI 38825* (KEP!) [stem with lower pitchers]; Cameron Highlands [near Gunung Siku], near road leading to Simpang Pulai, montane forest, summit, 4°35.18'N 101°23.33'E, 1482 m, 3



Figure A105 (above left): *Nepenthes sericea* (Gunung Brinchang). Sparse lid hairs of older intermediate pitcher (Andreas Wistuba). **Figure A106 (above right):** *Nepenthes sericea* (Gunung Brinchang). Lid underside of lower pitcher; note distribution of nectar glands. Lid hairs are poorly visible due to angle of light (Stewart McPherson).



Figures A107 (above left) and A108 (above right): *Nepenthes sericea* (Gunung Warpu). Ants walking on outside of lid hairs without making direct contact with lid surface (Michal Golos).

February 2007, *Saw FRI 48200* (KEP! [2 sheets]) [stem with upper pitchers (sheet 1); stem with upper pitcher and male inflorescence (sheet 2)]; Gunung Brinchang, trail to, primary montane forest, epiphyte on tree, 4°30.56'N 101°22.58'E, 1995 m, 22 May 2007, *Rosdi FRI 58758* (KEP!, SING!) [stem with lower pitcher(s) (both sheets)]; Gunung Irau [specifically 'Mini Irau'], top, primary montane forest, slope, on top of tree canopy, 4°31.80'N 101°22.37'E, 2034 m, 18 November 2009, *Imin FRI 68465* (KEP!) [stem with upper pitcher and infructescence]; Gunung Brinchang, new trail, from Parking Trail to Gunung Irau going down to Brinchang, on tree trunk, slightly shady, steep, 4°31.18'N 101°23.31'E, 1960 m, 26 April 2017, *Imin FRI 87122* (KEP!) [stem with lower pitcher]; [Gunung Brinchang], montane forest at summit, 4°31.18'N 101°23.31'E, 1960 m, 26 April 2017, *Wan Syafiq FRI 89162* (KEP!) [stem with upper pitchers]; Gunung Korbu, last water point, primary lower montane forest, on tree, 4°39.38'N 101°16.25'E, 1317 m, 4 July 2019, *Wan Syafiq FRI 94520* (KEP! [2 sheets], with attached habitat photo) [stem with upper pitcher (sheet 1); pitcherless stem with leaf, separate intermediate pitcher (sheet 2)].

Indeterminate material: “Malacca” [but see “Notes on specimens examined”], no elevation data, 188? [presumably 1884–1888; see Burkill, 1927:116], *Alvins s.n.* (SING!) [leaf with lower pitcher only; tentatively identified as *N. macfarlanei* × *N. sanguinea* by B.H. Danser, August 1927]; Cameron Highlands, no further locality data, no elevation data, no date [presumably 1940s–1960s], *Wyatt-Smith CH9* (KEP!) [seedling with pitchers]; Gunung Tahan, along trail from Camp Belumut to Camp Bonsai, tropical upper montane forest, 4.38°N 102.12°E, 1270 m, 7 August 1996, *Chua FRI 26664* (KEP! [2 sheets]) [stem with upper pitcher (sheet 1); stem with lower pitcher (sheet 2)].

Notes on specimens examined: Material from Gunung Jasar (1696 m) (*Chua FRI 38825*, KEP!; *Kochummen FRI 19070*, L!; *Wyatt-Smith KEP 66582*, KEP!) is highly unusual and may represent natural hybrids between *Nepenthes sanguinea* and *N. sericea* (cf. Clarke, 2002:22, fig.). However, the mention of a “big population” on the herbarium label of *Chua FRI 38825* argues against a hybrid identity. Citizen science photos suggest that comparable plants are not uncommon on Gunung Jasar. We have tentatively included this material under *N. sericea*, but further investigations of the *Nepenthes* flora of this mountain are warranted.

One anomalous specimen from Gunung Tahan (*Chua FRI 26664*, KEP! [sheet 1]), apparently matching the description of *Nepenthes sericea* in its broadly infundibular upper pitcher and relatively short lid hairs, is difficult to explain. We are aware of no other comparable material from this region. Clarke & Lee (2012:48) assigned this collection number to *N. gracillima*, which the second sheet (bearing a lower pitcher) is consistent with.

The collection locality of “Malacca” for *Alvins s.n.* (SING! [#93974]) is almost certainly wrong. The highest point in the modern state of Malacca (which is co-extensive with the Straits Settlement of the same name that preceded it) is Bukit Bemban at only 503 m; to the best of our knowledge, no highland *Nepenthes* have been recorded from the state.



Figure A109 (above left): *Nepenthes sericea* (Gunung Warpu). Ants walking on dense indumentum of fine hairs to access nectaries on lower surface of lid (Michal Golos). **Figure A110 (above right):** *Nepenthes sericea* (Gunung Brinchang). Lower pitcher embedded in *Sphagnum* moss (Rudolf Schmid-Hollinger).

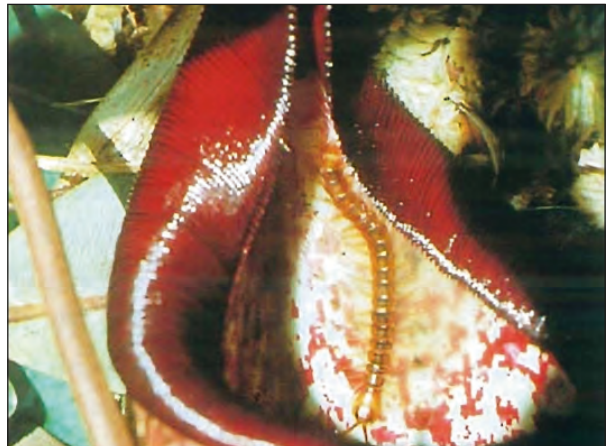


Figure A111 (above left): *Nepenthes sericea* (Gunung Brinchang). Cockroach (cf. *Ectobius* sp.) caught by lower pitcher (Rudolf Schmid-Hollinger). **Figure A112 (above right):** *Nepenthes sericea* (Gunung Brinchang). Centipede (cf. *Scolopendromorpha*) caught by lower pitcher (Rudolf Schmid-Hollinger).



Figure A113 (above left): *Nepenthes sericea* (Gunung Brinchang). Long-legged centipede (*Scutigleromorpha*) caught by upper pitcher (Rudolf Schmid-Hollinger). **Figure A114 (above right):** *Nepenthes sericea* (Gunung Warpu). Remains of at least two long-legged crickets caught by lower pitcher (Michal Golos).



