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New names and status for Pacific spiny species of *Solanum* (Solanaceae, subgenus *Leptostemonum* Bitter; the Leptostemonum Clade)

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Abstract

Five new species of spiny solanums (*Solanum* subgenus *Leptostemonum* Bitter; the Leptostemonum Clade) are described from the islands of the Pacific. Two of the new species are from Fiji (*S. pseudopedunculatum* D.McClelland, **sp. nov.** and *S. ratale* D.McClelland, **sp. nov.**), two from New Caledonia (*S. memoayanum* D.McClelland, **sp. nov.** and *S. semisucculentum* D.McClelland, **sp. nov.**), one from Papua New Guinea (*S. labyrinthinum* D.McClelland, **sp. nov.**) and another from Vanuatu (*S. vanuatuense* D.McClelland, **sp. nov.**). A new status and combination is provided for the rare Hawaiian endemic *S. caumii* (F.Br.) D.McClelland, **comb. et stat. nov.** and a new type designated for *S. peekelii* Bitter of Papua New Guinea, for which a description is also provided. All species are illustrated with digitized herbarium specimens, mapped and have been assigned a preliminary conservation status using current IUCN guidelines. Details of all specimens examined are provided in a Suppl. materials 1: file SM1.

Keywords

Endemism, Fiji, Hawaiian islands, New Caledonia, New Guinea, new species, Pacific islands, Solomon Islands, Vanuatu

Introduction

Solanum L. (Solanaceae) is one of the largest genera of angiosperms (Frodin 2004), with ca. 1,400 species occurring on all continents except Antarctica. Species of *Solanum* occur in a wide variety of habitats from deserts to tropical rainforests, and the highest species-level diversity occurs in South America. The last global monographic treatment of *Solanum* dates from the 19th century (Dunal 1852), which included 901 species (with an additional 19 incompletely known). *Solanum* taxonomy has proceeded in a piecemeal fashion until relatively recently and the genus had acquired a reputation of being intractable, but recent monographic work has begun to remedy this situation (e.g., Vorontsova and Knapp 2016).

The largest monophyletic group of *Solanum*, known as the Leptostemonum clade or *S.* subgenus *Leptostemonum* Bitter (Bohs 2005; Weese and Bohs 2007; Stern et al. 2011), includes prickly plants with stellate indumentum (the "spiny" solanums) and comprises approximately half the species diversity of the genus. It consists of a large lineage of approximately 570 species, of which approximately half are primarily New World in distribution, with significant diversity found in the Old World (including Oceania). Approximately 240 species are confined to the Old World tropics (see Aubriot et al. 2016), and a significant center of spiny solanum diversity is found in Australia (Symon 1981). The scattered islands of the Pacific Ocean are not a center of diversity for the spiny solanums, but the taxa found there are often highly endemic (see species described herein). The spiny solanums occurring in the Pacific were considered to belong to the traditional sections *Dunaliana* Bitter and *Irenosolanum* Bitter (Bitter 1917, 1922), and were grouped in the *S. dunalianum* and *S. sandwichense* species groups by Whalen (1984). Using a combination of morphological and molecular characters the species of these groups have been shown to fall into two monophyletic clades corresponding to Bitter's sections (McClelland 2012), but their members have generally not been included in wider molecular analyses of Old World spiny solanums (e.g., Aubriot et al. 2016). Those few that have been included (i.e., *S. sandwichense* Hook., *S. incompletum* Dunal, and *S. pancheri* Guillamin of section *Irenosolanum* sensu McClelland 2012; *S. dunalianum* Gaudich. of section *Dunaliana* sensu McClelland 2012) are nested within the larger "Sahul-Pacific clade" of Aubriot et al. (2016) that is itself sister to the rest of the Old World spiny solanums (sensu Stern et al. 2011). They are not recovered as either monophyletic or as sister to each other. Aubriot et al. (2016) resolve *S. dunalianum* as a member of a group with *S. lianoides* Merr. & L.M.Perry and *S. graciliflorum* Dunal of the Philippines and Indonesia respectively, neither of which was considered by McClelland (2012), while the other three taxa are sequential sisters to a clade of New Guinea species (see fig. 3 of Aubriot et al. 2016). Relationships of these Pacific taxa are not clear yet, and their inclusion in wider phylogenetic analyses with broad sampling of Australasian taxa is a priority.

Despite previous floristic work in the Pacific (e.g., Seemann 1866; Bitter 1917, 1921; Symon 1985, 1999; Smith 1991) the spiny solanums of the Pacific are relatively poorly known compared to other areas. Here we describe five taxa recognized as new

during the course of monographic work (McClelland 2012; D.H.R. McClelland and M. Nee, in prep.), recognize a variety of a Hawaiian endemic at the species level, and provide a new type and description for a misunderstood species from Papua New Guinea. We also provide preliminary conservation assessments for each of these species.

Materials and methods

The species descriptions and circumscriptions here are based on examination of herbarium specimens from 24 herbaria (103 collections, 266 specimens) worldwide (A, BH, BISH, BM, CANB, G, GH, K, L, LAE, MEL, MO, NOU, NSW, NY, P, PTBG, RSA, S, SING, U, UC, US, W) and field work undertaken in Hawaii and New Caledonia by DHRM and MN in 2009. All specimen data are presented in the Suppl. materials 1: file SM1 and on the Natural History Museum Data Portal (https://doi.org/10.5519/0072409).

To assess the conservation status of the species treated here Extent of Occurrence (EOO) and Area of Occupancy (AOO) were calculated using GeoCAT (www.geocat.kew.org) with a 2 km cell width for AOO calculation. The preliminary conservation status was assessed using the IUCN (2019) criteria based on the GeoCAT analyses (Moat 2007; Bachman et al. 2011) combined with field knowledge. All specimens examined are cited in the text. Our delimitation of these new taxa is based on the "morphological species concept" (Davis and Heywood 1963; Mallet 1995).

Taxonomic treatment

Section Dunaliana Bitter (sensu McClelland 2012)

Solanum labyrinthinum **D.McClelland, sp. nov.**
urn:lsid:ipni.org:names:77209325-1
Figure 1

Diagnosis. Like *S. dunalianum* Gaudich. but with narrowly elliptic to lanceolate leaves, many-branched inflorescences arising from the middle of the internode, and smaller fruits.

Type. Papua New Guinea. Milne Bay Province: Normanby Island, Waikaiuna [Bay], 5 m, 17 Apr 1956 (fl, fr), *L.J. Brass 25460* (holotype: LAE [acc. # 47392]; isotypes: A, K [K000922591], L [L.4307630], S, US [acc. # 2408171]).

Description. Erect shrub to ca. 2.5 m, the internodes to 6.5 cm long, apparently unarmed. Stems with a few scattered ferruginous sessile porrect-stellate trichomes when young, the rays 6–7, ca. 0.15 mm long, the midpoint more or less equal to the rays, the stems soon glabrescent; new growth sparsely pubescent with sessile stellate trichomes and minute glandular papillae; bark of older stems pale gray. Sympodial units difoliate,

Figure 1. *Solanum labyrinthinum* D.McClelland (isotype *Brass 25460*, US [acc. # 2408171]). Reproduced with permission.

the leaves geminate or not, if geminate members of a pair more or less equal in size and shape. Leaves simple; blades 8.0–16.0 cm long, 1.4–3.7 cm wide, ca. 4.5–6.0 times as long as wide, narrowly elliptic to lanceolate, subcoriaceous, concolorous, unarmed; adaxial surfaces glabrous or with a few sessile porrect-stellate trichomes with 5–8 rays 0.15–0.2 mm long, the midpoints much shorter than the rays; abaxial surfaces glabrous; principal veins 7–10 pairs, the midrib raised both abaxially and adaxially, the lateral veins weakly brochidodromous, raised both abaxially and adaxially, drying yellowish or dark; base cuneate; margins entire or slightly wavy; apex acute to somewhat acuminate; petiole 0.9–1.8 cm long, 0.8–1.3 mm in diameter, channeled adaxially, glabrous when mature, unarmed. Inflorescence to 7.5 cm long, appearing lateral, extra-axillary, unbranched to forked to many-branched, with few to ca. 50 flowers, sparsely to moderately pubescent with sessile porrect-stellate trichomes when young, soon glabrous, unarmed; peduncle 0.1–0.6 cm long,, unarmed; pedicels 0.6–1.0 cm long, ca. 0.3 mm in diameter at the base, ca. 0.5 mm in diameter below the calyx, straight, gradually increasing in diameter from the base distally, articulated at the base; pedicel scars congested to spaced 0.9 mm apart, rigid, in two rows. Buds conical, the calyx enclosing the corolla when young, the corolla sparsely pubescent with scattered stellate trichomes and glandular papillae on exposed abaxial surfaces, strongly exserted from the calyx lobes before anthesis. Flowers 5-merous, all perfect. Calyx 1.4–1.7 mm long, with the tube to 0.8–1.2 mm long, in bud appearing nearly truncate with apiculate lobe tips to 0.5 mm long, splitting in the scarious sinuses at anthesis, the lobes 1.1–1.7 mm long, 1–1.4 mm wide, deltate, abaxially glabrous to sparsely pubescent with scattered porrect-stellate trichomes and minute glandular papillae, adaxially glabrous. Corolla ca. 1.2 cm in diameter, purple or deep violet, stellate, the interpetalar tissue not well-developed, the lobes 3.7–5.4 mm long, 1.6–2 mm wide, long-deltate, spreading at anthesis. abaxially densely stellate pubescent where exposed in bud, adaxially glabrous or with a few stellate trichomes near the tips. Stamens equal; filament tube minute; free portion of the filaments ca. 0.5 mm long, glabrous; anthers 3.5–4 mm long, 0.6–1 mm wide, tapering, connivent, yellow, poricidal at the tips, the pores directed distally. Ovary conical, glabrous; style 3.0–5.0 mm long, ca. 0.2 mm in diameter, exserted from or equal to the anther cone, filiform, straight, glabrous; stigma ca. 0.4 mm in diameter, bilobed, minutely papillate. Fruit a globose berry, 4.0–6.0 mm in diameter, red when mature, glabrous, the pericarp thin, shiny, opaque; fruiting pedicels 1.2–1.6 cm long, 0.4–1 mm in diameter at the base, 0.8–1.1 mm in diameter at the apex, erect; fruiting calyx not accrescent, the lobes 1.4–2.2 mm long, 1.0–1.5 mm wide, glabrous, appressed to the berry surface or slightly reflexed. Seeds 10–40 per berry, 1.8–2.5 mm long, 1.5–1.8 mm wide, flattened, suborbicular to reniform, notched at the point of attachment, yellow-ferruginous when dry, the surface minutely pitted (alveolate), the testal cells with straight walls. Chromosome number not known.

Distribution and ecology (Figure 2). *Solanum labyrinthinum* is known from Normanby Island and adjacent East Cape on New Guinea; it has been collected along roads in rainforest from 5 to 185 m elevation.

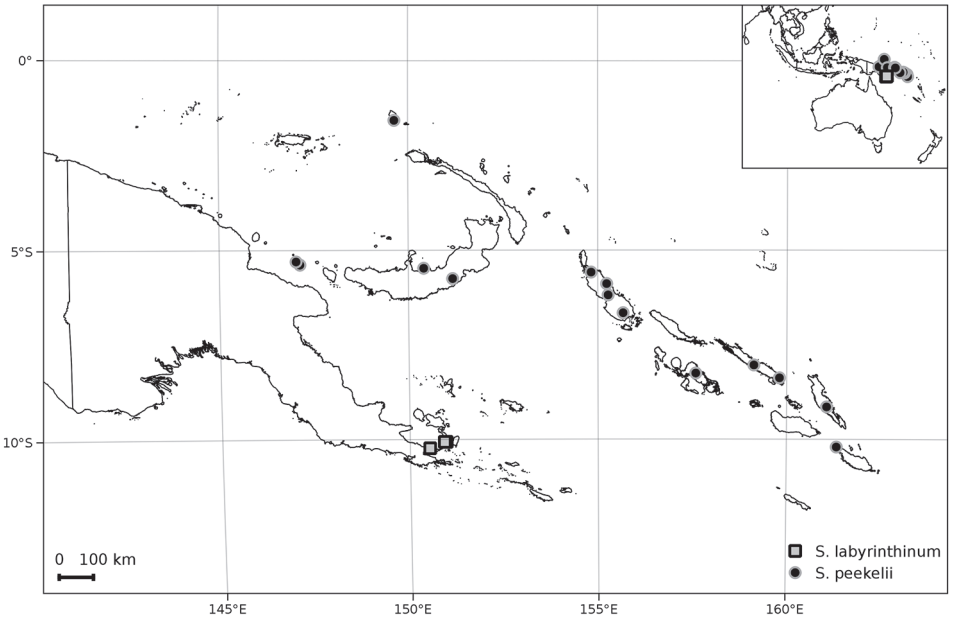

Figure 2. Distribution of *Solanum labyrinthinum* and *S. peekelii*.

Phenology. Known to flower and fruit in Apr. Perhaps fertile year round like the other members of *Solanum* section *Dunaliana*.

Etymology. The specific epithet was chosen to reflect the taxonomic labyrinth involving two other species of New Guinea *Solanum* that was unintentionally created by Symon (1985).

Preliminary conservation assessment (IUCN 2019). EOO = 51 km^2 [CR – Critically Endangered]; AOO = 12 km^2 [EN – Endangered]. We assess *Solanum labyrinthinum* as EN (Endangered) using IUCN Criteria B1a,b, due to its restricted distribution, its primary forest habitat and lack of recent collections indicating population decline. Although it is found both on New Guinea and in the Solomon Islands, the destruction of lowland forest habitat in coastal areas suggests conservation concern.

Discussion. *Solanum labyrinthinum* differs from other members of section *Dunaliana* (sensu McClelland 2012) in its almost completely glabrous narrowly elliptic or somewhat lanceolate leaves. Like *Solanum torricellense* Bitter of New Guinea, but unlike the other members of this group (section *Dunaliana* sensu McClelland 2012), the inflorescence of this species emerges from the middle of the internode. *Solanum labyrinthinum* differs from *S. peekelii* with which it has been confused (see below) in its narrow completely glabrous leaves at maturity with distinctive appressed stellate trichomes when young, its fewer principal leaf veins (7–10 versus 10–14) that often dry yellowish, its slightly smaller flowers (ca. 1.2 cm in diameter versus to 1.5 cm in diameter) and fruits, and in its distribution. The stems of *S. labyrinthinum* are often purplish tinged, and the flowers are darker purple than those of *S. peekelii*.

Symon (1985) applied the name *S. peekelii* to the plants we here recognise as *S. labyrinthinum*, then applied the name *S. torricellense* to plants matching the description of *S. peekelii* and provided a new name for plants matching the type of *S. torricellense*, thus creating a taxonomic labyrinth (see below under typification of *S. peekelii* for details, and Solanaceae Source (www.solanaceaesource.org) for descriptions of the other taxa involved).

Additional specimens examined. Papua New Guinea. Milne Bay Province: Awaiama, Sep 1895 (fr), *Fitzgerald 16* (MEL); Normanby Island, Sewa Bay, 600 ft, 20 Apr 1956 (fl), *J. Womersley & L. Brass NGF-8678* (A [2 sheets], BM [2 sheets], BO, BRI, CANB, K, L, LAE, NSW, SING).

Solanum peekelii **Bitter, Bot. Jahrb. Syst. 55: 73. 1917**
Figure 3

Solanum dunalianum var. *inerme* Witasek, Denkschr. Akad. Wiss. Wien 89: 601. 1914. Type: Papua New Guinea. Bougainville (North Solomons): "Salomonsinseln, Insel Bougainville, Am Strande bei dem Eingebornen dorf Numa-Numa", Sep 1905, *K. Rechinger & L. Rechinger 3607* (lectotype, designated here: W [acc. # 1916-10316]; isolectotype: W [acc. # 1916-10317]).

Type. Papua New Guinea. New Ireland Province: Bismark Archipelago, New Ireland ["Neu-Mecklenburg"], Buragamata near Namatanai, 12 m, Jul, *G. Peekel 523* (holotype: B [destroyed]). Papua New Guinea. New Britain Province: West New Britain, West Nakanai, Malalia near Cape Hoskins, 16 Aug 1954 (fl, fr), *A. Floyd NGF-6549* (neotype, designated here: LAE [acc. # 16333]; isoneotypes: A, BM [BM000886258], CANB [acc. # 75841.1], K [K000922697], L [L.4307653], MEL [MEL0625408A], NSW [acc. #594233], US [acc. # 2211029, barcode 02838857).

Description. Erect shrub or small tree to 4(5) m tall, the internodes to 13.5 long, unarmed to sparsely armed. Stems pubescent with yellow, sessile porrect-stellate trichomes, the rays 6–10, 0.15–0.2 mm long, the midpoint shorter than to more or less equal to the rays; new growth pubescent near the leaf bases with sessile porrect-stellate trichomes like those of the stems, soon glabrescent, the prickles if present 1–2 mm long, weak-walled, somewhat broadened at the base, very sparse; bark reddish brown, glabrescent, somewhat shiny, unarmed or with very sparse prickles 1–2 mm long. Sympodial units difoliate, the leaves geminate, members of a pair more or less equal in size and shape. Leaves simple; blades 10.0–25.5 cm long, 5.0–9.0 cm wide, 2.4–3.2 times as long as wide, obovate to elliptic, chartaceous, concolorous, unarmed; adaxial surfaces more or less glabrous, the pubescence denser near the basal portion of the blade, the trichomes porrect-stellate, the rays (5)6–8, 0.5–0.2 mm long, the midpoint shorter than or equal to the rays; abaxial surfaces sparsely pubescent with sessile porrect-stellate trichomes with 6–8-rays 0.2–0.3 mm long, the midpoint erect, shorter than to more or less equal to the rays; principal veins 10–14 pairs, the midrib raised abaxially and

Figure 3. *Solanum peekelii* Bitter (isoneotype *Floyd NGF-6595*, incorrectly labelled as *S. pancheri*, US [acc. # 2211029, barcode 02838857]). Reproduced with permission.

adaxially, the lateral veins weakly brochidodromous, raised abaxially and adaxially; base rounded to cuneate, occasionally long attenuate in vigorous growth, sometimes somewhat oblique; margins entire or slightly wavy; apex acuminate; petiole 1.6–5.0 cm long, 1.0–2.2 mm in diameter, channeled above, moderately stellate-pubescent when

young, unarmed, the pubescence becoming sparse to moderate and restricted to the adaxial channel with age. Inflorescence to 1.1–6 cm long, appearing lateral, extra-axillary, in the upper 1/3 of the internode often just below the leaf, unbranched or forked with a single pedicel attached below the fork, with up to 45 flowers, densely pubescent with sessile porrect-stellate trichomes like those of the stems; peduncle 0.7–1.2 cm long; pedicels 0.4–1.2 cm long, 0.3–0.4 mm in diameter at the base, 0.5–0.7 mm in diameter below the calyx, straight, gradually increasing in diameter from the base distally, articulated at the base; pedicel scars congested to spaced ca. 0.6 mm apart, rigid, in two rows. Buds conical, the calyx moderately to densely stellate-pubescent, the corolla densely stellate-pubescent where exposed abaxially, only somewhat exserted from the calyx before anthesis. Flowers 4–5-merous, all perfect or apparently so. Calyx 1.6–2.3 mm long, the tube 1.3–1.8 mm long, in bud appearing nearly truncate with lobe tips apiculate or reduced to minute protuberances 0.1–1.1 mm long, the sinuses transparent when dry, the lobes 0.7–1.7 mm long, 0.9–1.5 mm wide at anthesis, deltate, splitting in the sinuses at anthesis, moderately to densely pubescent abaxially with sessile porrect-stellate trichomes, glabrous adaxially, Corolla 1–1.5 cm in diameter, stellate, white or lavender to purple, the interpetalar tissue poorly-developed, glabrous, the lobes 5.7–6.5 mm long, 2.8–3.1 mm wide, triangular, apparently spreading at anthesis, densely pubescent along the petal midvein abaxially, more or less glabrous adaxially. Stamens equal; filament tube minute, with tiny teeth between each filament (fide Bitter 1917); free portion of the filaments ca. 0.6 mm long, glabrous; anthers 2.2–4.8 mm long, 0.6–0.9 mm wide, tapering, yellow, connivent, poricidal at the tips, the pores dorsally directed. Ovary 0.4–0.6 mm in diameter, ovoid, glabrous or with a few sessile porrect-stellate hairs at the very apex; style 3.7–5.4 mm long, 0.2–0.3 mm in diameter, filiform, straight, sparsely to moderately stellate pubescent at the very base to basal 1/3; stigma ca. 0.4 mm in diameter, capitate or slightly bilobed. Fruit a globose juicy berry, 4.0–7.0 mm in diameter, the immature fruits green, maturing red, glabrous, the pericarp thin, somewhat shiny, opaque; fruiting calyx lobes 1.2–2.3 mm long, 1.4–2.0 mm wide, sparsely to moderately pubescent, appressed in ripe fruit; fruiting pedicels 9.2–15.2 mm long, 0.3–0.7 mm in diameter at the base, 0.7–1.3 mm in diameter below the calyx, straight, gradually increasing in diameter from the base distally;. Seeds ca. 45 per fruit, 1.6–2.3 mm long, 1.4–1.9 mm wide, flattened, orbicular to reniform, notched at the point of attachment, yellow-ferruginous when dry, the surface the central area nearly smooth, the margins minutely pitted, the testal cells pentagonal or rectangular. Chromosome number not known.

Distribution and ecology (Figure 2). *Solanum peekelii* occurs from the Bismarck Archipelago of Papua New Guinea to the Solomon Islands. It has been collected in disturbed habitats such as old village gardens, forest edges, and secondary forest, from sea level to 170(–1070) m elevation. According to Peekel (1984), *S. peekelii* is one of the first plants to appear in abandoned gardens; the lectotype of *S. dunalianum* var. *inerme* was collected on the beach near a village.

Common names and uses. Papua New Guinea. Bougainville: Kala-bu-ku (*Kajewski 1790*); Madang: Airoroana (*Lepofsky 466*), New Georgia: Susuriata (*Waterhouse 31*), leaves said to be used in preparation of a cough medicine. Peekel (1984) reported

the Pala people used stems from the species to construct graters for taro and yams by binding them crosswise to a grid.

Preliminary conservation assessment (IUCN 2019). EOO = 477,504 km^2 [LC – Least Concern]; AOO = 52 km^2 [EN – Endangered]. We assess *Solanum peekelii* as LC (Least Concern) due to its relatively wide distribution (EOO) and its occurrence in secondary and other disturbed habitats. Its use by people may also afford it some protection.

Discussion. *Solanum peekelii* was named for P. Gerhard Peekel (1876–1949), a missionary in New Guinea who spent 43 years collecting plants in the Bismarck Archipelago, primarily on New Ireland, resulting in a flora of the region (Peekel 1984). Though Peekel did not consider himself a botanist, he was clearly dedicated to the plant diversity of the area. At the outbreak of the Second World War he took measures to preserve his manuscript. Notwithstanding, it suffered from the unfavorable conditions in dugouts and concentration camps; one volume was even pierced by a bullet from an airplane. During the Japanese occupation of New Ireland, Peekel's botanical knowledge saved his life. All people of European descent were brought to a concentration camp where Peekel was the only male not to be killed because the Japanese relied on his botanical knowledge (Peekel 1984).

Symon (1985) mistakenly treated *S. peekelii* under the name *S. torricellense*, from which it differs in its smaller berries (4–7 mm versus 7–9 mm in diameter) and sparser pubescence of stellate rather than the multangulate trichomes characteristic of *S. torricellense*. Symon (1985) applied the name *S. peekelii* to plants of what we have named here *S. labyrinthinum*. He then provided a new name, *S. mankiense* Symon, for plants matching the type of *S. torricellense* (see discussion under those species on Solanaceae Source, www.solanaceaesource.org). Because the type of *S. peekelii* was presumed destroyed at B, Symon (1985) designated *Womersley & Brass NGF-8678* from Normanby Island (here included in *S. labyrinthinum*) as the neotype of *S. peekelii*, adding a final twist to this taxonomic labyrinth. However, none of the duplicates of *Womersley & Brass NGF-8678* agree with Bitter's (1917) detailed protologue of *S. peekelii* in the pubescence of the leaves and stem, leaf size or length to width ratio, number of lateral leaf vein pairs, corolla size, and lack of small teeth between each filament. Additionally, the travels and collecting habits of P.G. Peekel are well-documented (Peekel 1984), and he never journeyed to Normanby Island. The protologue of *S. peekelii* and the neotype designated by Symon (1985) are thus serious conflict, and the neotypification of *S. peekelii* with *Womersley & Brass NGF-8678* should be superseded (Turland et al. 2018, Art. 9.19c); we neotypify the species again here with a specimen from New Ireland that exactly matches Bitter's protologue and comes from an area where Peekel is documented to have collected.

Specimens examined. Papua New Guinea. Bougainville: Kugu-maru, Buin, 150 m, 1 Jun 1930 (fl, fr), *Kajewski 1790* (A, BM, BRI, G, P); forest edge at the village Numa-Numa, Sep 1905 (fl, fr), *Rechinger & Rechinger 5365* (W); vic. of Barilo village, ca. 6 miles N of Buin Station, ca. 500 ft, 28 Aug 1964 (fl, fr), *Schodde & Craven 3938* (A, CANB, K, L, LAE); Namatoa, ca. 1500 ft, 7 Mar 1932 (fl), *Waterhouse 691* (K). East New Britain: Sub-district Gasmata, Torlu River, ca. 3500 ft, 27 Mar 1965

(fl, fr), *Sayers NGF-24265* (A, K, L, LAE). Madang: Sub-district Saidor, Long Island, beach of Lake Wisdom, 400 m, 4 Oct 1971 (fl, fr), *Essig & Lelean LAE-55039* (A, BH, CANB, K, L, LAE, NY); Sub-district Saidor, Long Island, 5 miles N of Matafuma Village, 50 ft, 15 Nov 1969 (fr), *Vandenberg & Katik NGF-42331* (A, CANB, K, L, LAE). New Georgia: sin. loc., 21 May 1929 (fr), *Waterhouse 31* (K, LAE). New Ireland: St. Matthias Group, Eloaua, 30 m, 16 Nov 1968 (fr) *Lepofsky 466* (BISH).

Solomon Islands. Makira. Maru Bay, 550 ft, 28 Nov 1968 (fr), *Gafui 12869* (K, L, LAE). Malaita: NE Malaita, 450 ft, 21 Nov 1968 (fl, fr), *Mauriasi 13463* (K, L); Su'u area, SE Malaita, 500 ft, 2 Dec 1968 (fl, fr), *Mauriasi 13601* (A, K, L, LAE). Santa Isabel: Suwa, Toabul, 26 Nov 1932 (fl, fr), *Brass 3231* (A, L); head of Tatamba Bay, sea level, 1 Jan 1965 (fl, fr), *Hunt 2835* (A, K, L, LAE, P).

Section Irenosolanum Bitter (sensu McClelland 2012)

***Solanum caumii* (F.Br.) D.McClelland, comb. et stat. nov.**
urn:lsid:ipni.org:names:77209326-1
Figure 4

Solanum nelsonii Dunal var. *caumii* F.Br., Bull. Bish. Mus. 81: 36, pl. 15B. 1931. Type. United States of America. Hawaii: Leeward Islands, Nihoa, 75 m, 19 Jun 1923 (fl, fr), *E. Caum 84* (holotype: BISH [acc. # 581193, barcode BISH1014622]; isotypes: BISH [acc. # 581194, barcode BISH1014623], K [K000922665], NY [00172288], UC [acc. #505079]).

Solanum nelsonii Dunal var. *acuminatum* F.Br., Bull. Bish. Mus. 81: 36, pl. 16A. 1931. Type. United States of America. Hawaii: Leeward Islands, Nihoa, 75 m, 19 Jun 1923 (fl, fr), *E. Caum 68* (holotype: BISH [acc. # 581186, barcode BISH1014620]; isotypes: BISH [acc. # 581185, barcode BISH1014621], K [K000922664], NY [00172287]).

Type. Based on *Solanum nelsonii* Dunal var. *caumii* F.Br.

Description. Erect to sprawling shrub to ca. 1.5 m, the internodes to 6.6 cm long, unarmed. Stems densely pubescent with yellow-ferruginous, short-stalked porrect-stellate trichomes, the stalks of various lengths to ca. 0.1 mm, the rays 6–10, 0.15–0.2 mm long, the midpoint shorter than the rays; new growth densely stellate-pubescent; bark of older stems reddish brown. Sympodial units difoliate, the leaves geminate or not, if geminate the leaves of a pair similar in size and shape. Leaves simple or shallowly lobed; blades 3.5–8.0 cm long, 2.2–6.4 cm wide, 1.3–1.6 times as long as wide, deltate to ovate, chartaceous, concolorous, unarmed; adaxial surfaces densely pubescent with short-stalked porrect-stellate trichomes, the stalks to ca. 0.1 mm long, the rays 6–9, 0.1–0.2 mm long, the midpoint much shorter than the rays; abaxial surfaces densely pubescent with short-stalked porrect-stellate trichomes, the stalks to ca. 0.1 mm long, the rays 7–9, 0.2–0.25 mm long, the midpoint of the stellate trichomes much shorter

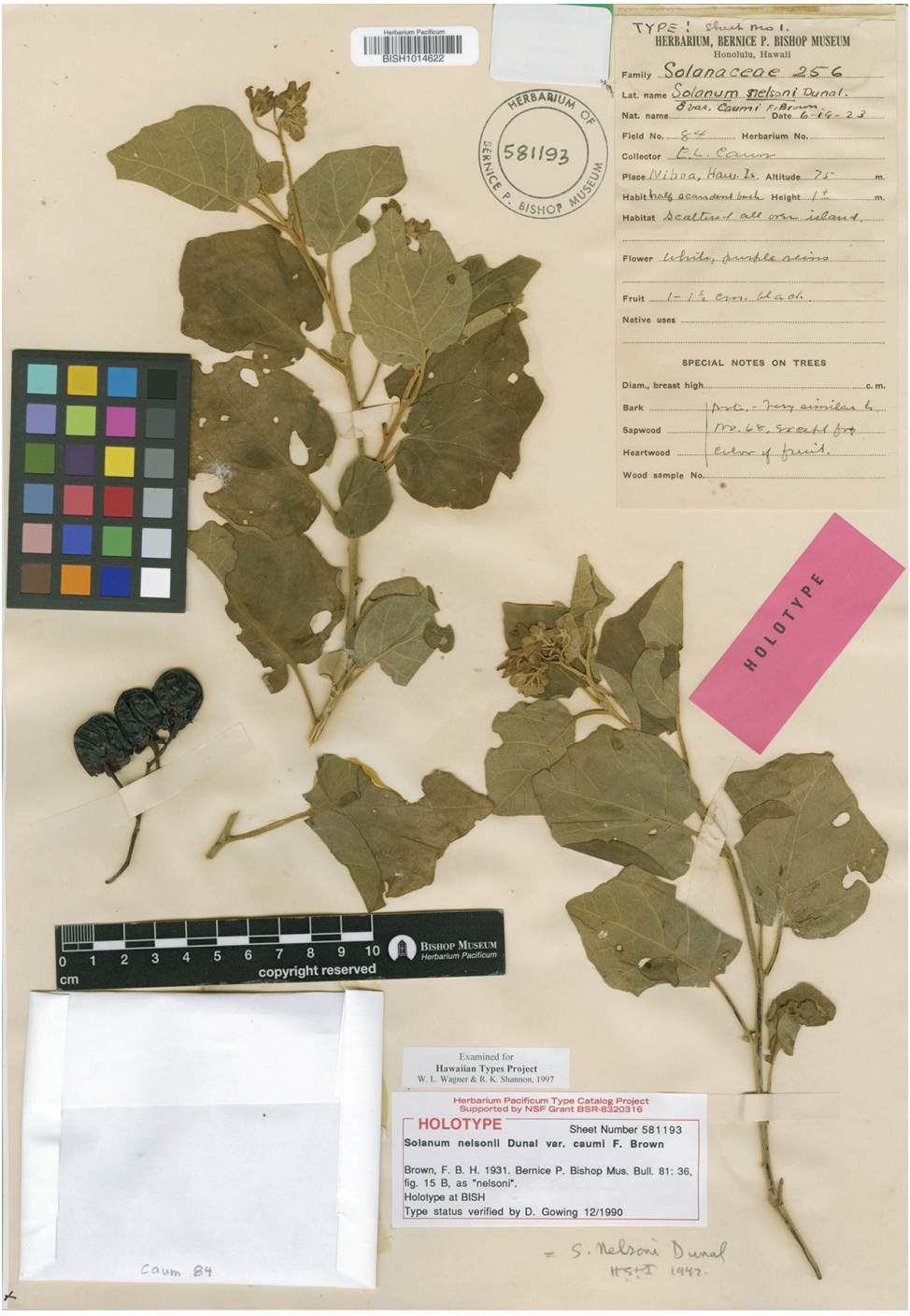

Figure 4. *Solanum caumii* (F.Br.) D.McClelland (holotype of *S. nelsonii* var. *caumii* F.Br., *E. Caum 84* BISH [acc. # 581193, barcode BISH1014622]). Reproduced with permission.

than the rays; principal veins 4–6 pairs, the midrib raised abaxially, distinct adaxially, the lateral veins weakly brochidodromous or semicraspedodromous, raised abaxially, distinct adaxially; base cordate, truncate, or rounded; margins entire or shallowly lobed, the sinuses less than 1/4 of the way to the midrib; apex acute to acuminate; petiole 0.8–3.3 cm long, 1.0–1.4 mm in diameter, channeled adaxially, densely pubescent with stalked porrect-stellate trichomes like the stems and leaves. Inflorescence to 8.1 cm long in flower, appearing lateral, extra-axillary, emerging from the distal 1/3 of the internode, typically unbranched but occasionally forked, with 10–16 flowers, densely pubescent with short-stalked porrect-stellate trichomes like the stems and leaves; peduncle 0.5–1.7 cm long; pedicels 0.9–1.2 cm long, 0.3–0.6 mm in diameter at the base, 0.5–0.9 mm in diameter below the calyx, straight, densely pubescent with porrect-stellate trichomes like those of the inflorescence axes, articulated at the base; pedicel scars evenly spaced to 8.8 mm apart, in two rows. Buds globose, the calyx densely stellate-pubescent, the corolla densely stellate-pubescent abaxially where exposed, strongly exerted from the calyx before anthesis. Flowers 4–5-merous, heterostylous, with short-styled flowers borne distally, the plants weakly andromonoecious. Calyx 3.1–4.9 mm long, the tube 1.7–1.8 mm long, the lobes 1.1–3.5 mm long, 1.2–2.1 mm wide, deltate, splitting in the sinuses during fruit development and then the lobes long-triangular, densely pubescent abaxially and adaxially. Corolla 1.3–2.0 cm in diameter, stellate, white, the interpetalar tissue well-developed, glabrous, the petal midveins purple, the lobes 5.1–5.7 mm long, 7.2–7.4 mm wide, deltate, spreading at anthesis, moderately pubescent abaxially, more or less glabrous adaxially. Stamens equal; filament tube minute; free portion of the filaments ca. 1.5 mm long, glabrous; anthers 2.9–3.2 mm long, 0.8–0.9 mm wide, tapering, strongly arcuate and spreading, purple sometimes appearing almost black, poricidal at the tips, the pores directed distally, not splitting with age. Ovary ca. 0.8 mm in diameter, ovate, white or cream in live plants, densely pubescent with porrect-stellate trichomes; styles of long-styled flowers ca. 3.8 mm long, ca. 0.4 mm in diameter, exserted from the anther cone, filiform, straight, densely stellate pubescent in the basal 2/3, in short-styled flowers 2.1–2.5 mm long, 0.1–0.2 mm in diameter, included in the anther cone; stigma ca. 0.3 mm in diameter, capitate, white or cream (live plants). Fruit a globose berry, 1.0–1.5 cm in diameter, green when immature, red or black when mature, juicy, glabrous, the pericarp thin, matte to slightly glossy, opaque; fruiting pedicels 1.1–1.9 cm long, 0.9–1.1 mm in diameter at the base, 2.1–2.3 mm in diameter below the calyx, straight and spreading; fruiting calyx lobes 3.4–6.3 mm long, 1.8–2.5 mm wide, moderately to densely pubescent, appressed to the berry surface. Seeds 20–30 per fruit, 2.8–3.5 mm long, 3.5–4.1 mm wide, flattened-reniform, red-brown when dry, the surface minutely pitted and evenly reticulate, the testal cells straight-sided. Chromosome number not known.

Distribution and ecology (Figure 5). *Solanum caumii* is restricted to the state of Hawaii (United States of America) on the tiny island of Nihoa in shallow rocky soil from 10 to 270 m elevation. Plants have been collected from both coastal and higher elevation areas on the island.

