

Hydnophytum puffii (Rubiaceae: Psychotrieae), a new ant-plant from Sabah, Malaysian Borneo

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Background – *Hydnophytum puffii* Y.W.Low, Sugau & K.M.Wong, a linear-leaved epiphytic ant-plant is described as new from Borneo using morphological characters based on specimens preserved in the Sandakan and Singapore Herbaria. This new species is so far known only from Sabah, Malaysia.

Methods – This study is based on herbarium materials and field observations in Sabah. Conventional herbarium techniques were applied for taxonomy, while the IUCN conservation status was assessed using GeoCAT.

Results – *Hydnophytum puffii* is closely related to *H. angustifolium* Merr. but differs in having glabrous young twigs, 4–5 pairs of leaf secondary veins on the lower leaf surface, a corolla tube that is densely covered with translucent hairs inside the throat around the anthers, and prolate mature fruits. This new taxon is the only species in Borneo to have linear leaves as the other two taxa, namely *H. coriaceum* Becc. and *H. formicarum* Jack have broad elliptic leaves.

Key words – Borneo, conservation status, *Hydnophytum*, Malaysia, new species, Psychotrieae, Rubiaceae, Sabah.

INTRODUCTION

The peculiar rubiaceae ant-plants in subtribe Hydnophytinae C.R.Huxley & Jebb (Psychotrieae) includes five genera, namely, *Anthorrhiza* C.R.Huxley & Jebb, *Hydnophytum* Jack, *Myrmecodia* Jack, *Myrmephytum* Becc., and *Squamellaria* Becc., with a geographical distribution from Southeast Asia to the northern parts of Queensland (Australia) and extending to the Fiji Islands (Huxley & Jebb 1991a). Most of the genera have been revised in a series (Jebb 1991, Huxley & Jebb 1991b, 1991c, 1991d), except for *Hydnophytum* which was reported to be in progress (Huxley 1993). Meanwhile, Forster (2001) described a new species, *H. ferrugineum* P.I.Forst., for Australia that is distinct from *H. moseleyanum* Becc., and Wistuba et al. (2014) described *H. caminiferum* Wistuba, U.Zimm., Gronem. & Marwinski for New Guinea that is distinct from *H. vacciniifolium* P.Royen.

Hydnophytum is the most diverse of all the genera recognised for Hydnophytinae, with an estimated 90 species occurring from the Indo-Malaya region extending to Australasia (Huxley & Jebb 1991a, Govaerts et al. 2014). The phylogenetic placement of *Hydnophytum*, while clearly included within the Psychotrieae, is as yet uncertain in terms of definite generic affinities, especially with regard to with the genus *Psychotria* L. In the studies of Nepokroeff et al.

(1999), Andersson (2002), Barrabé et al. (2014) and Razafimandimbison et al. (2014), *Hydnophytum* and its close allies (including *Anthorrhiza*, *Myrmecodia*, *Myrmephytum*, and *Squamellaria*) form a well-supported ‘Indo-Pacific’ sub-clade included within one of the *Psychotria* complex lineages, named the ‘Pacific clade’ or the ‘Pacific *Psychotria* clade’. But as acknowledged by Razafimandimbison et al. (2014), there is as yet no unequivocal support for including this alliance into a broadly circumscribed genus *Psychotria* because the major lineages are only partially resolved. Meanwhile, there are clearly definable morphological synapomorphies for the subclade comprising the Hydnophytinae (including axillary inflorescences and a swollen stem with anastomosing channels developing internally) coupled with an epiphytic habit that are not present in the other lineages in *Psychotria* and its close affiliates that typically have terminal inflorescences, stem not modified, and shrub, tree, and liana habit. We therefore continue to recognise the five Hydnophytinae genera in the sense of Huxley & Jebb (1991a) as distinct from *Psychotria*, while awaiting further molecular phylogenetic resolution that may appear with a more comprehensive taxon sampling and other markers.