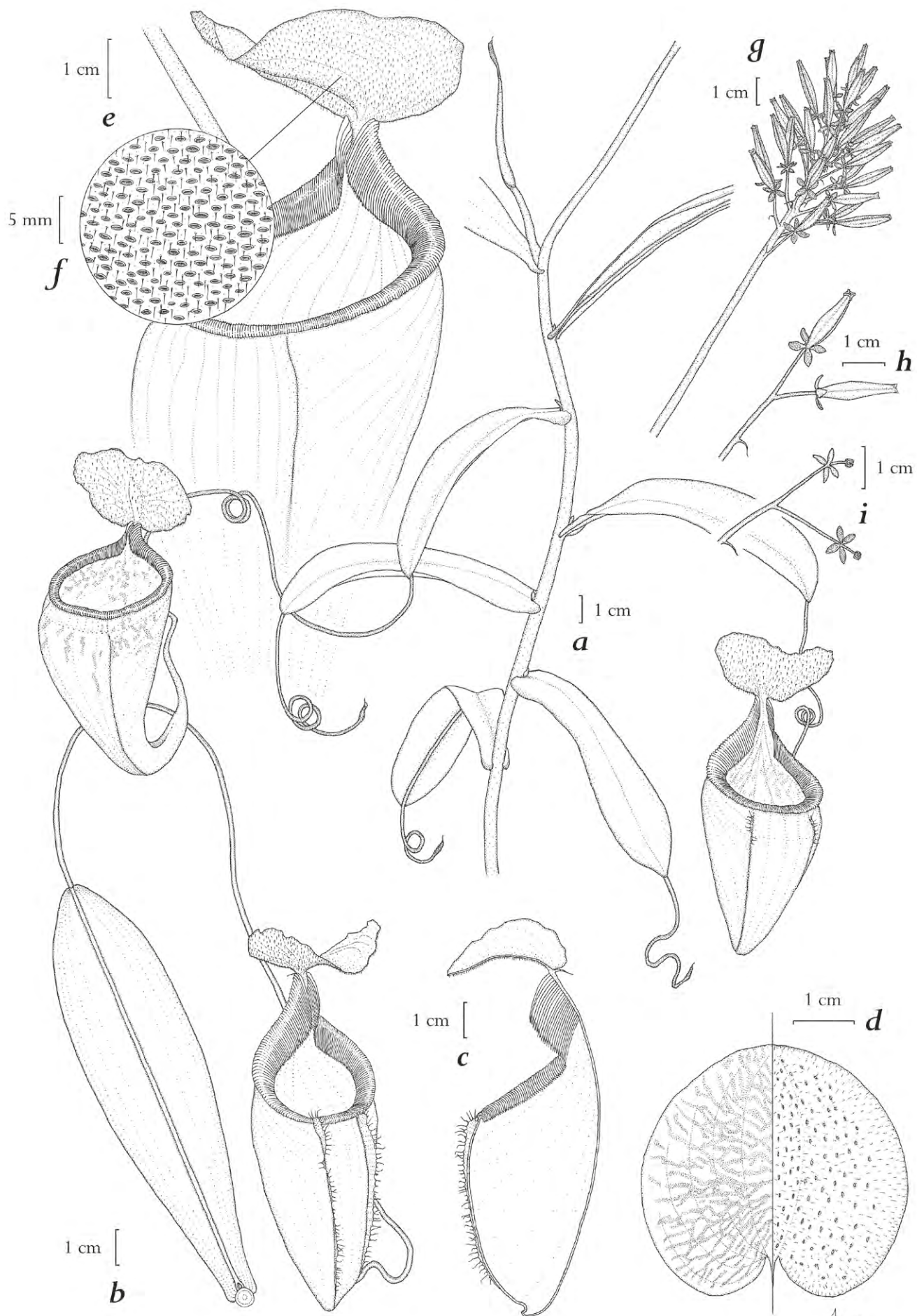
Figure A115 (above): *Nepenthes sericea* (Gunung Warpu). Aged upper pitcher with conspicuous leaf miner damage; note ants drinking nectar from marginal nectaries of peristome and glands on underside of lid (Michal Golos).



Figure A116 (above left): *Nepenthes sericea* (Gunung Warpu). Detail of stem and laminae; note indumentum of former (Stewart McPherson). **Figure A117 (above right):** Lower pitcher of putative cross between *Nepenthes sanguinea* and *N. sericea* on Gunung Warpu (Michal Golos).



Figure A118 (above left): Two young plants of putative *Nepenthes sanguinea* \times *N. sericea* on Gunung Warpu (François Mey). **Figure A119 (above right):** Upper pitchers of *Nepenthes sanguinea* (right) and putative cross with *N. sericea* growing sympatrically on Gunung Warpu (Gideon Lim).



Nepenthes ulukaliana A.S.Rob., Wistuba, Mey, Golos, G.Lim & S.McPherson, *spec. nov.* (Figs. A120–144)

Holotype: Pahang, Gunung Ulu Kali, primary lower montane forest, 3°26.21'N 101°47.11'E, 1707 m, 16 February 2007, *Julius FRI 54894* (KEP! [#144426]) [stem with three upper pitchers and two male inflorescences].

- *N. macfarlanei* sensu Ridley (1924:24), Danser (1928:323), Shivas (1984:35), Jebb & Cheek (1997:57), Cheek & Jebb (2001:91), Clarke (2001:158), Clarke (2002:21), McPherson (2009a:599), Cheek & Jebb (2012:263) & McPherson & Robinson (2012:35), *partim* (see *N. macfarlanei*)
- *N. macfarlanei* × *N. sanguinea* sensu Danser (1928:324) = *N. gracillima*, *N. sericea* & *N. ulukaliana*

Diagnosis: *Nepenthes ulukaliana* differs from *N. macfarlanei* in having (differences in parentheses) pitchers with dense indumentum of filamentous lid hairs ≤ 1 mm long (vs. pitchers with numerous thickened lid hairs 5–12 mm long), amphora-shaped to urceolate lower pitchers (vs. ovoid in the basal portion with a faint hip, cylindrical above), and peristome planar at front with well-defined column arising abruptly and perpendicularly at rear (vs. curved in lateral aspect with column arising gradually).

Description: Terrestrial or epiphytic, erect, subscaudent or climbing shrub, up to several metres tall. *Stems* terete to slightly angular, 6–10 mm in diameter. Internodal length 8–25 mm in rosettes, 20–55 mm in climbing stems. *Leaves* sessile, coriaceous. Lamina oblanceolate to oblong, 12.1–26 cm long, 2.7–5.6 cm wide, apex acute to rounded, often slightly emarginate, base cordate, clasping stem for half to more than $\frac{3}{4}$ of its circumference, vernation convolute, 2–3 longitudinal veins on either side of midrib, tendrils supporting lower pitchers *ca.* 30–50 cm long, 2–5 mm wide, uncoiled; those supporting upper pitchers *ca.* 15–23 cm long, 3–5 mm wide, coiled at least once. *Rosette pitchers* variable in shape, \pm ovoid throughout with faint medial hip, wings well-developed. Peristome subcylindrical. *Lower to intermediate pitchers* wholly amphora-shaped to urceolate, often appearing swollen in upper portion, with hip within 3 cm of peristome, 14–25 cm tall, ventrally up to 5.6–8.5 cm wide, widest at the hip, laterally up to 5.7–7.5 cm wide, wings up to *ca.* 5 mm wide, running full length of ventral surface or restricted to upper portion, with sparse fringe elements. Mouth round to ovate, peristome generally conspicuously flattened, planar and near-horizontal to oblique at front, rising abruptly and perpendicularly at rear to form pronounced column, 5–15 mm wide at front, 7–22 mm wide at column, ribs *ca.* 0.3 mm high, teeth *ca.* 1 mm long. Lid orbicular to sub-orbicular, 45–75 mm long, 50–83 mm wide, held \pm horizontally, lower surface with fine hairs *ca.* 1 mm long, of equal length

Figure A120 (facing page): *Nepenthes ulukaliana* A.S.Rob., Mey, Golos, Lim, Wistuba & S.McPherson (a) Habit with upper pitchers (b) Rosette leaf with lower pitcher (c) longitudinal section of a lower pitcher showing peristome structure and pronounced column (d) Upper (left) and lower (right) surfaces of a pitcher lid (e) Close-up of upper pitcher showing lid underside and mouth (f) Detail of lid underside showing hairs and glands (g) Infructescence (h) Ripening seedpods; note position of bract away from base of partial peduncle (i) Male flowers; note basal bract. Based on the type material, additional voucher specimens, as well as photographs and measurements made *in situ* on Gunung Ulu Kali (density of lid hairs reduced for clarity). Illustration by Alastair Robinson.