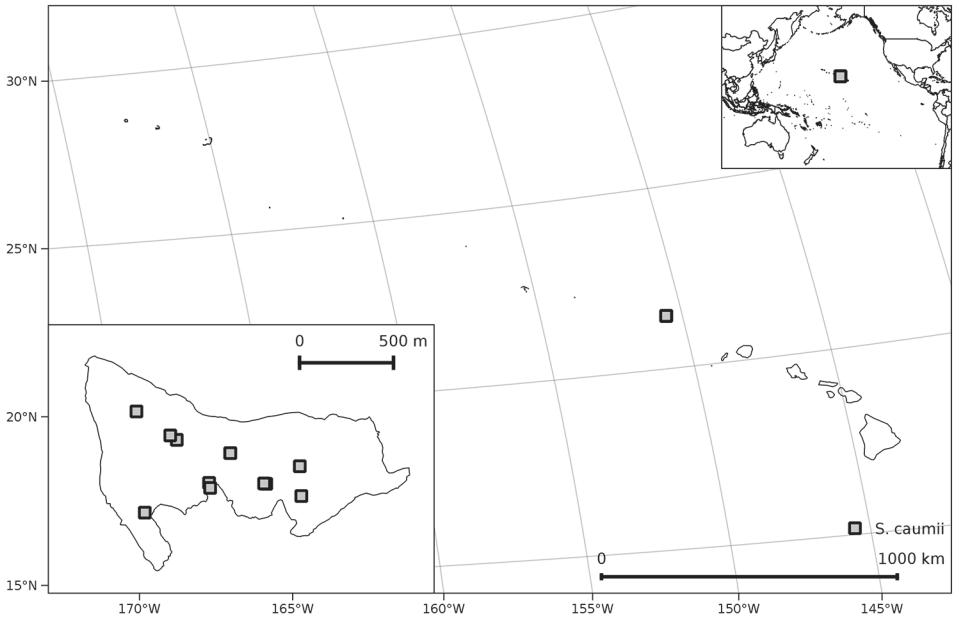

Figure 5. Distribution of *Solanum caumii*.

Phenology. Known to flower March–April and June–September and fruit March and June–July.

Common names and uses. United States of America. Hawaii (Nihoa): Akia (*St. John 22731*).

Etymology. The epithet honors Edward Leonard Caum (1893–1952), the American botanist who collected the type.

Preliminary conservation assessment (IUCN 2019). EOO = 0.25 km^2 [CR – Critically Endangered]; AOO = 4 km^2 [CR – Critically Endangered]. We assess *Solanum caumii* as CR (Critically Endangered) using IUCN Criteria of B1,2a,b; populations may be secure on the isolated island of Nihoa that is largely protected, but no recent studies on population stability have been undertaken. Recognition of *S. caumii* at the species level has conservation consequences. Symon (1999) included *S. caumii* within *S. nelsonii*. At that time *S. nelsonii* was listed as vulnerable; segregation of *S. caumii* the species may change the status of *S. nelsonii*. Threats to *S. caumii* include habitat destruction from natural causes and herbivory by an introduced grasshopper (Mitchell et al. 2005).

Discussion. Brown (1931) recognized the entity we here delimit as *S. caumii* as two varieties of *S. nelsonii*, a coastal species found on many islands in the Hawaiian archipelago. St. John (1988) placed *S. nelsonii* var. *acuminatum* in synonymy with *S. nelsonii* var. *caumii*. *Solanum caumii* is most similar to *S. nelsonii* but it can be distinguished by its semi-erect habit, larger leaf length to width ratio, and sometimes red fruit. In 2008, plants of *S. nelsonii* s.s. from Molokai were cultivated alongside individuals from Nihoa (*S. caumii*) in greenhouses at the New York Botanical Garden

(made available through the conservation program at the National Tropical Botanical Garden in Honolulu by Drs. David and Lida Burney and their staff). Under identical growing conditions plants here recognized as *S. caumii* and *S. nelsonii* s.s. maintained their distinct forms.

Endemism on the small island of Nihoa is relatively common, it is only one of four of the outer Hawaiian islands that still has exposed basalt substrate. There are other species of endemic or near-endemic plants (*Amaranthus brownii* Christoph. & Caum, Amaranthaceae; *Pritchardia remota* Becc., Arecaceae; *Scheidea verticillata* F.Br., Caryophyllaceae) and the entire island has been designated critical habitat for them (Mitchell et al. 2005). The island also hosts two endemic birds, at least seventeen endemic arthropods, and six endemic land snails (Mitchell et al. 2005).

Additional specimens examined. United States of America. Hawaii. Nihoa: sin. loc., 13 Jun 1923 (fl), *Bryan 3* (BISH); Miller Valley, 22 Apr 1983 (fl), *Conant 102* (BISH); base of Miller Valley, ca. 30 ft, 26 Aug 1968 (fl), *Herbst 1210* (BISH, US); Middle Valley, ca. 500 ft, 27 Jul 1980 (fl, fr), *Herbst & Takeuchi 6544* (US); East Palm Valley, ca. 300 ft, 27 Jul 1980 (fl, fr), *Herbst & Takeuchi 6555* (BISH; US); (fr), *Judd s.n.* (K); Rocky Gulch, 100 m, 20 Jun 1923 (fr), *Judd 6* (BISH); Rocky Gulch, 100 m, 20 Jun 1923 (fr), *Judd 7* (BISH); Rocky Gulch, 100 m, 20 Jun 1923 (fl), *Judd 8* (BISH); lower slopes above the east cove, 23 Sep 1964 (fl), *Long 2424* (US); top of Miller's Peak in crevice at top of "Devil's Slide", north side of peak, 24 Sep 1964 (fl), *Long 2434* (US); lower slopes west valley near water-course, ca. 350 ft, 24 Sep 1964 (fl), *Long 2439* (US); near helicopter landing, 6 Mar 1964 (fl, fr), *Munro s.n.* (BISH); Kawaewae, 75 ft, 12 Aug 1947 (fl), *St. John 22731* (K, PTBG, RSA, US); Papahanaumokuakea Marine National Monument, above Miller Valley W facing Miller Ridge, 76 m (fl, fr), 7 Apr 2006 *Tangalin 717* (US); Papahanaumokuakea Marine National Monument, lower Miller Valley just above sea shelf, near National Wildlife Refuge sign and base camp, 12 m, 7 Apr 2006 (fl), *Tangalin 722* (US).

***Solanum memaoyanum* D. McClelland, sp. nov.**
urn:lsid:ipni.org:names:77209327-1
Figure 6

Diagnosis. Like *Solanum semisucculentum* D.McClelland, but growing in the forest, a taller plant and with pubescent stems, leaves, and inflorescences.

Type. New Caledonia. Nord: Contrefort ouest du Mé Maoya audessus de la Mine Emma, 1450 m, 23 Apr 1970 (fr), *H.S. MacKee 21797* (holotype: NOU [acc. #017079]; isotypes: A, K [K000922612, K001155402], L [L0651810, L0651811], MO [acc. #2816917, barcode MO-2282963], NSW [acc. #594231], P [P00300081], U [U0182899]).

Shrub or small tree to 3 m tall with a trunk to 8 cm in diameter, the internodes to 2.8 cm long, unarmed. Stems densely pubescent with yellow-ferruginous, sessile porrect-stellate trichomes, the rays ca. 8, 0.05–0.1.5 mm long, the midpoint shorter than to more or less equal to the rays; new growth densely pubescent with sessile porrect-stellate tri-

Figure 6. *Solanum memoayanum* D.McClelland (isotype *MacKee 21797*, P [P00300081]). Reproduced with permission.

chomes on the veins and sparsely pubescent on the lamina, with minute glandular papillae to 0.04 mm long; bark of older stems brown, glabrescent. Sympodial units difoliate, the leaves not geminate. Leaves simple; blades 3.9–9.9 cm long, 2.0–3.3 cm wide, ca. 2.0–3.4 times as long as wide, lanceolate to elliptic, somewhat fleshy, discolorous, unarmed; adaxial surfaces sparsely pubescent, later glabrescent, the sessile porrect-stellate trichomes with (4–)8(–12) rays, 0.1–0.25 mm long, the midpoints shorter than to more or less equal to the rays; abaxial surfaces sparsely pubescent with sessile porrect-stellate trichomes, the rays 6–8, 0.1–0.2 mm long, the midpoint shorter than to more or less equal to the rays; principal veins 5–8 pairs, the midrib raised abaxially, distinct adaxially, the lateral veins weakly brochidodromous, raised abaxially, distinct adaxially; base rounded, equilateral or oblique; margins entire; apex acute to short-acuminate; petiole 1.0–2.2 cm long, 0.7–1.2 mm in diameter, channeled above, densely pubescent with sessile porrect-stellate trichomes like the stems. Inflorescence to 2.2 cm long, appearing lateral, extra-axillary, emerging from the upper 1/3 of the internode, unbranched, with 2–7 flowers, densely pubescent with sessile porrect-stellate trichomes; peduncle 0.8–1.7 cm long, 0.5–0.6 mm in diameter, unarmed; pedicels 0.7–1.3 cm long, 0.3–0.4 mm in diameter at the base, 0.6–0.9 mm in diameter below the calyx, bent to approximately 90° below the calyx, gradually increasing in diameter in the distal 1/4–1/2, sparsely pubescent, articulated at the base; pedicel scars congested to spaced 3.5 mm apart, rigid, in two rows. Buds ovate, the calyx densely stellate-pubescent, the lobe tips glabrous, the corolla densely stellate-pubescent abaxially where exposed in bud, strongly exserted from the calyx before anthesis. Flowers 5-merous, all perfect or apparently so (few flowering specimens have been collected). Calyx ca. 2.6 mm long, appearing nearly truncate with caudate lobe tips, the tube ca. 0.9 mm long, the lobes 1.4–1.7 mm long, the sinuses opaque when dry; splitting in the sinuses during fruit development and then the lobes deltate. Corolla ca. 2.4 cm in diameter, stellate, white, the interpetalar tissue well-developed, glabrous, the lobes ca. 0.8 cm long, 0.3 cm wide, triangular, spreading at anthesis, abaxially moderately pubescent, adaxially glabrous at the base with scattered pubescence towards the tips. Stamens equal; filament tube minute; free portion of the filaments ca. 1.7 mm long, glabrous; anthers ca. 5.1 mm long, 1.3 mm wide, tapering, straight, yellow, connivent, poricidal at the tips, the pores directed outward, extending around the tip edge. Ovary ca. 1.3 mm in diameter, globose, glabrous; style and stigma not seen. Fruit a globose juicy berry, 0.7–1.1 cm in diameter, red when mature, glabrous, the pericarp thin, glossy, translucent; fruiting calyx lobes 2.6–4.0 mm long, 1.7–3.8 mm wide, glabrous, reflexed; fruiting pedicels 1.3–2.6 cm long, 0.6–1.0 mm in diameter at the base, 1.7–2.5 mm in diameter below the calyx, gradually increasing in diameter in the distal 1/3–2/3, arching, glabrous to sparsely pubescent. Seeds 40–50 per fruit, 1.8–2.3 mm long, 2.2–2.6 mm wide, flattened-orbicular and notched at the point of attachment, yellow-tan when dry, the surface minutely and deeply pitted (cancellate), the testal cells somewhat sinuate in outline in the center, more straight-sided along the incrassate margins. Chromosome number not known.

Distribution and ecology (Figure 7). *Solanum memaoyanum* is narrowly restricted to the mountain of Mé Maoya on the Grande Terre, New Caledonia, and grows in rainforest from 1,300 to 1,500 m elevation.

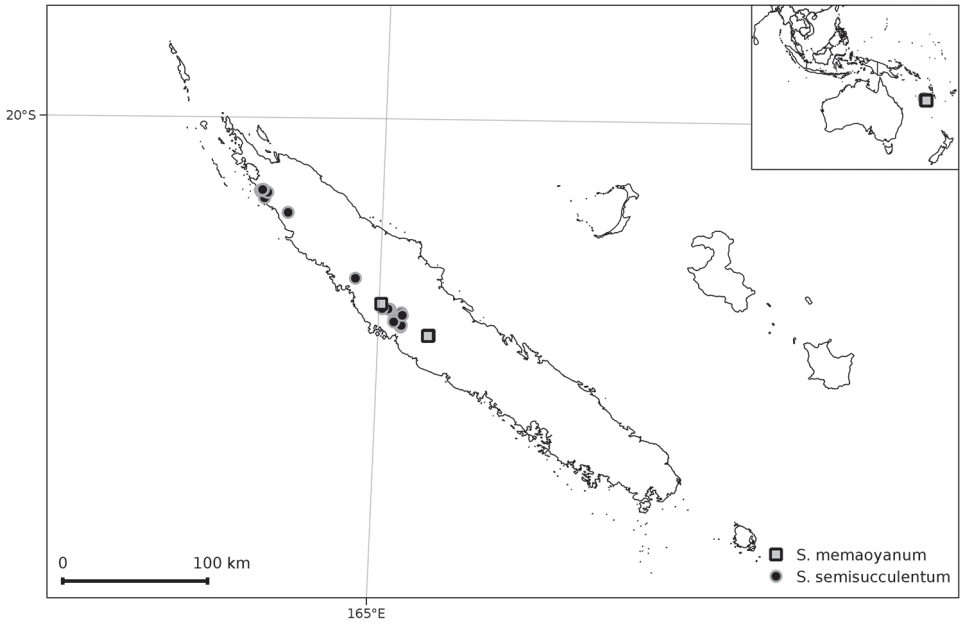

Figure 7. Distribution of *Solanum memoayoanum* and *S. semisucculentum*.

Phenology. Known to flower in January and fruit in April and August.

Etymology. This species is named after Mé Maoya, the mountain where the type was collected.

Preliminary conservation assessment (IUCN 2019). EOO = 9.35 km^2 [CR – Critically Endangered]; AOO = 12 km^2 [EN –Endangered]. *Solanum memaoyanum* is known from only a few collections, all of which are in montane serpentine soil areas now highly disturbed by mining activities. Although the AOO suggests an assessment of EN, we suggest *S. memaoyanum* should be assigned a status of CR (B2a,b) due to its fragmented distribution and threats to its montane habitat.

Discussion. *Solanum memaoyanum* is most similar to another new species described here, *S. semisucculentum*. Specimens here attributed to both were included in Heine's (1976) concept of *S. styraciflorum* Schltr.; McClelland (2012) treats *S. styraciflorum* as a synonym of *S. artense* Montroux (see description of *S. artense* on Solanaceae Source, www.solanaceaesource.org). From herbarium material *S. memayoanum* appears to have fleshy leaves like *S. semisucculentum*, but it differs in having a taller habit (*MacKee 21797* records the stems as being 8 cm in diameter), pubescent stems, leaves, and inflorescences, and seeds with a more deeply pitted (the lateral cell walls longer) surface. In addition, the habitat of the two species differs; *Solanum memaoyanum* grows in closed rainforest from 1,300 to 1,500 m elevation as opposed to *S. semisucculentum*, which grows in open shrubby habitat (maquis) and is typically not found above 700 m elevation. *Solanum artense* (incl. plants matching the protologue of *S. styraciflorum*) is found below 250 m on calcareous soils, rather than the serpentine soils in mountainous regions on which both *S. memaoyanum* and *S. semisucculentum* are found.

Additional specimens examined. New Caledonia. Nord: contrefort oest du Mé Maoya audessus de la Mine Emma, 1350–1500 m, 13 Jan 1970 (fl), *H.S. MacKee 21422* (NOU, P); Mt. Mé Maoya, above Mine Emma, ca 27 air-km northwest of Bourail, ca. 1300 m, 8 Aug 1980 (fr), *G. McPherson 2948* (MO, NOU, NSW, PTBG).

***Solanum pseudopedunculatum* D.McClelland, sp. nov.**
urn:lsid:ipni.org:names:77209328-1
Figure 8

Diagnosis. Like *Solanum inamoenum* Benth. but differing in the congested inflorescence with the basal flower borne at the very base of the inflorescence and the inflorescence with a pseudo-peduncle, longer pedicels, and larger flowers and fruits.

Type. Fiji. Vanua Levu: Mathuata, summit ridge of Mt. Numbuiloa, east of Lambasa, 500–590 m, 29 Oct – 6 Nov 1947 (fl, fr), *A.C. Smith 6467* (holotype: US [acc. #1966675, barcode 02838867]; isotypes: A, BISH [acc. #181936], K [K000922644], L [L0531787], NY [00828289], P [P00315297], S).

Description. Shrub or small tree to 4 m, the internodes to 6.5 cm long, unarmed. Stems densely pubescent with yellow, sessile or stalked porrect-stellate trichomes, the stalks to ca. 0.2 mm, the rays 4–8, 0.15–0.2 mm long, the midpoint shorter than the rays; new growth moderately pubescent adaxially with sessile and stalked porrect-stellate trichomes and minute glandular papillae ca. 0.05 mm long; bark reddish brown. Sympodial units difoliate, the leaves geminate, members of a pair more or less equal in size and shape. Leaves simple; blades 6.0–15.0 cm long, 2.0–4.7 cm wide, ca. 2.5–4.2 times as long as wide, ovate to elliptic, chartaceous, concolorous, unarmed; adaxial surfaces glabrescent with scattered stalked porrect-stellate trichomes, the stalks to ca. 0.2 mm long, the rays 4–8, 0.2–0.4 mm long, the midpoint equal to or longer than the rays; abaxially sparsely to moderately pubescent with stalked porrect-stellate trichomes, the stalks to ca. 0.2 mm long, the rays 4–8, 0.25–0.4 mm long, the midpoint equal to or longer than the rays; principal veins 6–8 pairs, the midrib raised abaxially, distinct adaxially, the lateral veins weakly brochidodromous, raised abaxially, distinct adaxially; base cuneate to attentuate, equilateral or oblique; margins entire; apex acuminate, occasionally obtuse; petiole 0.8–2.0 cm long, 0.5–1.0 mm in diameter, moderately stellate-pubescent with trichomes like those of the leaves, channeled above. Inflorescence to ca. 1.3 cm long, appearing lateral, extra-axillary, in the middle 1/3 of the internode, unbranched, with few to 8 flowers, densely pubescent with sessile and stalked porrect-stellate trichomes; peduncle ca. 0.6 cm long, ca. 0.5 mm in diameter, stellate-pubescent like the inflorescence axes; pedicels 0.8–1.4 cm long, 0.4–0.5 mm in diameter at the base, 0.8–1.4 mm in diameter below the calyx, straight, gradually increasing in diameter in the distal 1/4–1/3, moderately to densely pubescent, articulated at the base; pedicel scars evenly spaced 1.0–2.4 mm apart, rigid, in two rows. Buds globose, the calyx moderately stellate-pubescent, the corolla densely stellate-pubescent where exposed in bud, strongly exserted from the calyx before anthesis. Flowers 5-merous, all perfect or apparently so. Calyx 1.0–1.6 mm long, appearing nearly truncate with minute deltate or

Figure 8. *Solanum pseudopedunculatum* D.McClelland (holotype *Smith 6467*, incorrectly labelled as *S. nelsonii*. US [acc. # 1966675, barcode 02838867]). Reproduced with permission.

apiculate lobe tips, the tube 0.4–0.8 mm long, the lobes 0.5–0.8 mm long, not splitting or splitting in the sinuses during fruit development and then the lobes deltate, sparsely to moderately pubescent abaxially, glabrous adaxially. Corolla ca. 1.5 cm in diameter,

stellate, white, the interpetalar tissue poorly developed, glabrous, the lobes 3.1–4.2 mm long, 2.2–2.9 mm wide, deltate, spreading at anthesis, glabrous adaxially, moderately stellate-pubescent abaxially. Stamens equal; filament tube minute; free portion of the filaments 0.6–0.9 mm long, glabrous; anthers 1.5–2.1 mm long, 1.0–1.2 mm wide, somewhat tapering, straight, yellow, spreading, poricidal at the tips, the pores directed distally. Ovary ca. 1.2 mm in diameter, globose, with a few stellate hairs and a few minute and simple glandular hairs near the apex; style 3.1–4.0 mm long, 0.3–0.4 mm in diameter, longer than the stamens, exserted beyond the anther cone, filiform, straight, sparsely pubescent in the basal ca. 1/3 with minute glandular hairs; stigma 0.5–0.6 mm in diameter, capitate, minutely papillose. Fruit a globose juicy berry, 0.7–1.0 cm in diameter, variously reported as orange, red becoming black, and purple when mature, glabrous, the pericarp thin, glossy, somewhat translucent; fruiting calyx lobes 0.5–0.9 mm long, 1.5–1.7 mm side, sparsely stellate-pubescent, appressed to the surface of the berry; fruiting pedicels 1.7–2.3 cm long, 0.3–0.6 mm in diameter at the base, 1.1–1.6 mm in diameter below the calyx, straight, gradually increasing in diameter in the distal 1/3–1/2, sparsely stellate-pubescent. Seeds 20–40 per fruit, 1.8–2.0 mm long, 2.3–2.8 mm wide, flattened-orbicular and notched at the point of attachment to flattened-reniform, yellow-tan when dry, the surface with the central area nearly smooth, the margins minutely pitted with the testal cells straight-sided (alveolate). Chromosome number not known.

Distribution and ecology (Figure 9). *Solanum pseudopedunculatum* is endemic to Fiji on the islands of Kanduvau, Vanua Levu, and Viti Levu; it grows in forest and secondary thickets, from 50 to 1,150 m elevation.

Phenology. Known to flower and fruit February–March and July–December.

Common names and uses. Fiji. Moloa (*Smith 603*); tukitukiyandre (*Smith 6467*).

Etymology. The specific epithet is derived from the "pseudo-peduncle" of the inflorescence of this species, where the space between the lowermost flower and the rest gives the appearance of an elongate peduncle.

Preliminary conservation assessment (IUCN 2019). EOO = 17,482 km^2 [VU – Vulnerable]; AOO = 24 km^2 [EN –Endangered]. Based on the paucity of recent collections and the fragmented populations (5 locations) on three of the islands of the Fijian archipelago we assess *Solanum pseudopedunculatum* as VU (B1a,b D2).

Discussion. In his Flora of Fiji, Smith (1991) included many of the specimens here recognized as *S. pseudopedunculatum* in his concept of *S. inamoenum* Benth. The two species are not very similar morphologically, however, with leaf and stem pubescence differing in density (*S. inamoenum* pubescence is denser and the trichome rays are somewhat longer than in *S. pseudopedunculatum*), inflorescence structure (unbranched in *S. pseudopedunculatum* and highly branched in *S. inamoenum*), flower size (to 1 cm in diameter and homostylous in S. *pseudopedunculatum*, larger and heterostylous in *S. inamoenum*) and habitat preference (*S. pseudopedunculatum* is a plant of forests and secondary thickets, while *S. inamoenum* grows near the coast). *Solanum pseudopedunculatum* is much more similar to *S. ratale* but can be distinguished by its taller habit, mature leaves that retain pubescence along the veins and lamina, longer pedicels, and larger corolla, anthers, and berries.

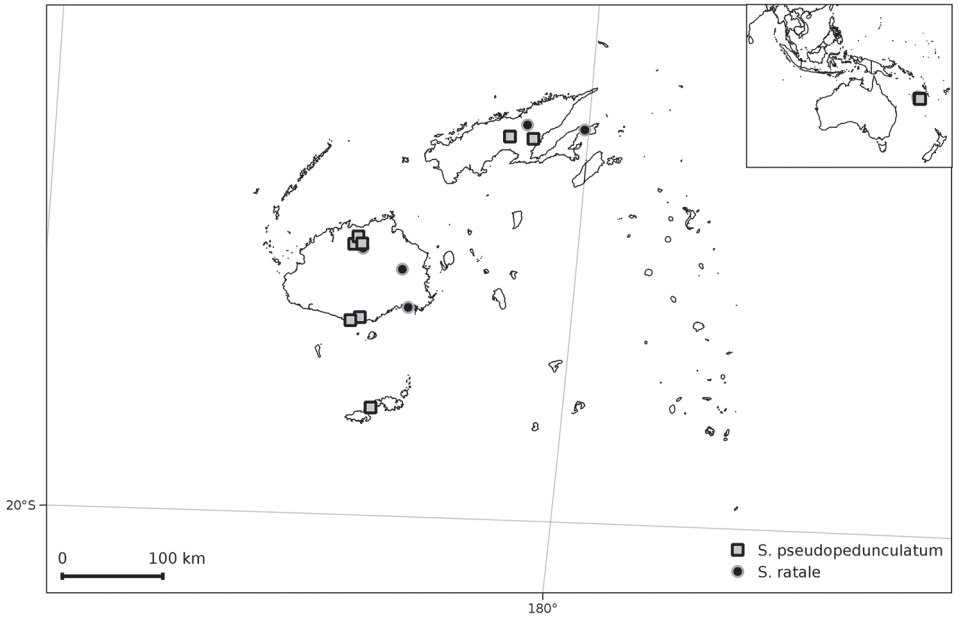

Figure 9. Distribution of *Solanum pseudopedunculatum* and *S. ratale*.

Specimens examined. Fiji. sin. loc., Dec 1904-Mar 1905 (fr), *Goddard s.n.* (NSW). Kandavu: Hills above Namalata and Ngaloa Bays, 200–400 m, 13–18 Oct 1933 (fl, fr), *Smith 141* (BISH, GH, K, NY, P, S, UC, US). Vanua Levu: Mt. Delaikoro, Macuata, 3050 ft, 21 Aug 1962 (fl, fr), *Parham & Koroi 12792* (BISH); Thakaundrove, SW slope of Mt. Mbatini [Batini], 300–700 m, 28–29 Nov 1933 (fl, fr), *Smith 603* (GH, K, NY, P, S, UC, US). Viti Levu: Serua district, 500 ft, 14 Jun 1961 (fl, fr), *Bola 42* (K); Mba ["Tholo North"], Sovutawambu, near Nandrivatu, 750–800 m, 27 Feb – 4 Mar 1941 (fl, fr), *Degener 14594* (A, K, NY, US); Nadarivatu, 2700 ft, 1907 (fl, fr), *Gibbs 615* (BM×2); Mba (formerly Tholo North), western and southern slopes of Mt. Tomanivi (Mt. Victoria), 850–1150 m, 7 Jul – 18 Sep 1947 (fl, fr), *Smith 5273* (A, K, L, NY, P, S, US); Serua, Hills west of Waivunu Creek, between Ngaloa and Korovou, 50–150 m, 23 Nov – 7 Dec 1953 (fl, fr), *Smith 9223* (BISH, GH, K, L, NY, P, S, UC, US); Nadarivatu, road to Suva, 27 Nov 1906 (fl, fr), *Thurn 294* (K).

***Solanum ratale* D. McClelland, sp. nov.**
urn:lsid:ipni.org:names:77209329-1
Figure 10

Diagnosis. Like *Solanum pseudopedunculatum* D.McClelland but differing in shorter stature, densely glandular new growth, stellate trichomes with elongate midpoints that sometimes lack rays, smaller flowers and smaller, few-seeded fruits.

Figure 10. *Solanum ratale* D.McClelland (isotype *Degener 14324*, US [acc. # 1943693, barcode 02838817]).

Type. Fiji. Viti Levu: Mba, (Tholo North), Western division, village of Nadarivatu, Fish Hatchery 2600 ft, 9 Feb 1941 (fl, fr), *O. Degener 14324* (holotype: A; isotypes: K [K000922635, K001155453], UC [acc. #1016245], US [acc. #1943693, barcode 02838817])

Description. Shrub or small tree 0.5–1.5 m, the internodes to 3.4 cm long, unarmed or densely armed. Stems densely pubescent with yellow-ferruginous, sessile or short-stalked porrect-stellate trichomes, the stalks of various lengths to 0.2 mm long, somewhat bulbous, the rays 6–8 or absent, 0.15–0.25 mm long, the midpoint to 1.2 mm long, the prickles, if present, 4–6 mm long, dense, straight and somewhat retrorse (downward pointing), yellow or straw-colored; new growth densely to sparsely pubescent with sessile and short-stalked porrect-stellate trichomes and densely pubescent with minute glandular papillae ca. 0.04 mm long; bark of older stems reddish brown. Sympodial units difoliate, the leaves geminate, members of a pair similar in size and shape. Leaves simple; blades 4.3–10.4 cm long, 1.3–2.6 cm wide, 2.8–5.2 times as long as wide, narrowly lanceolate to narrowly elliptic, chartaceous to subcoriaceous, concolorous, armed or unarmed; adaxial surfaces moderately to sparsely pubescent with sessile and very short-stalked porrect-stellate trichomes and in some individuals with scattered prickles 3–4 mm long, along the veins, the stellate trichomes with the stalks to 0.6 mm long, the rays 4–8 or absent and the trichomes appearing simple, 0.2–0.3 mm long, the midpoint 1–2 mm long, sometimes gland-tipped; abaxial surfaces densely pubescent with sessile and stalked porrect-stellate trichomes and sometimes with prickles along the veins, the stellate trichomes with bulbous stalks to 0.1 mm long, the rays 6–8 or absent and the trichomes appearing simple, 0.25–0.4 mm long, the midpoint 1–2 mm long, much longer than the rays, the prickles if present 2–4 mm long, on the principal veins only, not on the midrib; principal veins 5–7 pairs, the midrib raised abaxially, raised adaxially, the lateral veins weakly brochidodromous, raised abaxially, raised adaxially, if the rest of the plant prickly then the veins with scattered, straw-colored prickles; base cuneate or rounded, equilateral or oblique; margins entire; apex acuminate; petiole 0.4–1.3 cm long, 0.6–1.0 mm in diameter, moderately to densely stellate-pubescent and sometimes with a few straight prickles like the leaf surfaces and stems, channeled above. Inflorescence to 1.8 cm long, appearing lateral, extra-axillary, emerging from the middle 1/3 of the internode, usually unbranched, occasionally forked, with (1-)4–13 flowers, moderately to densely pubescent with sessile and stalked porrect-stellate trichomes like those of the stems, in prickly individuals with 1–3 prickles; peduncle to 0.9 cm long, to 0.6 mm in diameter, pubescent and prickly like the stems; pedicels 0.6–0.8 cm long, ca. 0.3 mm in diameter at the base, ca. 0.6 mm in diameter below the calyx, bent to approximately 90° below the calyx, gradually increasing in diameter in the distal ca. 1/3, moderately to densely pubescent, articulated at the base; pedicel scars congested to spaced 2.2 mm apart, rigid, in two rows. Buds globose, the calyx moderately stellate-pubescent, the corolla densely stellate-pubescent where exposed abaxially, strongly exserted from the calyx before anthesis. Flowers 5-merous, all perfect. Calyx 1.5–2.3 mm long, appearing nearly truncate with caudate to subulate lobe tips, the tube 0.6–1.1 mm long, the lobe tips 0.9–1.3 mm long, the sinuses opaque when dry, not splitting or splitting in the sinuses during fruit development and then the lobes deltate, moderately pubescent abaxially, glabrous adaxially. Corolla ca. 0.5 cm in diameter, stellate, white, the interpetalar tissue well-developed, glabrous, the lobes 3.2–3.8 mm long, 1.9–2.2 mm

wide, oblong, spreading at anthesis, moderately pubescent abaxially along the midvein, glabrous adaxially. Stamens equal; filament tube minute; free portion of the filaments ca. 0.5 mm long, glabrous; anthers ca. 1.3 mm long, 0.6 mm wide, oblong, somewhat incurved, apparently yellow, spreading, poricidal at the tips, the pores directed distally, extending around the edge of the apex. Ovary ca. 0.8 mm in diameter, globose, with a few simple glandular hairs at the apex; style ca. 2.8 mm long, ca. 0.3 mm in diameter, exserted from the anther cone, cylindrical, straight, glabrous; stigma ca. 0.5 mm in diameter, capitate, the surface minutely papillate. Fruit a globose, apparently juicy berry, 0.5–0.7 cm in diameter, black or deep purple when mature, glabrous, the pericarp thin, glossy, opaque; fruiting calyx not markedly accrescent, the lobes 2–3(-4) mm long, 1.3–1.6 mm wide, sparsely to moderately pubescent, appressed or somewhat reflexed; fruiting pedicels 0.8–1.5 cm long, ca. 0.5 mm in diameter at the base, 1.4–2.0 mm in diameter below the calyx, straight, gradually increasing in diameter in the distal ca. 2/3, sparsely to moderately pubescent,. Seeds 4–12 per berry, 2.3–2.5 mm long, 1.5–1.9 mm wide, flattened-reniform, yellow-tan when dry, the surface with the central area nearly smooth, the margins minutely and quite deeply pitted (alveolate), the walls of the testal cells straight. Chromosome number not known.

Distribution and ecology (Figure 9). *Solanum ratale* is endemic to Fiji on the islands of Viti Levu and Vanua Levu. It is known from elevation of 200 to 800 m but may grow at lower elevation near Suva (but see below). The habitat has been recorded as logged-off forest (*Degener 14324*) or dense forest along streams (*Smith 5370*).

Phenology. Known to flower and fruit February, May, and June.

Etymology. The specific epithet which means "pertaining to rafts" references a note on *Horne 679* indicating that the light wood was used for making rafts. Another specimen bearing Horne's collection number of 679 (K000687673, *Trichospermum calyculatum* (Seem.) Burret of the Tiliaceae) has a label "on waste land between Suva and the town of Koluba, Viti Levu, June 1878" but makes no mention of uses. This suggests a possible label mix-up, with the original label of *Horne 679* being affixed to the duplicate of *Horne 678*; *Trichospermum* is a small tree with light wood, more likely to be used for making rafts and growing at lower elevations. Horne (1881), however, lists "Solanum sp. nov." as both his 678 and 679, so it appears he used the number 679 twice.

Preliminary conservation assessment (IUCN 2019). EOO = 862 km^2 [EN –Endangered]; AOO = 16 km^2 [EN –Endangered]. *Solanum ratale* is known from only a few locations in forest, and no recent collections. We therefore assess it as EN (B1,2a,b), based on its relatively restricted distribution and the threats to forest habitat in island archipelagoes.

Discussion. Very little is known about *S. ratale* due to the few collections in herbaria. It is most similar to *S. pseudopedunculatum* but can be distinguished by its shorter habit, occasionally prickly individuals, shorter pedicels, and smaller corolla, anthers, and fruit.

Solanum ratale is polymorphic for presence of prickles on all parts, as is found in many other spiny solanums, both in the Old and New World (e.g., *S. elaeagnifolium* Cav., see Knapp et al. 2017; *S. setaceum* Dammer and *S. schumannianum* Dammer, see Vorontsova and Knapp 2016). The collection *Smith 5370* from Viti Levu is densely

prickly, but otherwise conforms exactly to the other collections of *S. ratale*. This collection has been identified in herbaria as *S. retrorsum* Elmer, a Philippine species with a similar polymorphism in the possession of retrorse prickles, but differing in its plurifoliate sympodial units, larger trichomes with midpoints equal to the rays, and bright red berry.

Additional specimens examined. Fiji. Vanua Levu: Mt. Labasa, 15 Jul 1883, *Greenwood 619* (K); Rabi [Rambi] Island, May 1878 (fl, fr), *Horne 678* (K). Viti Levu: Central Division, near Lutu, May 1878 (fl, fr), *Horne 595* (GH, K); near Suva, Jun 1878 (fl, fr) *Horne 679 [a]* (GH, K); Mba (formerly Tholo North), valley of Nggaliwana Creek, N of sawmill at Navai, 725–850 m, 21 Jul 1947, *Smith 5370* (A, US).

***Solanum semisucculentum* D. McClelland, sp. nov.**
urn:lsid:ipni.org:names:77209330-1
Figure 11

Diagnosis. Like *Solanum artense* Montroux, but differing in its high elevation serpentine substrate habitat, very fleshy, semi-succulent stems and leaves, glabrous petioles and larger berries.

Type. New Caledonia. Nord: Tiébaghi Massif, ca. 12 air-km northwest of Koumac, 8 Nov 1980 (fl, fr), *G. McPherson 3303* (holotype: NOU [acc. #017344]; isotypes: MO [acc. #2924404, barcode MO-2282964], NSW [acc. #594228], P [P00301276], PTBG [acc. #032935]).