Borneo is the third-largest island in the world, and it is included within the phytogeographical region called Malesia (Zollinger 1857, van Steenis 1950a) that is immensely rich

in plant life, with a flora estimated to include 42,000 seed plant species (Roos 1993). Located on the easternmost part of the Southeast Asian continental shelf called the Sunda Shelf, Borneo is also the largest island in West Malesia, and the richest in plant life compared to other Sunda Shelf islands (Wong 1998, Wong 2011). The total vascular flora of Borneo is estimated between 9,000 (Merrill 1921) and 15,000 species (Merrill 1950, Raes et al. 2009), with many more new to science still being discovered (recent examples include Buerki et al. 2013, Wong & Boyce 2014, Utteridge et al. 2014, Wong et al. 2014, Wong & Low 2015, Joffre et al. 2015, Low et al. 2015, Wong et al. 2015). The northern part of Borneo, with an area of about 74,000 km² is occupied by the Malaysian state of Sabah, home to Mount Kinabalu, the highest mountain in Borneo and a cradle of plant diversity with over 5,000 vascular plants estimated there alone (Beaman & Anderson 2004), where new taxa are still being discovered (Wong & van der Ent 2014, Chen et al. 2014, Peng et al. 2015). However, this botanical haven is vulnerable to deforestation, due to exploitation for timber or clearing for oil palm plantation agriculture in past decades (White 2008). A recent study by Bryan et al. (2013) shows that almost 80% of the land surface of Sabah and Sarawak combined was subjected to high-impact logging or clearing operation during 1990–2009, an alarming figure considering the biological wealth in these territories. Although Sabah is considered botanically well collected since colonial times (van Steenis 1950b, Wong 1995), it is still without a comprehensive flora account, fuelling concerns that new species may even go extinct before being documented.

Merrill (1921) in his bibliographic checklist of Bornean plants enumerated two species of *Hydnophytum*, namely *H. coriaceum* Becc. and *H. formicarum* Jack. Later, an attempt to update Merrill's checklist by Masamune (1942) also listed the same species. The latter is a widespread species with two varieties recorded for Borneo, viz., *H. formicarum* var. *borneense* (Becc.) Becc. and *H. formicarum* var. *lucidum* Becc. (Merrill 1921, Masamune 1942). Puff & Wong (1993) in their survey of Bornean Rubiaceae provided an up-to-date information of the genera occurring in Borneo and listed *Hydnophytum* with two taxa, and indicated as well the possibility of novelties to be discovered. More recently, an updated checklist for Borneo compiled by Kew (Govaerts et al. 2014) included an additional species, *Hydnophytum borneanum* Becc., apart from the two taxa listed by Merrill (1921) and Masamune (1942). A review of all the literature pertinent to the Bornean *Hydnophytum* taxa was carried out and revealed that '*Hydnophytum borneanum* Becc.' in the Kew Checklist (Govaerts et al. 2014) was in fact a typographical error for the accepted name *Hydnophytum horneanum* Becc., a native of Fiji (Beccari 1885). As such, only two species of *Hydnophytum* have been enumerated for Borneo, namely *Hydnophytum coriaceum* and *H. formicarum*.

In 1992, a peculiar *Hydnophytum* with distinctive linear leaves was collected at around 600 m a.s.l. from Gunung Tingkar (*K.M. Wong et al.* WKM 2244), one of the least botanically explored areas in Sabah (van der Ent et al. 2014). The vegetation where the specimen was collected is lowland forest over ultramafic soils, with tall trees over 50 m dominated by members of the Dipterocarpaceae and closed

canopy (Fox & Tan 1971, Whitmore 1984, van der Ent et al. 2014). This geological environment is well-documented as harbouring endemic species (Whittaker 1954). The Gunung Tingkar material is distinct from all known *Hydnophytum* species enumerated from Borneo that typically have broad-elliptic leaves. The present paper clarifies the identity of this unusual *Hydnophytum*, as more herbarium materials, particularly flowering and fruiting materials, of this peculiar taxon have been accumulated over time, enabling a full description and illustration as provided here.