throughout, evenly distributed, absent only from extreme margins, crateriform glands 0.3–0.6(–1) mm in diameter densely but usually \pm evenly distributed across entire lower surface, sometimes concentrated apicomediaally or even confined therein. Pitcher interior glandular in basal *ca.* 90%. Spur simple, filiform, (1–)7–8(–13) mm long, apex acute. *Upper pitchers* wholly infundibular with hip absent or located up to 2 cm below peristome, 17–18 cm tall, ventrally up to 6.0–6.7 cm wide, widest at hip (if present), laterally up to 5.8–6.2 cm wide. Mouth round to ovate, peristome subcylindrical, 2–9 mm wide at front, 4–15 mm wide at column, ribs conspicuous, striate, fine, teeth *ca.* 0.5 mm long. Lid sub-orbicular, 45–70 mm long, 51–62 mm wide, held \pm horizontally, lower surface as in lower pitchers but glands at lower density. Pitcher interior glandular in basal *ca.* 96%. Spur simple, filiform, 0–6 mm long, apex acute. *Inflorescence* a racemoid panicle. Male inflorescence *ca.* 44 cm long, peduncle *ca.* 12 cm long, rachis *ca.* 32 cm long, bearing *ca.* 225 flowers on 2-flowered partial peduncles, bracts prominent, basal, simple, filiform, consistently produced. Tepals *ca.* 4 mm long by 3 mm wide. Seeds *ca.* 1 cm long. Female inflorescence usually significantly shorter and less floriferous, bracts as in male flowers but situated closer to ramification of partial peduncle. *Indumentum* of rufous hairs *ca.* 0.5 mm long at base of lower pitchers and on associated tendrils; leaves, upper pitchers, and their associated tendrils appearing glabrous. *Colour* of lower pitchers yellowish green, sometimes with a reddish hue, mottled with brown, dark red, or purple. Peristome often yellow with diffuse reddish banding. Upper surface of lid similar to pitcher body though often with finer mottling. Upper pitchers basally green, yellow to creamy white above, sometimes with sparse reddish speckling, particularly in early-stage aerial traps. Peristome often white with reddish stripes.

For a description of leaf anatomy, see Ghazalli *et al.* (2021), where this species is treated under the name *Nepenthes macfarlanei*.

Etymology: The specific epithet refers to Gunung Ulu Kali, the *locus classicus* of this taxon. Owing to its accessibility and proximity to the Genting Highlands complex, the population on this mountain is undoubtedly the most visited of any species of the *Nepenthes macfarlanei* group and the source of the greatest number of herbarium specimens worldwide.

Phenology: *Nepenthes ulukaliana* flowers throughout the year, though with variable frequency. A two-year study carried out in 1993–1995 on Gunung Purun (*ca.* 1700 m) in the Genting Highlands found a periodicity to the flowering events, particularly in female plants, with a clear peak in anthesis observed around January (Chua, 1995:81–83, 103–105, 2000a). It should be noted, however, that the population on Gunung Purun was located *ca.* 1 km from major development works at the Genting Highlands complex and therefore likely subject to significant disturbance (Chua, 1995:104).

Distribution and ecology: This species is known from at least eight peaks in the southern Titiwangsa Range, ranging from Gunung Ulu Semangko in the north to the Genting Highlands area (Gunung Lari Tembakau, Gunung Mengkuang, Gunung Purun, and Gunung Ulu Kali) in the south, a span of just over 30 km (Fig. A10). In the intervening regions, it has been recorded on several mountains along the spine forming the Pahang–Selangor border, including Bukit Tunggul (1663 m), Gunung Hulu Bakau



Figure A121 (above): *Nepenthes ulukaliana* (Gunung Ulu Kali). Rosette plant bearing ovoid pitchers; note difference in shape as compared to mature lower pitchers of this species (François Mey).



Figure A122 (above left): *Nepenthes ulukaliana* (Gunung Ulu Kali). Short-stemmed plant with lower pitchers; note convolute vernation of developing leaf (François Mey). **Figure A123 (above right):** *Nepenthes ulukaliana* (Gunung Ulu Kali). Longer-stemmed plant still bearing lower pitchers (François Mey).



Figure A124 (above): *Nepenthes ulukaliana* (Gunung Ulu Kali). Short-stemmed plant with lower pitcher growing among fallen branches of *Dacrydium comosum*, a dominant element of the local summit vegetation (François Mey).

(1347 m), and Gunung Rajah (1685 m). Cheek & Jebb (2012) gave Gunung Nuang (1493 m), located ca. 20 km SSE of the Genting Highlands, as the southern limit of *Nepenthes macfarlanei* s.lat. (and therefore presumably *N. ulukaliana*), but we have been unable to confirm this record; it is possible that it stems from confusion with Gunung Mengkuang (1424 m), as the similar Gunung Menuang Gasing is another name for Gunung Nuang. The species' presence on Gunung Ulu Semangko is based on herbarium material, all of which dates from the early 20th century; the authors were only able to observe *N. sanguinea* at that locality in 2022. *Nepenthes ulukaliana* generally occurs above 1200 m and reaches its highest known elevation of 1772 m on the summit of Gunung Ulu Kali.

The distribution map for *Nepenthes macfarlanei* s.lat. in Cheek & Jebb (2012:265) indicates an outlying population of this taxon south of Kuala Lumpur. This appears to stem from confusion surrounding herbarium material of *N. ulukaliana* from Bukit Tunggul (1663 m), a peak just north of the Genting Highlands (e.g. *Wyatt-Smith* KEP 94563, KEP!, L! & 94569, KEP!, SING!), as the same toponym is applied to a hill of only 278 m elevation at 2°52.4'N 101°44.9'E, corresponding to the location indicated on the map; there is no terrain in the region of suitable elevation to support a species of the *N. macfarlanei* group.

Nepenthes ulukaliana grows terrestrially and epiphytically in mossy forest and is commonly encountered in areas of disturbance such as roadsides. It is one of the most conspicuous and dominant elements of the summit flora of Gunung Ulu Kali (see Null, 1972:88, 195 and Stone, 1981:19, 34 for importance indices). Kiew (1990) recorded that plants on Gunung Ulu Kali produce an average of two pitchers per year (range of one to four), with only 38% of leaves producing pitchers, and that the pitchers have a mean lifespan of 4 months. On average, plants bore one pitcher (range of none to three) at any one time. All of these numbers were smaller than those recorded for sympatric *N. ramispina* (see Kiew, 1990). This may represent an artefact of prevailing weather conditions during the period of observation, as observations by the authors in several different years since have found numerous plants with 3–5 active pitchers.

Natural hybrids: This species is often sympatric with *Nepenthes ramispina* and *N. sanguinea*, which are abundant in the same habitat, and hybridises with both (Figs. A144–146). Multiple authors have suggested that natural hybrids between these three species may locally outnumber their parent species. In particular, visitors to the Genting Highlands in the 1980s and '90s often reported a large proportion of hybrids in highly disturbed roadside populations (e.g. in the late 1980s by A. Wistuba, pers. observ.) and the site was renowned among *Nepenthes* enthusiasts at the time for its supposed hybrid swarms. Contrary to this, the vast majority of the plants we observed on Gunung Ulu Kali in 2022 appeared to represent 'pure' species. It is possible that large hybrid stands are found elsewhere or that those observed in decades past have since been destroyed or died out.

Prey, infauna, and other associated organisms: Bourke (2003) reported finding surprisingly few ants in the pitchers of this species, though ants were otherwise conspicuous in the surrounding mossy forest habitat; the few prey items observed consisted mostly of small flying insects.

The digestive enzymes of *Nepenthes ulukaliana* (under the name *N. macfarlanei*) were studied by Tökés *et al.* (1974) and Wang (2009). The pitcher fluid in both unopened (pH 3.2 ± 0.4) and opened pitchers (pH 2.1–2.8) was found to be significantly more acidic than that of other tested *Nepenthes* species, with an unusually small decrease in pH after opening (Tökés *et al.*, 1974; Juniper *et al.*, 1989:193). Nevertheless, a variety of commensal yeasts have been reported from pitcher fluid of this species sampled in the Genting Highlands (Shivas & Brown, 1989; see also Bittleston, 2018). During our observations, a live caterpillar was found above the fluid level in a lower pitcher (G. Lim, pers. observ.).