Description. Shrub 1.5 m, the internodes to 4.5 m long, unarmed. Stems glabrous or with occasional yellow-ferruginous, sessile porrect-stellate trichomes, the rays 7–11, 0.05–0.15 mm long, the midpoint more or less equal to the rays, flexed to lie parallel to the stem, the stellate trichomes soon deciduous; new growth sparsely pubescent with sessile porrect-stellate trichomes and minute glandular hairs to 0.7 mm long; bark of older stems grey, the young stems bright purple. Sympodial units difoliate, the leaves not geminate. Leaves simple; blades 2.3–11.2 cm long, 1.0–3.4 cm wide, 2.3–3.6 times as long as wide, lanceolate to elliptic, fleshy to semisucculent, concolorous; adaxial surfaces glabrous or with a few scattered sessile porrect-stellate trichomes, if present these with 8–10 rays 0.1–0.15 mm long, the midpoint more or less equal to the rays; abaxial surfaces glabrous; principal veins 6–8(–9) pairs, the midrib raised abaxially and adaxially, the lateral veins weakly or strongly brochidodromous, raised abaxially, distinct adaxially; base rounded, cuneate, or short-attenuate, sometimes oblique; margins entire; apex acute to acuminate; petiole 0.6–3.0 cm long, 0.6–0.9 mm in diameter, glabrous or sparsely pubescent on the adaxial surface, channeled above. Inflorescence to 3.8 cm long, appearing lateral, extra-axillary, emerging from the upper 1/3 of the internode, unbranched, with up to 23 flowers, nearly glabrous, with occasional sessile porrect-stellate trichomes and minute glandular papillae; peduncle 1.0–1.4 cm long, 0.4–0.6 mm in diameter; pedicels 0.9–1.2 cm long, 0.2–0.4 mm in diameter at the base, 0.6–0.8 mm in diameter below the calyx, straight,

Figure 11. *Solanum semisucculentum* D.McClelland (isotype *McPherson 3303*, MO [acc. # 2924404, barcode MO-2282964]). Reproduced with permission.

bent approximately 90° below the calyx, gradually increasing in diameter in the distal 1/3–1/2, glabrous, articulated at the base; pedicel scars widely and evenly spaced 5–8 mm apart. Buds ovate, the calyx more or less glabrous to sparsely stellate-pubescent, the corolla densely stellate-pubescent where exposed abaxially, strongly exserted from the calyx before anthesis. Flowers 5(–6)-merous, heterostylous and the plants weakly andromonoecious. Calyx 1.3–5.3 mm long, appearing nearly truncate with apiculate to caudate lobe tips, the tube 0.5–1.1 mm long, the sinuses translucent when dry, the lobes 0.7–4.2 mm long, long-caudate, glabrous adaxially, sparsely pubescent abaxially, splitting in the sinuses during fruit development and then the lobes deltate. Corolla 1.2–2.5 cm in diameter, stellate, white, the interpetalar tissue well developed, the lobes 5.5–8.9 mm long, 5.4–6.8 mm wide, deltate, spreading at anthesis, adaxially glabrous at the base becoming densely stellate pubescent towards the apex, abaxially moderately to densely pubescent. Stamens equal; filament tube minute; free portion of the filaments 0.6–1.0 mm long, glabrous; anthers 4.2–6.2 mm long, 1.3–1.7 mm wide, markedly tapering, straight, yellow, more or less spreading, poricidal at the tips, the pores directed distally, extending around the edge of the apex. Ovary ca. 1.0 mm in diameter, globose, densely stellate-pubescent at the very apex only; style of long-styled flowers 7.7–8.3 mm long, ca. 0.3 mm in diameter, exserted from the anther cone, filiform, straight, moderately to densely pubescent on the basal 1/2–2/3 portion, the style of short-styled flowers 1.0–1.3 mm long, ca. 0.2 mm in diameter, included within the anther cone; stigma 0.4–0.6 mm in diameter, capitate, green in live plants. Fruit a globose or slightly elongate juicy berry, 0.8–1.3 cm in diameter, when immature evenly green, red to orange when mature, glabrous, the pericarp thin, glossy, opaque; fruiting calyx lobes 1.8–2.8 mm long, 0.9–3.5 mm wide, glabrous, appressed to the berry surface or reflexed; fruiting pedicels 1.5–2.4 cm long, 0.6–1.1 mm in diameter at the base, 1.6–2.9 mm in diameter below the calyx, straight or arching, gradually increasing in diameter in the distal 1/2–2/3, glabrous. Seeds 20–30(-40) per berry, ca. 2.2 mm long, 2.3–2.8 mm wide, flattened-orbicular and notched at the point of attachment, red-brown or tan when dry, the surface minutely pitted (alveolate) under a smooth, translucent seed coat, the walls of testal cells straight or slightly sinuate towards the seed center. Chromosome number not known.

Distribution and ecology (Figure 7). *Solanum semisucculentum* is endemic to New Caledonia and is restricted to the ultramafic mountains of the western side of the Grande Terre. It is found in the North Province from (50–)100 to 700(–1,200) m elevation. This species is a serpentine endemic and grows in an open shrubby habitat (maquis) on soils which are fast draining and the semisucculent leaves of this species are possibly an adaptation for these harsh conditions.

Phenology. Flowering and fruiting year round.

Etymology. The specific epithet indicates the texture of the leaves and stems. This texture is best described as fleshy to semisucculent and is unusual in *Solanum*.

Preliminary conservation assessment (IUCN 2019). EOO = 814 km^2 [EN –Endangered]; AOO = 60 km^2 [EN –Endangered]. *Solanum semisucculentum* is found in a number of localities in northern New Caledonia, all of which are in montane serpen-

tine soil areas now highly disturbed by mining activities. We preliminarily assign an assessment of EN (B1a,b) due to its fragmented distribution and threats to its montane habitat from mining activities.

Discussion. Heine (1976) treated specimens here recognized as *S. semisucculentum* in his concept of *S. styraciflorum*. The type of *S. styraciflorum* was probably destroyed at B during the Second World War, and no duplicates have been traced; specimens matching the protologue of *S. styraciflorum* exist (see www.solanaceasource.org) and McClelland (2012) treats *S. styraciflorum* as a synonym of *S. artense* Montroux. *Solanum artense* is sparsely to densely pubescent on the stems, along the midvein of the leaves adaxially, and sometimes the inflorescence; its leaves are chartaceous and typically have a greater leaf length to width ratio than *S. semisucculentum*. Specimens of *S. semisucculentum* differ from the protologue of *S. styraciflorum* in petiole pubescence (glabrous or very sparsely pubescent versus densely stellate-subvillose), berry size (7.5–12.5 mm diameter versus ca. 6.0 mm) and elevational range (300–500 m versus 50 m). *Solanum artense* (incl. plants matching the protologue of *S. styraciflorum*) is found below 250 m on calcareous soils while *S. semisucculentum* is typically found at higher elevations, such as the plateau of the Dôme de Tiébaghi, at 300–500 m on lateritic soils.

Perhaps the most remarkable feature of *S. semisucculentum* is its very fleshy, semisucculent leaves. Many species of *Solanum* wilt shortly after collecting; *S. semisucculentum*, however, appears well adapted for water deprivation. With no difficulty, a specimen was kept alive after collecting it with a few roots but no soil and carrying it for a couple hours on a warm tropical afternoon (DHRM, pers. obs.). After a couple of days this specimen opened a flower which had been in bud when it was collected. *Solanum semisucculentum* has vividly purple stems which are quite striking in living material, but dry black on herbarium specimens. This coloration may provide a certain amount of protection of the high levels of solar radiation this species receives in its open maquis habitat.

Specimens examined. New Caledonia. Nord: Dôme de Tiébaghi, 22 Jan 1976 (fl, fr), *Blanchon 1444* (NOU, P); Mine Oubliée [near Pic Poya], 650 m, 7 Jan 1962 (fl, fr), *Catala-Stucki 160* (G); Tiébaghi, 24 Sep 1961 (fl, fr), *Denizot s.n.* (P); Dôme de Tiébaghi, 8 Nov 1980 (fl), *Hoff 2975* (NOU); Mt. Ninga, 1000 m, 15 Oct 1975 (fr), *Jaffré 1415* (NOU, P [date 2 May 1976]); Dôme de Tiébaghi, 350 m, 15 Nov 1975, *Jaffré 1415bis* (P); Plateau de la Tiébaghi, 500 m, 15 Nov 1976 (fl, fr), *Jaffré 1824* (NOU, P); Massif Boulinda, secteur Col Nekoro, 27 Jul 1972 (fl), *Jaffré 2183* (NOU); Massif de Boulinda, above river Ouaha, east of Muéo, 100–200 m, 21.20 S, 165.05 E, 12 Dec 1973 (fl), *Jaffré 19234* (NOU, P); Dôme de Tiébaghi, Pente Sud-Ouest du Dôme de Tiébaghi, 300–500 m, 9 May 1966 (fl), *MacKee 14921* (K, P); pente nord du Mt. Kaala, 400–700 m, 9 Jul 1966 (fl, fr), *MacKee 15272* (A, K, L, NOU, P); pente Nord du Mont Kaala, 700 m, 25 Dec 1966 (fl, fr), *MacKee 16152* (K, L, NOU, NY); Haute Népoui, Oué Péoué, contrefort sud du Kopéto, 500 m, 8 Jul 1970 (fl), *MacKee 22193* (P); Mt. Boulinda, 1200 m, 1 Jun 1972 (fl, fr), *McKee 25571* (P); Dôme de Tiébaghi, 400 m, 30 Nov 1972 (fl, fr), *MacKee 25953* (K, L, P); Nekoro, 200 m, 21 May 1977 (fr), *MacKee 33195* (NOU, P); Dôme de Tiébaghi, Plateau central, 550 m,

8 Jul 1978 (fl, fr), *MacKee 35432* (L, NOU, P); Koumac, Chagrin, 300 m, 8 Jan 1983 (fr), *MacKee 41156* (P); Dôme de Tiébaghi, on the plateau south of the old town, 590 m, 15 Jul 2009 (fl, fr), *McClelland & Nee 554* (MO, NOU, NY, P); Tiébaghi Massif, north of Koumac, 550 m, 20 Dec 1983 (fl, fr), *McPherson 6169* (MO, NOU, PTBG); Boulinda, base, 23 Jan 2008 (fl, fr), *Munzinger et al. 4959* (NOU); Tiébaghi, sur le plateau, côté Est, 14 Apr 2014 (fl, fr), *Munzinger et al. 7575* (NOU); Dôme de la Tiébaghi, 400–600 m, 25 Jul 2007 (fl, fr) *Pillon et al. 775* (NOU); pentes du Dôme de Tiébaghi, 13 Jun 1974 (fl, fr), *Sévenet 685* (NOU); route minière d'accès au Bulinda [Boulinda], 20 Feb 1978 (fl, fr), *Suprin 254* (NOU); Mt. Boulinda, 550 m, 26 Apr 1965 (fr), *Veillon 129* (NOU, P); Dôme de Tiébaghi, plateau, ca. 550 m, 17 Aug 1965 (fl), *Veillon 361* (NOU); Mt. Boulinda, ca. 400 m, 26 Jul 1967 (fl), *Veillon 1268* (K, NOU, P); Dôme de Tiébaghi, ca. 550 m, 25 Nov 1967 (fl, fr), *Veillon 1457* (NOU, P); pentes ouest du Dôme de Tiébaghi, ca. 500 m, 27 Oct 1943 (fl, fr), *Virot 1274* (A, NOU, P).

***Solanum vanuatuense* D.McClelland, sp. nov.**
urn:lsid:ipni.org:names:77209331-1
Figure 12

Diagnosis. Like *Solanum milnei* Seem. and *S. austrocaledonicum* Seem., but differing in usually geminate, lobed leaves, smaller corolla and anthers, and strongly curved style.

Type. Vanuatu. Efate: lower slopes of Pic Fatamalapa, 17°33'S, 168°22'E, 200 m, 15 Jul 1971 (fl, fr), *P.S. Green 1103* (holotype: P [P00315286]; isotypes: A, K [K001155324], L [L0531790], NSW [acc. # 594210]).

Description. Shrub to 2 m, the internodes to 5.1 cm long, unarmed. Stems densely pubescent with yellow to yellow-ferruginous, sessile and stalked porrect-stellate trichomes, the stalks of various lengths to 0.1 mm long, the rays 6–8, 0.2–0.3 mm long, the midpoint more or less equal to the rays; new growth densely pubescent with sessile or very short-stalked porrect-stellate trichomes and minute glandular hairs to 0.05 mm long; bark of older stems reddish brown. Sympodial units difoliate, the leaves geminate or not, if geminate the minor leaves 1/2–2/3 as large as the major leaves and similar in shape. Leaves simple or shallowly lobed; blades (major leaves) 4.9–11.2 cm long, 1.9–3.9 cm wide, 2.6–3 times as long as wide, lanceolate to ovate, chartaceous, discolorous; adaxial surfaces sparsely to moderately pubescent with short-stalked porrect-stellate trichomes, the stalks to 0.06 mm long, the rays 4–8, 0.15–0.25 mm long, the midpoint equal to or longer than the rays; abaxial surfaces sparsely to moderately pubescent with sessile or short-stalked porrect-stellate trichomes, the stalks to 0.3 mm long, the rays 4–8, 0.2–0.35 mm long, the midpoint equal to or longer than the rays; principal veins 4–6 pairs, the midrib raised abaxially and adaxially, the lateral veins weakly brochidodromous or semicraspedodromous, or craspedodromous in lobed leaves, raised abaxially, distinct adaxially; base rounded, typically oblique though occasionally equilateral; margins entire, sinuate, or shallowly lobed, the sinuses less than 1/4 of the distance

Figure 12. *Solanum vanuatuense* D.McClelland (holotype *Green 1103*, P [P00315286]). Reproduced with permission.

to the midrib; apex acute or acuminate; petiole 6.2–16.8 mm long, 0.6–1.3 mm in diameter, densely stellate-pubescent with trichomes like those of the leaves, channeled above. Inflorescence to 8.9 cm, appearing lateral, extra-axillary, emerging from the middle or upper 1/3 of the internode, branched 1–3 times, with 60+ flowers, densely pubescent with sessile porrect-stellate trichomes; peduncle 0.3–1.9 cm long, 0.6–1.8 mm in diameter, unarmed; pedicels 0.7–1.0 cm long, ca. 0.3 mm in diameter at the base, 0.6–0.9 mm in diameter below the calyx, straight, not bent below the calyx or bent to approximately 90°, swelling more or less evenly from the base to the base of the calyx, densely pubescent, articulated at the base; pedicel scars congested to spaced 5.7 mm apart, overlapping to spaced 0.4 mm apart in the distal portion of the inflorescence, rigid, in two rows. Buds ovate, the calyx densely stellate-pubescent, the corolla densely stellate-pubescent where exposed abaxially, strongly exserted from the calyx before anthesis. Flowers 5-merous, all perfect or apparently so. Calyx 2.2–2.8 mm long, appearing nearly truncate with caudate lobe tips, the tube 0.5–0.9 mm long, the sinuses opaque when dry, the lobes 1.2–2.0 mm long, caudate, moderately to densely pubescent abaxially, glabrous adaxially, splitting in the sinuses during fruit development and then the lobes deltate. Corolla 1.1–1.3 cm in diameter, stellate, white, the interpetalar tissue well-developed, glabrous, the lobes 3.9–4.5 mm long, 2.2–3.5 mm wide, deltate, spreading at anthesis, adaxially glabrous or with a few scattered sessile porrect-stellate trichomes, densely pubescent abaxially. Stamens equal; filament tube minute; free portion of the filaments ca. 0.8 mm long, glabrous; anthers 2.5–2.9 mm long, 0.9–1.1 mm wide, markedly tapering, straight, yellow, spreading, poricidal at the tips, the pores directed dorsally, extending around the edge of the apex. Ovary ca. 0.6 mm, globose, moderately pubescent at the apex with simple glandular trichomes; style 5.6–6.4 mm long, ca. 0.2 mm in diameter, exserted from the anther cone, deflexed and emerging from between two adjacent stamens, filiform, curved or hooked at the apex, glabrous or sparsely pubescent on the basal 1/3 with simple glandular hairs; stigma 0.3–0.6 mm in diameter, capitate, minutely papillate. Fruit a globose juicy berry, 0.6–0.8 cm in diameter, apparently orange or red when mature, glabrous, the pericarp thin, glossy; fruiting calyx lobes 1.7–2.4 mm long, 1.3–1.5 mm wide, sparsely to moderately stellate-pubescent, appressed to the berry surface; fruiting pedicels 11.1–16.2 mm long, ca. 0.4 mm in diameter at the base, 1.3–1.7 mm in diameter below the calyx, straight, not bent below the calyx, gradually increasing in diameter in the distal 1/2–2/3, sparsely to moderately stellate-pubescent. Seeds 10–20 per fruit, 1.5–1.8 mm long, 1.5–2.0 mm wide, flattened-orbicular and notched at the point of attachment to flattened-reniform, red-brown when dry, the surface evenly reticulate, the testal cells with straight walls, the seed margins incrassate. Chromosome number not known.

Distribution and ecology (Figure 13). *Solanum vanuatuense* occurs on several islands in the Vanuatu archipelago; it is reported as growing in grass or low herbage, seaside, and on outcroppings of limestone from sea level to 200 m elevation.

Phenology. Known to flower and fruit February, July, and October–November.

Etymology. This species is named for island state of Vanuatu.

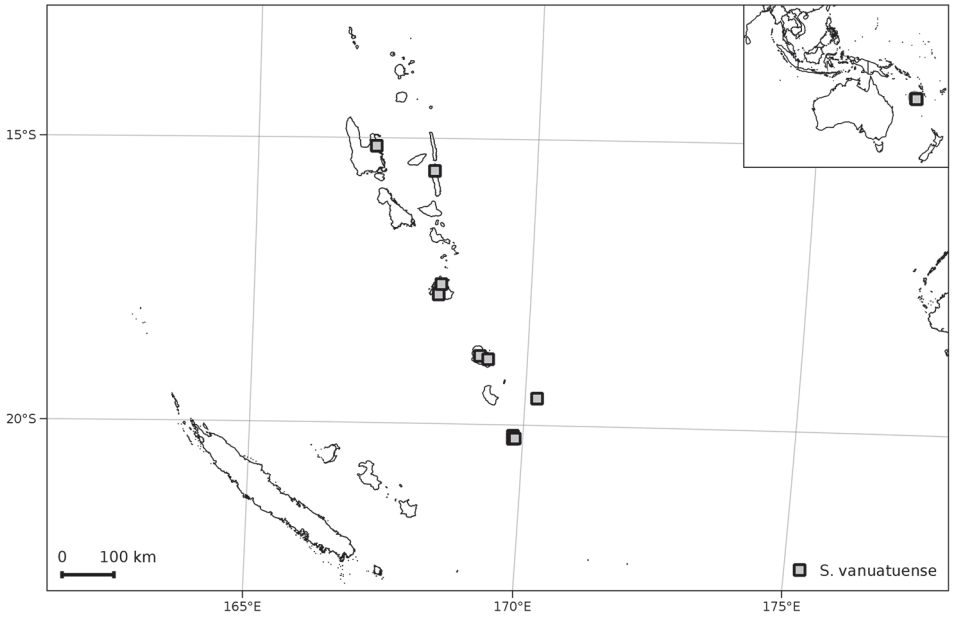

Figure 13. Distribution of *Solanum vanuatuense*.

Preliminary conservation assessment (IUCN 2019). EOO = 45,572 km^2 [LC – Least Concern]; AOO = 40 km^2 [EN –Endangered]. Although *Solanum vanuatuense* occurs on six islands in the archipelago, its coastal habitat is almost certainly threatened by human activities. We assign a preliminary status of EN (B2a,b) due to the fragmented nature of populations on different islands and threats to coastal habitats.

Discussion. Specimens of *Solanum vanuatuense* were included in the sympatric *S. milnei* Seem. (Seemann 1866) in the original description of the latter; it differs from that species in its smaller flowers and geminate leaves that are often lobed. *Solanum vanuatuense* is also similar to *S. austrocaledonicum* Bitter of New Caledonia and Vanuatu from which it can be distinguished by its geminate leaves that are often deeply lobed, its deltate calyx lobes (rather than long apiculate on a truncate rim) and small flowers. *Solanum vanuatuense* and *S. austrocaledonicum* co-occur on the island of Anatom (*Schmid 5149* is *S. vanuatuense* and *Schmid 5149b* is *S. austrocaledonicum* – both specimens mounted on P00315283).

Additional specimens examined. Vanuatu. Anatom: entre Umetch et Aneghowhat, 12 Feb 1986 (fl, fr), *Bourdy 442* (K, P); sin. loc., (fl) *McGillivray s.n.* (BM); secteur de Umec [Umetch], Nov 1974 (fl, fr), *Schmid 5149* (P). Efate: Port Vila, Oct 1883 (fl, fr), *Levat s.n.* (P). Erromango: entre Cook Bay et Ipota, ca. 5 m, 25 Jul 1983 (fl, fr), *Cabalion 2247* (K, P); tableland, 600 ft, 26 Jul 1930 (fl), *Cheeseman 38* (K). Espiritu Santo: Hog Harbour, 24 Nov 1933 (fl, fr), *Baker 58* (BM). Futuna: "tableland", Dec 1858 (fl, fr), *Milne 391* (K). Pentecost Island: north end, ca. 1972, *Walsh 208* (NSW).

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Supplementary material 1

File SM 1

Authors: Donald H.R. McClelland, Michael Nee, Sandra Knapp

Data type: Specimen and locality data

Explanation note: CSV file of specimen and locality data (including georeferencing) for all taxa treated here.

Link: https://doi.org/10.3897/phytokeys.145.48531.suppl1

PhytoKeys 145: 37–45 (2020)
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RESEARCH ARTICLE

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Calanthe sieboldopsis (Orchidaceae, Epidendroideae, Collabieae), a new species from Luoxiao Mountains, eastern China

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Abstract

Calanthe sieboldopsis, a new species, is here described and illustrated from Luoxiao Mountains, Jiangxi Province, eastern China. It is morphologically similar to *C. sieboldii* Decne. ex Regel, but differs from the latter in having smaller flowers, longer spurs, rectangular mid-lobes with emarginate apex (*vs.* elliptic mid-lobes with mucronate apex), disc with 3 ridges and the proximal ends of the lateral 2 ridges enlarged with light reddish spots and minute white hairs (*vs.* disc with 5 ridges and 2 rows of white short hairs at base) and pollinia equal in size (*vs.* unequal in size). A preliminary risk-of-extinction assessment, according to the IUCN Red List Categories and Criteria, is given for the new species.

Keywords

Calanthe sieboldii, Critically Endangered, Jiangxi Province, Jinggangshan Mountain, morphology

Introduction

Calanthe R. Br. is the largest genus of the tribe Collabieae (in the subfamily Epidendroideae), according to the updated classification of the orchid family (Chase et al. 2015). The genus contains about 160 species of terrestrial orchids, commonly oc-

curring in tropical, subtropical and temperate regions of Asia, Africa and the Pacific islands (Clayton and Cribb 2013), with a concentrated distribution of more than 50 species in China (Chen et al. 2009). Based on the latest infrageneric treatment, *Calanthe* was subdivided into five sections, viz., sect. *Alpinocalanthe* J.W.Zhai, Z.J.Liu et F.W.Xing, sect. *Calanthe*, sect. *Ghiesbrechtia* (A. Rich. & Galeotti) Schltr., sect. *Puberula* J.W.Zhai, Z.J.Liu et F.W.Xing and sect. *Tricarinata* J.W.Zhai, Z.J.Liu et F.W.Xing (Zhai et al. 2014). In the last two decades, new species of *Calanthe* have been discovered in China (Ren et al. 2011; Huang et al. 2015; Guo et al. 2017; Yu et al. 2017), Korea (Oh et al. 2015), Myanmar (Kurzweil 2013) and the Philippines (Naive 2017) and more discoveries can be expected, indicating that the diversity of *Calanthe* in Asia has not yet been fully revealed.

In order to ascertain the orchid diversity in Jiangxi Province of eastern China for preparing the Orchidaceae account of *Flora of Jiangxi*, we have carried out continuous field surveys from 2008 to 2019. When identifying specimens collected from Jinggangshan National Nature Reserve in 2017, we encountered an unknown collection of *Calanthe*, which is superficially similar to *C. sieboldii* Decne. ex Regel, but differs in having smaller flowers, longer spurs and emarginate lip mid-lobes with different characteristics of the disc (Figure 1). After carefully comparing the plant with all known congeneric taxa and consulting the relevant literature, we confirm that the plant represents an undescribed new species which is described here.

Methods

The locality of the new species in Jinggangshan National Nature Reserve of Jiangxi Province was revisited in April 2018 and one flowering individual was collected for the line-drawing. Expecting to discover more populations of the new species, we expanded our field surveys from Jinggangshan Mountain to the whole mountain range, Luoxiao Mountains, in 2018 and 2019 and finally found an additional population on Xianyueshan Mountain of Hunan Province. The morphological description is based on flowering plants in the two populations and morphological measurements were taken using a ruler and a Vernier caliper from at least 10 individuals. Flowers were dissected and photographed under a stereo dissecting microscope (StereoZoom Leica S8 APO, Leica Microsystems 2017).

Herbarium specimens of the genus *Calanthe* were examined at IBK, IBSC, JIU, JXU, KUN, LBG, NAS, PE and SYS (for herbarium acronyms, see Index Herbariorum: http://sweetgum.nybg.org/ih). Fresh plants of *C. sieboldii*, the most similar species of the new species, were collected from Tianmashan Mountain of Jiangxi Province in 2019 for morphological comparisons. The distribution map was prepared using geo-referenced locations, data obtained from herbarium specimens and our own field observations. The conservation status of the new species was evaluated, based on the guidelines of the International Union for Conservation of Nature (IUCN 2019).

Taxonomy

***Calanthe sieboldopsis* B.Y.Yang & Bo Li, sp. nov.**
urn:lsid:ipni.org:names:77209332-1
异大黄花虾脊兰
Figures 1A–F, 2

Diagnosis. This species is most similar to *Calanthe sieboldii* in habit, gross morphology and flower colour, but differs from the latter in having smaller flowers (dorsal sepal 15–20 mm in length in *C. sieboldopsis vs.* 22–30 mm in *C. sieboldii*, petals 15–17 in length *vs.* 19–24 mm), longer spurs (12–14 mm *vs.* 6–8 mm), lip mid-lobe nearly rectangular with emarginate apex (*vs.* elliptic with mucronate apex), disc with 3 ridges and the proximal ends of the lateral 2 ridges enlarged with light reddish spots and minute white hairs (*vs.* disc with 5 ridges and 2 rows of white short hairs at base), pollinia equal in size (*vs.* unequal in size with the lower 4 smaller and the upper 4 larger).

Type. China. Jiangxi Province: Ji'an City, Jinggangshan Mountain, Jinggangshan National Nature Reserve, in the valley, near margins of evergreen broad-leaf forest, 26°25'17"N, 114°35'02"E, ca. 540 m a.s.l., 19 April 2017, *B.Y.Yang 095* (Holotype: CSH!; Isotypes: JXU!).

Description. Plants 35–45 cm tall. Rhizome elongate, thick. Pseudobulbs small, inconspicuous, obscured by the bases of the leaves, with 3–5 basal sheaths. Leaves 4–7, well developed and spreading at anthesis, not deciduous; blade broadly elliptic, 14–28 × 6.5–9.0 cm, apex acute; petiole-like base 9.5–16 cm long, usually forming a pseudostem, 8.5–10 cm long, 1.0–1.5 cm in diam. Scape arising from leaf axil, 30–45 cm tall, sparsely puberulent; rachis 15–25 cm long, laxly 8–11-flowered; floral bracts persistent, lanceolate, 5.0–8.5 mm long, puberulent, apex acuminate. Flowers bright yellow, large, slightly fleshy, glabrous except for lip base; pedicel and ovary 18–20 mm long, minutely puberulent. Dorsal sepal elliptic, 15–20 × 5.0–6.5 mm, apex acute; lateral sepals narrowly oblong, 12–15 × 4–6 mm, apex acute. Petals obovate-lanceolate, 15–17 × 4.5–5.5 mm, base narrowed, apex acute; lip adnate to entire length of column wings, spreading horizontally, yellow, mottled red at base, deeply 3-lobed; lateral lobes oblong-elliptic or falcate-obovate, oblique, 6.5–8.0 × 4.5–5.5 mm, apex obtuse-rounded; mid-lobe nearly rectangular, 6.0–8.5 × 4.5–5.5 mm, apex emarginate; disc with 3 ridges, extending to middle of mid-lobe; the proximal ends of the lateral 2 ridges enlarged, with light reddish spots and minute white hairs; spur curved, cylindrical, 12–14 mm, inside puberulent. Column 5.0–6.0 mm, thick, wings decurrent and connecting to ridges on disc; rostellum 2-lobed; anther cap beaked; pollinia 8, clavate, equal in size, grouped into two clusters, each with a short caudicle, 0.5 mm long, attached to an elliptic viscidium.

Phenology. Flowering was observed from early April to early May and fruiting from late April to early June.

Distribution. The species is currently known only from two sites: one is the type locality in Jinggangshan National Nature Reserve, Jinggangshan Mountain, Luoxiao

Figure 1. Morphological comparison between *Calanthe sieboldopsis* B.Y.Yang & Bo Li, sp. nov. (**A–F**) and *C. sieboldii* Decne. ex Regel (**a–f**) **A, a** habit **B, b** pollinia **C, c** flowers **D, d** column (top view) and base of lips **E, e** column (lateral view) and spur **F, f** dissection of a flower.

Mountains of Jiangxi Province and another in Xianyueshan Mountain of Liling City, Hunan Province (Figure 3). The two localities belong to the same large mountain range, Luoxiao Mountains, which are the provincial border of Jiangxi and Hunan provinces. Plants of both populations grow in wet valleys and near margins of evergreen broad-leaf forest at elevations of 400–600 m a.s.l.

Etymology. The specific epithet "*sieboldopsis*" is a combination of two phrases "*siebold*" (which is derived from the specific epithet of the species *C. sieboldii*) and "*opsis*" (which means resembling), indicating that *C. sieboldopsis* is most similar to *C. sieboldii*.

Preliminary conservation assessment. The species is only known from two separate localities in the Luoxiao Mountains range: one is in the Jinggangshan National Nature Reserve of Jiangxi Province, where its habitat is well protected and 21 mature individuals were counted; the second locality in Xianyueshan Mountain of Liling City, Hunan Province, is not located in a nature reserve and only five flowering individuals have been found. Based on our observations, deforestation is the main threat to the Hunan population. Though there are probably other populations that have not been discovered in the Luoxiao Mountains or adjacent regions, we have carried out thorough field surveys in Jiangxi Province for more than 10 years and, so far, found that the total mature individuals of *C. sieboldopsis* are much less than 50, thus the new species should be categorised as critically endangered (CR) under criteria D, following the *Guidelines for Using the IUCN Red List Categories and Criteria* (IUCN 2019).

Other specimens examined. *Calanthe sieboldopsis*: China. Hunan Province: Liling City, Xianyueshan Mountain, in the valley, 27°38'02"N, 113°27'22"E, 410 m a.s.l., 11 April 2018, *B.Y.Yang 119* (JXU!); Jiangxi Province: Ji'an City, Jinggangshan National Nature Reserve, 26°25'17"N, 114°35'02"E, 540 m a.s.l., 25 April 2018, *B.Y.Yang 122* (JXU!); *ditto*, 10 April 2019, *B.Y.Yang 151* (JXU!).

Calanthe sieboldii: China. Hubei Province: Shennongjia Forestry District, Shennongjia National Nature Reserve, roadside, 31°23'51"N, 110°34'55"E, 475 m a.s.l., 11 August 2008, *D.G.Zhang zdg7268* (JIU!); Shennongjia Forestry District, Yangri Village, mountain slope, in evergreen broad-leaf forests, ca. 2000 m a.s.l., 15 May 2012, *D.G.Zhang zdg6189* (JIU!); Hunan Province: Linwu County, Xishan National Forest Park, in evergreen broad-leaf forests, 570 m a.s.l., 4 April 2014, *X.L.Yu et al. 140404* (six sheets, CSFI!); Jiangxi Province: Ji'an City, Qingyuan District, Tianmashan Mountain, in forests, 26°40'54"N, 115°24'19"E, 560 m a.s.l., 15 April 2015, *B.Y.Yang JA201504017* (JXU!); *ditto*, 22 April 2019, *B.Y.Yang 154* (JXU!); Taiwan Province: Xinzhu County, Jianshi Town, along Shihlu Historic Road, near Paishih Drawbridge, on steep rocky slope, 24°33'18"N, 121°13'38"E, 1420 m a.s.l., 21 February 2002, *Y.Y.Huang 979* (HAST!); *ditto*, Jianshi Town, Litungshan Mountain, way to Nalo-Yulao, 7 March 1987, *H.J.Su 7772* (HAST!).

Note. When preparing the Orchidaceae account for *Flora of Jiangxi*, we have carried out many years of field surveys, resulting in the discovery of a large number of new records for Jiangxi and a few taxa new to science (e.g. Yang et al. 2017, Wang et al. 2018). In *Calanthe*, 11 species have been found in Jiangxi Province, including the new species *C. sieboldopsis* and the newly-recorded *C. sieboldii* (Wang et al. 2018). Though in the latest revision of the genus *Calanthe*, *C. sieboldii* was reduced as a synonym of *C. striata* Lindl. (Clayton and Cribb 2013), this taxonomic treatment was not widely accepted in recent literature (e.g. Zhai et al. 2014; Zhou et al. 2016; Jin et al. 2019), thus we here recognise *C. sieboldii* as a separate species. *Calanthe sieboldii* was previously mainly reported from Ryukyu Islands of Japan, from Korea and from Hunan

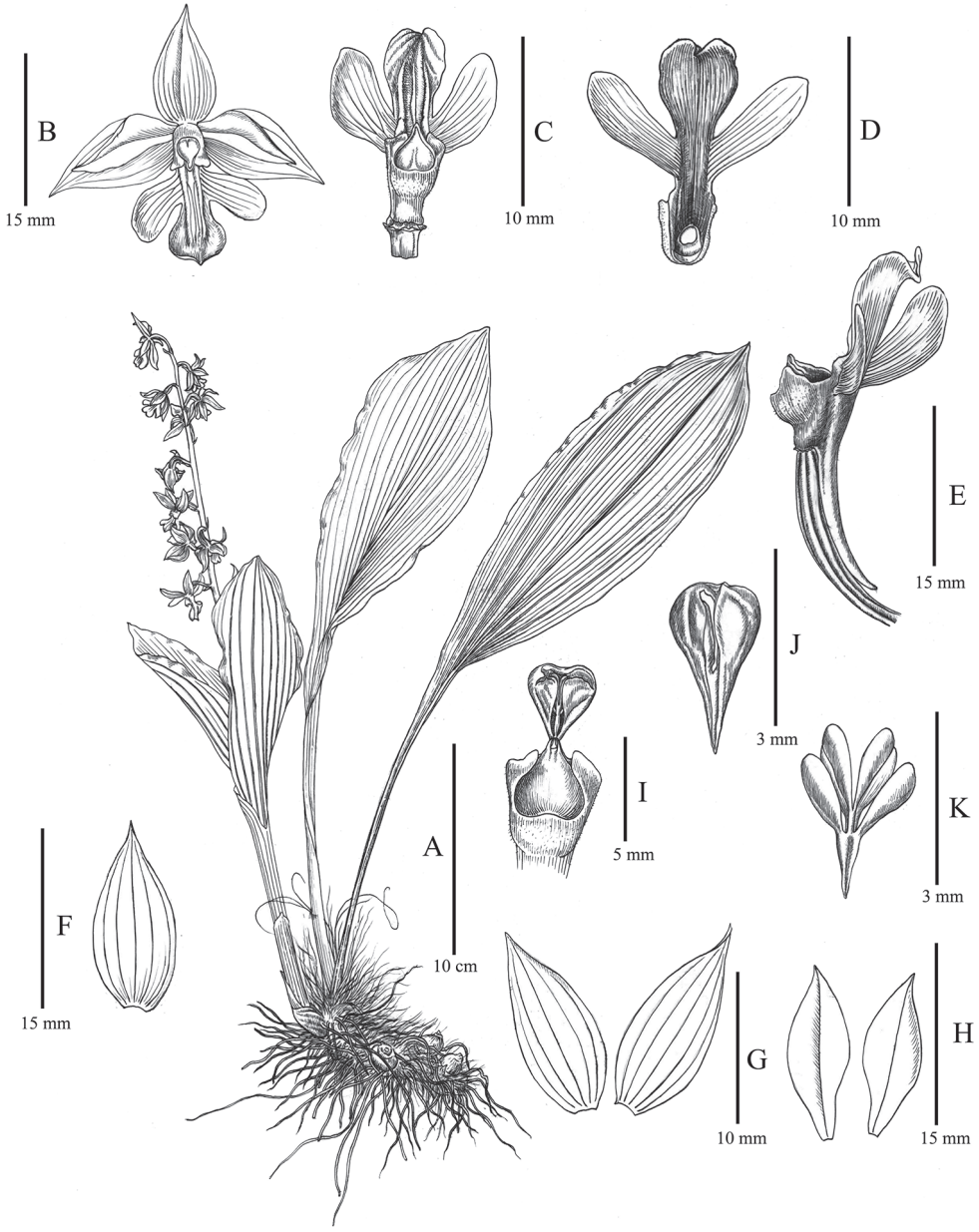

Figure 2. Line drawing illustration of *Calanthe sieboldopsis* B.Y.Yang & Bo Li, sp. nov. **A** habit **B** flower **C** column and lip (top view) **D** lip (bottom view) **E** ovary, column, lip and spur (lateral view) **F** dorsal sepal **G** lateral sepals **H** petals **I** column, rostellum and anther cap (uncovered) **J** anther cap (top view) **K** pollinia.

and Taiwan provinces of China (Chen et al. 2009), but it was recently discovered from Shennongjia National Nature Reserve of Hubei Province (Xie et al. 2017) and Ji'an City of Jiangxi Province (Wang et al. 2018) (Figure 3). *Calanthe sieboldopsis* is super-

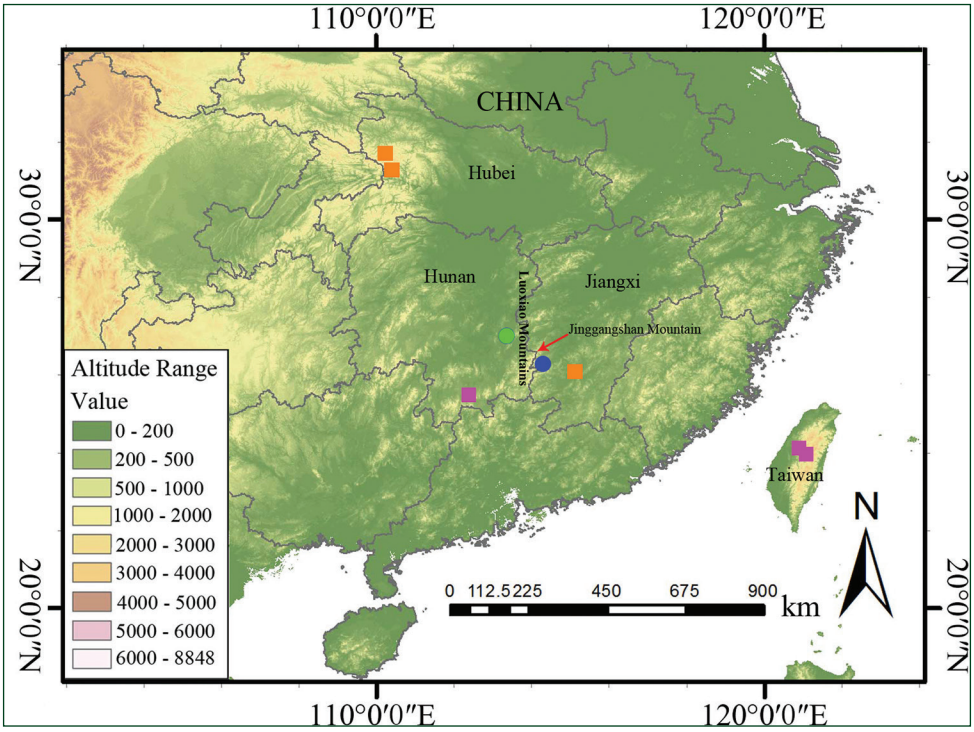

Figure 3. Distribution map of *Calanthe sieboldopsis* (blue and green circles show the type locality and another occurrence, respectively) and *C. sieboldii* (purple and orange squares show historical records and the recently-discovered localities, respectively).

ficially most similar to *C. sieboldii* because both of them are characterised by having large bright yellow flowers, but they are clearly different from each other in flower size, spur length, shape and characteristics of mid-lobes of lips and pollinia size (Figure 1). Amongst these differences, the shape of the lip mid-lobe and the characteristics of the disc could be used as the main identification trait to distinguish the two species.