MATERIALS AND METHODS

This research was conducted based on dried herbarium materials preserved in BRUN, KLU, SAN, SAR, SING and SNP (herbarium acronyms used in this study follow Thiers continuously updated). Conventional methods of herbarium taxonomy were applied. Type images were examined at JSTOR® Global Plants (<http://plants.jstor.org/>), as well as other virtual herbaria available online such as FI, K, L, NY, P, US. In an effort to locate the missing syntypes of *H. angustifolium* Merr., special assistance was requested from curatorial colleagues at A, B, BM, BO, F, G, GH, K, NY, PNH, SING, and UC, to search for relevant herbarium sheets systematically in their collections. Botanical terms used in this study largely follows Beentje (2012), and definition of types of tropical rain forests follows Whitmore (1984).

The IUCN conservation status of *Hydnophytum puffii* was assessed using the Criterion B of the IUCN Red List (IUCN 2012). The extent of occurrence (EOO) and the area of occupancy (AOO) were calculated using GeoCAT (Bachman et al. 2011). Data used for the assessment here are based on herbarium records represented in SAN and SING.

DISCUSSION

In Borneo, there are only two genera of the rubiaceous ant-plants ever recorded, namely *Hydnophytum* and *Myrmecodia* (Merrill 1921, Masamune 1942, Puff & Wong 1993). Meanwhile, *Anthorrhiza* is exclusive to southeastern New Guinea (Huxley & Jebb 1991b); *Myrmephytum* is restricted to the Philippines, Sulawesi, and the Bird's Head Peninsula (northwest New Guinea) (Huxley & Jebb 1991c); and *Squamellaria* is confined to the eastern Fijian Islands (Jebb 1991). Although there is a possibility that *Myrmephytum* could occur in Borneo, that genus is the only one in Hydnophytinae with blue 6-lobed corolla, whereas the Gunung Tingkar taxon has a white 4-lobed corolla. Generally, *Hydnophytum* differs from *Myrmecodia* in having (i) several branching stems arising from the top part of the tuber, (ii) smooth stems without alveoli and tubers rarely with spines present (iii) sessile inflorescences often appearing as a pair of fertile mounds, (iv) 2-lobed stigmas, and (v) two pyrenes. In contrast, *Myrmecodia* has (i) typically solitary unbranched stems arising from the top part of the tuber, (ii) spiny stems and tubers with alveoli present along the stem, (iii) inflorescences sunken into alveoli, (iv) 4–8-lobed stigmas, and (v) 4–8 pyrenes. Based on these characters, the Gunung Tingkar taxon clearly belongs to *Hydnophytum*.

Table 1 – Comparison of morphological characteristics, distribution and habitat between *Hydnophytum puffii* Y.W.Low, Sugau & K.M.Wong and *H. angustifolium* Merr.

	<i>Hydnophytum puffii</i>	<i>Hydnophytum angustifolium</i>
Young twig surface	glabrous	furfuraceous
Leaf blade, length (mm)	(40–)60–94(–110)	50–100
Leaf blade, width (mm)	2.5–4(–9)	6–18
Secondary veins on lower leaf surface	4–5 pairs	Secondary veins inconspicuous
Corolla tube surface, inside	Densely covered with translucent hairs at the throat, around the anthers	Sparsely covered with translucent hairs around the middle of the tube
Fruit shape (length × width) (mm)	Prolate (6 × 4)	Barrel-shaped (10 × 4)
Distribution	Restricted to northern Borneo (Sabah: Beluran, Keningau, Lahad Datu, Nabawan, Sandakan and Tongod)	Known only from Philippines (Mindanao: Lake Lanao, Camp Keithley and San Ramon, Zamboanga)
Habitat	Lowland to hill <i>kerangas</i> or heath forest over sedimentary rocks and forest over ultramafic geology	unknown