The flowers of *Nepenthes ulukaliana* are visited by a diverse guild of arthropods, including flies, wasps, bees, plant hoppers, ants, cockroaches, spiders, and even crabs; only some of these, particularly flies, are likely to be potential pollinators (see Chua, 1995:207–208, 2000b).

Conservation status: The construction and progressive expansion of the Genting Highlands complex on the summit area of Gunung Ulu Kali since the late 1960s (see Kiew, 1985; Kiew *et al.*, 1985; Barlow, 1992) has undoubtedly had a significant impact on the local population of this species. In a reassessment of the mountain's summit flora conducted 25 years after the previous study of its kind, Chua & Saw (2001) concluded: "The changes in species composition clearly indicate that there have been immense environmental changes at Gunung Ulu Kali." Brearley (2021) reported surprisingly high concentrations of both foliar nitrogen and lead from roadside *Nepenthes ulukaliana* on Gunung Ulu Kali, which he suggested might be attributable to local automobile traffic.

Another threat is posed by collection for the commercial plant trade. Kiew (1985) wrote that plants of *Nepenthes macfarlanei s.lat.* in cultivation at the time were most likely to be sourced from Gunung Ulu Kali. In the period 1988–1993, only three CITES-recorded plants were traded under this name (surely a gross underestimate given the more than 64,000 unidentified *Nepenthes* species recorded during the same time; see Simpson, 1995:114). In 1995, 100 live plants of *N. macfarlanei s.lat.* are known to have been exported to the United Kingdom alone, though this figure likewise only reflects legal trade (Clarke, 2001:240).

Nepenthes ulukaliana would certainly satisfy the IUCN 3.1 Red List VU (*Vulnerable*) criteria A2acde+4cde (IUCN, 2012) if assessed on its Gunung Ulu Kali populations alone, as a direct result of advanced habitat clearance and conversion for various recreational development purposes. However, this assessment is problematic for several reasons: the clearance of habitat for the Genting Highlands has undoubtedly opened up ruderal habitat niches for all *Nepenthes* species that occur there, though the longevity of such habitat as it achieves a climax vegetation state over time is poorly understood; the Genting Group has been proactive in creating a conservation facility aimed at protecting some of the peak's native flora, including *Nepenthes*, which are removed and transplanted from areas that face destruction where possible (see Lim, 2016), though it is difficult to ascertain the effectiveness of this strategy as there have been observations of a large number of casualties throughout this process (E. Chan, pers. comm.); and finally the species is known from several geographically close peaks where development is minor or absent and where its numbers may thus remain stable. Accordingly, *N. ulukaliana* is assessed as NT (*Near Threatened*), with the recommendation that its populations be actively monitored.



Figure A125 (above): *Nepenthes ulukaliana* (Gunung Ulu Kali). Short-stemmed plant with distinctly amphora-shaped lower pitcher (Michal Golos).



Figure A126 (above left): *Nepenthes ulukaliana* (Gunung Ulu Kali). Typical infundibular lower pitchers (Andreas Wistuba). **Figure A127 (above right):** *Nepenthes ulukaliana* (Gunung Ulu Kali). Plant bearing lower pitchers that exhibit typical shape and colouration (François Mey).



Figures A128 (above left) and A129 (above right): *Nepenthes ulukaliana* (Gunung Ulu Kali). Typical lower pitchers in lateral (left) and ventral aspects (above left by François Mey, above right by Alastair Robinson).



Figure A130 (above left): *Nepenthes ulukaliana* (Gunung Ulu Kali). Lower pitcher exhibiting typical shape and colouration (Alastair Robinson). **Figure A131 (above right):** *Nepenthes ulukaliana* (Gunung Ulu Kali). Particularly large lower pitcher measuring 25 cm excluding the lid (Andreas Wistuba).

Additional specimens examined: Semangko Pass, 4000 ft [≈1220 m], 20 February 1904, *Burn-Murdoch s.n.* (SING!) [stem with upper pitcher and male inflorescence, separate leaf with upper pitcher; identified as *N. macfarlanei* by B.H. Danser, August 1927]; Semangko Pass, 4550 ft [≈1390 m], 20 February 1904, *Burn-Murdoch s.n.* [not H.N. Ridley as stated on new label] (SING!) [stem with upper pitcher; identified as *N. macfarlanei* by B.H. Danser, August 1927]; [Gunung] Ulu Semangko, top, no elevation data, 1904, *Ridley s.n.* (SING! [2 sheets]) [stem with upper pitcher and infructescence (sheet 1); stem with lower pitchers (sheet 2); identified as *N. macfarlanei* by B.H. Danser, August 1927]; Gunung [Ulu?] Semangko, 4000 ft [≈1220 m], April 1911 [per Danser, 1928:324], *Ridley 15562* (SING!) [pitcherless stem with male inflorescence, separate leaf with lower pitcher; tentatively identified as *N. macfarlanei* × *N. sanguinea* by B.H. Danser, August 1927]; Gunung Mengkuang, just south-west of, open ridge, 4900 ft [≈1490 m], 29 March 1959, *Wyatt-Smith KEP 79152* (KEP!) [stem with lower pitcher, stem with male inflorescence]; Bukit Tunggul, mountain top, primary forest, epiphyte, 5457 ft [=1663 m], 15 May 1960, *Wyatt-Smith KEP 94563* (KEP!, L!) [stem with upper pitcher and male inflorescence, stem with infructescence (KEP); stem with upper pitcher, separate stem (L)]; Bukit Tunggul, hill side, primary forest, 5300 ft [≈1620 m], 15 May 1960, *Wyatt-Smith KEP 94569* (KEP!, SING!) [stem with lower pitcher and infructescence (KEP); pitcherless stem with infructescence (SING)]; [Gunung] Ulu Kali, summit, forest dominated by *Dacrydium*, 5000–6000 ft [≈1520–1830 m], 4 April 1968, *Soepadmo HUM 9021* (L!) [stem with lower pitcher]; Gunung Ulu Kali, summit, *ca.* 6000 ft [≈1830 m; *sic!*], 7 March 1969, *Beauchamp 836* (RSA!) [stem with upper pitchers and male inflorescence]; Gunung Ulu Kali, 6000 ft [≈1830 m; *sic!*], 27 March 1969, *Stone 8422* (L!) [stem with male inflorescence, separate leaf with upper pitcher]; Gunung Ulu Kali, summit, montane elfin forest, 1620 m, 6 November 1969, *Anderson 2835* (MO!, NLU!, RSA! [2 sheets]) [stem with lower pitcher(s) (all sheets)]; Gunung Ulu Kali, near summit, montane elfin forest, 1600 m, 24 January 1970, *Anderson 2946* (MO!, NLU!, RSA!) [pitcherless stem with male inflorescence(s) (MO, NLU); stem with upper pitchers and male inflorescences (RSA)]; Gunung Ulu Kali, upper montane rainforest dominated by *Dacrydium comosum*, 5800 ft [≈1770 m], 24 March 1970, *Davidson 1144* (L!, RSA!), *1152* (RSA!), *1153* (RSA!) [pitcherless stem with male inflorescence (*1144* L); stem with upper pitcher and male inflorescence (*1144* RSA); pitcherless stem with female inflorescence, stem with upper pitcher (*1152*); separate lower pitchers (*1153*)]; Gunung Ulu Kali, ridge north of towers, dense mist forest, 5600 ft [≈1710 m], 30 January 1972, *Phillips 1296* (RSA! [2 sheets]) [stem with lower pitcher (sheet 1); pitcherless stem, separate lower pitcher (sheet 2)]; Gunung Ulu Kali, near wireless station, *ca.* 5800 ft [≈1770 m], 11 June 1973, *Shah & Ali MS 2961* (KEP!, SING!) [stem with lower pitcher (both sheets)]; Gunung Ulu Kali, summit, elfin thickets over peat, *ca.* 1700 m, 18 December 1973, *Sohmer 9025* (MO!, WIS!) [complete plant with roots and lower pitcher(s) (both sheets)]; Gunung Ulu Kali, dwarf montane forest, *ca.* 5000 ft [≈1520 m], 3 July 1977, *University of Hong Kong Geography Department s.n.* (SING!) [stem with lower pitcher]; Gunung Ulu Kali, no elevation data, 3 October 1978, *Kiew RK 641* (KEP!), *642* (KEP!) [pitcherless stem with female inflorescence (both sheets)]; Gunung Ulu Kali, summit zone, mossy montane forest, elfin thicket, 5800 ft [≈1770 m], 31 March 1979, *Stone 14084* (RSA!) [stem with lower pitcher (dissected), separate pitcherless leaf]; Gunung Ulu Kali, 6000 ft [≈1830 m; *sic!*], 30 March 1980, *Rao 9579* (SING!), *9580* (SING!) [stem with upper pitcher and male inflorescence (*9579*); stem with lower pitchers (*9580*)]; Gunung Ulu Kali, mossy forest, no