Key to the species of *Calanthe* in Jiangxi Province of China

1 Floral bracts caducous; rostellum unlobed ..... ***C. clavata***
– Floral bracts persistent; rostellum 2- or 3-lobed **2**
2 Lip spurless **3**
– Lip spurred **4**
3 Sepals to 7 mm long; sepals and petals not reflexed ..... ***C. tsoongiana***
– Sepals 15–20 mm long; sepals and petals strongly reflexed ..... ***C. reflexa***
4 Lip adorned with wart-like calli on disc **5**
– Lip adorned with ridges or lamellae **7**

5 Mid-lobe of lip entire or shallowly 2-lobed ..... ***C. sylvatica***
– Mid-lobe of lip divided by a deep sinus into 2 lobules..... **6**
6 Leaves with several silver-grey bands on adaxial surface; spur 15–19 mm long; flowers yellowish-green..... ***C. argenteostriata***
– Leaves without silver-grey bands; spur ca. 10 mm long; flowers white, sometimes tinged purplish-violet or occasionally purplish-red..... ***C. alismifolia***
7 Disc with 3 membranous, triangular lamellae ..... ***C. discolor***
– Disc with 3–5 parallel ridges..... **8**
8 Sepals and petals yellowish-brown, white or pink, occasionally flushed purple.... **9**
_ Sepals and petals bright yellow..... **10**
9 Sepals and petals white or pink; disc without brown spots; spur 20–32 mm long ..... ***C. aristulifera***
– Sepals and petals yellowish-brown; disc with 4 brown spots; spur 10–18 mm long ..... ***C. graciliflora***
10 Lip mid-lobe elliptic with mucronate apex; spur 6–8 mm long; pollinia unequal in size..... ***C. sieboldii***
– Lip mid-lobe nearly rectangular with emarginate apex; spur 12–14 mm long; pollinia equal in size..... ***C. sieboldopsis***

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Carpinus gigabracteatus, a new species from southeast Yunnan, China

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Abstract

Carpinus gigabracteatus Z. Qiang Lu, a new hornbeam species from southeast Yunnan of China, is described and illustrated in this study. It possesses extremely large bracts and is closely related to *C. tsaiana* Hu and *C. tschonoskii* Maxim., based on the characters of large bract size and bracts without lobes at the base of inner margins. Furthermore, morphological comparison suggested it was distinctly different from *C. tschonoskii* by a series of characters from leaf, infructescence, bract and nutlet and from *C. tsaiana* by its leaf length to width ratio (1.4–2.0 vs. 2.0–2.4), lateral veins significantly impressed adaxially, number of lateral veins on each side of midvein (9–14 vs. 14–17), bract length (3.9–4.8 vs. 2.5–3.2 cm) and bract length to width ratio (2.3–3.1 vs. 1.5–2.1). Therefore, this hornbeam, based on only one population from southeast Yunnan, is here erected as a new species, named as *C. gigabracteatus*.

Keywords

Carpinus gigabracteatus, large bract, new species

Introduction

The hornbeam genus *Carpinus* L. is the largest genus in the subfamily Coryloideae of Betulaceae (Holstein and Weigend 2017; Li et al. 2018). To the present time, more than 40 species have been published (Hu 1964; Qi 1981; Liang and Zhao1991; Li and Skvortsov 1999; Tong et al. 2014; Holstein and Weigend 2017; Lu et al. 2017, 2018). Due to their peculiar and beautiful fruit cluster, some hornbeams are used

as important ornamental plants (Fini and Ferrini 2011; Li et al. 2018). The bract characters of fruit clusters are also important evidence for species identification (Hu 1964; Li and Skvortsov 1999; Lu et al. 2017). According to the bract characters, three morphological groups are separated by bracts completely covering the nutlet, all bracts with conspicuous lobes at the base of inner margins and bracts without lobes or rarely with inconspicuous lobes at the base of inner margins, respectively (Li and Skvortsov 1999; Lu et al. 2017). In China, the last is the largest group, including about 26 species (Holstein and Weigend 2017; Lu et al. 2018), most of them being narrow endemics within China (Li and Skvortsov 1999). Bract size is the critical trait for distinguishing these species between each other (Hu 1964; Li and Skvortsov 1999). Almost all species in this group have bracts less than 3.2 × 1.3 cm. However, the present author found a hornbeam population during field surveys in southeast Yunnan with bracts without lobes at the base of inner margins, but with large bracts (3.9–4.8 × 1.4–2.0 cm) and these could not be ascribed to any described species. In addition, those hornbeams distributed in other regions, including *Carpinus betulus* L., *C. caroliniana* Walter, *C. faginea* Lindl., *C. laxiflora* (Siebold & Zucc.) Blume, *C. orientalis* Mill. and *C. tropicalis* (Donn.Sm.) Lundell, all have smaller bract size than this Yunnan population, which also distinctly differs in bract lobes at the base of inner margins and leaf characters (Hu 1964; Furlow 1987; Holstein and Weigend 2017). However, in China, within the morphological group possessing bracts without lobes at the base of inner margins, only *C. tsaiana* Hu has the same bract width but differs from the Yunnan population by bract length. *C. tschonoskii* Maxim. has similar bract length but with different bract width (Li and Skvortsov 1999). The present author, therefore, hypothesised that this morphologically different population from southeast Yunnan may represent a potential new hornbeam. In order to test this hypothesis, the present author carried out morphological comparisons with representatives of all hornbeams in China.

Material and methods

Field surveys and specimen examination

Multiple rounds of field surveys on hornbeams in southeast Yunnan were conducted in the years 2013–2019. At first, only one population was found with extremely large bracts in 2018, this being different from all described Chinese hornbeams by the large bract size. In 2019, the present author collected samples to characterise species morphology, habitat, distribution and conservation status. Voucher specimens were deposited as *Zhiqiang Lu 2019GY0801–Zhiqiang Lu 2019GY0802* (HITBC) and *Zhiqiang Lu 20189801–Zhiqiang Lu 20189804* (LZU). Specimens (including type specimens) of all related hornbeams in China (Li and Skvortsov 1999) were consulted through CHV and GBIF platforms. However, hornbeams with bracts whose nutlets are covered completely are excluded from the morphological analysis (Li and Skvortsov 1999; Holstein and Weigend 2017). All information from all the 115 specimens examined is listed in Table 1.

Table 1. Specimens preserved in herbarium used for morphological comparison.

Species name	Collector	Collection number	Collection site	Herbarium	No. of specimens
C. gigabracteatus	*Z.Q. Lu*	*2019GY0801–2019GY0802*	Wenshan, Yunnan	HITBC	4
	Z.Q. Lu	*20189801–20189804*	Wenshan, Yunnan	LZU	2
C. chuniana	*C.L. Tso*	*20872*	Ruyuan, Guangdong	HUH	1
C. chingiana	*Q.S. Zhao et al.*	*6980 (three duplicates)*	Muli, Sichuan	CDBI	3
C. dayongina	*K.W. Liu*	*33359*	Zhangjiajie, Hunan	CSFI	1
C. fargesiana	*Q. Li*	*77351*	Jinchuan, Sichuan	PE	1
C. firmifolia	*P.H. Yu*	*810*	Bijie, Guizhou	KUN	1
C. hebestroma	*Anonymous*	*118773*	Hualian, Taiwan	Tai	1
C. henryana	*W.Y. Chun*	*4173*	Liangsungkou, Hubei	PE	1
C. insularis	*K.M. Tam*	*0770924*	Hongkong	IBSC	1
C. kawakamii	*K. Taiya*	*1998*	Taiwan	Tai	1
C. lipoensis	*Y.K. Li*	*9940*	Libo, Guizhou	HGAS?	1
C. luochengensis	*J.Y. Liang*	*K1644 (two duplicates)*	Luocheng, Guizhou	IBK	2
C. mengshanensis	*F.Z. Zhao*	*84001*	Pingyi, Shandong	SDFS	1
C. microphylla	*Z.C. Chen*	*54089*	Tianyang, Guangxi	IBK	1
C. mollicoma	*K.M. Feng*	*1203*	Xichou, Yunnan	PE	1
	Z.Q. Lu	*201511501-201511517*	Xichou, Yunnan	LZU	17
C. monbeigiana	*H.R.E. von Handel-Mazzetti*	*3431*	Yunnan	K	1
	Z.Q. Lu	*2016WXYZ001- 019*	Weixi, Yunnan	LZU	19
C. omeiensis	*K.H. Yang*	*57490 (three duplicates)*	Emei, Sichuan	PE, NAS	3
C. paohsingensis	*T.H. Tu*	*4356 (two duplicates)*	Baoxing, Sichuan	PE	2
C. polyneura	*E.H. Wilson*	*5791*	Emei, Sichuan	HUH	1
C. pubescens	*A. Henry*	*9928 (two duplicates)*	Mile, Yunnan	PE, K	2
C. purpurinervis	*Y.K. Li*	*P01567 (five duplicates)*	Duan, Guangxi	IBK	5
C. rupestris	*J. Cavalerie, Z.S. Zhang*	*4560, 6624*	Guizhou	PE	2
C. shensiensis	*Y.Y. Pai*	*2860, 2891*	Shaanxi	PE	2
C. shimenensis	*P.C. Cai*	*20241*	Shimen, Hunan	CSFI	1
C. turczaninovii	*S.W. Williams*	*12681*	Beijing	GH	1
C. tibetana	*Z.Q. Lu*	*2016QTP001-011*	Bomi, Xizang	LZU	11
C. kweichowensis	*Y. Tsiang*	*4406*	Zhenfeng, Guizhou	PE	1
C. viminea	*N. Wallich*	*2800a (two duplicates)*	Nepal	K	2
C. londoniana	*A. Henry*	*11640*	Puer, Yunnan	K	1
C. tientaiensis	*Y.L. Keng*	*1065*	Tiantai, Zhejiang	PE	1
C. putoensis	*K.K. Tsoong*	*94 (two duplicates)*	Putuo, Zhejiang	PE	2
C. langaoensis	*Z.Q. Lu*	*2016LZQ029*	Langao, Shaanxi	LZU	1
C. tschonoskii	*M. Furuse*	*52662-52665, 52569, 12997*	Japan	PE	6
	S. Tschonoski	*s.n.*	Japan	PE	1
	Sichuan team	*3759*	Yuexi, Sichuan	PE	1
	Y.X. He	*23333*	Changhua, Zhejiang	HHBG	1
C. tsaiana	*H.T. Tsai*	*62398 (three duplicates)*	Pingbian, Yunnan	PE	3
	C.W. Wang	*85686 (four duplicates)*	Xichou, Yunnan	PE	4
	Anonymous	*217*	Huishui, Guizhou	GFS	1

Morphological analysis

Comparative analyses of bract size for these related hornbeams were conducted. For the measurement of bract width, bract lobes were not calculated. Then, the closely related hornbeams, based on bract size, were selected from 33 hornbeam species. Furthermore, morphological differences of the Yunnan population were illustrated, based on a series of morphological characters from the leaf, infructescence, bract and nutlet. One to three representative bracts were chosen to conduct the measurement for each

of the specimens. In addition, values of minimum and maximum bract width/length, recorded in *Flora of China* and other published studies (Hu 1964; Li and Skvortsov 1999; Tong et al. 2014; Holstein and Weigend 2017; Lu et al. 2017, 2018), were also used to determine the closely related species, based on the comparative analysis of bract size and other characters. Finally, many morphological differences between this Yunnan population and other closely related hornbeams were clarified through the morphological comparison, based on 115 specimens (including type specimens).

Results

This hornbeam population from southeast Yunnan possesses extremely large bracts (3.9–4.8 × 1.4–2.0 cm) (Figures 1, 2). Phenotypic differentiation of bract length and width for hornbeams in China showed it was closely related to *C. langaoensis*, *C. tsaiana* and *C. tschonoskii* (Figure 3). Bracts, with and without lobes at the base of inner margins, corresponded to *C. langaoensis* and the Yunnan population, respectively (Figure 3). Morphological comparison with *C. tsaiana* and *C. tschonoskii* showed the Yunnan population distinctly differed from *C. tschonoskii* by leaf length to width ratio (1.4–2.0 vs. 2.0–2.3), lateral veins significantly impressed adaxially, infructescence size (8.0–12.0 × 5.0–5.5 cm vs. 6.0–10.0 × 3.0–4.0 cm), bract width (1.4–1.8 vs. 0.6–1.2 cm), nutlet shape (ovoid-ellipsoid vs. broadly ovoid), nutlet size (5.3–7.0 × 4.0–5.5 mm vs. 4.0–5.0 × 3.0–4.0 mm) and densely pubescent or villous and resinous glandular on nutlet (Table 2) and from *C. tsaiana* by leaf length to width ratio (1.4–2.0 vs. 2.0–2.4), lateral veins significantly impressed adaxially, number of lateral veins on each side of midvein (9–14 vs. 14–17), bract length (3.9–4.8 vs. 2.5–3.2 cm) and bract length to width ratio (2.3–3.1 vs. 1.5–2.1).

Taxonomic treatment

***Carpinus gigabracteatus* Z. Qiang Lu, sp. nov.**
urn:lsid:ipni.org:names:77209333-1
Figures 1, 2
大苞鹅耳枥

Diagnosis. *Carpinus gigabracteatus* differs from *C. tsaiana* by leaf length to width ratio 1.4–2.0 (compared to 2.0–2.4), lateral veins impressed adaxially, 9–14 lateral veins on each side of the midvein (compared to 14–18), bract length 3.9–4.8 cm (compared to 2.5–3.0 cm) and bract length to width ratio 2.3–3.1 (compared to 1.5–2.1).

Type. China. Yunnan: Wenshan Prefecture, 23°09'35"N, 104°05'53"E, 1591 m alt., karst limestone hill, 23 Sep 2019, *Z.Q. Lu 2019GY0801* (holotype, HITBC; isotypes, HITBC and LZU).

Description. Tree to 8 m tall, deciduous; bark grey, smooth. Branchlets black-brown, glabrescent. Petiole 7–14 mm, densely yellow pubescent when young, glabrescent in the

Table 2. Morphological comparison of *C. gigabracteatus* with *C. tsaiana* and *C. tschonoskii*.

Characters	*C. gigabracteatus*	*C. tsaiana*	*C. tschonoskii*
LEAF			
Shape and size	Leaf blade elliptic, ovate-elliptic or ovate, 7.0–12.0 × 4.0–7.0 cm, **length to width ratio 1.4–2.0**, base rounded, rounded-cuneate or cordate, margin regularly or irregularly and doubly minutely serrate, apex acuminate	Leaf blade elliptic, oblong, oblong-lanceolate or ovate-lanceolate, 8.0–14.0 × 4.0–7.0 cm, **length to width ratio 2.0–2.4**, base cordate or obliquely cordate, margin irregularly and doubly minutely serrate, apex acuminate	Leaf blade elliptic, oblong or ovate-lanceolate, 5.0–12.0 × 2.3–5.0 cm, **length to width ratio 2.0–2.3**, base subrounded or subrounded-cuneate, margin doubly setiform serrate, apex acuminate or caudate-acuminate
Length of petiole	7–14 mm	7–15 mm	7–15 mm
Number of lateral veins on each side of midvein	**9–14**	**14–17**	**12–16**
Lateral veins significantly impressed adaxially or not	**Significantly impressed adaxially**	**Not**	**Not**
Abaxially densely villous or sparsely villous along veins	Densely or sparsely villous	Sparsely villous	Sparsely villous
INFRUCTESCENCE			
Size of infructescence	8.0–12.0 × **5.0–5.5 cm**	10.0–15.0 × **4.0–5.5 cm**	6.0–10.0 × **3.0–4.0 cm**
Length of peduncle	1.5–2.5 cm	1.5–3 cm	1–4 cm
BRACT			
Size of bract	**3.9–4.8 × 1.4–1.8 cm**	**2.5–3.2 × 1.3–1.8 cm**	**1.8–5.0 × 0.6–1.2 cm**
Length to width ratio	**2.3–3.1**	**1.5–2.1**	**2.4–4.2**
NUTLET			
Shape and size of nutlet	**Ovoid-ellipsoid, 5.3–7.0 × 4.0–5.5 mm**	**Ovoid-ellipsoid, 5.0–6.0 × 4.5–5.0 mm**	**Broadly ovoid, 4.0–5.0 × 3.0–4.0 mm**
Densely pubescent or villous	**Densely pubescent, densely villous at apex**	**Densely pubescent, densely villous at apex**	**Glabrous except sparsely villous at apex**
Densely resinous glandular or not	**Densely resinous glandular**	**Densely resinous glandular**	**Usually no resinous glandular**

following few months; leaves alternate, leaf blade elliptic, ovate-elliptic or ovate, usually 7–12 × 4–7 cm, length to width ratio 1.4–2.0, leathery, abaxially sericeous-villous or sparsely villous along veins, bearded in axils of lateral veins, adaxially densely villous when young, base rounded, rounded-cuneate or cordate, margin regularly or irregularly and doubly minutely serrate, apex acuminate; lateral veins 9–14 on each side of midvein, raised abaxially, significantly impressed adaxially. Male inflorescence pendulous, spicate-cymose, cylindrical, enclosed by buds during winter, with many overlapping bracts, 1.0–3.0 × 0.4–0.6 cm when mature; flowers without bracteoles, inserted at base of bracts. Female inflorescence terminal or axillary on dwarf shoots, racemose; flowers paired; bracts leaf-like, complanate, overlapping. Mature infructescence 8.0–12.0 × 5.0–5.5 cm; peduncle 1.5–2.5 cm, densely yellow hirsute; giant bracts loosely overlapping, 3.9–4.8 × 1.4–1.8 cm, abaxially densely yellow hirsute along reticulate veins, outer margin coarsely dentate and rarely entire, commonly without but sometimes with basal lobe, inner margin entire, with inflexed basal auricle, apex acuminate; veins 5–6.

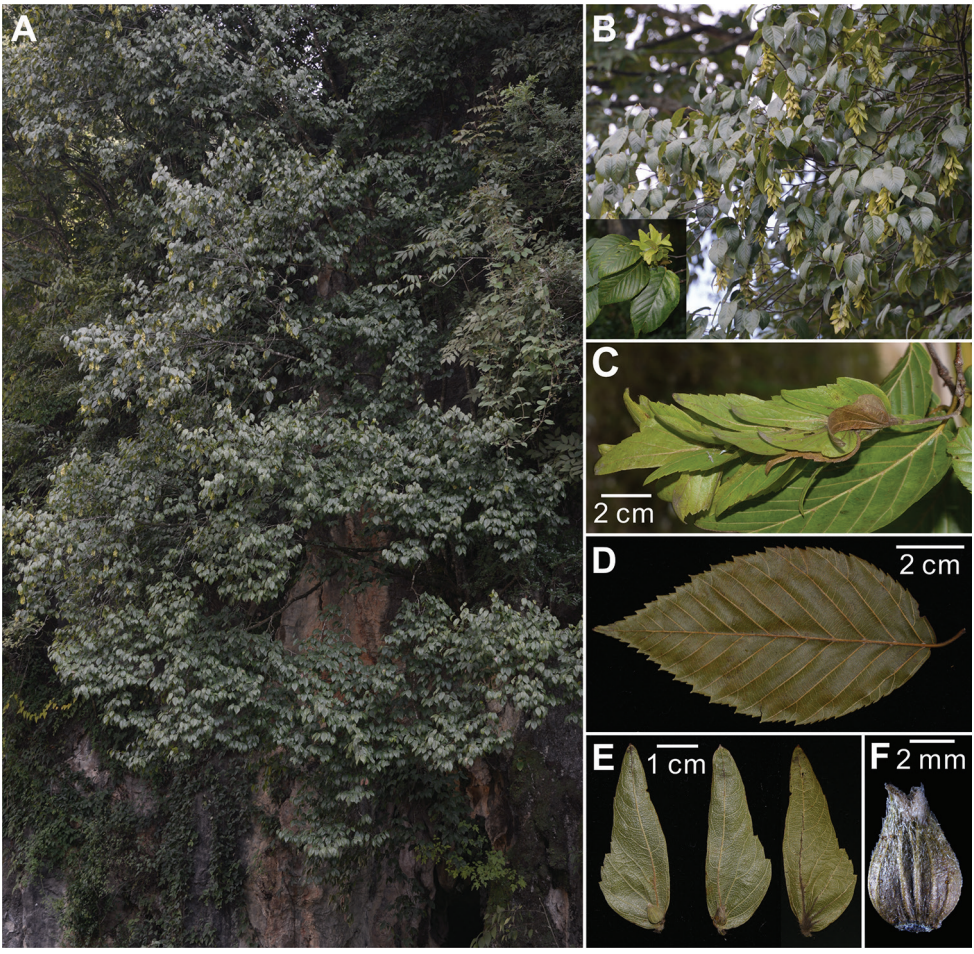

Figure 1. *Carpinus gigabracteatus* Z. Qiang Lu **A** the whole plant, habitat and location **B** branches with infructescences and leaves **C** infructescences **D** leaf **E** bracts **F** nutlet.

Nutlet ovoid-ellipsoid, 5.3–7.0 × 4.0–5.5 mm, densely pubescent, densely villous at apex, densely brown resinous glandular, prominently 9 or 11-ribbed.

Etymology. This hornbeam from southeast Yunnan has extremely large bracts, which are distinctly different from other closely related hornbeams, and therefore is given the epithet *gigabracteatus*.

Phenology. Flowering from April to May and fruiting from July to September.

Habitat, distribution and conservation. Up to now, only one *C. gigabracteatus* population has been collected from southeast Yunnan. For its population census, only six mature trees (6–8 m in height) and 13 seedlings grow on a steep karst limestone hill. To the present author's knowledge, the bract size of this species is now the largest across the whole hornbeam genus in China. Hence, it has great horticultural and ornamental value and some people like to dig them up to grow them as ornamental

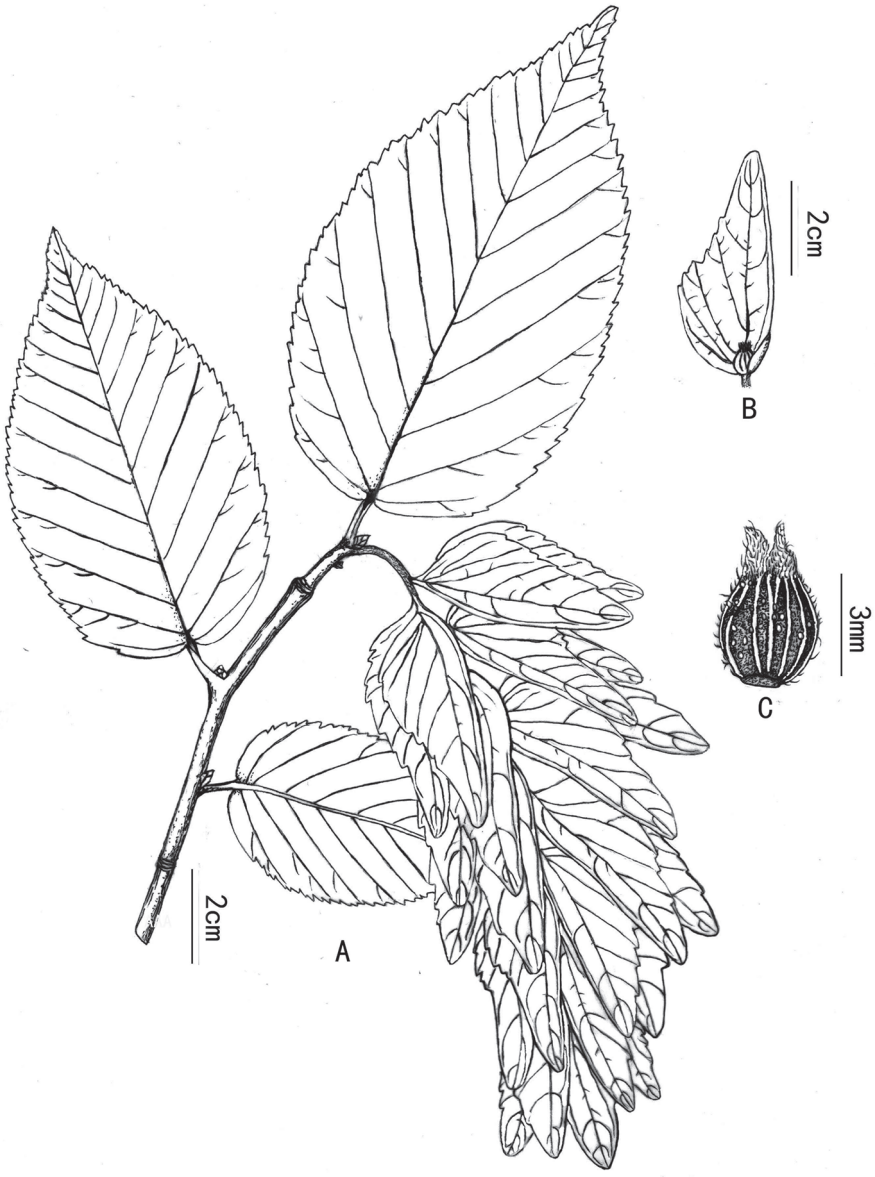

Figure 2. *Carpinus gigabracteatus* Z. Qiang Lu was drawn from *Z.Q. Lu 2019GY0801* (HITBC).

trees. Manual digging involves removing lots of large rocks on the limestone hill where this new species grows, resulting in significant damage to the habitat. So far, no other population has been found, even though multiple rounds of field surveys in Wenshan Prefecture and adjacent regions have been carried out in the years from 2013 to 2019. Therefore, this hornbeam is exposed to significant threats from human activity due to

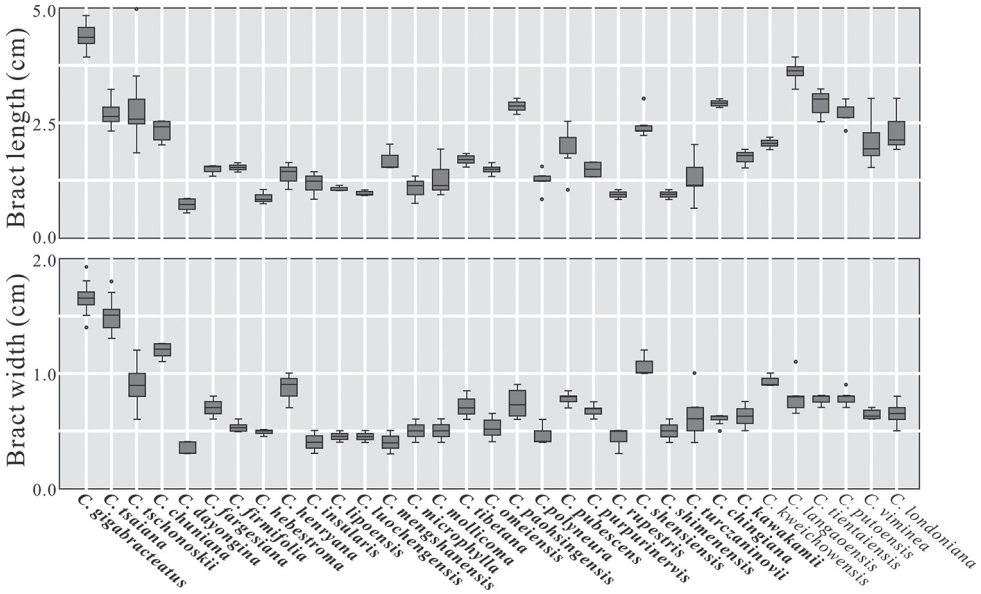

Figure 3. Phenotypic differentiation of bract length and width, across all Chinese hornbeam species according to Holstein and Weigend (2017). Data from all examined specimens in Table 1 and descriptions by Hu (1964), Qi (1981), Liang and Zhao (1991), Li and Skvortsov (1999), Tong et al. (2014) and Lu et al. (2017, 2018). Those hornbeams, whose bracts are without lobes or rarely with inconspicuous lobes at the base of inner margins, are in bold.

its rarity and horticultural and ornamental value. According to the IUCN Categories and Criteria (IUCN 2016), the present author here classifies this species as "Critically Endangered" (CR). Fortunately, these mature trees can provide the possibility to expand population based on seeds.

Additional specimens examined. China. Yunnan: Wenshan Prefecture, 23°09'35"N, 104°05'53"E, 1591 m alt., karst limestone hill, 23 Sep 2019, *Z.Q. Lu 2019GY0802*; the same locality, 10 July 2019, *Z.Q. Lu 20189801–Z.Q. Lu 20189804.*

Discussion

Bract morphology in the *Carpinus* genus provides important traits for species identification (Hu 1964; Li and Skvortsov 1999; Lu et al. 2017, 2018). In this study, the present author demonstrated a hornbeam population from southeast Yunnan as a new species, based on the following evidence. First, its large bract size, including the characters of bract length and width, showed it to be closely related to *C. langaoensis*, *C. tsaiana* and *C. tschonoskii* (Figure 3). However, this Yunnan population, with its bract without lobes at the base of inner margins, can be easily distinguished from *C. langaoensis*, whose bracts have conspicuous lobes at the base of inner margins (Li and

Skvortsov 1999; Lu et al. 2017, 2018). In addition, more characters, based on leaf and nutlet, can also distinguish both of them (Lu et al. 2017). Furthermore, other hornbeams distributed outside of China, including *C. betulus, C. caroliniana, C. faginea, C. laxiflora, C. orientalis* and *C. tropicalis*, are all different from this hornbeam population from southeast Yunnan, by the smaller bract size and other characters of bract and leaf (Hu 1964; Furlow 1987; Holstein and Weigend 2017). Finally, morphological comparison suggested it differed from *C. tschonoskii* by a series of characters from leaf, infruGctescence, bract and nutlet (Table 2), which was consistent with the description by Li and Skvortsov (1999). Therefore, the most similar species to the Yunnan population is *C. tsaiana*, based on similar morphology and distribution (Li and Skvortsov 1999; Holstein and Weigend 2017). However, all eight typical specimens of *C. tsaiana* (including seven type specimens) from three populations were distinctly different from this Yunnan population by leaf length to width ratio (1.4–2.0 vs. 2.0–2.4), lateral veins significantly impressed adaxially, number of lateral veins on each side of midvein (9–14 vs. 14–17), bract length (3.9–4.8 vs. 2.5–3.2 cm) and bract length to width ratio (2.3–3.1 vs. 1.5–2.1) (Table 2; Figures 1–3). Hence, the present author proposes to recognise this hornbeam population from Yunnan as a new species.

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SHORT COMMUNICATION

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Nomenclatural changes in Onagraceae

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Abstract

A new subspecies and two new combinations are proposed in Onagraceae. *Ludwigia glandulosa* Walter subsp. *brachycarpa* C.-I Peng, **subsp. nov**. is morphologically distinct from the typical subspecies, with smaller capsules and leaves, different seed coat, and a restricted distribution. *Epilobium* sect. *Pachydium* (Fischer & C. A. Meyer) Hoch & K. Gandhi, **comb. nov**. refers to a distinctive group of species formerly known as *Boisduvalia* Spach and as *Epilobium* sect. *Boisduvalia* (Spach) Hoch & P. H. Raven. And *Chamaenerion speciosum* (Decaisne) Hoch & K. Gandhi, **comb. nov**. is proposed for a distinctive Himalayan species originally described in *Epilobium*.

Keywords

Boisduvalia, Chamaenerion, fireweeds, Ludwigia, nomenclature

Introduction

The plant family Onagraceae is known in considerable detail as a result of modern monographic studies of almost the entire family and numerous comparative morphological analyses, summarized in Wagner et al. (2007). Recent phylogenetic analyses (especially Levin et al. 2003, 2004) provided much insight into the relationships in the family and necessitated many changes in the classification. Most of these changes were included in Wagner et al., but recent work revealed the need for several additional nomenclatural changes.

Methods

This contribution is the result of careful nomenclatural review by K. Gandhi of the treatment of Onagraceae by WL Wagner and PC Hoch for the Flora of North America. Gandhi detected several nomenclatural problems, which are corrected by the following changes.

Taxonomic treatment

Ludwigia L., a pan-subtropical genus of 82 species, forms a strongly monophyletic lineage sister to the rest of Onagraceae (e.g., Levin et al. 2003, 2004). Recent molecular analysis (Liu et al. 2017) has challenged the complex sectional classification of *Ludwigia* (22 sections), but full resolution awaits more detailed analysis. One strongly monophyletic clade is section *Isnardia* (L.) W. L. Wagner & Hoch, a group of 19 species centered in southeastern North America (Liu et al. in press) and formerly treated as sections *Dantia* (DeCandolle) Munz (Peng et al. 2005) and *Microcarpium* Munz (Peng 1989; Wagner et al. 2007). While reviewing the treatment of Onagraceae for the Flora of North America, one of us (KG) noticed an error in the treatment of *L. glandulosa* Walter, a widespread species of section *Isnardia*. Peng (1986) initially published *L. glandulosa* subsp. *brachycarpa* (Torrey & A. Gray) C. Peng as a comb. nov., based on *L. cylindrica* Elliott β. *brachycarpa* Torrey & A. Gray, but that latter name was a comb. nov. based on *Jussiaea brachycarpa* Lam., which Peng considered to be a synonym of *L. glandulosa* subsp. *glandulosa*. Therefore, *L. glandulosa* subsp. *brachycarpa* was not a comb. nov., as Peng proposed, but instead a subsp. nov. However, it was invalid since it lacked a diagnosis/description in Latin, as required at that time, and designation of a type specimen. Here we correct the mistake, and validate the name with a type and description. Unfortunately, our colleague Ching-I Peng died in 2018, but since his original intention was clear and he provided the name and description (Peng 1986, 1989), with this authorship we honor his enormous contributions to our understanding of *Ludwigia*.