The Gunung Tingkar taxon is morphologically similar to *Hydnophytum angustifolium* Merr., a taxon known only from Mindanao described based on four collections at the Manila Herbarium (PNH), namely three unnumbered sheets by Mary Strong Clemens from Lake Lanao, Camp Keithley, but dated April 1906, May 1907, and June 1907; and an unnumbered sheet by Copeland from San Ramon, Zamboanga (Merrill 1908). Merrill left Manila in 1907 for the United States, and on his way back to Manila in 1908, he spent two months in Europe visiting the Berlin Herbarium (B), Natural History Museum, London (BM), Genève Herbarium (G), Florence Herbarium (FI), Kew Herbarium (K), and Leiden Herbarium (L) examining types of Philippine plants (Robbins 1958). It is plausible that the unidentified Mindanao *Hydnophytum* was named following his two months of research in the European herbaria. The taxon, *Hydnophytum angustifolium*, was published on 18 July 1908, shortly after Merrill arrived back in Manila in April 1908. Merrill, however, did not indicate a type, but as the title suggested “New Philippine plants from the collections of Mary Strong Clemens, I”, the unnumbered sheets from Lake Lanao, Camp Keithley would have to be the type material. Unfortunately, the Manila Herbarium was destroyed during World War II (Howard 2000), and very likely the material examined by Merrill perished when the herbarium was razed; these sheets are certainly not present at PNH today (L.T. Evangelista, Philippine National Herbarium, pers. comm.). Although a good number of Philippine specimens were well distributed (van Steenis-Kruseman 1950), these four sheets are not found in A, B, BM, BO, F, FI, G, K, L, NY, P, PNH, SING, UC and US. Measurements and information pertinent to *Hydnophytum angustifolium* used for this study were based entirely on the article published in Merrill (1908). Table 1 compares *H. puffii* and *H. angustifolium* for a number of characters that distinguish these two species apart.

It is worth noting that in the horticultural circles of Europe, Japan, and Taiwan, a mysterious *Hydnophytum* species with linear leaves purported to have originated from Borneo is being traded under the name “*Hydnophytum perangustum*”. We have not specially examined materials traded under this name, and also this unpublished name has no bearing on the nomenclature.

TAXONOMIC TREATMENT

Hydnophytum puffii Y.W.Low, Sugau & K.M.Wong, **sp. nov.**

This species appears to be related to *Hydnophytum angustifolium* Merr. from the Philippines, but differs in having glabrous young twigs, 4–5 pairs of leaf secondary veins, a corolla tube that is densely covered with translucent hairs inside at the throat around the anthers and prolate mature fruits. In contrast, *H. angustifolium* has thickly pubescent young twigs, inconspicuous leaf secondary veins, a corolla tube that is only sparsely hairy inside at the middle and barrel-shaped mature fruits. The leaves are much narrower than those of *H. angustifolium* and only approached by those of *H. ramispinum* Merr. & L.M.Perry of New Guinea which, however, has a spiny tuber. – Type: Borneo, Sabah (Malaysia), Tongod, Gunung Tingkar, 2000 ft [609 m] alt., 26 Aug. 1992, *K.M.Wong et al.* WKM 2244, flowers and fruits (holo-: SAN; iso-: L).