Figure A132 (above left): *Nepenthes ulukaliana* (Gunung Ulu Kali). Unusual lemon-yellow lower pitcher (François Mey). **Figure A133 (above right):** *Nepenthes ulukaliana* (Gunung Ulu Kali). Lower pitcher (right) and intermediate pitcher; note elongation and loss of ventral wings in latter (François Mey).



Figures A134 (above left) and A135 (above right): *Nepenthes ulukaliana* (Gunung Ulu Kali). Intermediate pitchers (Alastair Robinson).

elevation data, 5 December 1982, *Som RMS 1* (KEP!) [stem with upper pitcher, male inflorescence, and developing inflorescence]; Gunung Ulu Kali, no elevation data, 22 December 1983, *Som RMS 43* (KEP!) [stem with upper pitcher]; Gunung Ulu Kali, relatively open and sunny area (“*milieu ouvert relativement ensoleillé*”), 1800 m [*sic!*], 29 March 1984, *Aumeeruddy 37* (MPU!) [stem with upper pitcher and infructescence, separate leaf with upper pitcher]; Gunung Ulu Kali, mossy forest, no elevation data, March 1986, *Som RMS 134* (KEP!), *135* (KEP!) [stem with upper pitcher (*134*); stem with upper pitcher and male inflorescence (*135*)]; [Gunung Ulu Kali], vicinity of Genting Hotel (3°25'N 101°45'E), elfin woodland, 5000 ft [≈1520 m], 14 February 1987, *Worthington 12422.5* (L!, MO!) [pitcherless stem with male inflorescence (L); pitcherless stem fragment, separate leaf with lower pitcher (MO)]; Gunung Ulu Kali, vicinity of Genting Hotel (3°25'N 101°45'E), 5000 ft [≈1520 m], 16 May 1987, *Worthington s.n.* (L!) [leaf with lower pitcher only]; [Gunung Ulu Kali], vicinity of Genting Hotel (3°25'N 101°45'E), elfin woodland, 5000 ft [≈1520 m], 22 November 1987, *Worthington 13517* (NY!, TEX!) [stem with lower pitcher, separate lower pitchers (NY); leaf with lower pitcher (TEX)]; Gunung Ulu Kali, no elevation data, 9 May 1991, *Tan et al. TWK8* (SING!) [stem with lower pitcher]; Gunung Mengkuang, upper montane forest, 6600 ft [≈2010 m; *sic!*], 15 January 1994, *Chua et al. FRI 39027* (KEP! [2 sheets]) [stem with developing inflorescence and dehisced and dehiscing infructescences (sheet 1); stem with upper pitcher (sheet 2)]; summit ridge from Gunung Ulu Bakau to Gunung Rajah, upper montane forest, 5000 ft [≈1520 m], no date [likely early 1994], *Chua et al. 40516* (KEP! [2 sheets]) [stem with lower pitchers (both sheets)]; Gunung Ulu Kali, trail to army tower, secondary lower montane forest, exposed roadside slope, 3°26.12'N 101°47.06'E, 1734 m, 16 February 2007, *Imin FRI 50927* (KEP! [2 sheets]) [pitcherless stem with infructescence (sheet 1); stem with lower pitchers (sheet 2)]; Gunung Ulu Kali, mossy forest, partly shaded area, 3°25.91'N 101°47.08'E, 1729 m, 16 February 2007, *Nor Ezzawanis FRI 52572* (KEP!), *52573* (KEP!) [stem with lower pitcher, separate lid fragment (*52572*); pitcherless stem with male inflorescence (*52573*)]; Gunung Ulu Kali, mossy forest, exposed area, 3°25.91'N 101°47.08'E, 1729 m, 16 February 2007, *Nor Ezzawanis FRI 52576* (KEP!) [stem with upper pitcher and male inflorescence]; [Gunung Ulu Kali], 3°25.07'N 101°47.23'E, no elevation data, 11 March 2009, *Sun Nma-1* (KEP!) [stem with upper pitcher]; Gunung Ulu Kali, trail to Radio Amatur (Pulau Pinang) station, primary lower montane forest, slightly shaded slope, 3°26.18'N 101°47.05'E, 1770 m, 3 February 2010, *Imin FRI 66468* (KEP! [2 sheets], L!) [pitcherless stem with male inflorescence (KEP sheet 1); stem with lower pitcher (KEP sheet 2); stem with lower pitcher and male inflorescence (L)]; Gunung Ulu Kali, trail to Radio Amatur (Pulau Pinang) station, primary lower montane forest, slightly shaded slope, 3°26.18'N 101°47.05'E, 1770 m, 3 February 2010, *Imin FRI 66469* (KEP!) [stem with upper pitcher and male inflorescences].

Notes on specimens examined: Material from Semangko Pass and the summit of Gunung Ulu Semangko (*Burn-Murdoch s.n.* [2 sheets: #93972 & 93994], *Ridley 15562* & *s.n.* [2 sheets: #93989 & 94009], all SING!) appears to be referable to *Nepenthes ulukaliana*, especially by the infundibular form of the lower pitchers (cf. *Ridley 15562*), making it the northernmost known locality for the species. However, all of these specimens were collected more than a century ago and we were unable to find the species on Gunung Ulu Semangko in 2022.



Figure A136 (above left): *Nepenthes ulukaliana* (Gunung Ulu Kali). Upper pitcher with dark speckling (Stewart McPherson). **Figure A137 (above right):** *Nepenthes ulukaliana* (Gunung Ulu Kali). Upper pitcher exhibiting typical pale colouration; note distal gibbosity (François Mey).



Figures A138 (above left) and A139 (above right): *Nepenthes ulukaliana* (Gunung Ulu Kali). Typical upper pitchers showing variation in shape and colouration (Andreas Wistuba).



Figure A140 (above): *Nepenthes ulukaliana* (Gunung Ulu Kali). Pendent climbing stem with upper pitcher; note aerial offshoot (bottom) produced on woody portion of stem some distance from apical growth point (François Mey).



Figure A141 (above): *Nepenthes ulukaliana* (Gunung Ulu Kali). Detail of lower lid surface with minute hairs of consistent length and density; note absence of hairs from extreme margins of lid (Andreas Wistuba).



Figure A142 (above left): *Nepenthes ulukaliana* (Gunung Ulu Kali). Ants on peristome and lid of upper pitcher (Gideon Lim). **Figure A143 (above right):** *Nepenthes ulukaliana* (Gunung Ulu Kali). Female inflorescence with young, developing fruits; note enlarged bract of basalmost partial peduncle (Gideon Lim).



Figure A144 (above left): Seedling *Nepenthes ulukaliana* growing with *N. ramispina* on Gunung Ulu Kali (Gideon Lim). **Figure A145 (above right):** Putative hybrid between *Nepenthes ramispina* and *N. ulukaliana* growing on Gunung Ulu Kali; note extreme pitcher-to-leaf size ratio (Stewart McPherson).