***Ludwigia glandulosa* Walter subsp. *brachycarpa* C.-I Peng, subsp. nov.**
urn:lsid:ipni.org:names:77209334-1

Diagnosis. *Ludwigia glandulosa* subsp. *brachycarpa* differs from typical *L. glandulosa* in its smaller stature, 10–55(–90) cm (vs. (20–)40–80(–100) cm); narrower leaf blades, 0.3–0.5(–1) cm (vs. 0.3–2.1 cm); shorter sepals, 1.1–1.9 mm (vs. 1.3–2.3 cm); smaller capsules, 2–5 × 1.3–2 mm (vs. (4–)5–8(–9) × 1.6–2(–3) mm); and seed surface cells elongate transversely to length (vs. surface cells elongate parallel to length).

Type material. USA, Louisiana, Cameron Parish, 3.2 km W of junction State Highways 82 and 27, 29°48.62'N, 93°08.25'W, 1 m, 16 August 1980, *C.-I Peng, W. Peng and J. Chen 4367* (holotype: MO 2806683); see fig. 42 in Peng (1989).

Description. ***Stems*** rarely reddish green, 10–55(–90) cm. ***Leaves*****:** petiole 0–1 cm, blades linear-elliptic to linear, sometimes very narrowly elliptic, those on main axis 3–5(–7) × 0.3–0.5(–1) cm, those on branches 0.8–3.6 × 0.2–0.3(–0.8) cm. ***Inflorescences*****:** bracteoles attached at base of ovary, 0.4–0.8 × 0.1–0.2 mm. ***Flowers*****:** sepals 1.1–1.9 × 1–1.8 mm, apex acute or short-acuminate; nectary disc obscurely, minutely papillose; style 0.4–0.8 mm, stigma 0.2–0.3 mm diam. ***Capsules*** obscurely 4-angled, 2–5 × 1.3–2 mm, pedicel 0–0.2 mm. ***Seeds*** 0.6–0.8 × 0.3–0.4 mm, surface cells elongate transversely to seed length. ***Chromosome number***: $n = 16$.

Phenology. Flowering and fruiting April to November.

Etymology. The subspecific epithet '*brachycarpum*' refers to the short capsules.

Distribution and habitat. *Ludwigia glandulosa* subsp. *brachycarpa* is endemic to the US Gulf Coast from southwestern Louisiana to Nueces County, Texas, and more sporadically northward in eastern Texas to south-central Oklahoma. This distribution is at the extreme southwestern edge of that for subsp. *glandulosum*, which grows from Texas and Oklahoma east to Virginia and Florida and north to southern Missouri, Illinois, and Indiana (Peng 1989). Although they overlap in part, the two taxa are only rarely locally sympatric. *Ludwigia glandulosa* subsp. *brachycarpa* grows in ditches, low meadows, coastal prairies, seeps in sandy woods, moist sinkholes in granite outcrops, old clay fields at an elevation of 0–200 m.

New combinations

Epilobium L. is the largest genus in the family Onagraceae; its 165 species are widely distributed in cool or cold regions of the world, with a center of diversity in western North America (Wagner et al. 2007). A group of annual species with affinities to *Epilobium* but considered distinct because they lack seed comas was historically segregated as *Boisduvalia* Spach (Raven 1976). However, molecular and other evidence (Hoch and Raven 1992; Baum et al. 1994; Wagner et al. 2007) unequivocally place *Boisduvalia* within *Epilobium* as two non-monophyletic sections. *Epilobium* sect. *Epilobiopsis* (Spegazzini) Lievens, Hoch & PH Raven is a group of two species characterized by tough, tardily dehiscing capsules, seeds in two rows per locule, and a chromosome number of $n = 15$; and *E.* sect. *Boisduvalia* (Spach) Hoch & P. H. Raven is a group of four species characterized by friable, readily dehiscing capsules, seeds in one row per locule, and chromosome numbers of $n = 9, 10, 19$. In naming this latter section, however, we overlooked an earlier name at the sectional level, one of two proposed for this group by Fischer and Meyer (1836), who treated the group as part of *Oenothera* L. due to the absence of seed comas. Therefore, a new combination is required.

Epilobium **Linnaeus sect. *Pachydium* (Fischer & C.A. Meyer) Hoch & K. Gandhi, comb. nov.**
urn:lsid:ipni.org:names:77209335-1

Basionym. *Oenothera* sect. *Pachydium* Fischer & C.A. Meyer, Ind. sem. hort. petrop. 2: 45. 1836 ["1835"]. *Boisduvalia* [unranked] *Pachydium* (Fischer & C.A. Meyer) Endlicher, Gen. pl. 1191. 1840. *B.* subg. *Pachydium* (Fischer & C.A. Meyer) Reichenbach, Deut. Bot. Herb.-Buch. 170. 1841; *Boisduvalia* sect. *Pachydium* (Fischer & C.A. Meyer) Munz, N. Amer. Flora 5, II: 228.

Type. *Oenothera densiflora* Lindley [= *Epilobium densiflorum* (Lindley) Hoch & P.H. Raven].

The distinctive, circumboreal/ circumpolar group commonly known as fireweeds has been treated either as a section of *Epilobium* (Haussknecht 1884; Raven 1976; Chen et al. 1992) or as the separate genus *Chamaenerion* Séguier. Although the two groups share the distinctive comose seeds, several floral features, and a base chromosome number of $x = 18$, *Chamaenerion* differs from *Epilobium* in having leaves nearly always spirally arranged, rarely subopposite or verticillate near stem base (vs. opposite at least on proximal stem); lack of a floral tube (vs. more or less distinct floral tube); flowers slightly zygomorphic with subequal stamens that are erect, then deflexed, and styles that are deflexed, then erect (vs. actinomorphic with erect stamens in two series and erect styles); petals entire (vs. emarginate); and pollen shed in monads (vs. tetrads) (Wagner et al. 2007). Recent molecular analyses (Baum et al. 1994; Levin et al. 2004) also demonstrated that the fireweeds form a strongly supported clade sister to the rest of *Epilobium* (Wagner et al. 2007).

Holub (1972) argued that the correct name for the fireweeds at the generic level should be *Chamerion* (Raf.) Raf. ex Holub, not *Chamaenerion*, which he argued was illegitimate. However, as noted in personal correspondence between KG and Ulf Eliasson in 2009, and summarized by Sennikov (2011), clarifications in the botanical code and in the lectotypification of *Chamaenerion* and *Epilobium* negate Holub's analysis, and Sennikov concluded that the correct and valid name for the fireweeds at the generic level is *Chamaenerion* Séguier.

All but one of the eight species recognized in this genus have been treated at some point as species in *Chamaenerion*, the only exception being a species described in *Epilobium* that is endemic to the Himalayan region from Kashmir to Nepal and Xizang (Tibet), China (Chen et al. 1992), for which the following new combination is provided:

Chamaenerion speciosum **(Decaisne) Hoch & K. Gandhi, comb. nov.**
urn:lsid:ipni.org:names:77209336-1

Basionym. *Epilobium speciosum* Decaisne, Voy. Ind. (Jacquemont) 4: 57, t. 69 [Apr 1835 – Dec 1844]. *Epilobium latifolium* L. subsp. *speciosum* (Decne.) P. H. Raven, Bull. Brit. Mus. (Nat. Hist.), Bot. 2(12): 349. 1962. *Chamerion speciosum* (Decne.)

Holub, Folia Geobot. Phytotax. 7: 86. 1972; non *Chamaenerion speciosum* Lodd. ex Steudel, Nomencl. Bot. ed. 2, 1: 343. 1840, pro syn.

Type material. India. Himachal Pradesh, near Yurpo, 3800m 1830–1831, *V. Jacquemont 1739* (***holotype:*** P; ***isotypes:*** G, K).

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RESEARCH ARTICLE

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Four decades of new vascular plant records for Greenland

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Abstract

Records of new species of vascular plants in Greenland from the last four decades are presented and new phytogeographical data leading to extension of the known distribution limits in Greenland are discussed. Since the publication of the latest edition of the Flora of Greenland in 1978 (Böcher et al. 1978) fieldwork by Greenland Botanical Survey and other expeditions have taken place especially in West and East Greenland and in many remote areas in North and Northeast Greenland. This paper serves as an update of the Flora of Greenland. Twenty species, one subspecies and one new forma have been added to the flora of Greenland: *Carex membranacea* Hook., *Carex miliaris* Michx., *Carex rhomalea* (Fernald) Mack., *Equisetum hyemale* L., *Festuca edlundiae* S. Aiken, Consaul and Lefkovich, *Festuca groenlandica* (Schol.) Frederiksen, *Festuca saximontana* Rydb., *Galium verum* L., *Geum rossii* (R. Br.) Ser., *Papaver cornwallisense* D. Löve, *Papaver dahlianum* Nordh., *Papaver labradoricum* (Fedde) Solstad and Elven, *Papaver lapponicum* (Tolm.) Nordh., *Pedicularis sudetica* Willd. ssp. *albolabiata* Hult., *Poa flexuosa* Sm., *Puccinellia bruggemanni* Th. Sør., *Ranunculus subrigidus* W.B. Drew., *Silene vulgaris* (Moench) Garcke, *Trientalis europaea* L. and *Veronica officinalis* L. in addition to one subspecies *Phippsia algida* (Sol.) R. Br. ssp. *algidiformis* (H. Sm.) Löve and Löve. The viviparous form of *Poa hartzii* f. *prolifera* has been reported for the first time in Greenland. Presently, the total number of vascular plant species in Greenland is 532. 89 new northern and 28 new southern distribution limits are presented and 26 species are new to the flora province East Greenland, whereas 15 species are new to West Greenland. The numbers of new species to flora provinces North and South Greenland are 14 and one, respectively.

Keywords

Vascular plants, flora, Greenland, phytogeography, distribution limits

Introduction

Greenland is the largest island in the world, extending from c. 60° to c. 83° northern latitude, and it includes all the Arctic bioclimatic zones (Raynolds et al. 2019) from the subarctic zone in continental areas in southernmost Greenland to the polar desert zone in coastal areas of North Greenland (Bay 1997). Ice-free areas have a varying width of up to 200 km from the outer coast to the Inland Ice. This large variation in climate from coastal to inland areas, in addition to large differences in regional geology and soils, gives rise to a large number of biological niches. Despite this fact only 532 species of vascular plants are known from Greenland, which is a low number considering the size and distribution of the island in all the bioclimatic zones of the Arctic. The immigration of species is restricted because of the remoteness of Greenland to neighboring territories in North America and Eurasia. The species number in the neighboring arctic territories in Canada, Russia, and Norway, which covers larger or smaller areas compared to Greenland, is 375 (Gillespie et al. 2015), 1691 (Sekretareva 2004) and 184 (Alsos et al. 2017), respectively. Generally, the Arctic flora is young with low species diversity, low endemicity, and is little influenced by alien species (Daniëls et al. 2013). Recently an updated red list of Greenland has been published including all endemic species of vascular plants (Boertmann and Bay 2019).

An updated flora is an important baseline information when assessing the changes in number and species composition in a changing climate in the near future.

The vascular plant flora of Greenland has been studied intensively during the latest decades and three phytogeographical papers have been published based on material in the Copenhagen herbarium (C) and other herbaria. South Greenland was studied by Feilberg (1984), North Greenland by Bay (1992), and West Greenland by Fredskild (1996); in addition the material from East Greenland is under preparation by C. Bay. Taxonomical revisions of species complexes by Solstad and Elven (*Papaver* complex) and Myhre Pedersen and Elven (*Carex saxatilis* complex) have added a few species.

The botanical exploration of Greenland started in the easily accessed areas in South and West Greenland, whereas the exploration of the remote areas in North and Northeast Greenland followed decades later. Greenland Botanical Survey at University of

Copenhagen carried out floristic and vegetation studies in most parts of Greenland during the period 1962–1998 (Bay et al. 2017).

Since the publication of the Flora of Greenland (Böcher et al. 1978), one update was made 25 years ago (Bay 1993) that summarized the total number of vascular plant species to 513. During the latest 15 years the total number of vascular plants has been increased by nineteen species giving a total of 532 species. The present paper concerns all the finds of new taxa to Greenland and the new distributional records since the Flora of Greenland was published forty years ago.

An updated flora is an important baseline information when assessing the changes in number and species composition in a changing climate in the near future. An update of the none-native vascular plants in the Arctic has been published recently (Wasowicz et al. 2020).

Methods and materials

Fieldwork in recent years by the Greenland Botanical Survey (GBS) and others (Table 1) have resulted in finds of species new to the flora of Greenland and have extended the knowledge on northern and southern distribution limits for many species. Especially, fieldwork in North and Northeast Greenland in the eighties and nineties, which have been inaccessible for decades because of their remoteness, has added new phytogeographical knowledge. In addition valuable data have been collected from mid-West Greenland when Jon Feilberg and Vilhelm Dalgaard were leaders of the Arctic station on the island Disko.

Several botanist have contributed with important knowledge to the flora of Greenland. B. Fredskild worked in Northeast Greenland ten summers in the period 1982–1996 and more than twenty seasons in West Greenland, while C. Bay worked 29 summers in Greenland, mostly in high arctic areas.

Other important contributors are P. Gelting, G. Seidenfaden, T. Sørensen, F. Rune, G. Halliday, R. Corner, R. and S. David, H. Lang and F. Schwartzenbach, who have contributed with important collections from West, East and North Greenland to the Greenland herbarium of University of Copenhagen. A large number of specimens was collected, identified and stored in C. This information is gathered in the yearly Greenland Botanical Survey reports and is the main basis for this paper together with specimens from other herbaria and recent finds. The nomenclature is according to Böcher et al. 1978.

Results

Twenty species, one subspecies and a new forma have been added to the flora of Greenland since the last edition of The Flora of Greenland (Böcher et al. 1978): *Carex membranacea* Hook., *Carex miliaris* Michx., *Carex rhomalea* (Fernald) Mack., *Equisetum hyemale* L., *Festuca edlundiae* Aiken, Consaul and Lefkovich, *Festuca groenlandica* (Schol.) Frederiksen, *Festuca saximontana* Rydb., *Galium verum* L., *Geum rossii* (R. Br.) Ser., *Papaver cornwallisense* D. Löve, *Papaver dahlianum* Nordh., *Papaver labradoricum* (Fedde) Solstad and Elven, *Papaver lapponicum* (Tolm.) Nordh., *Pedicularis sudetica* Willd. ssp. *albolabiata* Hult., *Poa flexuosa* Sm., *Puccinellia bruggemanni* Th. Sør., *Ranunculus subrigidus* W.B. Drew., *Silene vulgaris* (Moench) Garcke, *Trientalis europaea* L. and *Veronica officinalis* L. In addition one subspecies *Phippsia algida* (Sol.) R. Br. ssp. *algidiformis* (H. Sm.) Löve and Löve is a new taxon to the flora of Greenland. The viviparous form of *Poa hartzii* f. *prolifera* has been reported for the first time in Greenland. The total number of vascular plant species for Greenland is 532. The results are presented in Table 1.

Of the 532 species in Greenland 89 species (17%) are recorded north of their known northern distribution limit, and 28 species (5%) are recorded south of their known southern limit. Twelve species are new to East Greenland and three are new to West Greenland. The new phytogeographical records are summarized in Table 1 and the floristic provinces are shown in Figure 1.

Figure 1. The floristic provinces of Greenland (Böcher et al. 1978).

Table 1. New phytogeographical records of vascular plant by the Greenland Botanical Survey and others during 1979–2019. For each species the floristic province, locality, phytogeographical record and the publication or the collector are provided.

Taxon	Floristic province and locality	Phytogeographical records	Reference; Publication/ Collector
Alchemilla glomerulans Bus.	East Greenland: Bjørneøer	New north limit: 71°10'N	I. Smart leg. 1980
Antennaria angustata Greene	West Greenland: Isua	New south limit: 65°12'N	Bay and Simonsen 2013
Antennaria canescens (Lge.) Malte	West Greenland: Melville Bugt. East Greenland: Grandjean Fjord	New north limit in West: 75°25'N; New north limit in East Greenland 75°00'N	Bay 1992 Halliday 2019a
Antennaria porsildii E. Ekmann	East Greenland: Kuhn Ø	New north limit 74°44'N	G. Halliday leg. 1990
Arabis arenicola (Richards) Gel.	East Greenland: Lindemann Fjord	New north limit: 74°38'N	G. Halliday leg. 1980
Arctostaphylos alpina (L.) Spreng.	East Greenland: Kuhn Ø	New north limit: 75°N	R. Corner and G. Halliday leg. 1990
Arnica angustifolia M. Vahl	North Greenland: Frigg Fjord	New north limit: 83°04'N	Bay 1992
Arenaria humifusa Wahlenb.	East Greenland	New north limit: 75°52'N New south limit: 70°20'N	Halliday 2019a
Arctagrostis latifolia (R.Br.) Griseb.	East Greenland: Hjørnedal	New south limit: 70°19'N	Halliday 2019a
Bartsia alpina L.	East Greenland: Kap Beaupré	New north limit: 68°54'N	Gilg et al. 2005
Betula nana L.	East Greenland: Adolf Jensen Land	New north limit: 76°16'N	Halliday 2019a
Botrychium lunaria (L.) Swe.	East Greenland: Gaus Halvø	New north limit: 73°18'N	O. Gilg leg. 2005
Braya thorild-wulffii Ostf.	West Greenland: Disko	New south limit: 69°54'N	Fredskild 1996
Calamagrostis lapponica (Wbg.) Hartm. var. *groenlandica* Lge.	West Greenland	New south limit: 66°13'N	Bay and Simonsen 2009
Calamagrostis neglecta (Ehrh.) Gaertm., Mey. & Scherb.	East Greenland: Kuhn Ø	New north limit: 74°44'N	R. Corner and G. Halliday leg. 1990
Calamagrostis purpurascens R. Br.	East Greenland: Skjoldungen district	New south limit: 63°21'N	C. Bay leg. 1992
Campanula gieseckiana Vest in R. and S.	East Greenland: Dove Bugt	New north limit: 76°16'N	D. Shaw leg. 2006
Cardamine pratensis L.	North Greenland: Nansen Land	New north limit: 82°58'N	Bay 1992
Carex atrofusca Schkuhr.	North Greenland: Nansen Land	New to North Greenland: 82°58'N	Bay 1992
Carex chordorrhiza Ehrh.	East Greenland: Jameson Land and Tyrolerfjord	New to East Greenland: 71°10'N and 74°30'N	A. Elvebakk leg. 1993, Bay 2015
Carex glacialis Mack.	North Greenland: Wulff Land	New north limit: 82°10'N	Bay 1992
Carex glareosa Wahlenberg	East Greenland: Kuhn Ø	New north limit: 75°01'N	G. Halliday leg. 1990
Carex holostoma Drej.	West Greenland	New south limit: 65°32'N	C. Bay leg. 2009
Carex lachenalii Schkuhr.	West Greenland: Etah. East Greenland: Langesø	New north limit in West Greenland: 78°20'N and in East Greenland: 75°49'N	Bay 1992, Halliday 2019a
Carex macloviana D´Urv	Northeast Greenland: Adolf Jensen Land	New north limit: 74°38'N	R. Corner leg. 2002

Taxon	Floristic province and locality	Phytogeographical records	Reference; Publication/ Collector
Carex marina Dew. ssp. *pseudolagopina* (Th. Sør.) Böch.	North Greenland: Nansen Land	New to North Greenland 82°58'N New north limit: 83°16'N	Bay 1991, F. Schwartzenbach leg. 1996
Carex membranacea Hook.	West Greenland: Inglefield Land and Fortune Bay	New to Greenland	R. Elven pers. com.
Carex microglochin Wbg.	West Greenland: Uvkusigssat Fj., East Greenland: Grandjean Fjord	New north limit in West Greenland: 72°15'N and in East Greenland: 74°57'N	Fredskild 1996, J. Hoodson and C. Wells leg. 1990
Carex misandra R. Br.	West Greenland: Isua	New south limit: 65°12'N	Bay and Simonsen 2013
Carex miliaris Michx.	West Greenland	New to Greenland	Myhre Pedersen pers. com.
Carex norvegica Retz.	East Greenland: Femdalen	New north limit: 75°18'N	Bay 1992
Carex parallela (Læst.) Sommerf.	East Greenland: Adolf S. Jensen Land	New north limit: 76°16'N	R. Corner leg. 2006
Carex rhomalea (Fernald) Mack.	West and East Greenland	New to Greenland	Myhre Pedersen pers. com.
Carex rupestris	North Greenland: Nansen Land	New north limit: 82°58'N	Bay 1992
Carex rostrata Stokes	East Greenland: Skjoldungen	New to East Greenland: 63°21'N	C. Bay 1992 leg.
Carex scirpoidea Michx.	East Greenland: Kuhn Ø	New north limit: 74°46'N	R. Corner and Halliday leg. 1990.
Carex supina Wbg. ssp. *spaniocarpa* (Steud.) Hult.	West Greenland: Siorapaluk	New north limit: 77°48'N	Bay 1992
Cerastium cerastoides (L.) Britton	East Greenland: Lindemann Fjord	New north limit: 74°38'N	Bay 1992
Comarum palustre L.	West Greenland:	New north limit: 68°40'N	Fredskild 1996
Deschampsia pumila Ostenf.	East Greenland: Norske Øer	New north limit: 79°03'N	Bay 1992
Deschampsia alpina (L.) R. and S.	West Greenland	New north limit: 68°37'N	Fredskild 1996
Diapensia lapponica L. ssp. *lapponica*	West Greenland: Qaanaaq	New north limit: 77°28'N	Bay 1992
Diphasiastrum complanatum (L.) Holub	East Greenland: Milne Land	New to East Greenland 70°35'N	C. Bay leg. 2014
Draba adamsii Led.	West Greenland Nugssuaq	New south limit: 70°17'N	Fredskild 1996
Draba arctica J. Vahl	East Greenland: Sortekappasset	New south limit: 68°31'N	Halliday 2019b
Draba cana Rydb.	South Greenland: Kvanefjeld	New south limit: 61°00'N	C. Simonsen 2014
Draba crassifolia Graham	East Greenland: Kuhn Ø	New north limit: 74°46'N	Halliday 2019a
Draba fladnizensis Wulf.	East Greenland: Skjoldungen	New south limit: 63°28'N	C. Bay leg. 1992
Draba subcapitata Simm.	Tasiilaq dist.	New south limit: 66°55'N	Halliday 2019b
Dryas octopetala L. ssp. *punctata* (Juz.) Hult.	East Greenland: Amdrup Land	New to North Greenland: 80°49'N	Bay and Fredskild 1994
Dryopteris assimilis Walker	East Greenland: Fridtjof Nansens Halvø	New to East Greenland: 64°20'N	K. Gormsen leg. 1968
Dryopteris filix-mas (L.) Schott	East Greenland: Skjoldungen	New to East Greenland: 63°21'N	C. Bay 1992 leg.
Dupontia fisheri R. Br.	East Greenland: Wollaston Forland	New to East Greenland: 74°29′-74°37'N	Fredskild and Bay 1993
Dupontia psilosantha Rupr.	East Greenland: Hochstetter Forland	New north limit: 75°28'N	Bay 1992

Taxon	Floristic province and locality	Phytogeographical records	Reference; Publication/ Collector
Elymus hyperarcticus (Polunin) Tzvel.	East Greenland: Jameson Land	New south limit: 70°44'N	Fredskild and Bay 1984
Empetrum nigrum L. ssp. *hermaphroditum* (Hagerup) Böch.	North Greenland: Mylius Erichsen Land	New north limit and new to North Greenland: 80°20'N	F. Daniëls leg. 1995
Epilobium anagallidifolium Lam.	West Greenland: Hareøen East Greenland: Allday dal	New north limit in West Greenland: 70°23'N New north limit in East Greenland 71°44'N	Fredskild 1996 S. Holt leg. 1983
Epilobium arcticum Sam.	North Greenland: Frigg Fjord	New north limit: 83°15'N	F. Schwartzenbach leg. 1996
Equisetum hyemale L.	East Greenland: Tasiilaq	New to Greenland: 65°53'N	Daniëls and Van Herk 1984
Erigeron humilis Graham	East Greenland: Godfred Hansen Ø	New north limit: 76°23'N	Bay 1992
Eriophorum angustifolium Honck. ssp. *subarcticum* (V. Vassil.) Hult.	West Greenland: Thule district	New north limit: 77°28'N	Bay 1992
Eriophorum callitrix Cham.	West and North Greenland: Qaanaaq and Nansen Land	New to West Greenland at 77°28'N and new north limit in North Greenland: 82°58'N	C. Bay 1988, leg. 1989
Eutrema edwardsii R. Br.	East Greenland: Sødal	New south limit: 70°42'N	R. Corner leg. 1986
Festuca baffinensis Polunin	East Greenland: Kangerlussuaq	New south limit: 68°49'N	Halliday 2019b
Festuca edlundiae S. Aiken, Consaul and Lefkovich	East Greenland: Hold with Hope	New to Greenland: 73°28'N	Aiken, Consaul and Lefkovich 1995
Festuca groenlandica (Schol.) Frederiksen	Low Arctic Greenland	New to Greenland	Frederiksen 1982
Festuca saximontana Rydb.	Low Arctic West Greenland	New to Greenland	Fredskild 1996
Galium verum L.	East Greenland: Tasiilaq	New to Greenland	Gartmann 1990
Gentiana detonsa Rottb.	East Greenland: Tyrolerfjord; Renland	New north limit: 74°30'N New south limit: 70°26'N	R. and S. David leg. 1992; G. Halliday 1971
Gentiana nivalis L.	East Greenland: Geographical Society Ø	New north limit: 72°52'N	D. Shaw leg. 2005
Geum rossii (R. Br.) Ser.	East Greenland: Lambert Land	New to Greenland: 79°10'N	Bay 1992
Gymnocarpium dryopteris (L.) Newman	East Greenland: Liverpool Ld.	New north limit: 71°08'N	B. Fredskild leg. 1985
Harrimanella hypnoides (L.) Coville	East Greenland: Kuhn Ø	New north limit: 74°42'N	Halliday 2019a
Isoëtes echinospora Dur. ssp. *muricata* (Dur.) Löve and Löve	East Greenland: Skjoldungen	New to East Greenland: 63°21'N	C. Bay leg. 1992
Juncus alpinus Vill. ssp. *nodulosus* (Wbg.) Lindm.	West Greenland	New north limit: 69°35'N	Fredskild 1996
Juncus arcticus Willd.	East Greenland: Nørlund Land	New north limit: 75°51'N	G. Halliday leg. 1980
Juncus castaneus Sm.	North Greenland: Nansen Land	New north limit: 82°58'N	Bay 1992
Juncus filiformis L.	East Greenland: Skjoldungen	New to East Greenland: 63°21'N	C. Bay leg. 1992
Juncus ranarius Perr. and Song.	East Greenland: Liverpool Ld.	New north limit: 71°08'N	B. Fredskild leg. 1985

Taxon	Floristic province and locality	Phytogeographical records	Reference; Publication/ Collector
Juncus trifidus L.	West and East Greenland	New north limits in West: 72°40'N and in East: 74°44'N	Fredskild 1996 Bay 1992
Kobresia simpliciuscula (Wbg.) Mack.	North Greenland: Warming Land	New to western North Greenland	Bay 1992
X Ledodendron vanhoeffeni (Abromeit) Dalgaard and Fredskild	West Greenland: Paradisdalen	New south limit: 66°30'N	Fredskild 1996
Ledum groenlandicum Oed.	West Greenland: Egedesminde	New north limit: 68°42'N	Fredskild 1996
Ledum palustre L. ssp. *decumbens* (Ait.) Hult.	West Greenland: Mac Cormick Fjord	New north limit: 77°44'N	Bay 1992
Loiseleuria procumbens (L.) Desv.	East Greenland: Jameson Land	New north limit: 70°44'N	C. Bay leg. 1983
Luzula arctica Blytt	West Greenland: Isua	New south limit: 65°12'N	Bay and Simonsen 2013
Luzula multiflora (*Retz.*) Lej.	East Greenland: Geographical Society Ø	New north limit: 72°42'N	D. Shaw leg. 2005
Luzula parviflora (Ehrh.) Desv.	East Greenland: Skjoldungen	New to East Greenland: 63°21'N	C. Bay leg. 1992
Luzula spicata (L.) DC	East Greenland: Godfred Hansen Ø	New north limit: 76°23'N	Bay 1992
Luzula wahlenbergii Rupr.	East Greenland: Dove Bugt	New north limit: 76°17'N	R. Corner and D. Shaw leg. 2006
Melandrium affine J Vahl coll.	East Greenland: Mt. Forel	New south limit: 66°46'N	Halliday 2019b
Menyanthes trifoliata L.	East Greenland: Jameson Land	New to East Greenland: 71°17'N	B. Fredskild and C. Bay leg. 1982
Mertensia maritima (L.) S. F. Gray	East Greenland: Zackenberg	New north limit in East Greenland: 74°28'N	C. Bay leg. 2005
Minuartia biflora (L.) Sch. and Th.	West and East Greenland	New north limits in West Greenland: 77°48'N and in East Greenland: 79°08'N	Bay 1992
Minuartia groenlandica (Retz.) Ostf.	West Greenland: Kitdlerngata	New north limit: 68°32'N	Fredskild 1996
Minuartia stricta (Sw.) Hiern	West and East Greenland	New north limits in West Greenland: 76°31'N and new south and north limit in East Greenland: 66°35'N and 77° 30'N, resp.	Bay 1992 Halliday 2019b
Montia fontana L.	East Greenland, Forsblads Fjord	New north limit in East Greenland: 72°25'N	R. and S. David leg. 1993
Papaver cornwallisense D. Löve	North and East Greenland	New to Greenland	H. Solstad pers. com.
Papaver dahlianum Nordh.	West, North and East Greenland	New to Greenland	H. Solstad pers. com.
Papaver labradoricum (Fedde) Solstad and Elven	West and East Greenland	New to Greenland	H. Solstad pers. com.
Papaver lapponicum (Tolm.) Nordh.	West Greenland	New to Greenland	H. Solstad pers. com.
Pedicularis capitata Adams	West Greenland	New south limit: 77°42'N	Bay 1992
Pedicularis flammea L.	West Greenland: Qaanaaq	New north limit: 77°28'N	F. Rune leg. 2017
Pedicularis lapponica L.	East Greenland: Bessel Fjord	New north limit: 75°58'N	G. Halliday leg. 1980

Taxon	Floristic province and locality	Phytogeographical records	Reference; Publication/ Collector
Pedicularis sudetica Willd. ssp. *albolabiata* Hult.	West Greenland: Thule district	New to Greenland: 77°28'N	Bay 1992
Phleum commutatum Gaud.	East Greenland: Jameson Land	New north limit: 70°58'N	Fredskild and Feilberg 1984
Phippsia algida ssp. *algidiformis* (H. Sm.) Löve and Löve	Northern Greenland	New subspecies to Greenland	Bay 1992
Poa abbreviata R.Br.	East Greenland: Kangerlussuaq	New south limit: 68°49'N	Halliday 2019b
Poa alpina L.	East Greenland: Nørlund Land	New north limit: 75°49'N	Halliday 2019b
Poa flexuosa Sm.	West Greenland	New to Greenland	Fredskild 1996
Poa hartzii Gandoger forma *prolifera* (Simm.) Boivin	North Greenland, Easternmost part	New forma to Greenland	Bay 1992
Poa pratensis L. ssp. *colpodea* (Th. Fr.) Tzvelev	East Greenland: Constable Pynt	New south limit: 70°44'N	Fredskild and Feilberg 1983
Potamogeton filiformis Pers.	East Greenland: Droning Louise Land	New north limit: 76°52'N	Bay 1992
Potamogeton praelongus Wulf.	West Greenland: Kangerdlugssuaq	New to West Greenland: 66°N	Bennike and Anderson 1998
Potamogeton pusillus L. ssp. *groenlandicus* (Hagstr.) Böch.	East Greenland: Skjoldungen	New to East Greenland: 63°21'N	C. Bay leg. 1992
Potentilla stipularis L.	East Greenland: Kuhn Ø	New north limit: 74°47'N	Bay 1992
Primula stricta Hornem.	East Greenland: Kuhn Ø	New north limit: 74°44'N	G. Halliday leg. 1990
Puccinellia bruggemanni Th. Sør.	North Greenland	New to Greenland	Bay 1992
Puccinellia vaginata (Lange) Fernald and Weath.	East Greenland: Bessel Fjord	New north limit: 75°58'N	G. Halliday leg. 1980
Pyrola grandiflora Rad.	East Greenland: Lindeman Fjord	New north limit: 74°40'N	K. Cartwright leg. 2002
Pyrola minor L.	West Greenland East Greenland: Milne Land	New north limit in West Greenland: 70°44'N New north limit in East Greenland: 70°44'N	Fredskild 1996 Corner leg. 1986
Ranunculus auricomus L. coll.	East Greenland: Clavering Ø	New north limit: 74°19'N	Halliday 2019a
Ranunculus glacialis L.	East Greenland: Nørre Mellemland	New north limit: 78°33'N	Bay 1992
Ranunculus nivalis L.	North Greenland: Peary Land	New north limit and new to North Greenland: 82°30'N	Bay 1992
Ranunculus pygmaeus Wbg.	East Greenland: Lambert Land	New north limit: 78°08'N	Bay 1992
Ranunculus sabinei R. Br.	East Greenland	New south limit: 74°51'N	Andersson leg. 1988
Ranunculus subrigidus W.B. Drew.	West and North Greenland	New to Greenland	R. Elven pers. com.
Rumex acetosella	East Greenland: Bessel Fjord	New north limit: 75°59'N	Halliday 2019a
Sagina caespitosa (J. Vahl) Lge.	West Greenland: Thule district; East Greenland: Kangerlussuaq	New north limit in West Greenland: 77°28'N New south limit in East Greenland: 68°09'N	Bay 1992 Kristine Westergaard leg. 2019
Sagina procumbens L.	East Greenland: Nørrefjord	New north limit in East Greenland: 71°08'N	B. Fredskild leg. 1985
Sagina saginoides (L.) Karst.	East Greenland: Jameson Land	New north limit: 70°47'N	R. Corner leg. 1986
Salix glauca L. coll.	West Greenland: Tugtuligssuaq	New north limit: 75°25'N	Bay 1992

Taxon	Floristic province and locality	Phytogeographical records	Reference; Publication/ Collector
Saxifraga aizoides L.	North Greenland: Campanula Dal	New north limit: 81°13'N	Bay 1992
Saxifraga foliolosa R. Br.	West Greenland: Narsaq East Greenland: Tasiilaq	New south limit in West Greenland: 61°N East Greenland: 65°35'N	Simonsen 2014; L. de Bonneval
Saxifraga hieracifolia W. and K.	West Greenland: Inglefield Land	New to West Greenland: 78°35'N	J. Feilberg leg. 1999
Saxifraga hirculus L.	East Greenland: Søndre Mellemland	New north limit: 78°05'N	Bay 1992
Sibbaldia procumbens L.	East Greenland: Kuhn Ø	New north limit: 74°44'N	Bay 1992
Silene vulgaris (Moench) Garcke	East Greenland: Tasiilaq	New to Greenland	Gartmann 1990
Taraxacum brachyceras Dahlst.	East Greenland: Kuhn Ø	New north limit: 74°44'N	G. Halliday leg.1990
Taraxacum pumilum Dahlst.	East Greenland: Shannon	New south limit: 75°11'N	Bay 1992
Tofieldia coccinea Richards.	North Greenland: Mylius Erichsen Land	New to North Greenland: 80°30'N	F. Daniëls leg. 1995
Tofieldia pusilla (Mixch) Pers.	East Greenland: Bessel Fjord	New north limit: 75°58'N	G. Halliday leg. 1980
Trientalis europaea L.	South Greenland	New to Greenland: 60°58'N	Bay 1993
Triglochin palustris L.	East Greenland: Tyroler Fjord	New north limit: 74°29'N	C. Bay leg. 2015
Tripleurospermum maritima (L.) W.D.J. Koch	East Greenland	New north and south limits: Revet (74°22'N); Sydkap (71°18'N).	Fredskild leg. 1991; Halliday 2019a
Utricularia minor L.	East Greenland: Jameson Land	New north limit: 71°33'N; New south limit: 71°06'N	R. Corner leg.; Bay and Fredskild 1982
Vaccinium myrtillus L.	East Greenland: Skjoldungen	New to East Greenland: 63°12'N	C. Bay leg. 1992
Veronica officinalis L.	East Greenland: Tasiilaq	New to Greenland	Gartmann 1990
Woodsia alpina (Bolt.) S. F. Grey	West Greenland: Melville Bugt East Greenland: Lyell Land	New north limit in West Greenland: 75°25'N; New north limit in East Greenland limit: 72°40'N	Bay 1992 R. and S. David leg. 1993
Woodsia ilvensis (L.) R. Br.	East Greenland: Hold With Hope	New north limit: 73°33'N	Hartz leg. 1891

Discussion

Generally, the findings of species new to Greenland and extensions of the distribution areas are mostly due to the fact that botanical explorations have taken place in remote areas supported by helicopter and aircrafts, which hitherto had only been accessible by boat. Many inland areas both in West and East Greenland have been investigated in recent decades. The extension of the distribution limits is not considered a result of climate change but rather a result of the intensification of the botanical exploration of remote areas. The fruits or spores of new species have either been brought to Greenland by migrating geese (i.e. *Geum rossii*) or introduced by man (i.e. *Galium verum*, *Silene vulgaris*, *Veronica officinalis*). Table 1 summarize the new phytogeographical data and the most notable finds are annotated.