Tuber subglobose to slightly compressed ovoid, to 2–7 × 3–7 cm, spineless, glabrous, surface smooth to sparsely tuberculate and often with entrance holes for ants at the base; chambers complex and forming a honeycomb of chambers. **Stems** several, branching, 24–57 cm long, (0.2–)0.25–0.4 cm wide, semi-pendulous to erect; arising from the apical part of the tuber. **Stipules** triangular fused and sheathing at the base,

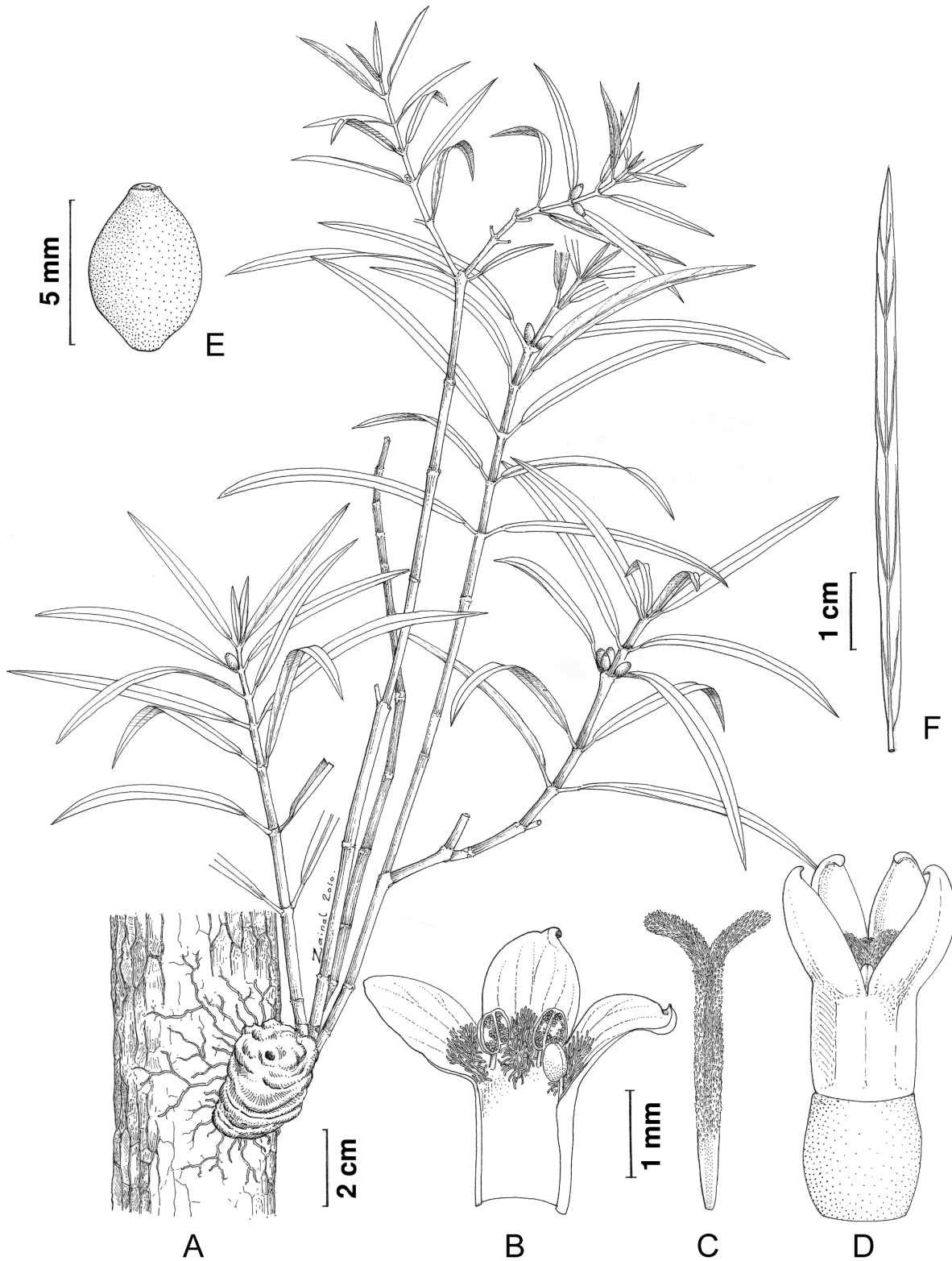


Figure 1 – *Hydrophytum puffii*: A, habit and fruiting leafy branches; B, corolla (longitudinally opened with a segment removed) showing inner surface with dense translucent hairs at the throat; C, detail of style and stigmas (note surface densely papillate); D, close-up of an open flower (note the truncate upper margin of the hypanthium); E, close-up of a prolate fruit; F, detail of the lower side of leaf lamina showing five pairs of secondary veins. All drawn from *Y.W.Low* LYW 367 (SING) by Zainal Mustafa.