Figure A146 (above): Putative *Nepenthes sanguinea* × *N. ulukaliana* plant with proportionally large lower pitcher growing on Gunung Ulu Kali (François Mey).

Discussion

Interspecific Differences

The *Nepenthes macfarlanei* group comprises species that are known exclusively from the highlands of Peninsular Malaysia. They all produce hairs beneath the lid to variable extents, the functions of which are unknown. Within this group, it is possible to immediately distinguish those taxa with long, stiff bristles (*N. berbulu* and *N. macfarlanei*; Figs. A31–36, A65–68) from those with short to very short, filamentous hairs (*N. alba*, *N. gracillima*, *N. sericea*, and *N. ulukaliana*; Figs. A19–20, A43, A104, A141).

Moreover, the nectar glands on the lower surface of the lid of *Nepenthes macfarlanei* (Fig. A67), and particularly *N. berbulu* (Fig. A32), tend to be significantly larger than those of the remaining four species of the group. The diagnostic value of these structures highlights the importance of pressing herbarium material with the lower lid surface exposed as part of a ‘best practice’ approach (cf. Clarke & Moran, 2011).

Of the three main taxa dealt with in this work, *Nepenthes ulukaliana* is easily set apart. Its urceolate, amphora-shaped lower pitchers are distinctive, and the very short hairs beneath its lid rarely exceed 1 mm in length. The toothed peristome with its developed column is also significantly more pronounced than in either *N. macfarlanei* or *N. sericea*. The mouth of *N. ulukaliana* also has a different shape, being planar at the front of the pitcher before rising to form a perpendicular column, rather than appearing curved when viewed from the side.

Nepenthes macfarlanei appears to be very closely related to *N. sericea*. The two taxa are easily told apart by their divergent lid hairs; *N. macfarlanei* develops tens to several hundred bright white bristles up to 12 mm long, while *N. sericea* produces thousands of orange to bronze hairs just 2 mm long. *Nepenthes sericea* can also be distinguished from *N. macfarlanei* by its frequent production of upper pitchers that are broadly cylindrical in shape, while *N. macfarlanei* develops only broadly infundibular upper pitchers.

Lid hair characteristics aside, and in the absence of the cylindrical upper pitchers often found in *Nepenthes sericea*, it can be difficult to tell *N. macfarlanei* and *N. sericea* apart, though they do diverge on several features (see Table A1). There is room to consider the use of the subspecific rank for *N. sericea* because its differences with *N. macfarlanei* can be considered less significant than with other taxa of the genus or even within the *N. macfarlanei* group.

Moreover, geographical distribution, which is often advocated with respect to the use of the subspecific rank, is supported here with the clear separation of Gunung Bubu, the type locality of *Nepenthes macfarlanei*, from the range of *N. sericea*. However, at this point, we are reluctant to ascribe *N. sericea* as a subspecies of *N. macfarlanei* until sound and functional concepts of subspecific ranks can be applied to the whole genus (cf. Clarke *et al.*, 2009a).

Phylogenetic Relationships

The *Nepenthes macfarlanei* group appears closely related to some other highland species from Peninsular Malaysia: *N. sanguinea* and its close relatives *N. latiffiana* and *N. malayensis*, and also *N. ramispina*, all species with coriaceous, sessile leaves. This clade of Peninsular Malaysian species itself appears to be closely related to a small group of lowland to intermediate species formed by *N. benstonei* and *N. domei*, from Peninsular Malaysia, and *N. thai*, which occurs in Thai territory near the shared border between Malaysia and Thailand. These three taxa are very closely related and further investigation might show that they are conspecific.

All the aforementioned species from Peninsular Malaysia also appear to be closely related to the species of the *Nepenthes thorellii* aggregate from Indochina. The divergence between these two groups might originate in the geographic and climatic division between the strongly seasonal Indochina, with its group of tuberous-rooted pyrophytic species (Mey *et al.*, 2010), and the perhumid conditions of much of Peninsular Malaysia.

Danser (1928) placed all of the then-known species of the *Nepenthes macfarlanei* group in his section *Montanae*, together with *N. sanguinea* and a number of species endemic to Sumatra and Java. Recent phylogenomic work strongly supports *Montanae s.lat.* as a monophyletic group, recovering a clade comprising all of the Peninsular Malaysian endemics (plus *N. kongkandana*) that is sister to a clade comprising the Indochinese pyrophytes (*N. thorellii* aggregate of Mey *et al.*, 2010), this pair being successively sister to a clade exclusively of species endemic to Sumatra and Java (Murphy *et al.*, 2020; Murphy, 2021). Though broader, this grouping closely matches the species assemblage of section *Montanae* used in recent literature on morphological grounds alone (e.g. Cheek & Jebb, 2009; cf. cladogram in Clarke, 2001:87).

Section *Pyrophytae* was erected by Cheek & Jebb (2016b) to accommodate the pyrophytic *Nepenthes* of Indochina, but Clarke *et al.* (2018a, b) also included within it the montane species of Peninsular Malaysia, together with *N. albomarginata*, *N. hemsleyana*, *N. rafflesiana*, and *N. reinwardtiana*. Excepting this last group of species not endemic to Indochina and Peninsular Malaysia, both of these delimitations are consistent with the tree topology recovered in the phylogenomic study of Murphy *et al.* (2020), though if *Montanae* is to encompass *Pyrophytae* then the latter would need to be reduced to a subsection of the former.

The montane *Nepenthes* of Peninsular Malaysia have consistently been recovered as a monophyletic group in phylogenetic and phylogenomic studies to date (Mullins, 2000; Meimberg *et al.*, 2001, 2006; Meimberg, 2002; Meimberg & Heubl, 2006; Golos, 2012; Alamsyah & Ito, 2013; Bunawan *et al.*, 2017; Murphy *et al.*, 2020; Tamizi *et al.*, 2020b; Murphy, 2021), though often with *N. ramispina* and *N. sanguinea* nested within the *N. macfarlanei* group as defined herein. These studies sampled a limited number of species and the identification of the sampled plants is sometimes questionable (e.g. much early cultivated material of *N. ramispina* was introgressed with *N. ulukaliana*; A. Wistuba, pers. observ.) or their geographical provenance unknown. Additionally, it is possible that the true evolutionary

relationships between the species have been obscured by historical hybridisation. Nevertheless, if more detailed studies confirm the nesting of *N. ramispina* and *N. sanguinea* within the here-defined *N. macfarlanei* group, then it would be prudent to expand the latter to include these two species despite their lack of lid hairs, so that the infrageneric taxonomy of the genus accurately reflects the evolutionary history of its constituent species. This would need to be accompanied by a redefinition of the *N. macfarlanei* group on morphological grounds or the introduction of a phylogenetic definition.^[22] The status of *N. latiffiana* and *N. malayensis* (Ghazalli *et al.*, 2020; Tamizi *et al.*, 2020b) would also need to be considered.

^[22]Phytochemical data may also prove phylogenetically informative; there is limited evidence for variant naphthoquinone profiles among members of this group (see Schlauer *et al.*, 2005).

Upper Pitcher Dimorphism

Nepenthes sericea is notable for its upper pitcher dimorphism. Upper pitchers may be wholly infundibular (Figs. A96–100) or infundibular in the basal portion and cylindrical above (Figs. A90–95). The two different shapes of *N. sericea* upper pitcher have been observed in the same location and during the same season; G. Lim, F. Mey, and A. Wistuba observed them concurrently on Gunung Brinchang, and while M. Golos, G. Lim, S. McPherson, F. Mey, and A. Wistuba only observed infundibular upper pitchers on Gunung Warpu, both cylindrical and infundibular upper pitchers have been photographed on the adjacent Gunung Yong Belar by hikers and experienced enthusiasts (e.g. the late Christophe Maerten, pers. comm. with F. Mey). The possibility of there being two species was ruled out through simple field observations, which confirmed that the pitchers are produced by plants that are otherwise identical.