Annotated list of new vascular plant records for Greenland New species to the flora of Greenland since 1978

Carex membranacea Hook., *Carex miliaris* Michx, *Carex rhomalea* (Fernald) Mack.

During the revision of the *Carex saxatilis* complex a new species to Greenland, *Carex membranacea* Hooker, was found in Inglefield Land, Northwest Greenland, and in Fortune Bay in central West Greenland. Furthermore the complex was divided into three taxa by R. Elven: *Carex saxatilis* s.str., *Carex rhomalea* (Fernald) Mack., and *Carex miliaris* Michx. of which *Carex rhomalea* (Fernald) Mack., and *Carex miliaris* Michx. are new to the flora of Greenland.

Equisetum hyemale L.

The boreal species *Equisetum hyemale* was found in Tasiilaq district, Southeast Greenland (65°53'N) by Daniels and Van Herk (1984). The species is indigenous in Greenland and has probably immigrated to the east coast from Iceland by means of airborn spores.

Festuca edlundiae S. Aiken, Consaul and Lefkovich

Only one specimen of this recently described species is available in C. The collection is from Hold with Hope (73°28'N) in Northeast Greenland. Aiken et al. (2007) indicate that the species is found both in West and East Greenland. These specimens has not been included in the present study.

Festuca groenlandica (Schol.) Frederiksen

In Böcher et al. (1978) *Festuca groenlandica* is included as the var. *groenlandica* of *Festuca brachyphylla*. This taxon has been accepted at species level by Frederiksen (1982).
Festuca saximontana Rydb.

Frederiksen (1982) published the find of this species as a new to Greenland and Fredskild (1996) mapped the distribution in Greenland between 64° and 70°N on the west coast.

Galium verum L.

This boreal species has been found once in Tasiilaq in Southeast Greenland (Gartmann 1990).

Geum rossii R. Br.

This species was found in Lambert Land (79°10'N) during the botanical mapping project in Northeast Greenland (Bay 1992). Only one individual of this Arctic-Alpine species was found in an open fell field vegetation

Papaver radicatum complex

Hitherto, the Greenlandic material of *Papaver* has been referred to *P. radicatum* Rotth. coll. but in the flora (Böcher et al. 1978) a few subspecies are mentioned. However, a taxonomical revision by Solstad and Elven concluded that the *Papaver radicatum* complex consist of four occurring in Greenland: *Papaver cornwallisense* D. Löve, *P. dahlianum* Nordh., *P. labradoricum* (Fedde) Solstad and Elven and *P. lapponicum* (Tolm.) Nordh. Consequently, *P. radicatum* Rotth. is excluded from the flora.

All four species occur in East Greenland although *P. cornwallisense* was only found once in the Scoresbysund area, whereas the other species are widespread (Solstad pers. com.). *Pedicularis sudetica* Willd. ssp. *albolabiata* Hult.

The first record of this species new to Greenland was collected in the vicinity of Qaanaaq (77°28'N) in northwest Greenland in 1975, but it was first correctly identified in 1985 as *Pedicularia sudetica* ssp. *albolabiata* by Halliday and Lang (1986). The species is only known from five localities in Thule district, Northwest Greenland (Bay 1992).

Poa flexuosa Sm.

This species was recognized and accepted as occurring in Greenland by Gjærevoll and Ryvarden (1977). Its present distribution in Greenland is from Ingitait Fjord (61°09'N) in Southeast Greenland to Ikorfat (70°45'N) in West Greenland. Nearly all collections in C and AAU are found at an altitude of 450–1400 m a.s.l. (Fredskild 1996).

Puccinellia bruggemanni Th. Sør.

In connection with the phytogeographical study of North Greenland (Bay 1992), the revision of the *Puccinellia angustata* material revealed 15 collections of a species new to Greenland: *Puccinellia bruggemanni* Th. Sør. The species was considered as endemic to the Canadian Arctic Archipelago (Aiken et al. 2007), now also including high arctic Greenland (Bay 1992).

Ranunculus subrigidus W.B. Drew.

R. Elven found this *Ranunculus* species new to the flora of Greenland among specimens from Northwest and North Greenland during a revision of *Ranunculus confervoides* Fr. specimens in C. *Silene vulgaris* (Moench) Garcke

This boreal amphi-atlantic species has been found once in Tasiilaq (66°N) in Southeast Greenland (Gartmann 1990).

Trientalis europaea L.

New to Greenland, found for the first time in 1992 in South Greenland (60°58'N) (Gartmann 1990). This boreal-alpine species is distributed mainly in Europe with its northern outpost in subarctic South Greenland and Iceland.

Veronica officinalis L.

This amphi-atlantic species has been found once in Tasiilaq in Southeast Greenland (66°N) (Gartmann 1990).

New subspecies to the flora of Greenland

The subspecies *Phippsia algida* ssp. *algidiformis* (H. Sm.) Löve and Löve was found during the phytogeographical work in North Greenland (Bay 1992). It is distributed in high arctic Greenland from Scoresbysund (70°N) in East Greenland through North Greenland to the Thule district in Northwest Greenland (Bay 1992).

New forma to the flora of Greenland

The viviparous form of *Poa hartzii* Gandoger forma *prolifera* (Simm.) Boivin has been found three times in Greenland. The localities are close to each other in the eastern-most part of North Greenland. Two collections are from Kap København (82°23–24'N) in Peary Land and one from Prinsesse Margrethe Ø southeast of Peary Land. The form is described from material collected at Ellesmere Island and the only other collection outside

Greenland is from a small island near Devon Island (Scoggan 1978–1979). The distribution of *Poa hartzii* s.l. is Amphi-Atlantic high arctic.

Species new to West Greenland

Eriophorum callitrix Cham.

First record is from Qaanaaq (77°28'N) in West Greenland collected by C. Bay in 1988.

Potamogeton praelongus Wulf.

First record in West Greenland at Kangerdlugssuak (66°32'N) by Bennike and Anderson (1998). The species is otherwise only known from Rypefjord (71°02) in central East Greenland.

Saxifraga hieracifolia W. and K.

This species was found in Inglefield Land (78°35'N) by F. Feilberg in 1999.

Species new to East Greenland

Carex chordorrhiza Ehrh.

Until 1993 the species was only known from a few localities in southernmost Greenland (Feilberg 1984). A. Elvebakk found the species in Jameson Land (71°10'N) on the east coast in 1993 and C. Bay found the species further to the north at Tyroler Fjord (74°28'N) in 2015 – an extension of the distribution area of c. 350 kilometers. Fruits from the species are presumably transported to East Greenland by migrating geese from Iceland.

Carex rostrata Stokes

This species was found at one locality in Skjoldungen district (63°21'N) by C. Bay. It is the first record of *Carex rostrata* in East Greenland (Fredskild and Bay 1993).

Diphasiastrum complanatum (L.) Holub.

During fieldwork in 2014 C. Bay found one specimen of the species at Mudderbugten, Milne Land (70°35'N) in central East Greenland.

Dryopteris assimilis Walker

This species was collected at Fridtjof Nansens Halvø (64°20'N) by K. Gormsen in 1968. *Dryopteris filix-mas* (L.) Schott

This boreal species was found at three sites in Skjoldungen district (63°13'–21'N) during Greenland Botanical Surveys fieldwork in Southeast Greenland in 1992.

Dupontia fisheri R. Br.

The species was collected by B. Fredskild at Zackenberg (74°28'N) for the first time in East Greenland in 1992.

Isoëtes echinospora Dur. ssp. *muricata* (Dur.) Löve and Löve

The species was found by C. Bay at one locality (63°21'N) in Skjoldungen district.

Juncus filiformis L.

The species was found at three localities in Skjoldungen district between 63°16' and 63°21'N by Bay in 1992.

Luzula parviflora (Ehrh.) Desv.

The species was found at two localities in Skjoldungen district by C. Bay. The northernmost at 63°16'N

Menyanthes trifoliata L.

This species has been found for the first time on the west coast of Jameson Land (71°17'N) during the biological fieldwork prior to an oil exploration (Fredskild, Bay and Holt 1982). Totally, it was found in three lakes.

Potamogeton pusillus ssp. *groenlandicus* (Hagstr.) Böch.

This species was recorded once in Skjoldungen district (63°21'N) by C. Bay in 1992.

Vaccinium myrtillus L.

This species was found at Kap Niels Juel (63°12'N) by C. Bay and it is only the second record in Greenland. Hitherto it had only been found on the island Alangorssuaq in South Greenland.

Species new to North Greenland

Cardamine pratensis L.

During fieldwork in eastern Peary Land (82°30'N) in 1987 and in Nansen Land (82°58'N) in 1991 collected the first records of the species in North Greenland (Bay 1992).

Carex atrofusca Schkuhr.

Finds by C. Bay in 1985 and 1991 in central North Greenland are the first records from North Greenland (Bay 1992). The species has a disjunct distribution in Greenland: In West Greenland it is recorded between Disko (69°16' N and 71°30'N), in Northwest Greenland between Dundas (76°34'N) and Siorapaluk (77°48'N), plus the isolated records from Warming Land and Brainard Sund in North Greenland. In East Greenland it is distributed between Jameson Land (70°38' N) and Lambert Land (79°10' N).

Carex glacialis Mack.

The species was collected at 82°10'N in Wulff Land in 1985 by C. Bay.

Carex marina Dew. ssp. *pseudolagopina* (Th. Sør.) Böch.

Found at Brainard Sund (82°58'N) in Nansen Land which is the first record from North Greenland (Bay 1992). The only other find from North Greenland is from Mylius Erichsen Land (80°20'N) collected by Daniëls in 1995.

Dryas octopetala L. ssp. *punctata* (Juz.) Hult.

This species was collected in Amdrup Land (80°49'N) during the NEWland project in 1993 by C. Bay and B. Fredskild.

Eriophorum callitrix Cham.

C. Bay collected the species in Qaanaaq (77°28'N) in 1988 and in Nansen Land (82°58'N) in central North Greenland in 1991, which are the first records from West Greenland and a new north distribution limit in North Greenland.

Empetrum nigrum L. ssp. *hermaphroditum*

Empetrum was not known from North Greenland until F. Daniëls visited Mylius Erichsen Land (80°20'N) in 1995 and found a small population at Amdrup Højland. This is the first find in North Greenland, the previous northernmost record was Danmarkshavn (76°46'N) c. 500 km to the south.

Ranunculus nivalis L.

Collected by C. Bay at Kap København in eastern Peary Land (82°30'N), which is the first record from the flora province North Greenland (Bay 1992).

Tofieldia coccinea Richards.

F. Daniëls extended the known northern distribution limit in 1995 by finding the species for the first time in North Greenland at Mylius Erichsen Land at 80°30'N

North range extensions in West Greenland

Antennaria canescens (Lge. Malte)

Found in 1979 at Tugtuligssuaq, Melville Bugt (75°20'N) in northwest Greenland (Fredskild et al. 1979), which is an extension of 300 kilometers from Prøven (72°22'N) and in East Greenland the north range was extended to Kuhn Ø (75°38'N) by G. Halliday.

Carex glacialis Mack.

The flora states that it is recorded northward to 73°25'N in West Greenland and has an isolated record at Dundas (76°34'N). It is in addition recorded at six localities in North Greenland, the northern record at 82°10'N in Wulff Land.

Carex lachenalii Schkuhr.

According to Böcher et al. (1978) Upernavik (72°48'N) is the northernmost record in West Greenland. However the species is collected at four localities north of Upernavik: Tugtuligssuaq (75°25'N), Dunads (76°34'N), Qeqertat (77°30'N) and Etah, Inglefield Land; the new northern distribution limit at (78°18'N).

Carex microglochin Wbg.

The species was found at Svartenhuk (72°15'N) (Fredskild 1996).

Carex supina Wbg. ssp. *spaniocarpa*

Böcher et al. (1978) mentions Upernavik (72°47'N) as the northern limit, but it has been recorded four times northwards to Siorapaluk (77°48'N) (Bay 1992).

Comarum palustris L.

New north limit in Sydostbugten in West Greenland (68°40'N) (Fredskild 1996).

Deschampsia alpina (L.) R. and S.

New north limit in Sydostbugten in West Greenland at 68°37'N (Fredskild 1996).

Diapensia lapponica L. ssp. *lapponica*

North range extension from Upernavik (72°47'N) to Tugtuligssuaq (75°25'N) in 1979 (Fredskild et al. 1979) and further c. 200 kilometers to Qaanaaq (77°28'N) in 1988 (Bay 1992).

Eriophorum angustifolium Honk. ssp. *subarcticum* (V. Vassil.) Hult.

During GBS´ work in Northwest Greenland in 1979–1988 the species was found in several localities and the northern distribution limit was extended from 74°22'N to Qaanaaq (77°28'N).

Eriophorum callitrix Cham.

New to West and North Greenland (Bay 1992). It has isolated occurrences in Thule district and Nansen Land collected by C. Bay in 1988 and 1991, respectively.

Juncus trifidus L.

New north limits in West Greenland at 72°40'N (Fredskild 1996).

Ledum palustre L. ssp. *decumbens* (Ait.) Hult.

The species was known from West Greenland between 62°54'N and 72°51'N before it was found at McCormic Ford in Thule district (77°41'N), which extended the northern distribution limit by c. 500 km.

Pedicularis flammea L.

Bay found it during fieldwork at Moriusaq (76°45'N), West Greenland in 1988 (Bay 1992) and Rune (pers. com.) found it further to the north at Qaanaaq 77°28'N in 2017.

Pyrola minor L.

New northern distribution limit at Disko island (70°44'N) in West Greenland.

Puccinellia vaginata (Lange) Fernald and Weath.

New north limit at 75°58'N in West Greenland (Fredskild et al. 1982).

Sagina caespitosa (J. Vahl) Lge.

North range extension in West Greenland from Upernavik (72°47'N) to Tugtuligssuaq (75°25'N) in 1979 and further to Qaanaaq (77°28'N) in 1988 (Bay 1992).

Salix glauca L. coll.

Found in 1979 at Tugtuligssuaq, Melville Bugt (75°25'N) (Fredskild et al. 1979). Previous northernmost record was at 74°30'N.

Woodsia alpina (Bolt.) S. F. Grey.

This species was found at Tugtuligssuaq (75°25'N) in 1979, which is a new north limit for West Greenland (Bay 1992).

North range extensions in East Greenland

Arabis arenicola (Richards) Gel.

Found further to the north at 74°38'N at Lindeman Fjord by G. Halliday in 1980, an extension of c. 200 kilometers to the north (Halliday 2019b).

Botrychium lunaria (L.) Swe.

O. Gilg collected this species in 2005 on Gaus Halvø (73°18'N), which is a new north limit in East Greenland (Gilg 2005). Halliday (2019a) mentions Shaws collection in 2007 from Ella Ø as the northernmost locality in East Greenland (72°47'N).

Carex macloviana D´Urv.

Recorded at Adolf S. Jensen Land (75°25'N) in East Greenland by Corner in 2008 as new north limit. The species was hitherto only known from one locality north of Mestersvig (72°14'N) in East Greenland at Myggbukta (73°31'N) collected by Corner in 2001.

Carex norvegica Retz.

New north limit in East Greenland at Femdalen, Ostenfeldts Land (75°18'N).

Carex parallela (Læst.) Sommerf.

Corner collected the species at Adolf S. Jensen Land (76°16'N) in 2006, c 100 kilometers north of the known northern distribution limit.

Carex scirpoidea Michx.

The species was found at Kuhn Ø (74°46'N) in East Greenland by R. Corner and G. Halliday in 1990.

Cerastium cerastoides (L.) Britton

New north limit in East Greenland at Lindemann Fjord (74°38'N) collected by G. Halliday (2019b).

Deschampsia pumila Ostenf.

Found at Norske Øer (79°03'N) during the biological mapping project in 1989–1990, which is a new north limit in East Greenland (Bay 1992).

Draba fladnizensis Wulf.

In 1990 it was found at Lambert Land extending the northern distribution limit to 79°08'N (Bay 1992).

Dryopteris assimilis Walker

New north limit in Skjoldungen district (64°20'N).

Elymus hyperarcticus (PoluN) Tzvel.

During the environmental survey prior to an oil exploration in Jameson 1982–1985 the species was found as far south as (70°44'N), which is a new south distribution limit.

Galium triflorum Michx.

New north limit in East Greenland at 63°28'N (Fredskild et al. 1992).

Gentiana detonsa Rottb.

R. and S. David collected the species at Tyroler Fjord (74°30'N). This is the northernmost collection in Greenland.

Gymnocarpium dryopteris (L.) Newman

Fredskild found *Gymnocarpium dryopteris* at a hot spring in Liverpool Land (71°08'N) in central East Greenland (Fredskild et al. 1987). This is an extension of the northern distribution limit by more than 200 km.

Juncus ranarius Perr. and Song.

The collection from 1985 by Fredskild from Liverpool Land (71°08'N) in central east Greenland is a new northern record. Hitherto the species is not found north 69°22 ´N
Juncus trifidus L.

New north limit in East Greenland at Kuhn Ø (74°44'N) collected by G. Halliday (2019b).

Luzula wahlenbergii Rupr.

The species was only known from Zackenberg (74°28'N) until the intensive botanical investigations took place in East Greenland in 1989–1990 (Fredskild and Bay 1990, 1991). The species was found at another ten localities (74°28'–75°55'N) extending

the northern distribution limit to Bessel Fj. (75°55'N) (Bay 1992). Corner and Shaw found it further to the north at 76°17'N in 2006.

Mertensia maritima (L.) S. F. Gray

The species is mainly distributed in the Disko-Nugssuaq (68°–72°30'N) in West Greenland and known from Thule district on the west coast. It was found at Zackenberg research station (74°28'N) in East Greenland in 2005 and disappeared few years later. It was presumably brought from West Greenland by a researcher who had worked in central West Greenland before appearing in East Greenland. In East Greenland it is only known from Tasiilaq (66°N) and Skjoldungen (63°N) in addition to Zackenberg.

Minuartia biflora (L.) Sch. and Th.

Found at all localities explored in 1979 and 1988 in Northwest Greenland (Fredskild and Bay 1990) and East Greenland in 1989–1990 (Fredskild and Bay 1991, Bay 1992). The known distribution limit is now at 77°48'N in Northwest Greenland and 79°08'N in Northeast Greenland (Bay 1992).

Minuartia stricta (Sw.) Hiern

The distribution is extended both in West and East Greenland. The species is distributed between 66°20'N and Dundas (76°31'N) in West Greenland (Fredskild 1996) and from Tasiilaq district (66°35') (Halliday 2019a) to Skærfjorden (77°35'N) in East Greenland (Bay 1992).

Montia fontana L. ssp. *fontana*

R. and S. David collected *Montia fontana* at Forsblads Fjord (72°25'N) in 1993, 700 kilometers north of the hitherto northernmost record in East Greenland at 66°04'N *Pedicularis flammea* L.

C. Bay collected the species at Nordre Mellemland (80°38'N) in 1990, which is a new northern distribution limit (Bay 1992).

Phleum commutatum Gaud.

New north limit at Jameson Land (70°58'N) recorded by C. Bay in 1983 (Fredskild 1984).

Pyrola minor L.

New northern distribution limit at Milne Land (70°04'N) by C. Bay in 2014.

Poa alpina L.

New north limit at 75°49'N (Halliday 2019b)

Potamogeton filiformis Pers.

Until 1989, when it was found at Droning Louise Land (76°52'N) during the biological mapping of East Greenland, the species was recorded northwards in East Greenland to Clavering Ø (74°20'N).

Potentilla stipularis L.

New north limit at Kuhn Ø (74°47'N) (Bay 1992).

Primula stricta Horn

Found on Kuhn Ø during the British North-east Expedition 1990 (Halliday and Corner 1991); an extension of the north limit of c. 100 kilometers.

Pyrola grandiflora Rad.

New north limit at 74°40'N collected by Cartwright in 2002.

Pyrola minor L.

New northern distribution limit at 70°44'N in Sødal, where the species was found by Corner in 1986.

Ranunculus auricomus L. coll.

New north limit at 74°19'N in East Greenland (Halliday 2019a).

Ranunculus glacialis L.

The species was found at Nørre Mellemland (78°33'N) in Northeast Greenland in 1989, which is a new northern distribution limit (Bay 1992).

Ranunculus pygmaeus Wbg.

New north limit at Lambert Land (78°08'N) collected by C. Bay and Fredskild in 1990 (Bay 1992).

Sagina procumbens L.

Found at a hot spring at Nørrefjord, Liverpool Land (71°08'N) during fieldwork of Greenland Botanical Survey in 1985; hitherto not found north of Knighton Bugt (69°22'N) on the east coast.

Sagina saginoides (L.) Karst.

Found in Jameson Land (70°47'N) by Corner in 1986. Previous northernmost record is at Rømer Fjord (69°43'N).

Saxifraga hirculus L.

It was found during the biological mapping of Northeast Greenland in 1990 at Søndre Mellemland (78°05'N) (Bay 1992).

Sibbaldia procumbens L.

The northern limit was extended by c. 200 kilometers to Kuhn Ø (74°44'N) during the British North-east Expedition in 1990 (Halliday and Corner 1991).

Triglochin palustre L.

C. Bay found this species at Tyroler Fjord (74°30'N) in 2015, which is the northernmost record in East Greenland. *Woodsia alpina* (Bolt.) S. F. Grey.

Halliday (2019a) mentions it from Lyell land (72°40'N), which is a new record for East Greenland.

Woodsia ilvensis (L.) R. Br.

Böcher et al. (1978) states that the species is not recorded north of 71°N in East Greenland. However, a specimen from Hold with Hope (73°33'N) by Hartz from 1891 is the northernmost collection from East Greenland.

North range extensions in North Greenland

Arenaria pseudofrigida (Ostf. and Dahl) Juz.

Found at Brainard Sund, Nansen Land (82°58'N) in North Greenland, which is a new north limit (Bay 1992).

Arnica angustifolia M. Vahl

This species has been found four times in central north Greenland; northernmost find at 83°04'N collected by C. Bay in 1985 (Bay 1992).

Carex glacialis Mack.

The species was collected at 82°10'N in Wulff Land in 1985 by C. Bay.

Carex rupestris All.

New north limit at Brainard Sund (82°58'N) in North Greenland collected by Bay (1992).

Epilobium arcticum Sam.

F. Schwartzenbach collected the species at Frigg Fj. (83°15'N), this is only the third find in the flora province North Greenland. Previously, it has been collected at Centrum Sø (80°10'N).

Juncus castaneus Sm.

New north limit at Brainard Sund, Nansen Land (82°58'N), which is only the sixth record from North Greenland (Bay 1992).

Kobresia simpliciuscula (Wbg.) Mack.

New to western North Greenland. Hitherto only known from four localities in North Greenland (Bay 1992). It was collected at two localities in Warming Land in central North Greenland in 1985 (Aastrup et al. 1986).

Saxifraga aizoides L.

New northern distribution limit at 81°13'N in Mylius Erichsen Land.

South range extensions in West Greenland

Antennaria angustata Greene

The species was found at Isua (65°12'N) in West Greenland by Bay and Simonsen (2013).

Braya thorild-wulffii Ostf.

The species was found on the east coast of Disko Island 69°54'N (Fredskild 1996).

Carex holostoma Drej.

Found by C. Bay during fieldwork in 2009 and 2013 south of the southern distribution limit. The southernmost find is at 65°32'N.

Carex misandra R. Br.

The new south record at Isua in West Greenland (65°12'N) was recorded in 2012 (Bay and Simonsen 2013).

Carex rupestris All.

This northern species has extended the southern distribution limit to 63°59'N in West Greenland.

Draba cana Rydberg

Found at Narsaq (61°N) by Simonsen in 2014. This is an extension of the south distribution limit by 400 kilometers.

X Ledodendron vanhoeffeni (Abromeit) Dalgaard and Fredskild.

The species was only known from one locality in central West Greenland (Böcher et al. 1978), but the knowledge of the distribution has been extended by eight finds in central West Greenland southward to 66°30'N (Dalgaard and Fredskild 1993).

Luzula arctica Blytt

This northern distributed species was found at a new southern distribution limit in West Greenland during fieldwork in the mining area Isua in West Greenland (Bay and Simonsen 2013).

South range extensions in East Greenland

Calamagrostis purpurascens R. Br.

The species was found at six localities during a Greenland Botanical Surveys expedition to Skjoldungen district in 1992. The southernmost record was at 63°21'N and it is an extension of the distribution area of c. 700 km to the south.

Draba fladnizensis Wulf.

The find of *Draba fladnizensis* in Skjoldungen district (63°28'N) was an extension of the species east Greenland distribution to the south; hitherto known from East Greenland between Jameson Land (70°N) and Lambert Land (79°10'N).

Elymus hyperarcticus (PoluN) Tzvel.

The species was collected in Jameson Land (70°44'N) by B. Fredskild and C. Bay in 1982. The hitherto southernmost record was at Botanikerbugt, Ymer Ø (73°10'N).

Galium brandegei A. Gray.

Found in Southeast Greenland (63°21'N) by C. Bay in 1992. This is the first find on the east coast between South Greenland and Tasiilaq.

Melandrium affine J Vahl

New south limit at Mt. Forel (66°39'N) in East Greenland (Halliday 2019b).

Poa abbreviata R.Br.

Found at Kangerlussuaq in East Greenland (68°49'N), which is a new south limit (Halliday 2019b).

Poa pratensis L. ssp. *colpodea* (Th. Fr.) Tzvelev

New south limit at Constable Pynt (70°44'N).

Ranunculus sabinei R. Br.

New south limit at 74°51'N found by Hauge Andersson in 1988.

Sagina caespitosa (J. Vahl) Lge.

K. Westergaard found the species at Kangerlugssuaq (68°09'N) in East Greenland in 2019.

Saxifraga foliolosa R. Br.

New south limit at Tasiilaq (65°35'N) in Southeast Greenland collected by M. Strandberg.

Taraxacum pumilum Dahlst.

New south limit at Shannon at 75°11'N (Bay 1992).

Corrections to the Flora of Greenland (Böcher et al. 1978)

During the study of the vascular plant flora of East Greenland a few corrections to the flora of Greenland (Böcher et al. 1978) showed up.

Callitriche anceps Fern

No collections from Skjoldungen district have been found in herb. C, BM, LANC or O as stated in the flora of Greenland. Consequently, the species is strictly distributed at the west coast of Greenland.

Callitriche palustris L.

Northernmost record is from 71°17'N in East Greenland and not as stated in the Flora of Greenland at 72°40'N.

Hippuris vulgaris L.

Recent studies show that *Hippuris lanceolata* Retz. is the most common species in the Western Arctic (Elven et al. 2012). It is the only species documented from Greenland and the Canadian Arctic Archipelago; its two relatives (*Hippuris tetraphylla* L. f. and *H. vulgaris* L.) occur together with H. lanceolata on the American mainland, but not in Greenland.

Honckenya peploides (L.) Ehrh.

The northernmost locality is Siorapaluk (77°48'N) in West Greenland (Fredskild and Bay 1988) and Mørkefjord (77°55'N) in East Greenland. No specimens of *Honckenya peploides* has been found in Inglefield Land, which is the northern limit according to Böcher et al. (1978).

Subularia aquatica L.

No evidence has been found of *Subularia aquatica* L. occurring at 69°43'N in East Greenland. Consequently, the northernmost find in East Greenland is at 65°39'N

Woodsia ilvensis (L.) R. Br.

Böcher et al. (1978) states that the species is not recorded north of 71°N in East Greenland. However, a specimen from Hold with Hope (73°33'N) by Hartz from 1891 is the northernmost collection from East Greenland.

Conclusions

The number of vascular plant taxa in the flora of Greenland

The latest update of the number of vascular species of the flora of Greenland, which is 25 years old (Bay 1993) summarized the total number to 513. During the latest 25 years the total number of vascular plants has been increased by twenty species giving a total of 532 species. Holt et al. (2019) recently presented a photo flora on the internet totaling 625 species of vascular plants including introduced species and planted tree species.

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Mountains of the Mist: A first plant checklist for the Bvumba Mountains, Manica Highlands (Zimbabwe-Mozambique)

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Abstract

The first comprehensive plant checklist for the Bvumba massif, situated in the Manica Highlands along the Zimbabwe-Mozambique border, is presented. Although covering only 276 km^2, the flora is rich with 1250 taxa (1127 native taxa and 123 naturalised introductions). There is a high proportion of Orchidaceae and Pteridophyta, with both groups showing a higher richness than for adjacent montane areas, which may be due to the massif's relatively high moisture levels as a result of frequent cloud cover. However, in contrast to other mesic montane regions in southern Africa, there are relatively few near-endemic or range-restricted taxa: there is only one local endemic, *Aeranthes africana*, an epiphytic forest orchid. This is likely to be an effect of the massif having limited natural grassland compared to forest, the former being the most endemic-rich habitat in southern African mountains outside of the Fynbos Biome. Six other near-endemic taxa with limited distribution in this portion of the Manica Highlands are highlighted. The high number of invasive species is probably a result of diverse human activities in the area. The main species of concern are *Acacia melanoxylon*, a tree that is invading grassland and previously cultivated land, the forest herb *Hedychium gardnerianum* which in places is transforming forest understorey with an adverse

effect on some forest birds, and the woody herb *Vernonanthura polyanthes* which invades cleared forest areas after fire. Future botanical work in the massif should focus on a more detailed exploration of the poorly known Serra Vumba on the Mozambican side and on the drier western slopes. This will allow for a more detailed analysis of patterns of endemism across the Manica Highlands.

Keywords
endemics, floristics, invasive species, Manica Highlands, montane, plant diversity

Introduction

Southern African mountains continue to fascinate biologists, ecologists and conservationists with their high endemism, high species diversity, and as a haven for taxonomically complex and cryptic evolutionary lineages (White 1978; Taylor et al. 2013; Uys and Cron 2013; Conradie 2014; Mynhardt et al. 2015; Padayachee and Procheş 2016; Phiri and Daniels 2016; Conradie et al. 2018; Branch et al. 2019). From a floristic perspective, there has been a steady output of comprehensive data from the region over the past 25 years, for example the Nyika Plateau (Burrows and Willis 2005) and Mount Mulanje (Strugnell 2006) in Malawi; Mounts Gorongosa, Mabu and Namuli (Müller et al. 2008; Timberlake et al. 2009; Bayliss et al. 2014; Timberlake, in prep.) in Mozambique; Chirinda Forest (Drummond and Mapaure 1994) in Zimbabwe; the Angolan Highlands (Goyder and Gonçalves 2019); the heterogeneous southern African Great Escarpment (Clark et al. 2011, 2014; Roth et al. 2014; Darbyshire et al. 2018; Carbutt 2019). This has greatly improved our regional understanding of montane floristics, patterns of endemism, biogeography and conservation needs. In addition, an account of all the endemic and near-endemic plants from Mozambique has recently been published (Darbyshire et al. 2019b), some of which occur in these border areas. Despite these advances, ongoing biodiversity research in southern African mountains remains a key regional need (Clark et al. 2011, 2019; CEPF 2012), and there remains a substantial lag in the production of fundamental biodiversity and taxonomic data compared to other mountains in Africa.

The Manica Highlands (Clark et al. 2017), which lie on the border between Zimbabwe and Mozambique and are mostly synonymous with Van Wyk and Smith's (2001) Chimanimani-Nyanga Centre of Floristic Endemism, comprise an area that has been well-botanised over the last 100 years, yet with few publications. Over the past decade, attention has been focused on improving our knowledge of plant diversity and endemism for this ecologically complex 8,000 km^2 mountain system. For instance, the first comprehensive floristic treatment of the Nyanga massif was published only recently (Clark et al. 2017), as was the first substantial revision in 50 years of the Chimanimani flora (Wursten et al. 2017).

The central parts of the Manica Highlands (from north to south: Stapleford, Penhalonga, Bvumba, Banti, Himalaya, Tsetserra) are now the outstanding areas that require synthesis of available data and further fieldwork, with the Bvumba being prob-

ably the most thoroughly botanised component of the Manica Highlands. Here we present the first comprehensive plant checklist for the Bvumba massif, with some notes on the massif and its flora.

The Bvumba area

Defining the study area

Clark et al. (2017) defined the Bvumba as the entire central component of the Manica Highlands, which includes the Bvumba as well as the Penhalonga and Stapleford uplands that occur immediately to the north, i.e. between the Bvumba and Nyanga. However, due to lack of adequate floristic data for Penhalonga and Stapleford, we here restrict ourselves to the Bvumba massif *sensu stricto* and not to the broader Bvumba area as shown in Clark et al. (2017). The checklist area is defined as that part lying primarily above 1200 m altitude with significant vegetation cover, an extent of around 276 km^2, and differs slightly from the more rigid use of the 1200 m contour used by Childes and Mundy (2001).

Location and topography

Centred on 19°06'S, 32°47'E, the Bvumba lies 20 km south-east of the border city of Mutare and straddles the Zimbabwe-Mozambique border (Figure 1). The largest extension lies within Mutare District in eastern Zimbabwe, but a significant area of around 30 km^2 lies over the border in Manica District in Mozambique's Manica Province. This north-eastern extension terminates at the peak of Serra Vumba (1646 m) at 18°58'35"S, 32°53'25"E, just 5 km south of Manica town (previously Vila da Manica) on the main Mutare–Beira highway. The area as a whole is bounded in the north by the Muneni valley (in which the Forbes/Machipanda border post is situated) and in the south by the Burma valley (Nyamataka River), which separates it from the Banti-Himalaya-Tsetserra massif. The Mozambique midlands/lowlands and Chicamba Real dam form the eastern limits, while the Odzi River valley forms the western boundary. Outlying ridges and inselbergs to the west – including Cecil Kop – have been excluded. The lower elevational cut-off of approximately 1000–1200 m used here roughly follows the base of the Bvumba massif where it emerges from the surrounding plains.

Consisting of an upland massif, the highest points in the study area are Castle Beacon (1911 m) and Chinyakwaremba (1714 m), while the main rivers are the Nyamataka in the south, which drains into the Rio Vanduzi via the Chicamba Real dam and then on into the Rio Búzi, the Zonwe River in the centre and the Ndonwe River in the north, both also draining into the Vanduzi. To the west the main river is the Nyachowa, which drains into the Odzi and eventually into the Save River.

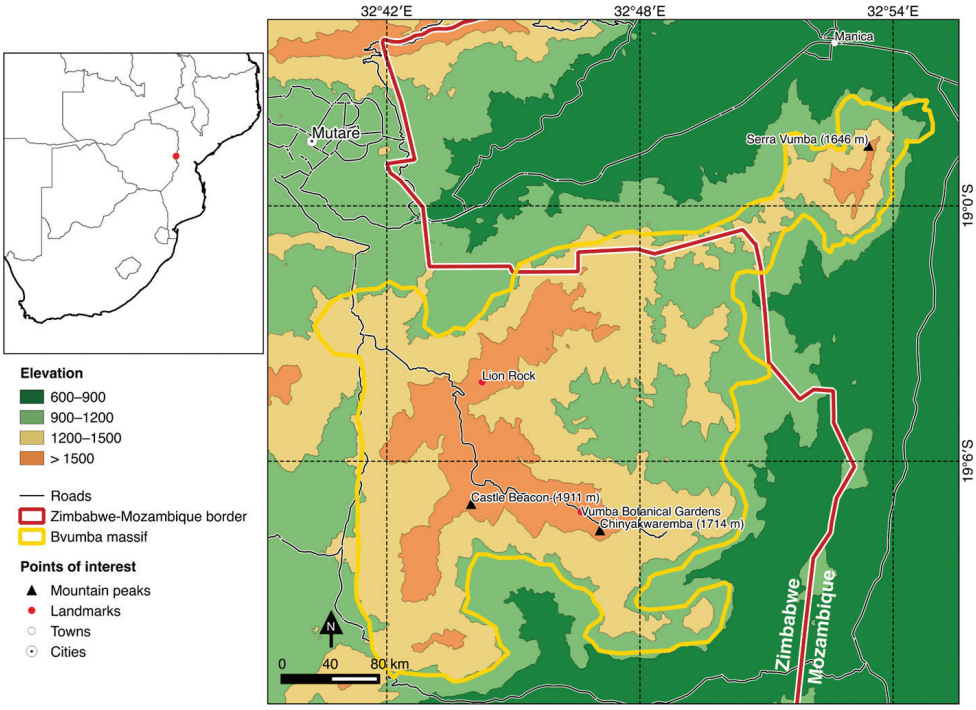

Figure 1. Map of the geographic location and selected elevations of the Bvumba massif and vicinities, with main points of interest.