Figure 2 – *Hydnophytum puffii*, habit of a relatively young fruiting plant, taken in Tawai Forest Reserve, Telupid, Sabah. Photographed by Ubaldus Majawal.

c. 1.5 mm long, c. 1 mm wide, glabrous, caducous; apex acute. Petiole inconspicuous to c. 0.9–2.5 mm long, glabrous, terete in cross section. Leaf lamina linear, (40–)60–94(–110) mm long, 2.5–4(–9) mm wide, thin-leathery, glabrous on both sides; base attenuate; apex acute; margin entire; mid-rib inconspicuous and glabrous on upper side, prominent and glabrous on the lower side; secondary veins 4–5 pairs, inconspicuous on upper side, faintly raised and glabrous on lower side; tertiary venation inconspicuous on both sides. In-florescences sessile, axillary and paired at nodes; bracts inconspicuous. Flowers 4-merous, heterogeneity not evident. Calyx cupuliform, tube c. 0.6–1 mm long, glabrous on both sides; margin lobes not present. Corolla tubular, white; tube 1.5–2 mm long, outside glabrous, inside with a band of dense translucent hairs at the throat; aestivation valvate; lobes 4, triangular, c. 1.5 mm long, c. 1 mm wide, outside surface glabrous, inside hairy at the basal-most part attached to the corolla tube; apex not unciniate. Stamens 4, alternipetalous, inserted at the corolla throat, basifixed; filaments subsessile; anthers c. 0.5 mm long, exserted. Style c. 2.5 mm long, densely papillate except at the basal quarter. Stigma 2-lobed, c. 0.5 mm long, surface densely papillate, exserted above the anthers; ovules 2. Fruit prolate, c. 6 mm × 4 mm, smooth, fleshy drupe, maturing reddish orange; locules 2. Pyrenes 2, fusiform, broadest slightly above middle, c. 3.5 mm long, 1.7 mm wide, with a semi-transparent fleshy thread at the basal

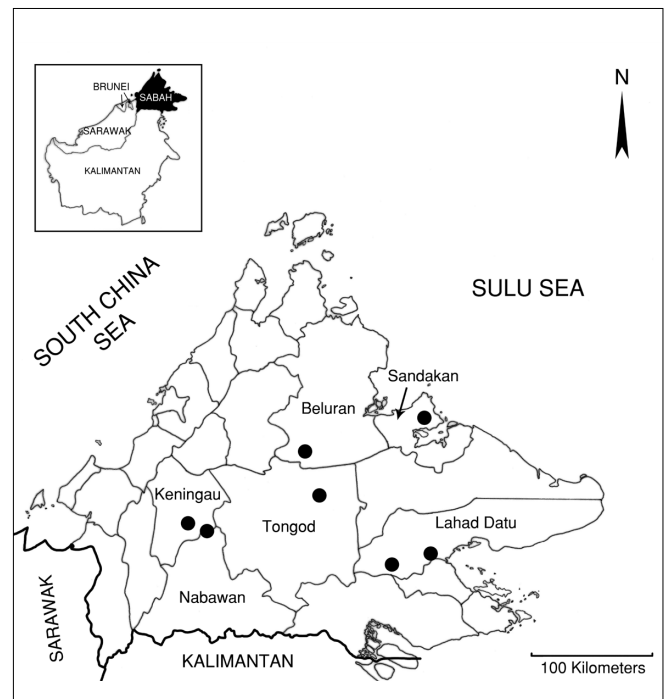


Figure 3 – Distribution of *Hydnophytum puffii* in Sabah, indicated by dots; (inset) Borneo, showing Brunei, Kalimantan (Indonesia) and Sabah and Sarawak (Malaysia).

end; base attenuate; apex obtuse; plano-convex in cross section; endosperm non-ruminate. Figs 1 & 2.