Whereas infundibular upper pitchers of *Nepenthes sericea* are generally light-coloured throughout, cylindrical ones may be richly pigmented. In at least some of the northern parts of its range (e.g. Gunung Korbu, Gunung Yong Belar, and Gunung Yong Yap), *N. sericea* tends to have heavily red-speckled cylindrical upper pitchers, sometimes superficially approximating those of *N. berbulu* in colour (Fig. A93).

Time in the field was limited and it was not possible to locate cylindrical and infundibular upper pitchers of *Nepenthes sericea* produced on the same plant, as Clarke & Lee (2012) did for *N. gracillima* on Gunung Tahan, leading them to classify the large, dark aerial traps referred to as “upper pitchers” by McPherson (2009a) as intermediate pitchers, whilst indicating that the ‘true’ uppers are diminutive and slender. It is possible that, like *N. gracillima*, *N. sericea* has three distinct phases of pitcher production, whereby lower pitchers are followed by ‘intermediate’ or early-stage (cylindrical) upper pitchers that are produced for an extended time in the early vining stage and only much later replaced by entirely infundibular upper pitchers in established climbing stems. Alternatively, these differences may reflect natural variation and/or be induced by environmental factors. Further field work is needed to resolve this question.

Interestingly, the group of pyrophytic Indochinese species also includes taxa that exhibit the same dimorphism observed in *Nepenthes gracillima*: the widespread *N. kampoiana* and *N. smilesii* often produce broadly cylindrical upper pitchers but also, within the same specimen, infundibular to obovate upper pitchers as the plant ages (F. Mey, pers. observ.).

Aerial trap dimorphism has also been proposed by Cheek *et al.* (2015) for *Nepenthes barcelonae* from Luzon, the Philippines (said to produce two types of upper pitchers but no lower pitchers), and by Cheek *et al.* (2018) for *N. biak* from the eponymous island off northwestern New Guinea (said to produce two types of upper pitchers in addition to intermediate and, briefly, lower pitchers). However, the occurrence of trap dimorphism in the former species has been disputed by other authors based on observations made of the plant *in situ* (see Baj *et al.*, 2023).

Lid Hairs and Prey Spectra

The most distinctive unifying character of the *Nepenthes macfarlanei* group is the presence of conspicuous hairs or bristles on the lower surface of the lid in both lower and upper pitchers. Comparable structures on the lower surface of the lid have only been documented in two members of sect. *Tentaculatae* from Sulawesi—*N. diabolica* and *N. maryae*, which bear fine hairs no more than 0.8 mm long (Cheek & Jebb, 2016a; Bianchi *et al.*, 2020)—and the closely related Bornean pair of *N. ehippiata* and *N. lowii*, which have thick, qualitatively different structures that variously take the form of fleshy bristles or tubercles, and exceptionally reach 20 mm in length (Clarke, 1997), though they typically do not exceed 10 mm (McPherson, 2009).^[23] Given the distant phylogenetic placement of these two species pairs with respect to each other and to the *N. macfarlanei* group (see Murphy *et al.*, 2020), it would appear that lid hairs have evolved independently at least three times among extant *Nepenthes*.

Nepenthes lowii (and presumably *N. ehippiata*) is highly specialised towards a resource–resource mutualism with tree shrews, which provide the plants with nitrogen-rich droppings in exchange for the exudate that is copiously produced by the underside of the reflexed lid (Clarke *et al.*, 2009b; Chin *et al.*, 2010; Moran *et al.*, 2012; Cross *et al.*, 2022). Here, as in all other species, the function of the lid bristles is unknown, but is perhaps related to keeping the exudate in place against the action of visiting animals and/or rain (the surface is exposed to the elements as the lid is upturned), or maximising the time the tree shrews spend feeding. Studies on *N. ehippiata* are lacking, but *N. lowii* is known to catch few arthropod prey, particularly in its upper pitchers, owing to its tree shrew specialisation (Adam, 1997; Clarke, 1997:36).

In contrast, the pitchers of members of the *Nepenthes macfarlanei* group and the two Sulawesi species often contain significant arthropod biomass (Schmid-Hollinger, 1997; Cheek & Jebb, 2016a; Bianchi *et al.*, 2020; M. Golos, G. Lim, F. Mey & A. Wistuba, pers. observ.) and their lids assume a more conventional position overhanging the pitcher cup. Given the location of the lid hairs directly over the pitcher orifice in these species, it might be conjectured that they play a role in prey capture. It has been suggested that they might be an adaptation to retain arthropods visiting the lid nectaries for longer and with more precarious footholds, thereby increasing the likelihood of prey capture (Tan *et al.*, 2023).

A “flick of the lid” trapping mechanism akin to that identified in *Nepenthes gracilis* (Bauer *et al.*, 2012b, 2015; Lenz & Bauer, 2022) has been proposed for both *N. macfarlanei s.lat.* and *N. maryae* (Cheek & Jebb, 2016a; Cheek *et al.*, 2020). In *N. sericea* on Gunung Warpu, it was observed that sharply striking the lid from above (to simulate the impact of rain drops) was entirely ineffective at dislodging ants traversing the lower surface, even though the ants were not making direct contact with the lid surface but only adhering to the lid hairs themselves (Figs. A107–108; M. Golos, pers. observ.). However, this rudimentary test was performed when the hairs were dry and it is possible that they might only function as proposed when activated by environmental wetness (cf. hydrophilic trichomes reported in the distantly related North American pitcher plants of the family Sarraceniaceae; Bauer *et al.*, 2013; Chen *et al.*, 2018). This being said, the long lid bristles of *N. berbulu* and *N. macfarlanei* appear to be hydrophobic, as they were observed to cause water condensate to bead (Fig. A71; see also Tan *et al.*, 2023:28, fig. 10A).

A still different possibility is that such hanging droplets, when disturbed by visiting arthropods (or otherwise), may come loose and fall into the pitcher cup below, taking prey with them (Tan *et al.*, 2023). As such, it is interesting to note that the distribution of the two species with long lid bristles (*Nepenthes berbulu* and *N. macfarlanei*) appears to coincide with the regions within the range of *N. macfarlanei s.lat.* that have historically received the greatest average rainfall (see Nieuwolt, 1965:fig. 14; Null, 1972:19, fig. 3). In both of these species, older pitchers tend to have few intact bristles, with most being broken at their bases (Figs. A69–70). A similar phenomenon has been observed in *N. sericea* (Fig. A105). Whether this loss is caused by breakage due to mechanical force, perhaps as part of a prey capture mechanism, is unknown.

Members of the *Nepenthes macfarlanei* group have been noted for catching significant numbers of large prey items such as centipedes, cockroaches, crickets, beetles, and spiders (Schmid-Hollinger, 1997; Tan *et al.*, 2023; M. Golos, G. Lim, F. Mey & A. Wistuba, pers. observ.). This has led to the suggestion that *N. macfarlanei s.lat.* may exhibit prey specialisation (Rice, 2010). It would be tempting to link the capture of such prey items with the presence of lid hairs, particularly as the pitchers of these species appear to otherwise exhibit conventional trapping adaptations¹²⁴, but this would be premature as similar prey have been recorded from *Nepenthes* species lacking lid hairs entirely (e.g. Jebb, 1989, 1991:50; Adam, 1997; see summary in Cross *et al.*, 2022).

It is possible that the lower pitchers of some species, especially *Nepenthes sericea*, employ a ‘booby-trap’ mechanism, as they are often buried in moss with only their mouths and lids exposed (Fig. A110; Schmid-Hollinger, 1997), and this might explain the capture of e.g. ground-dwelling centipedes (Fig. A112). However, arboreal scutigermorph centipedes have also been found in the *upper* pitchers of both *N. berbulu* (Tan *et al.*, 2023) and *N. sericea* (Fig. A113; Schmid-Hollinger, 1997). It is possible that the smell of rotting prey plays a role in attracting some of these animals (Schmid-Hollinger, 1997).