Geology

The principal rocks underlying the Bvumba area are gneissic granites of Proterozoic age, perhaps 2560 million years old, interlaced with intrusions of finer-grained darker dolerite rock perhaps 1800 million years old (Bartholomew 1990; Martin 2000). Millions of years of erosion have left the granite domes exposed, standing above the surrounding younger landscape. Some peri-glacial features date from the Pleistocene period (25,000 years BP). No minerals of economic significance are noted, although gold has been mined for hundreds of years from areas just north of Mutare. The soils are often deep and well-weathered, but are not considered particularly fertile owing to their age and weathering.

Climate

Surprisingly, there does not appear to be a long-term rainfall recording station in the Bvumba area (Agritex 1989), the nearest being at Mutare, which is significantly lower in elevation and with a lower annual rainfall. On isohyet maps, rainfall is indicated as being around 1800 mm/year (Agritex 1989). The warm rainy or growing season extends from November to mid-March, with a colder dry season from June through

to August. Frosts are scarce. A major feature, and one which gives the mountains their name of Mountains of the Mist, are the frequent mists and low moist cloud during the dry season, sometimes called *guti* (Martin 2000). It is these mists that reduce the physiological stress of the dry season for many plant species and allow forest to thrive.

History and land use

The area has been settled, on the Mozambique side in particular, for perhaps 1000 years, with the first written record of people living there dating from Portuguese explorers in the first half of the 17th century (Bannerman 2010; Martin 2000). It was possibly more heavily settled in the past than it is now, as seen from the many grinding stones found inside the forests. When European occupation first started, much of the area was settled by people of the Chirara dynasty (Martin 2000), particularly on the Mozambique side and along the Nzombe valley. The first European settlement on the Zimbabwe side started around 1890, and the first formal concession was granted by the British South African Company for the farm Cloudlands in 1898, now a private nature reserve. A road was cut in 1917 to the Bunga Forest from Mutare (then Umtali), and by 1921 the road continued over and into the Burma Valley (Martin 2000).

Within Zimbabwe, the Bvumba area is now nearly all on privately held land, much of it in small agricultural holdings, plantations or managed for conservation or ecotourism, including the famous Leopard Rock Hotel and golf course. There is a good road network and the area is well-settled with many properties, a number of which are used as holiday homes with many owners making strong efforts to conserve both the flora and bird life. Commercial farming in the Bvumba area includes dairy, *Protea* flowers, coffee, and with some wattle and *Eucalyptus* plantations. The only formal conservation areas are the Bvumba National Park and Botanic Gardens (201 ha) and the now much-expanded Bunga Forest Botanical Reserve (1,560 ha) managed by the Zimbabwe Parks and Wildlife Management Authority. There are no formally conserved areas on the Mozambique side, although from recent Google Earth imagery much of Serra Vumba's vegetation cover appears to be relatively intact and it may be protected by local traditions.

Vegetation

There are four broad vegetation types occurring in the Bvumba area − montane grassland, Afromontane evergreen forest, high-rainfall miombo woodland, and secondary scrub savanna (Martin 2000). The edges of the forests are surrounded by a dense scrub of *Pteridium*, *Smilax*, *Buddleja*, *Vangueria* and *Vernonia* (Childes and Mundy 2001). In addition, there are plantations of exotic timber trees and cultivated or fallow agricultural land. It is possible that montane forest originally covered much of the Bvumba, principally owing to dry season precipitation in the form of low wet clouds (*guti*). But

there is little montane grassland, a vegetation type of great botanical significance in the Nyanga and Chimanimani areas (Timberlake et al. 2016a). It is not clear why this is so, but it might be due to the somewhat lower elevations of the Bvumba compared to Nyanga and/or the greater amount of winter precipitation that allows forest to sustain itself. The high-rainfall woodlands contain many epiphytic ferns and orchids, which also have a high frequency in montane forest. Burrows (1990) suggests that the Bvumba has perhaps the richest fern flora in southern Africa owing to the pervasive mists. Secondary scrub savanna is generally found on infertile or gravelly soils or in degraded forests or reverted agricultural land, and it is here that a number of invasive tree and shrub species are found (S. Childes, pers. obs.).

Previous studies

The Bvumba has seen much botanical activity and many collections over the last 50 years, but almost entirely from the Zimbabwe side. Two notable collectors were Norman Chase, who assembled over 8,000 specimens with meticulous notes, mostly from the Manica Highlands but with a large number from the Bvumba, and John Ball, for whom the Bvumba and Chimanimani provided the inspiration for his book on epiphytic orchids (Ball 1978). Other significant collectors include Hiram Wild, Darrel Plowes, Tom Müller and Hamish Gilliland. Three of the current authors (Mark Hyde, Petra Ballings and Bart Wursten) have collected extensively there over the last 20 years, and another (Susan Childes) runs a small forest and bird conservation area. Although no comprehensive overall checklist was available, detailed lists of the orchids and ferns of the broader area are found on the Vumba Nature website (Ballings and Wursten 2019) and a preliminary Bvumba plant list was compiled by Mark Hyde from a manuscript list by Norman Chase (Chase, no date) and Tree Society and Orchid Society records (Hyde 1999).

The Bvumba Highlands are considered to be an Important Bird Area (IBA ZW004, Childes and Mundy 2001), known for the richness of its montane avifauna. The IBA is taken to be the area above 1200 m elevation, considered to be the lower limit for montane bird species (Harwin et al. 1994). A total of 242 bird species have been recorded, including three of global conservation concern.

The only detailed plant ecological work done so far specifically in the Bvumba area is that by Plowes (2002), who looked at the impacts of the devastating Cyclone Eline on the 40-ha Bunga Forest in February 2000. He noted nearly 200 fallen trees that had created 46 patches totalling 1.57 ha, equivalent to a loss of 13% of forest cover. Gilliland (1938), in his study of the vegetation of Zimbabwe's Manicaland, surprisingly does not mention areas this far south.

During his major study on Eastern Zimbabwe's moist forests (Müller 1999, 2006), Tom Müller recorded 37 georeferenced 50 × 50 m forest plots in the Bvumba area. These fell into seven of his 12 described forest types, with most being Type 5 (*Syzygium guineense* subsp. *afromontanum* montane forest, 10 plots), Type 7 (Mixed

sub-montane forest, 8 plots) and Type 11 (Medium elevation forest, 8 plots). In addition, there were a few plots each of Type 6 (Regenerating montane forest), Type 8 (*Craibia brevicaudata* forest), Type 9 (*Albizia*-dominated regenerating forest) and Type 10 (*Albizia schimperiana* forest). Hence most of the Bvumba forest plots recorded fell into what Muller calls sub-montane forest, with only a few from the montane or medium elevation forest zones. An interesting finding is that of the 37 plots marked on aerial photographs from the early 1970s, only three have been obviously lost or damaged from what can be seen of their canopy cover using recent Google Earth imagery (most dating from June 2019).

Although not formally documented, it does appear that disturbance over the last 100 years has led to a drying out of some of the forests and an invasion of alien plants (T. Müller, pers. comm. 2017). The impression (S. Childes, pers. obs.) is that the fern flora is moving towards the more generalist species and that some drought-sensitive species of angiosperms such as *Streptocarpus umtaliensis* and *Cryptostephanus vansonii* are reducing.

Materials and methods

As the Bvumba is well-documented botanically, with approximately a century of botanical collecting, a checklist approach to documenting plant diversity and endemism was decided upon in order to be comparable to floristic lists recently compiled for Nyanga massif (Clark et al. 2017) and the Chimanimani mountains (Wursten et al. 2017). The two main sources were (i) an extract of the Harare Herbarium (SRGH) database of all records containing the word 'Vumba' in the locality field, with any records obviously from below 1200 m elevation removed, and (ii) records from the Bvumba area above 1200 m elevation cited on the Flora of Zimbabwe website (https://www.zimbabweflora.co.zw/, Hyde et al. 2020). In addition to these there were (iii) records from published volumes of Flora Zambesiaca, (iv) orchid and pteridophyte records listed on the Nature Vumba website (Ballings and Wursten 2019), (v) confirmed records from an unpublished Bvumba checklist (Hyde 1999) including those cited as being from Chase's list (Chase, no date), (vi) any additional records from forest plot studies undertaken by Müller in the 1970s (Müller 2006), and finally (vii) personal records from the authors. A herbarium specimen or record citation (i.e. from the Flora of Zimbabwe website) is given for each taxon, or a confirmed sighting (s.r.) indicated. If there was any uncertainty over an occurrence, the record was omitted.

Families and species are listed alphabetically under pteridophytes, gymnosperms, monocotyledons and dicotyledons. Nomenclature and family arrangement follow those used on the Flora of Zimbabwe website (Hyde et al. 2020, accessed 1 February 2020). Pteridophyte families follow that used in the Pteridophyte Phylogeny Group (2016). Species authorities are abbreviated following Brummitt and Powell (1992). Synonyms are given only for significant recent changes or for taxa that have been known or recorded locally under a different name (e.g. in Mapaura and Timberlake

2004) or where confusion may occur. Where a taxon is believed to be endemic or near-endemic, this is indicated with an E or NE, respectively. Species that are said to be naturalised or introduced on the Flora of Zimbabwe website are indicated with an asterisk (*).

Results and discussion

The checklist contains 1250 taxa, comprising 137 pteridophytes, 2 gymnosperms and 1111 flowering plants (Table 1). Of these, 1127 are native species and 123 (9.8%) are naturalised or semi-naturalised introductions, most, unsurprisingly, being cosmopolitan weeds in the Asteraceae (25 species), Poaceae (8 species) and Amaranthaceae (7 species). The largest families represented in the checklist are shown in Table 2.

In terms of species, there are three findings of particular note. First, there is a particularly high number of orchids (125 taxa across 276 km^2), higher than might have been expected and significantly more than the number found in the more extensive Nyanga area above 1200 m elevation (92 taxa across 2181 km^2; Clark et al. 2017) and in the Chimanimani mountains (97 taxa across 530 km^2; Wursten et al. 2017). There are also a large number – 137 taxa – of pteridophytes (particularly ferns), compared to 136 taxa in the Nyanga area and just 105 in the Chimanimani. This is probably due to the greater moisture levels and frequent clouds in the Bvumba; the area is said to be possibly the richest locality for pteridophytes in southern Africa (Burrows 1990).

The third point of interest, again possibly linked to the high precipitation levels, is the lack of the montane conifer *Widdringtonia nodiflora* on the Bvumba, a species

Table 1. Total number of taxa and introduced taxa in the Bvumba checklist, by group.

	No. taxa	No. introduced
Pteridophytes	137	1
Gymnosperms	2	1
Monocotyledons	336	15
Dicotyledons	775	106
TOTAL	1250	123

Table 2. The 10 largest families represented on the Bvumba checklist.

Family	No. taxa
Orchidaceae	125
Asteraceae	119
Fabaceae *sensu lato*	93
Poaceae	93
Rubiaceae	59
Acanthaceae	33
Lamiaceae	29
Cyperaceae	28
Aspleniacaeae (Pteridophyta)	27
Apocynaceae	22

that is locally common both in the Nyanga and Chimanimani areas as well as on Mt Mulanje in southern Malawi (where it also occurs with *W. whytei*) and Mt Gorongosa in Mozambique (Müller et al. 2008). *Widdringtonia* is generally found on the drier rain-shadow side of these large mountains.

Endemics and taxa of restricted distribution

There is only one taxon known to be endemic to the Bvumba, the epiphytic orchid *Aeranthes africana*. Noted just twice, it is apparently now not found in its first-recorded location in the forests near Castle Beacon (S. Childes, pers. comm.). This species was recently assessed using IUCN Red List criteria (IUCN 2001) as Critically Endangered (Timberlake 2020, in press) and could be almost extinct, but it is cryptic among the leaves of *Podocarpus milanjianus* and difficult to see except on fallen branches so may have been overlooked.

Six other near-endemic taxa – here defined as taxa found only on nearby montane massifs such as Nyanga, Serra Choa, Stapleford, Banti/Himalaya and Tsetserra, but not including those also found on the Chimanimani or further afield (including Chirinda and Mt Gorongosa) – are found in the Bvumba area (Table 3). Two of them – *Aloe cameronii* var. *bondana* and *Aloe inyangensis* var. *kimberleyana* – are varieties of more widespread species and thus of lesser taxonomic significance; both have recently been assessed as Least Concern using IUCN criteria (Timberlake, in press). Of the remaining four taxa, *Barleria fissimuroides* is restricted to just the Bvumba area and a farm just over the border in Mozambique north of Mutare, but three are more widespread, being found from Serra Choa in Mozambique or over the border in Nyanga south to the Himalaya/Tsetserra area or, in the case of *Anthospermum zimbabwense*, to Mt Pene

Table 3. Taxa of restricted distribution found in the Bvumba area.

Family/species	Distribution	IUCN Red List assessment
Asphodelaceae		
Aloe cameronii *Hemsl.* var. bondana *Reynolds*	Troutbeck, Juliasdale, Bvumba	LC
Aloe inyangensis *Christian* var. kimberleyana *S.Carter*	Nyanga NP, Juliasdale, Stapleford, Bvumba	LC
Orchidaceae		
Aeranthes africana *J.L.Stewart*	Bvumba [endemic]	CR D
Acanthaceae		
Barleria fissimuroides *I.Darbysh.*	Bvumba, Quinta da Frontiera	EN B2ab
Gesneriaceae		
Streptocarpus umtaliensis *B.L.Burtt*	Serra Choa, Nyanga, Stapleford, Bvumba, Tsetserra	LC
Loranthaceae		
Englerina oedostemon *(Danser) Polhill & Wiens*	Serra Choa, Nyanga, Stapleford, Mutare, Bvumba, Tsetserra	–
Rubiaceae		
Anthospermum zimbabwense *Puff*	Nyanga, Stapleford, Bvumba, Himalaya, Mt Pene	NT B1ab+2ab

in Chimanimani District. Only one of the near-endemic taxa is threatened, *B. fissimuroides* (Endangered, Darbyshire et al. 2019a). Also of note is the orchid *Angraecum stella-africae*, believed to be extinct in Zimbabwe (Mapaura and Timberlake 2002), but a small colony has been found on the Bvumba in recent years (Wursten 2007). This species has also been found in Malawi (Viphya, Mt Mulanje) and northern South Africa (Wolkberg Mountains) but is nowhere common.

It is surprising that the Bvumba massif has so few endemic or near-endemic taxa, especially when compared to the Chimanimani Mountains (71 endemic taxa, Wursten et al. 2017) or the Nyanga area (19 endemic taxa, revised from Clark et al. 2017). This is obviously not due to under-collection, but possibly the result of the relatively small size of the Bvumba and the preponderance of forest vegetation compared to montane grassland and scrub habitats. Most Nyanga and Chimanimani endemics, for example, are found in montane grassland or montane scrub (Clark et al. 2017; Wursten et al. 2017), habitats poorly represented in the Bvumba and which are also substantially disturbed there.

Introduced and invasive species

There are 123 introduced species present in the Bvumba, a result of the diverse human activities there. Although most of these non-native species are benign, a handful are causing major problems. In contrast to other parts of the Manica Highlands, the Bvumba has a high proportion of introduced species that are garden escapes while the rest of the Manica Highlands is affected more by those from commercial forestry.

Invasive woody invasive species on the Bvumba are typically those also found in other parts of the Manica Highlands, and include the Australian *Acacia mearnsii* (wattle) and *A. melanoxylon* (Australian Blackwood) and *Pinus patula*. Australian Blackwood is a particular problem, taking over tracts of open grassland and areas previously under *Protea* cultivation (S. Childes, pers. obs.). Other woody but non-commercial species that have naturalised and have invasive potential (based on evidence elsewhere in the region) are *Bauhinia variegata* var. *variegata*, *Cinnamomum camphora*, *C. verum*, *Homalanthus populifolius*, *Jacaranda mimosifolia*, *Psidium cattleianum*, *P. guajava*, *Sambucus canadensis* and *Syzygium jambos*. Classic invasive shrubs are *Lantana camara* and *Solanum mauritianum*, for which there are no easy management solutions, while *Cestrum aurantiacum* is clearly a local problem. A more recent challenge is *Vernonanthura polyanthes* – locally called 'Beebush' – which has become rampant since it spread into the Bvumba and Chimanimani areas after its introduction from Brazil to Mozambique (Timberlake et al. 2016b). It spreads rapidly into disturbed and burnt areas that were under wattle, blackwood or eucalyptus (S. Childes. pers. obs.). Clark et al. (2019) postulate that Cyclone Idai (March 2019) might have encouraged the spread of this wind-dispersed species even further afield, although it had earlier also been encountered on the Ribáuè mountains in northern Mozambique (I. Darbyshire, pers. comm. 2017). Indigenous montane forests are being invaded by the garden escap-

ees *Tradescantia fluminensis* and *T. zebrina*, while perhaps the worst forest invader is *Hedychium gardnerianum* – a species that can transform the forest understory and has adverse effects on ground-foraging birds such as Orange Thrush (*Geokichla gurneyi*), Buff-spotted Flufftail (*Sarothrura elegans*) and Cinnamon Dove (*Columba larvata*) that need an open understory with leaf litter (S. Childes, pers. obs.).

Limitations and future work

Despite the detailed collections, this list is a compilation. As a result, some taxa may have been accidentally omitted whereas others that are found only below 1200 m elevation may have inadvertently been included. In particular, it should be recognised that there are virtually no records from Serra Vumba on the Mozambique side, an area that needs a more detailed collection. Similarly, the drier western slopes of the Bvumba in Zimbabwe have also been undercollected (J. Burrows, pers. comm.). However, with these provisos we estimate that the list is over 90% complete, suggesting a total indigenous flora of around 1250 taxa, of which approximately 1100 would be native flowering plants.

The remaining data gaps for the botanical inventory of the Manica Highlands are centred on the areas immediately to the north and south of the Bvumba, namely Penhalonga-Stapleford and Banti-Himalaya-Tsetserra, respectively. However, some recent survey work has been conducted on Tsetserra and a list of the endemic and range-restricted species has been compiled for that area (J. Osborne, pers. comm.). In contrast to Nyanga, Chimanimani and Bvumba, which had comprehensive available data with which to work, both areas require detailed botanical collecting before reliable lists can be compiled.

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Appendix 1

Table A1. Vascular plant checklist for the Bvumba area, E Zimbabwe above 1200 m altitude. Nomenclature follows the Flora of Zimbabwe website (Hyde et al. 2020) with some minor changes. * – introduced species; E – endemic species; NE – near-endemic; FoZ # – Flora of Zimbabwe website record number; s.r. – sight record.

Name / authority	Voucher
PTERIDOPHYTA	
Anemiaceae	
Pteris quadriaurita Retz subsp. *catoptera* (Kunze) Schelpe	Chase 7485
Mohria lepigera (Baker) Baker	Chase 3823
Mohria nudiuscula J.P.Roux	Chase 7033
Mohria vestita Baker	Ballings & Wursten 875
Aspleniaceae	
Asplenium aethiopicum (Burm.f.) Bech. agg.	Chase 7044
Asplenium anisophyllum Kunze	Chase 3471
Asplenium blastophorum Hieron.	Müller 3071
Asplenium boltonii Brause & Hieron.	Müller 3051
Asplenium ceii Pic.Serm.	Ballings & Wursten 39
Asplenium dregeanum Kunze	Chase 3457
Asplenium erectum Willd.	Ballings & Wursten 40
Asplenium flexuosum Schrad.	Chase 3252
Asplenium formosum Willd.	Burrows 2151
Asplenium friesiorum C.Chr.	Chase 1018
Asplenium gemmiferum Schrad.	Ballings s.r.
Asplenium hypomelas Kuhn	Chase 7145
Asplenium inaequilaterale Willd.	Chase 3516
Asplenium linckii Kuhn	Chase 5989
Asplenium lividum Kuhn	Chase 6571
Asplenium lobatum Pappe & Raws.	Chase 3535
Asplenium mannii Hook.	Chase 3526

Name / authority	Voucher
Asplenium monanthes L.	Chase 4663
Asplenium preussii Brause	Burrows 1667
Asplenium protensum Schrad.	Chase 3514
Asplenium pumilum Sw.	Chase 6990
Asplenium rutifolium (P.J.Bergius) Kunze	Chase 3137
Asplenium sandersonii Hook.	Chase 3490
Asplenium simii A.F.Braithw.& Schelpe	Chase 7253
Asplenium stuhlmannii Hieron.	Chase 3495
Asplenium sulcatum Lam.	Chase 6558
Asplenium theciferum (Kunth) Mett.	Ballings & Wursten 19
Athyriaceae	
Athyrium newtonii Baker	Ballings & Wursten 860
Athyrium schimperi Feé	Chase 4407
Deparia boryana (Willd.) M.Kato	Ballings & Wursten 857
Diplazium nemorale (Baker) Schelpe	Chase 5701
Diplazium zanzibaricum (Baker) C.Chr.	Chase 6092
Blechnaceae	
Blechnum attenuatum (Sw.) Mett.	Chase 3421
Blechnum tabulare (Thunb.) Kuhn	Chase 3356
Cyathea capensis (L.f.) Sm.	Eyles 3639
Cyathea dregei Kunze	Chase 6047
Cyathea manniana Hook.	Chase 6696
Cyathea thomsonii Baker	Chase 6219
Davalliaceae	
Davallia chaerophylloides (Poir.) Steud.	Chase 31810
Dennstaedtiaceae	
Blotiella glabra (Bory) R.M.Tryon	Chase 6275
Blotiella natalensis (Hook.) R.M.Tryon	Chase 3364
Histiopteris incisa (Thunb.) J.Sm.	Fisher 1303
Hypolepis sparsisora (Schrad.) Kuhn	Chase 4585
Pteridium aquilinum (L.) Kuhn subsp. *capense* (Thunb.) C.Chr.	Wursten & Ballings 1194
Didymochlaenaceae	
Didymochlaena truncatula (Sw.) J.Sm.	Fisher 1330
Dryopteridaceae	
Arachniodes webbiana (A.Braun) Schelpe subsp. *foliosa* (C.Chr.) Gibby	Ballings & Wursten s.r.
Ctenitis cirrhosa (Schumach.) Ching	Ballings & Wursten s.r.
Dryopteris athamantica (Kunze) Kuntze	Chase 1048
Dryopteris kilemensis (Kuhn) Kuntze	Chase 2034
Dryopteris manniana (Hook.) C.Chr.	Chase 6572
Dryopteris pentheri (Krasser) C.Chr.	Ballings & Wursten 24
Megalastrum lanuginosum (Kaulf.) Holttum	Ballings & Wursten 877
Nothoperanema squamiseta (Hook.) Ching	Burrows 1910
Polystichum transvaalense N.C.Anthony	Chase 1104
Polystichum zambesiacum Schelpe	Chase 7489
Gleicheniaceae	
Dicranopteris linearis (Burm.f.) Underw.	Ballings 7
Hymenophyllaceae	
Abrodictyum rigidum (Sw.) Ebihara & Dubuisson	Burrows 2383
Crepidomanes inopinatum (Pic.Serm.) J.P.Roux	Ballings & Wursten 853
Crepidomanes melanotrichum (Schltdl.) J.P.Roux	Chase 3302
Didymoglossum erosum (Willd.) J.P.Roux	Wild 6443
Hymenophyllum capense Schrad.	Burrows 2681
Hymenophyllum kuhnii C.Chr.	Ballings & Wursten 1623
Polyphlebium borbonicum (Bosch.) Ebihara & Dubuisson	Ballings & Wursten 60
Lomariopsidaceae	
Elaphoglossum acrostichoides (Hook.& Grev.) Schelpe	Chase 6287
Elaphoglossum aubertii (Desv.) T.Moore	Chase 4509
Elaphoglossum kuhnii Hieron.	Chase 3413
Elaphoglossum lancifolium (Desv.) C.V.Morton	Chase 3308
Elaphoglossum lastii (Baker) C.Chr.	Chase 118
Elaphoglossum macropodium (Fée) T.Moore	Chase 2194
Elaphoglossum spathulatum (Bory) T.Moore var. *spathulatum*	Burrows 2376
Lycopodiaceae	
Huperzia dacrydioides (Baker) Pic.Serm.	Chase 1121
Huperzia ophioglossoides (Lam.) Rothm.	Chase 1137

Name / authority	Voucher
Huperzia verticillata (L.f.) Trevis.	Chase 3140
Lycopodiella cernua (L.) Pic.Serm.	Ballings & Wursten 20
Lycopodium clavatum L.	FoZ #4033
Lygodiaceae	
Lygodium kerstenii Kuhn	Chase 2024
Marattiaceae	
Ptisana fraxinea (Sm.) Murdock var. *salicifolia* (Schrad.) Murdock	Ballings & Wursten 31
Nephrolepidaceae	
Nephrolepis undulata (Sw.) J.Sm.	Chase 3307
Oleandraceae	
Oleandra distenta Kunze	Chase 3389
Ophioglossaceae	
Ophioglossum gomezianum A.Braun	Burrows & Burrows 5193
Ophioglossum polyphyllum A.Braun var. *polyphyllum*	Ballings & Wursten s.r.
Ophioglossum reticulatum L.	Ballings & Wursten 131
Osmundaceae	
Osmunda regalis L.	Chase 7139
Polypodiaceae	
Belvisia spicata (L.f.) Copel.	Burrows 2380
Lepisorus excavatus (Willd.) Ching	Ballings & Wursten 10
Lepisorus schraderi (Mett.) Ching	Ballings & Wursten 14
Loxogramme abyssinica (Baker) M.G.Price	Ballings & Wursten 15
Microgramma mauritiana (Willd.) Tardieu	Wild & Chase 78
Microsorum pappei (Kuhn) Tardieu	Chase 7113
Pleopeltis macrocarpa (Willd.) Kaulf.	Ballings & Wursten 18
Pleopeltis polypodioides (L.) E.G.Andrews & Windham subsp. *ecklonii* (Kunze) J.P.Roux	Ballings & Wursten 80
Pyrrosia rhodesiana (C.Chr.) Schelpe	Chase 1038
Pyrrosia schimperiana (Kuhn) Alston var. *schimperiana*	Wursten & Ballings 81
Pteridaceae	
Actiniopteris dimorpha Pic.Serm. subsp. *dimorpha*	Chase 7578
Actiniopteris radiata (Sw.) Link	Chase 5576
Adiantum capillus-veneris L.	Ballings & Wursten 1431
Adiantum poiretii Wikstr.	Chase 4630
**Adiantum raddianum* C.Presl	Chase 4688
Pityrogramma argentea (Willd.) Domin	Chase 3173
Pteris catoptera Kunze	Ballings & Wursten 114
Pteris cretica L.	Chase 3525
Pteris dentata Forssk.	Fisher 1547
Pteris friesii Hieron.	Ballings & Wursten 78
Pteris vittata L.	Ballings & Wursten 83
Vittaria guineensis Desv. var. *orientalis* Hieron.	Chase 6641
Vittaria isoetifolia Bory	Fisher 1549
Vittaria volkensii Hieron.	Ballings & Wursten 144
Selaginellaceae	
Selaginella dregei (C.Presl) Hieron.	Chase 1126
Selaginella kraussiana (Kunze) A.Braun	Chase 4035
Selaginella mittenii Baker	Chase 5622
Sinopteridaceae	
Cheilanthes bergiana Schltdl.	Chase 4591
Cheilanthes buchananii (Baker) Domin	Burrows 2324
Cheilanthes involuta (Sw.) Schelpe & N.C.Anthony var. *obscura* (N.C.Anthony) N.C.Anthony	Chase 3469
Cheilanthes leachii (Schelpe) Schelpe	Ballings & Wursten 67
Cheilanthes multifida N.C.Anthony & Schelpe	Chase 3979
Cheilanthes quadripinnata (Forssk.) Kuhn	Chase 4010
Cheilanthes viridis (Forssk.) Sw. var. *glauca* (Sim) Schelpe & N.C.Anthony	Ballings & Wursten 68
Cheilanthes viridis (Forssk.) Sw. var. *viridis*	Chase 7141a
Pellaea calomelanos (Sw.) Link var. *calomelanos*	Ballings & Wursten 64
Pellaea calomelanos (Sw.) Link var. *swynnertoniana* (Sim) Schelpe	Chase 4413
Pellaea doniana Hook.	Chase 2028
Pellaea dura (Willd.) Hook. var. *dura*	Chase 5591
Pellaea pectiniformis Baker	Chase 4412
Tectariaceae	
Arthropteris monocarpa (Cordem.) C.Chr.	Chase 3506
Arthropteris orientalis (J.F.Gmel.) Posth. var. *orientalis*	Chase 2007
Tectaria gemmifera (Feé) Alston	Chase 3519

Name / authority	Voucher
Thelypteridaceae	
Amauropelta bergiana (Schltdl.) Holltum var. *bergiana*	Ballings & Wursten 29
Christella dentata (Forssk.) Brownsey & Jermy	Burrows 1636
Christella gueinziana (Mett.) Holttum	Chase 3377
Cyclosorus interruptus (Willd.) H.Itô	Ballings & Wursten 82
Pneumatopteris unita (Kunze) Holttum	Ballings & Wursten 21
Pseudocyclosorus pulcher (Willd.) Holttum	Chase 6698
Thelypteris confluens (Thunb.) Morton	Ballings & Wursten 23
GYMNOSPERMAE	
Pinaceae	
**Pinus patula* Schltdl.& Cham.	FoZ #3770
Podocarpaceae	
Podocarpus milanjianus Rendle	Chase 5477
MONOCOTYLEDONS	
Agavaceae	
**Furcraea foetida* (L.) Haw.	FoZ #40164
Amaryllidaceae	
Boophone disticha (L.f.) Herb.	FoZ #353
Crinum macowanii Baker	FoZ #356
Cryptostephanus vansonii I.Verd.	Bamps 711
Cyrtanthus galpinii Baker	FoZ #359
**Nothoscordum borbonicum* Kunth	FoZ #15
Tulbaghia alliacea (L.f.) Thunb.	Chase 4187
Anthericaceae	
Chlorophytum andongense Baker	Chase 7321
Chlorophytum bowkeri Baker	FoZ #4051
Chlorophytum comosum (Thunb.) Jacq.	Jacobsen 3051
Chlorophytum gallabatense Baker	Wild 5570
Chlorophytum galpinii (Baker) Kativu	FoZ #32168
Chlorophytum macrosporum Baker	Chase 1452
Araceae	
Zantedeschia albomaculata (Hook.) Baill. subsp. *albomaculata*	FoZ #34616
Arecaceae	
Phoenix reclinata Jacq.	FoZ #15154
Asparagaceae	
Asparagus africanus Lam.	Ferrar 4084
Asparagus asparagoides (L.) Wight	FoZ #2885
Asparagus falcatus L. var. *falcatus*	FoZ #2698
Asparagus laricinus Burch.	FoZ #249
Asparagus setaceus (Kunth) Jessop	Chase 1623
Asparagus virgatus Baker	Müller 3374
Asphodelaceae	
Aloe arborescens Mill.	FoZ #6111
Aloe cameronii Hemsl. var. *bondana* Reynolds **NE**	Christian 450
Aloe excelsa A.Berger var. *excelsa*	FoZ #3451
Aloe inyangensis Christian var. *kimberleyana* S.Carter **NE**	Plowes 2021
Aloe pretoriensis Pole-Evans	Chase 5603
Aloe rhodesiana Rendle	FoZ #3817
Aloe swynnertonii Rendle	FoZ #3458
Bulbine latifolia (L.f.) Roem.& Schult.f.	FoZ #6231
Kniphofia linearifolia Baker	FoZ #633
Behniaceae	
Behnia reticulata (Thunb.) Didr.	Grosvenor 267
Colchicaceae	
Androcymbium striatum A.Rich.	FoZ #529
Gloriosa superba L.	FoZ #1046
Commelinaceae	
Aneilema aequinoctiale (P.Beauv.) Loudon	FoZ #37419
Aneilema welwitschii C.B.Clarke	Bamps 684
Commelina africana L.	FoZ #33055
Commelina welwitschii C.B.Clarke	FoZ #33108
Cyanotis speciosa (L.f.) Hassk. subsp. *speciosa*	Chase 609
**Gibasis pellucida* (M.Martens & Galeotti) Hunt	FoZ #18940
Murdannia simplex (Vahl) Brenan	Hopkins 7097
**Tradescantia fluminensis* Vell.	FoZ #36272

Name / authority	Voucher
* *Tradescantia zebrina* Bosse	FoZ #40886
Cyperaceae	
Bulbostylis burchellii (Ficalho & Hiern) C.B.Clarke	Jacobsen 3126
Bulbostylis hispidula (Vahl) R.W.Haines	Browning 566
Bulbostylis schoenoides (Kunth) C.B.Clarke	FoZ #14528
Carex spicato-paniculata C.B.Clarke	Chase 7425
Coleochloa setifera (Ridl.) Gilly	Bamps 606
Costularia natalensis C.B.Clarke	Fisher 1643
Cyperus albostriatus Schrad.	Chase 8114
Cyperus amabilis Vahl	Browning 576
Cyperus cuspidatus Kunth	Browning 554
Cyperus cyperoides (L.) Kuntze	FoZ #15126
Cyperus denudatus L.f. var. *denudatus*	Browning 281
Cyperus distans L.f.	Jacobsen 3028
Cyperus hemisphaericus Boeck.	FoZ #5797
Cyperus involucratus Rottb.	Loveridge 1094
Cyperus pseudoleptocladus Kük.	Jacobsen 3026
Cyperus pseudovestitus (C.B. Clarke) Kük.	Chase 5561
Cyperus rigidifolius Steud.	Jacobsen 3023
Cyperus tenuispica Steud.	Browning 555
Cyperus zambesiensis C.B.Clarke	Müller 3487
Fuirena stricta Steud. var. *stricta*	Browning 574
Kyllinga crassipes Boeck.	Jacobsen 3024
Kyllinga odorata Vahl	Jacobsen 3025
*Kyllinga sp.*cf. erecta Schumach.& Thonn.	Hyde s.r.
Kyllinga squamulata Vahl	FoZ #6523
Lipocarpha nana (A.Rich.) Cherm.	Browning 550
Mariscus albopilosus C.B.Clarke	Jacobsen 3047
Mariscus hemisphaericus (Boeck.) C.B.Clarke	Jacobsen 3027
Pycreus pelophilus (Ridl.) C.B.Clarke	Browning 556
Dioscoreaceae	
Dioscorea dumetorum (Kunth) Pax	FoZ #19137
Dioscorea schimperiana Kunth	Müller 3376
Dioscorea sylvatica Eckl.	FoZ #19141
Dracaenaceae	
Dracaena fragrans (L.) Ker-Gawl.	Chase 1440
Dracaena mannii Baker	Chase 875
Dracaena steudneri Engl.	Müller plot 76
Eriocaulaceae	
Eriocaulon inyangense Arw.	Wild 5540
Eriospermaceae	
Eriospermum mackenii (Hook.f.) Baker subsp. *mackenii*	Ferrar s.n.
Hyacinthaceae	
Albuca kirkii (Baker) Brenan	Ferrar 4040
Bowiea volubilis Hook.f.	Chase 362
Drimia elata Jacq.	FoZ #7512
Eucomis autumnalis (Mill.) Chitt. subsp. *autumnalis* (=*E. zambesiaca* Baker)	Plowes 2240
Ledebouria unidentified sp.no.1.	FoZ #41510
Litanthus pusillus Harv. (=*Drimia uniflora* J.C.Manning & Goldblatt)	FoZ #69141
Stellarioides tenuifolia (F.Delaroche) Speta subsp. *tenuifolia* (=*Ornithogalum tenuifolium* F.Delaroche)	FoZ #863
Hydrocharitaceae	
Lagarosiphon major (Ridl.) Moss	Whellan 1561
Hypoxidaceae	
Hypoxis galpinii Baker	FoZ #15385
Hypoxis nyasica Baker	FoZ #53770
Hypoxis rigidula Baker	Zimudzi 57
Iridaceae	
Anomatheca grandiflora Baker (=*Freesia grandiflora* (Baker) Klatt)	FoZ #5749
Aristea abyssinica Pax	FoZ #791
Aristea angolensis Baker	Garley 119
Aristea ecklonii Baker	Chase 63
Aristea woodii N.E.Br.	Wild 2845
Crocosmia aurea (Hook.) Planch. subsp. *aurea*	Chase 5488
Crocosmia paniculata (Klatt) Goldblatt	Chase 6315
Dierama formosum Hilliard	Chase 6023