Distribution and habitat – An epiphyte in lowland to hill ‘kerangas’ or heath forest over sedimentary rocks (see Whitmore 1984 for definition of forest types) and forest over ultramafic geology in Sabah (fig. 3). Flowering and fruiting is recorded from June to December.

Etymology – This species commemorates Prof. Dr. Christian Puff (1949–2013) of the University of Vienna (Austria), a distinguished Rubiologist and tropical botanist, mentor and friend, who contributed significantly to the understanding of Southeast Asian plants, particularly in Borneo and Thailand.

Proposed IUCN Conservation Assessment – This species is given an IUCN Red List Category of Vulnerable (VU B1+2ab(iii,iv)). *Hydnophytum puffii* is so far recorded only in Sabah (Borneo), and its habitat is highly threatened by logging and clearing for oil palm plantations (White 2008). The extent of occurrence (EOO) of the species is estimated to be 10,998.387 km² (which falls within the limits 20,000 km² upper limit for VU status under the subcriterion B1), whereas its area of occupancy (AOO) is estimated to be 28 km² (which falls within the limits for EN status under the subcriterion B2). This species has so far been known only from seven localities based on herbarium specimens collected, namely Keningau (Sook Plain), Nabawan, Beluran (Tawai Forest Reserve), Tongod (Gunung Tingkar), Sandakan (Mile 81, Labuk Road), and Lahad Datu (Danum Valley and Ulu Segama Forest Reserve). These subpopulations at seven locations, according to the IUCN guidelines, qualify the species as Vulnerable under condition “a” (less than or equal to 10). Considering also factors such as (i) decrease in the quality of habitat, and (ii) the number of locations, the species qualifies under condition “b”. Habitat loss is a major conservation concern for the species as forest cover in Sabah has declined tremendously (Bryan et al. 2013). Mining of copper was active at Ranau since 1975, with the establishment of the Mamut copper mine, but this ceased operation in 1999 (The Star 2007). It was the only, and the last, copper mine established in Sabah. However, the proposed status for the species would require reassessment as more botanical surveys in Sabah are being carried out.

Additional specimens examined – Borneo, Sabah (Malaysia): Keningau, Mile 6, Sook Plain, Tulid road, *kerangas* forest, 4 Jun. 1965, *Meijer* 51704 (K n.v., SAN); Nabawan, locality unknown, *kerangas* forest, 17 Jul. 2010, *Suzana et al.* SAN 152603 (K n.v., SAN); Tongod, Gunung Tingkar Forest Reserve, secondary forest, 3 Apr. 2013, *Suzana et al.* SAN 150236 (SAN); Beluran, Telupid, Tawai Forest Reserve, Ultramafic forest, 5 Aug. 2011, *Joel et al.* SAN 153055 (SAN); Sandakan, Mile 81, Labuk Road, 14 Dec. 1971, *Dewol et al.* SAN 74968 (SAN); Lahad Datu, Ulu Sg. Danum, near Kuala Sg. Segama, 31 Aug. 1976, *B.C.Stone et al.* SAN 85200 (SAN); Lahad Datu, Ulu Segama Forest Reserve, Kennedy Bay, 12 Aug. 1986, *Joseph & Gambio* SAN 116885 (SAN). **Malay Peninsula, Peninsular Malaysia (Malaysia):** Kuala Lumpur, University of Malaya, Rimba Ilmu Botanical Garden, cultivated [specimen originated from Sabah], 18 Apr. 2009, *Y.W.Low* LYW 367 [KLU, SING: barcode 0166293 and spirit material (barcode 0202896)].

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