Though ants are often abundant on the underside of the pitcher lid in species of the *Nepenthes macfarlanei* group (Figs. A35, A72, A109, A142), they do not appear to necessarily be the main prey of these species. This raises the possibility that ants might instead serve as ‘bait’ for larger, more

nutritionally significant species that prey on them. In this context, it is interesting to note the possible confinement of visiting insects to the central region of the lower lid in *N. berbulu*, due to the largely peripheral distribution of its bristles (Figs. A32–33; Tan *et al.*, 2023). Hemsley already opined that the long bristles of *N. macfarlanei* could serve to prevent flying insects from accessing the lower lid surface, while allowing ants to do the same (Hemsley, 1905c). Clearly, the function of these structures requires further investigation.

^[23] Cheek *et al.* (2020) also reported such lid hairs from *Nepenthes oblanceolata* from New Guinea (a species often lumped under *N. maxima*) without elaborating further. The Sumatran *N. xiphioides* (often treated as a synonym of *N. gymnamphora*) is said to have minute stellate lid hairs 0.05–0.1 mm long (Salmon & Maulder, 1995); *N. tamini*, also from Sumatra and a putative close relative, has similar hairs (A. Robinson & S. McPherson, pers. observ.).

^[24] Moran *et al.* (2013) reported the presence of viscoelastic pitcher fluid in *Nepenthes macfarlanei* *s.lat.* (based on 15 populations) but not *N. alba* (10 populations) or *N. gracillima* (7 populations). These results were based on direct observations of wild plants rather than rheological measurements thereof and should therefore be treated with some caution; they merit further investigation. According to Bauer *et al.* (2012a), lower pitchers of *N. macfarlanei* *s.lat.* have peristomes that are near-symmetrical in transverse section, with the inward arm being of similar length to the outward (*ca.* 55% vs. 45% of the total, respectively). However, our observations suggest that the inward arm is usually substantially longer in the relevant species.

Acknowledgements

We express our gratitude to the Director-General of the Forest Department of Peninsular Malaysia, Dato' Indera Mohd Ridza Bin Awang, who allowed our studies to be carried out (permit ref. JH/100 Jld. 33(35)); the Deputy Director (Development) of the Perak Forestry Department, Pn. Siti Dessyma Binti Isnani, for her approval (permit ref. PPN.PK. 600/03/01 Jld. 21(12)) to conduct our research on several important peaks in the Perak Forest Reserves, including the type localities of *Nepenthes macfarlanei* and *N. berbulu*; the Deputy Director (Development) of the Kelantan Forestry Department, En. Haji Abdul Wahab Bin Deraman, for permission to conduct research at the *N. sericea* type locality (permit ref. PHN.KN.130/1/9.J9 (27)); Ms. Nabila from the Perak Forestry Department for assistance with the Perak permit application; and the officers at the Forest Department of Peninsular Malaysia, Forest Planning & Economics Division, including Mr. Mohd Hafiz Bin Mohd Noor, Ms. Najihah binti Aderis, and their team, who assisted us throughout the permit application process.

We are also indebted to Dr. Richard Chung Cheng Kong from Forest Research Institute Malaysia (FRIM) for permission to study voucher materials at Kepong Herbarium (KEP); Mr. Cheah Yih Horng, Mrs. Syahida Emiza Suhaimi, and Ms. Rafidah binti Abdul Rahman for assistance at KEP; Ms. Siti Nur Bazilah binte Mohamed Ibrahim for facilitating access to herbarium and type materials at the Singapore Botanic Gardens Herbarium (SING); Dr. Sovanmoly Hul for facilitating our visit at the Paris Herbarium (P); Jasper Michael Mambrasar for assistance with voucher specimens at Herbarium Bogoriense (BO); the Board of Trustees of the Royal Botanic Gardens, Kew for permission to reproduce scans of the *Nepenthes macfarlanei* lectotype series and Yvette Harvey for facilitating access to herbarium material at Kew (K); Dr. Chen Jit Ern and Dr. Sagathevan Kuppasamy from Sunway University and

Sunway College, respectively, for providing a letter of support to the relevant authorities and the resources to deposit and continue to study live samples of *N. macfarlanei* group species in the Sunway Highland Conservatory; the team of volunteers from Malaysia Carnivorous Plants (MyCP) at the Sunway Highland Conservatory for their time and effort in keeping the specimens alive; and Ms. Neoh Li May for helping author G. Lim in meticulously re-hydrating, pressing, and mounting the herbarium specimens.

We extend our thanks to our co-author on the *Nepenthes berbulu* paper, Mr. Tan Hong Liang, and to Dr. Tan Ji of Universiti Tunku Abdul Rahman (UTAR), for their contribution towards furthering our understanding of the *N. macfarlanei* complex through that species; Robert Ziemer and the International Carnivorous Plant Society (ICPS) for overseeing the publication of *N. berbulu* in the March 2023 issue of the *Carnivorous Plant Newsletter*; Chien Lee for providing images of *N. gracillima* for publication, images of *N. alba* and *N. sericea* for reference, and for discussions with author F. Mey; Kenneth Hiew for providing images of *N. alba*, *N. gracillima*, and *N. sericea*; Greg Palena for providing images of *N. macfarlanei*; Benjamin Hagger for sharing habitat photos of *N. berbulu*; Dr. Alexey Yakovlev and the late Christophe Maerten for habitat photos of *N. sericea*; Dr. Rudolf Schmid-Hollinger for images of prey thereof (which originally appeared in Schmid-Hollinger, 1997); Greg Bourke for providing photos of *N. gracillima* for reference; Dr. Yangchen Lin for sharing relevant content from his copy of Anon. (ca. 1970s); and Dr. Charles Clarke for fruitful discussions with author F. Mey relating to the taxonomy of Peninsular Malaysian *Nepenthes*.

We thank Mr. Eddie Chan and his team for his guided conservation tour of Genting Highlands to view *Nepenthes ulukaliana*; our guides Mrs. Evie Chen and Mr. Ah V Hei for their efforts to lead us to the *N. berbulu* type locality during our first climb; our professional guides and coordinators Mr. Taqim, Mr. Mat Dee, and Ms. Sizuka, along with their respective crew of porters, chefs, and drivers during the many legs of the second expedition: Basri, Jaki, Amran, Jamri, Nazril, Amorei, Ayie, Aree, Muhamad Asrar, Mohd Fauzi, Ahmad Faizal, Pa'an, Ahmad Faizul, Shafri Kamal Shafei, Anuar, Zairul Hafis, Shahlan, Suria, Boy, Mohd Su'aidi, M. Ashraf, M. Fikri, Azzarro, Nas, Norazly, Muhammad Syahmi Bin Mohd Noh, Aiyen Carlos, Ali, Arip, Azhar, Ben, Cai, Faiz, Faizal, Fatin, Fikal Cicak, Jai, Jatd, Jay, Mieto, Mirul, Nizam, Shalan, Zoulzoul, Halfian, Peja, Abuubaidah Aziz, Farid, and Syafiq, whose combined survival skills and mountaineering knowledge contributed greatly to the success of our expeditions.

We thank our friends and travel companions Bryan ChongYik Khuan and Khairisyahmie Bin Khairisham for participating in the first expedition to the *Nepenthes berbulu* type locality in February 2020; and Bart Jeurninck, Ed Lee, Greg Palena, Francis Quesada-Pallares, Teddy Vayssade, and Alexander Young, whose fellowship and camaraderie made the three-week-long series of botanical expeditions in August 2022 so memorable. Final thanks go to Malaysia Carnivorous Plants for initiating this venture of expeditions to expand our understanding of the carnivorous plants of Peninsular Malaysia.



Figure A147 (above): Three short-stemmed *Nepenthes macfarlanei* plants bearing lower pitchers, observed on the very summit of Gunung Bubu at 1657 m (François Mey).

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