Name / authority	Voucher
Dietes iridioides (L.) Klatt	Biegel 2422
Gladiolus crassifolius Baker	Plowes 2020
Gladiolus dalenii Van Geel subsp. *dalenii*	FoZ #796
Gladiolus flavoviridis Goldblatt	FoZ #35667
Hesperantha petitiana (A.Rich.) Baker	Chase 6036
Moraea spathulata (L.f.) Klatt	FoZ #2397
Juncaceae	
Juncus oxycarpus Kunth	FoZ #40749
Liliaceae	
**Lilium formosanum* (Baker) Wallace	FoZ #674
Musaceae	
Ensete ventricosum (Welw.) Cheesman	FoZ #1060
Orchidaceae	
Aerangis kotschyana (Rchb.f.) Schltr.	Chase 7083
Aerangis mystacidii (Rchb.f.) Schltr.	Chase 5574
Aeranthes africana J.L.Stewart **E**	Ball 1283
Angraecopsis amaniensis Summerh.	FoZ #1000
Angraecopsis parviflora (Thouars) Schltr.	FoZ #34512
Angraecum chamaeanthus Schltr.	FoZ #991
Angraecum conchiferum Lindl.	Chase 44
Angraecum minus Summerh.	Chase 5997
Angraecum sacciferum Lindl.	Ferrar 3979
Angraecum stella-africae P.J.Cribb	FoZ #995
Bolusiella iridifolia (Rolfe) Schltr. subsp. *picea* P.J.Cribb	Wild 2803
Bonatea steudneri (Rchb.f.) T.Durand & Schinz	Ball 443
Brachycorythis lastii Rolfe	FoZ #4871
Brachycorythis ovata Lindl. subsp. *welwitschii* (Rchb.f.) Summerh.	Chase 4213
Brachycorythis pleistophylla Rchb.f. subsp. *pleistophylla*	Chase 5548
Brownleea maculata P.J.Cribb	Chase 217
Brownleea parviflora Lindl.	Chase 6013
Bulbophyllum ballii P.J.Cribb	Chase 6170
Bulbophyllum elliotii Rolfe	Wild 2808
Bulbophyllum fuscum Lindl. var. *melinostachyum* (Schltr.) J.J.Verm.	Wild 2813
Bulbophyllum josephii (Kuntze) Summerh.	Wild 2804
Bulbophyllum longiflorum Thouars	Ball 1378
Bulbophyllum maximum (Lindl.) Rchb.f.	Chase 992
Bulbophyllum sandersonii (Hook.f.) Rchb.f. subsp. *sandersonii*	Wild 5544
Bulbophyllum scaberulum (Rolfe) Bolus	FoZ #1017
Bulbophyllum unifoliatum De Wild. var. *infracarinatum* (G.Will.) J.J.Verm.	FoZ #1019
Calanthe sylvatica (Thouars) Lindl.	Chase 7333
Cynorkis anacamptoides Kraenzl. var. *anacamptoides*	FoZ #34629
Cynorkis debilis (Hook.f.) Summerh. (=*C. hanningtonii* Rolfe)	Chase 5541
Cynorkis kassneriana Kraenzl.	Wild 2798
Cynorkis kirkii Rolfe	FoZ #99847
Cyrtorchis arcuata (Lindl.) Schltr. subsp. *arcuata*	Ball 1423
Cyrtorchis praetermissa Summerh. subsp. *praetermissa*	FoZ #33087
Cyrtorchis ringens (Rchb.f.) Summerh.	FoZ #2478
Diaphananthe fragrantissima (Rchb.f.) Schltr.	FoZ #21698
Diaphananthe rutila (Rchb.f.) Summerh.	Wild 6446
Diaphananthe stolzii Schltr.	Ball 1303
Diaphananthe subsimplex Summerh.	Ball 1406
Diaphananthe xanthopollinia (Rchb.f.) Summerh.	Ball 1236
Disa aconitoides Sond. subsp. *concinna* (N.E.Br.) H.P.Linder	Chase 6268
Disa fragrans Schltr. subsp. *fragrans*	Chase 4065
Disperis anthoceros Rchb.f.	Wild 2816
Disperis dicerochila Summerh.	FoZ #2374
Disperis lindleyana Rchb.f.	Chase 7030
Disperis virginalis Schltr.	Wild 2810
Eulophia callichroma Rchb.f.	Symoens et al. 669
Eulophia cucullata (Sw.) Steud.	FoZ #4873
Eulophia eylesii Summerh.	Chase 5562
Eulophia fridericii (Rchb.f.) A.V.Hall	Ball 440
Eulophia gonychila Schltr.	Chase 5572
Eulophia hians Spreng. var. *hians*	FoZ #21961
Eulophia horsfallii (Bateman) Summerh.	Ball 5256

Name / authority	Voucher
Eulophia norlindhii Summerh.	Wild s.n.
Eulophia nyasae Rendle	Ball 717
Eulophia parviflora (Lindl.) A.V.Hall	Chase 3075
Eulophia petersii (Rchb.f.) Rchb.f.	Chase 51
Eulophia rolfeana Kraenzl. (=*E. williamsonii* P.J.Cribb)	Beasley 121
Eulophia speciosa (Lindl.) Bolus	Chase 4180
Eulophia streptopetala Lindl.	FoZ #3623
Eulophia tenella Rchb.f.	Wild 6746
Eulophia venulosa Rchb.f.	Ball 586
Habenaria amoena Summerh.	Ballings s.r.
Habenaria armatissima Rchb.f.	Ball 442
Habenaria cornuta Lindl.	Ball 522
Habenaria galpinii Bolus	Ball 528
Habenaria macrostele Summerh.	Chase 6050
Habenaria malacophylla Rchb.f.	Chase 4403
Habenaria nyikana Rchb.f. subsp. *nyikana*	FoZ #7002
Habenaria praestans Rendle var. *praestans*	Chase 206
Habenaria rautaneniana Kraenzl.	Chase 6348
Habenaria silvatica Schltr.	Chase 6334
Habenaria subaequalis Summerh.	Wild 2806
Jumellea walleri (Rolfe) la Croix	Wild 3223
Liparis bowkeri Harv.	Grosvenor 784
Liparis mulindana Schltr.	Ball 1267
Liparis nervosa (Thunb.) Lindl.	FoZ #1411
Malaxis weberbaueriana (Kraenzl.) Summerh. (=*M. stolzii* (Schltr.) Summerh.)	Chase 6363
Microcoelia exilis Lindl.	Ferrar s.n.
Microcoelia globulosa (Ridl.) L.Jonss.	FoZ #5781
Microcoelia stolzii (Schltr.) Summerh.	Ball 1392
Mystacidium tanganyikense Summerh. (incl. *M. pusillum* sensu Wild 6442)	FoZ #2455
Nervilia ballii G.Will.	Ball 585
Nervilia crociformis (Zoll.& Moritzi) Seidenf.	Ball 1407
Nervilia kotschyi (Rchb.f.) Schltr. var. *purpurata* (Rchb.f.& Sond.) Börge Pett.	Ball 511
Nervilia pectinata P.J.Cribb	Ball 410
Nervilia shirensis (Rolfe) Schltr.	Chase 6235
Orthochilus eustachyus (Rchb.f.) Bytebier	FoZ #2854
Orthochilus mechowii Rchb.f.	FoZ #102482
Orthochilus milnei (Rchb.f.) Bytebier (=*Eulophia milnei* Rchb.f.)	Jacobsen 3030
Orthochilus odontoglossus (Rchb.f.) Bytebier	FoZ #37451
Platycoryne pervillei Rchb.f.	FoZ #4075
Polystachya adansoniae Rchb.f.	Chase 5609
Polystachya albescens Ridl. subsp. *imbricata* (Rolfe) Summerh.	Drummond 5097
Polystachya caespitifica Engl. subsp. *hollandii* (Bolus) P.J.Cribb & Podz.	FoZ #36207
Polystachya campyloglossa Rolfe [incl. *P. ottoniana* sensu Ball 1282, Chase 86]	Ball 1282
Polystachya concreta (Jacq.) Garay & H.R.Sweet (=*P. tessellata* Lindl.)	Chase 4400
Polystachya cultriformis (Thouars) Spreng.	Grosvenor 659
Polystachya fusiformis (Thouars) Lindl.	FoZ #1659
Polystachya golungensis Rchb.f.	Ball 1329
Polystachya modesta Rchb.f.	FoZ #15642
Polystachya simplex Rendle	Ball 1377
Polystachya stuhlmannii Kraenzl.	Philcox et al. 8959
Polystachya subumbellata P.J.Cribb & Podz.	Wild 6445
Polystachya transvaalensis Schltr.	FoZ #1667
Polystachya vaginata Summerh.	Wild 2977
Polystachya zambesiaca Rolfe	Ball 1364
Rangaeris muscicola (Rchb.f.) Summerh.	Plowes 2893
Satyrium anomalum Schltr.	FoZ #1415
Satyrium chlorocorys Rolfe	Chase 6014
Satyrium longicauda Lindl.	Hopkins 7077
Satyrium trinerve Lindl.	FoZ #34622
Solenangis conica (Schltr.) L.Jonss.	FoZ #3052
Stenoglottis woodii Schltr.	Woodburn 30b
Stenoglottis zambesiaca Rolfe (incl. *S. fimbriata* sensu Summerh.)	Chase 6018
Stolzia repens (Rolfe) Summerh. var. *obtusa* G.Will.	Ball 1398
Stolzia repens (Rolfe) Summerh. var. *repens*	Wild 2811
Taeniophyllum coxii (Summerh.) Summerh.	FoZ #64342

Name / authority	Voucher
Tridactyle anthomaniaca (Rchb.f.) Summerh.	Grosvenor 862
Tridactyle bicaudata (Lindl.) Schltr.	Plowes 2892
Tridactyle inaequilonga (De Wild.) Schltr.	Obermeyer 2087
Tridactyle tricuspis (Bolus) Schltr.	Chase 6101
Tridactyle tridactylites (Rolfe) Schltr.	Ball 160
Tridactyle tridentata (Harv.) Schltr.	FoZ #15348
Vanilla polylepis Summerh.	Plowes 2667
Ypsilopus erectus (P.J.Cribb) P.J.Cribb & J.L.Stewart	Ball 1315
Poaceae	
Agrostis lachnantha Nees	Corby 244
Andropogon eucomus Nees subsp. *eucomus*	FoZ #15338
Andropogon eucomus Nees subsp. *huillensis* (Rendle) Sales	Hyde s.r.
Andropogon schirensis A.Rich.	Pope et al. 6608
Arthraxon lancifolius (Trin.) Hochst.	Chase 7096
Bewsia biflora (Hack.) Gooss.	Pope et al 6606
Brachypodium flexum Nees	Hyde 97
**Briza maxima* L.	FoZ #93
**Briza minor* L.	FoZ #95
**Bromus catharticus* Vahl	Hyde 297
**Cenchrus clandestinus* (Chiov.) Morrone (=*Pennisteum clandestinum* Chiov.)	FoZ #4006
Coelachne africana Pilg.	Biegel 2427
Craspedorhachis africana Benth.	Runhaar 844
Cymbopogon nardus (L.) Rendle	Runhaar 77
Cynodon dactylon (L.) Pers.	Hyde s.r.
Digitaria diagonalis (Nees) Stapf	Rattray 1460
Digitaria eriantha Steud.	Cleghorn 1360
Digitaria gazensis Rendle	Hyde s.r.
Digitaria maitlandii Stapf & C.E.Hubb.	Fisher 1127
Digitaria scalarum (Schweinf.) Chiov.	Allison s.n.
Diheteropogon amplectens (Nees) Clayton var. *catangensis* (Chiov.) Clayton	FoZ #15215
Ehrharta erecta Lam.	Corby 247
Eleusine africana Kenn.-O'Byrne	FoZ #16428
Elionurus muticus (Spreng.) Kuntze	Corby 249
Eragrostis acraea De Winter	Crook P70
Eragrostis capensis (Thunb.) Trin.	Runhaar 840
Eragrostis chapelieri (Kunth) Nees	Fisher 220
Eragrostis cilianensis (All.) Janch.	Crook 1050
Eragrostis congesta Oliv.	Corby 262
Eragrostis hispida K.Schum.	FoZ #15208
Eragrostis patens Oliv.	Runhaar 761
Eragrostis plana Nees	Wild 2
Eragrostis racemosa (Thunb.) Steud.	Corby 261
Eragrostis sclerantha Nees subsp. *villosipes* (Jedwabn.) Launert	Runhaar 757
Eragrostis tenuifolia (A.Rich.) Steud.	FoZ #15225
Heteropogon contortus (L.) Roem.& Schult.	Hyde s.r.
Hyparrhenia anamesa Clayton	Hyde 345
Hyparrhenia cymbaria (L.) Stapf	Hyde 350
Hyparrhenia filipendula (Hochst.) Stapf	Hyde s.r.
Hyparrhenia newtonii (Hack.) Stapf var. *macra* Stapf	Corby 246
Hyparrhenia newtonii (Hack.) Stapf var. *newtonii*	Runhaar 762
Hyparrhenia nyassae (Rendle) Stapf	Runhaar 764
Imperata cylindrica (L.) Raeusch.	FoZ #37404
Isachne mauritiana Kunth	Crook 2016
Ischaemum fasciculatum Brongn.	Runhaar 767
Koeleria capensis (Steud.) Nees	Corby 268
**Lolium multiflorum* Lam.	Corby 269
Loudetia flavida (Stapf) C.E.Hubb.	Rattray 1457
Loudetia simplex (Nees) C.E.Hubb.	FoZ #16425
Melinis ambigua Hack. subsp. *ambigua*	Runhaar 838
Melinis minutiflora P.Beauv.	Fisher 1596
Melinis nerviglumis (Franch.) Zizka	Hyde 295
Melinis repens (Willd.) Zizka subsp. *grandiflora* (Hochst.) Zizka	Schweickert 227
Microchloa caffra Nees	Corby 264
Monocymbium ceresiiforme (Nees) Stapf	Hyde 72
Olyra latifolia L.	Müller 3381

Name / authority	Voucher
Oplismenus burmannii (Retz.) P.Beauv.	Pope 3728
Oplismenus compositus (L.) P.Beauv.	Müller 3047
Oplismenus hirtellus (L.) P.Beauv.	Rattray 1449
Oplismenus undulatifolius (Ard.) Roem.& Schult.	Runhaar 752a
Oxytenanthera abyssinica (A.Rich.) Munro	Chase 2172
Panicum inaequilatum Stapf & C.E.Hubb.	Crook 2020
Panicum laticomum Nees	Müller s.n.
Panicum maximum Jacq.	Rattray 1458
Panicum monticola Hook.f.	Runhaar 755
Panicum wiehei Renvoize	Drummond 5094
**Paspalum dilatatum* Poir.	Hyde s.r.
Paspalum scrobiculatum L.	FoZ #15125
**Paspalum urvillei* Steud.	FoZ #2054
Perotis patens Gand.	Wild 5
**Poa annua* L.	Hyde 103
Poecilostachys oplismenoides (Hack.) Clayton (=*Chloachne oplismenoides* (Hack.) Robyns)	Chase 1144
Pogonarthria squarrosa (Roem.& Schult.) Pilg.	Hyde s.r.
Pseudechinolaena polystachya (Kunth) Stapf	Runhaar 842
Rhytachne rottboellioides Desv.	Hyde s.r.
Sacciolepis typhura (Stapf) Stapf	Chase 7836
Schizachyrium sanguineum (Retz.) Alston	Pope 6607
Setaria homonyma (Steud.) Chiov.	FoZ #33050
Setaria megaphylla (Steud.) T.Durand & Schinz	Müller 3078
Setaria sphacelata (Schumach.) Moss	Wild 1
Setaria verticillata (L.) P.Beauv.	FoZ #2086
Sporobolus acinifolius Stapf	Hyde 94
Sporobolus molleri Hack.	Hyde s.r.
Sporobolus piliferus (Trin.) Kunth	Hyde s.r.
Sporobolus pyramidalis P.Beauv.	FoZ #15122
Sporobolus sanguineus Rendle	Hyde 135
Stereochlaena cameronii (Stapf) Pilg.	Hyde s.r.
Streblochaete longiarista (A.Rich.) Pilg.	Müller 3377
Themeda triandra Forssk.	FoZ #15216
Tragus berteronianus Schult.	Crook 1052
Tricholaena monachne (Trin.) Stapf & C.E.Hubb.	FoZ #15211
Tristachya nodiglumis K.Schum.	Chase 7835
Urochloa oligotricha (Fig.& De Not.) Henrard	Sheppard 43
Potamogetonaceae	
Potamogeton nodosus Poir.	FoZ #7454
Potamogeton octandrus Poir.	Chase 5981
Potamogeton pusillus L.	Denny 1315
Smilaceae	
Smilax anceps Willd.	Wild 496
Strelitziaceae	
Strelitzia caudata R.A.Dyer	FoZ #1208
Typhaceae	
Typha capensis (Rohrb.) N.E.Br.	FoZ #99860
Velloziaceae	
Xerophyta sp.	Hyde s.r.
Xyridaceae	
Xyris obscura N.E.Br.	Chase 6027
Zingiberaceae	
Aframomum albiflorum Lock	FoZ #39633
Aframomum angustifolium (Sonn.) K.Schum.	FoZ #34511
**Hedychium gardnerianum* Ker Gawl.	FoZ #294
Siphonochilus aethiopicus (Schweinf.) B.L.Burtt	Eyles 6962
DICOTYLEDONS	
Acanthaceae	
Anisotes pubinervis (T.Anderson) Heine (=*Metarungia pubinervia* (T.Anderson) C.B.Clarke)	Chase 8161
Asystasia gangetica (L.) T.Anderson subsp. *micrantha* (Nees) Ensermu	Chase 2154
Barleria aromatica Oberm.	Hopkins 8049
Barleria fissimuroides I.Darbysh. **NE**	Chase s.n.
Barleria spinulosa Klotzsch subsp. *kirkii* (T.Anderson) I.Darbysh.	Chase 6495
Barleria ventricosa Nees	FoZ #24678
Brillantaisia cicatricosa Lindau (=*B. ulugurica* Lindau)	Chase 854

Name / authority	Voucher
Dicliptera clinopodia Nees	FoZ #1238
Dicliptera extenta S.Moore	Müller 3042
Dyschoriste nagchana (Nees) Bennet	FoZ #33058
Dyschoriste trichocalyx (Oliv.) Lindau subsp. *verticillaris* (C.B.Clarke) Vollesen (=*D. verticillaris* C.B.Clarke)	Carter 2123
Hypoestes aristata (Vahl) Roem.& Schult.	Carter 2119
Hypoestes forskaolii (Vahl) Roem.& Schult. subsp. *forskaolii*	Chase 6493
**Hypoestes phyllostachya* Baker	FoZ #36366
Isoglossa gregorii (S.Moore) Lindau	Müller 3404
Isoglossa milanjiensis S.Moore (=*I. mossambicensis* Lindau)	Chase 7104
Justicia betonica L.	Chase 2159
Justicia bracteata (Hochst.) Zarb (=*Monochema debile* (Forssk.) Nees)	Chase 4557
Justicia matammensis (Schweinf.) Oliv.	Wild 2838
Justicia nyassana Lindau	Chase 5578
Justicia phyllostachys C.B.Clarke	FoZ #15150
Justicia striata (Klotzsch) Bullock	FoZ #28977
Mellera lobulata S.Moore	Chase 5721
Mimulopsis solmsii Schweinf.	FoZ #1616
Phaulopsis imbricata (Forssk.) Sweet subsp. *imbricata*	Chase 786
Pseuderanthemum subviscosum (C.B.Clarke) Stapf	Chase 1785
Ruellia cordata Thunb.	FoZ #33086
Sclerochiton harveyanus Nees	Hopkins 7093
Thunbergia alata Sims	Obermeyer 2141
Thunbergia natalensis Hook.	Biegel 2421
Thunbergia oblongifolia Oliv. (incl. *T. lancifolia* sensu Mapaura & Timberlake)	FoZ #3602, Chase 4689
Thunbergia petersiana Lindau	Grosvenor 783
Thunbergia usambarica Lindau	FoZ #228
Achariaceae	
Kiggelaria africana L.	Chase 7797
Rawsonia lucida Harv.& Sond.	Fisher 1513
Amaranthaceae	
**Achyranthes aspera* L. var. *pubescens* (Moq.) C.C.Towns.	Müller 3090
**Achyranthes aspera* L. var. *sicula* L.	Chase 2151
**Alternanthera caracasana* Kunth	FoZ #15032
**Amaranthus hybridus* L.	FoZ #37392
Amaranthus lividus L. subsp. *polygonoides* (Moq.) Probst	FoZ #15033
Centemopsis gracilenta (Hiern) Schinz	FoZ #4876
**Chenopodium ambrosioides* L.	FoZ #41453
**Chenopodium album* L.	FoZ #25901
Cyathula cylindrica Moq.	Schelpe 363
Cyathula uncinulata (Schrad.) Schinz	FoZ #301
**Gomphrena celosioides* Mart.	FoZ #33043
Anacardiaceae	
Lannea edulis (Sond.) Engl. var. *edulis*	FoZ #15148
**Mangifera indica* L.	FoZ #3612
Searsia chirindensis (Baker f.) Moffett (=*Rhus chirindensis* Baker f.)	Müller 3596
Searsia dentata (Thunb.) F.A.Barkley (=*Rhus dentata* Thunb.)	Müller 806
Searsia longipes (Engl.) Moffett var. longipes (=*Rhus longipes* Engl. var. *longipes*)	Loveridge 1090
Searsia lucida (L.) F.A.Barkley (=*Rhus lucida* L.)	Chase 7358
Searsia natalensis (C.Krauss) F.A.Barkley (=*Rhus natalensis* C.Krauss)	Müller 3619
Searsia tomentosa (L.) F.A.Barkley (=*Rhus tomentosa* L.)	FoZ #26271
Annonaceae	
Annona senegalensis Pers. subsp. *senegalensis*	FoZ #15212
Artabotrys monteiroae Oliv.	Chase 5822
Monanthotaxis chasei (N.Robson) Verdc.	Müller 3075
Uvaria lucida Benth. subsp. *virens* (N.E.Br.) Verdc.	Müller 3094
Xylopia parviflora (A.Rich.) Benth.	Müller 3618
Aphloiaceae	
Aphloia theiformis (Vahl) Benn.	Chase 517
Apiaceae	
Alepidea peduncularis A.Rich.	FoZ #7647
**Apium leptophyllum* (Pers.) Benth.	FoZ #98903
Centella asiatica (L.) Urb.	FoZ #24588
Centella virgata (L.f.) Drude var. *gracilescens* Domin	Chase 6116
Diplolophium buchananii (Oliv.) C.Norman subsp. *suynnertonii* (Baker f.) Cannon	Symoens et al. 667

Name / authority	Voucher
Heteromorpha arborescens (Spreng.) Cham.& Schltdl. var. *abyssinica* (A.Rich.) H.Wolff	Chase 4417
Heteromorpha arborescens (Spreng.) Cham.& Schltdl. var. *montana* P.J.D.Winter	FoZ #35269
Hydrocotyle mannii Hook.f.	Wild 2840
Pimpinella caffra (Eckl.& Zeyh.) D.Dietr.	Chase 6032
Sanicula elata D.Don	FoZ #23850
Steganotaenia araliacea Hochst. var. *araliacea*	FoZ #33124
Apocynaceae	
Asclepias cucullata (Schltr.) Schltr. subsp. *scabrifolia* (S.Moore) Goyder	Wursten & Ballings 211
Carissa bispinosa (L.) Brenan subsp. *zambesiensis* Kupicha	Chase 7018
Carissa spinarum L. (=*C. edulis* (Forssk.) Vahl)	FoZ #98852
Ceropegia abyssinica Decne.	Chase 5535
Ceropegia lugardae N.E.Br.	Chase 1234
Cryptolepis oblongifolia Schltr.	FoZ #31948
Cynanchum umtalense Liede (=*Cynanchum* sp. no.1)	Chase 6465
Glossostelma carsonii (N.E.Br.) Bullock	Chase 66
Huernia hislopii Turrill subsp. *hislopii*	Wild 2805
Landolphia buchananii (Hallier f.) Stapf	Chase 4594
Landolphia kirkii Hook.f.	FoZ #33147
Margaretta rosea Oliv. subsp. *whytei* (K.Schum.) M.Mwanyambo	FoZ #15142
Mondia whitei (Hook.f.) Skeels	FoZ #2472
Pachycarpus chirindensis (S.Moore) Goyder	Obermeyer 2113
Rauvolfia caffra Sond.	Bamps 587
Secamone alpini Schult.	Pole Evans 5114
Sphaerocodon caffrum (Meisn.) Schltr.	Chase 5563
Strophanthus speciosus (Ward & Harv.) Reber	FoZ #2873
Tabernaemontana stapfiana Britten	Biegel 2418
Tabernaemontana ventricosa A.DC.	Drummond 5082
Tylophora anomala N.E.Br. (=*Cynanchum chirindense* S.Moore)	FoZ #28705
Tylophora sp.no. 2 cf. *tenuipedunculata* (Müller 2841)	Harder 3817
Aquifoliaceae	
Ilex mitis (L.) Radlk. var. *mitis*	Chase 3084
Araliaceae	
Cussonia arborea A.Rich.	Bamps 634
Cussonia spicata Thunb.	FoZ #1163
Polyscias fulva (Hiern) Harms	Chase 1971
Schefflera goetzenii Harms	Wild 2837
Schefflera umbellifera (Sond.) Baill.	Chase 5591
Aristolochiaceae	
Aristolochia albida Duch.	Pole Evans 4822
Asteraceae	
**Acanthospermum australe* (Loefl.) Kuntze	FoZ #433
Adenostemma mauritianum DC.	Müller 1950
**Ageratum conyzoides* L.	FoZ #3545
**Ageratum houstonianum* Mill.	FoZ #435
Anisopappus chinensis (L.) Hook.f.& Arn. subsp. *chinensis* var. *dentatus* (DC.) S.Ortíz, Paiva & Rodr.Oubiña	Chase 5581
Anisopappus kirkii (Oliv.) Brenan	Schelpe 378
Aspilia mossambicensis (Oliv.) Wild	FoZ #4882
Aspilia pluriseta Schweinf. subsp. *pluriseta*	Bamps et al. 640
Athrixia rosmarinifolia (Walp.) Oliv.& Hiern var. *rosmarinifolia*	Loveridge 1089
Berkheya setifera DC.	FoZ #39978
Berkheya zeyheri (Sond.& Harv.) Oliv.& Hiern	FoZ #3926
**Bidens biternata* (Lour.) Merr.& Sherff	Chase 2153
**Bidens pilosa* L.	FoZ #443
Bothriocline inyangana N.E.Br. var. *inyangana*	Hopkins 6935
**Centratherum punctatum* Cass. subsp. *punctatum*	FoZ #6295
Chrysanthemoides monilifera (L.) Norl. subsp. *septentrionale* Norl.	FoZ #3596
Cineraria deltoidea Sond.	Chase 7787
Cineraria pulchra Cron	FoZ #21501
**Conyza aegyptiaca* (L.) Aiton	FoZ #37464
**Conyza bonariensis* (L.) Cronquist	FoZ #19057
Conyza gouanii (L.) Willd.	FoZ #2258
Conyza pinnata (L.f.) Kuntze	FoZ #7645
**Conyza sumatrensis* (Retz.) E.Walker	FoZ #2471
**Coreopsis lanceolata* L.	FoZ #489

Name / authority	Voucher
**Cotula australis* (Sieb.& Spreng.) Hook.f.	FoZ #933
Crassocephalum crepidioides (Benth.) S.Moore	Chase 8303
Crassocephalum rubens (Jacq.) S.Moore var. *rubens*	FoZ #447
Crassocephalum rubens (Jacq.) S.Moore var. *sarcobasis* (DC.) C.Jeffrey & Beentje	Chase 4576
Crassocephalum × picridifolium (DC.) S.Moore	Chase 2148
Dichrocephala integrifolia (L.f.) Kuntze subsp. *integrifolia*	Chase 7391
Emilia coccinea (Sims) G.Don	FoZ #4114
Emilia discifolia (Oliv.) C.Jeffrey	FoZ #7655
**Erigeron karvinskianus* DC.	FoZ #3551
Erythrocephalum zambesianum Oliv.& Hiern	Wild 469
**Euryops chrysanthemoides* (DC.) B.Nord.	FoZ #41177
**Galinsoga parviflora* Cav.	FoZ #7662
**Galinsoga quadriradiata* Ruiz & Pav.	FoZ #7665
Gerbera piloselloides (L.) Cass.	Chase 8421
Gerbera viridifolia (DC.) Sch.Bip. subsp. *viridifolia*	FoZ #651
**Gnaphalium purpureum* L.	FoZ #2248
Gutenbergia cordifolia Oliv. var. *marginata* (O.Hoffm.) C.Jeffrey	Chase 8291
Helichrysum adenocarpum DC. subsp. *adenocarpum*	Bacon 6844
Helichrysum asperum (Thunb.) Hilliard & B.L.Burtt	FoZ #21420
Helichrysum buchananii Engl.	Chase 6114
Helichrysum candolleanum H.Buek	Carter et al. 2121
Helichrysum cephaloideum DC.	Chase 6026
Helichrysum goetzeanum O.Hoffm.	FoZ #41358
Helichrysum kilimanjari Oliv.	Symoens et al. 687
Helichrysum kraussii Sch.Bip.	Bishop 394
Helichrysum lepidissimum S.Moore	Chase 6115
Helichrysum nitens Oliv.& Hiern subsp. *nitens*	Bacon 6843
Helichrysum nudifolium (L.) Less. var. *nudifolium*	FoZ #4883
Helichrysum nudifolium (L.) Less. var. *oxyphyllum* (DC.) Beentje	FoZ #4884
Helichrysum nudifolium (L.) Less. var. *pilosellum* (L.f.) Beentje	Wild 468
Helichrysum odoratissimum (L.) Sweet	FoZ #2344
Helichrysum panduratum O.Hoffm. var. *panduratum*	Chase 1237
Helichrysum panduratum O.Hoffm. var. *transvaalense* Moeser	FoZ #7468
Helichrysum schimperi (A.Rich.) Moeser	Chase 1237
Helichrysum umbraculigerum Less.	Chase 1355
Hypericophyllum compositarum Steetz	Chase 7093
**Hypochaeris radicata* L.	FoZ #2048
Inula glomerata Oliv.& Hiern	FoZ #1413
Kleinia chimanimaniensis Van Jaarsv. (=*K. galpinii* Hook.f.)	Schelpe 377
Lactuca inermis Forssk.	FoZ #19054
Laggera crispata (Vahl) Hepper & J.R.I.Wood	FoZ #33120
Lipotriche scandens (Schumach.) Orchard subsp. *madagascariensis* (Baker) D.J.N.Hind (=*Melanthera scandens* (Schumach.& Thonn.) Roberty)	Chase 7111
Microglossa pyrifolia (Lam.) Kuntze	FoZ #1621
Mikania carteri Baker	FoZ #4007
Mikania sp. of FoZ	Müller 3036
Mikaniopsis cisampelina (DC.) C.Jeffrey	Fisher 1576
**Montanoa hibiscifolia* Benth.	Wild 5513
**Neojeffreya decurrens* (L.) Cabrera	FoZ #7332
Nidorella auriculata DC. subsp. *auriculata*	FoZ #15227
Nidorella resedifolia DC. subsp. *resedifolia*	Chase 761
Osteospermum monocepahalum (Oliv.& Hiern) Norl.	FoZ #3919
Phymaspermum bolusii (Hutch.) Källersjö	FoZ #15330
**Pseudognaphalium luteo-album* (L.) Hilliard & B.L.Burtt	FoZ #2186
Pseudognaphalium oligandrum (DC.) Hilliard & B.L.Burtt	FoZ #2188
Schistostephium crataegifolium (DC.) Harv. (=*S. artemisiifolium* Baker)	Bishop 395
Schistostephium heptalobum (DC.) Oliv.& Hiern	FoZ #15218
Schistostephium oxylobum S.Moore	Chase 8423
Senecio deltoideus Less.	FoZ #2219
Senecio gazensis S.Moore	FoZ #15411
Senecio hochstetteri A.Rich.	Wild 2821
Senecio inornatus DC.	Chase 6105
Senecio latifolius DC.	Wild 38
**Senecio macroglossus* DC.	Fisher 1545
Senecio milanjianus S.Moore	Wild 2830

Name / authority	Voucher
Senecio oxyriifolius DC.	Wild 520
Senecio purpureus L.	Chase 7140
Senecio ruwenzoriensis S.Moore	Wild 2822
Senecio syringifolius O.Hoffm.	Hopkins 8046
Senecio tamoides DC.	FoZ #2222
Senecio triactinus S.Moore	FoZ #5793
Sigesbeckia orientalis L.	FoZ #84888
Solanecio mannii (Hook.f.) C.Jeffrey	FoZ #469
Sonchus friesii Boulos var. *integer* G.V.Pope	FoZ #922
**Sonchus oleraceus* L.	FoZ #920
Spilanthes mauritiana (Pers.) DC.	Eyles 7082
Stomatanthes africanus (Oliv.& Hiern) R.M.King & H.Rob.	FoZ #15199
**Tagetes minuta* L.	FoZ #35492
Tolpis capensis (L.) Sch.Bip.	FoZ #3753
**Tridax procumbens* L.	FoZ #3925
**Vernonanthura polyanthes* (Sprengel) Vega & Dematteis	FoZ #3740
Vernonia acuminatissima S.Moore	Hopkins 8053
Vernonia adoensis Sch.Bip.	FoZ #25856
Vernonia bainesii Oliv.& Hiern subsp. *bainesii*	Whellan 747
Vernonia calvoana (Hook.f.) Hook.f. subsp. *meridionalis* (Wild) C.Jeffrey	FoZ # 475
Vernonia colorata (Willd.) Drake subsp. *colorata*	FoZ #2322
Vernonia galpinii Klatt	Chase 3105
Vernonia glaberrima O.Hoffm.	FoZ #4878
Vernonia holstii O.Hoffm.	Chase 5595
Vernonia karaguensis Oliv.& Hiern	Chase 7138
Vernonia lundiensis (Hutch.) Wild & G.V.Pope	Ferrar 4069
Vernonia melleri Oliv.& Hiern var. *melleri*	Chase 5582
Vernonia myriantha Hook.f.	Plowes 2706
Vernonia natalensis Walp.	Fisher 212
Vernonia wollastonii S.Moore	Müller 3060
Vernonia petersii Oliv.	FoZ #43356
Balsaminaceae	
Impatiens cecilii N.E.Br. subsp. *cecilii*	Plowes 2322
Impatiens sylvicola Burtt Davy & Greenway	Eyles 5476
Begoniaceae	
Begonia sonderiana Irmsch.	Chase 995
Bignoniaceae	
**Amphilophium crucigerum* (L.) L.G.Lohmann	FoZ #18307
**Dolichandra unguis*-cati (L.) L.G.Lohmann	FoZ #3975
**Jacaranda mimosifolia* D.Don	FoZ #18352
Podranea brycei (N.E.Br.) Sprague	FoZ #3576
Boraginaceae	
Cynoglossum lanceolatum Forssk.	Chase 4390
Cynoglossum wildii E.S.Martins	Williams 215
Brassicaceae	
Cardamine africana L.	FoZ #15459
**Cardamine flexuosa* With.	FoZ #636
**Coronopus didymus* (L.) Sm.	FoZ #19047
**Lepidium bonariense* L.	FoZ #41218
Cactaceae	
Rhipsalis baccifera (J.Mill.) Stearn	Eyles 6589
Campanulaceae	
Lobelia erinus L.	Schelpe 366
Lobelia goetzei Diels	FoZ #867
Lobelia stricklandiae Gilliland	Wild 1592
Wahlenbergia denticulata (Burch.) A.DC.	FoZ #34881
Wahlenbergia madagascariensis A.DC.	FoZ #5012
Wahlenbergia subaphylla (Baker) Thulin subsp. *scoparia* (Wild) Thulin	Chase 3104
Wahlenbergia undulata (L.f.) A.DC.	Chase 6125
Wahlenbergia virgata Engl.	FoZ #3750
Capparaceae	
Cleome monophylla L.	Hyde s.r.
Ritchiea albersii Gilg	Chase 6225
Caprifoliaceae	
**Sambucus canadensis* L.	FoZ #37446

Name / authority	Voucher
Caryophyllaceae	
**Cerastium glomeratum* Thuill.	Whellan 1560
Drymaria cordata (L.) Roem.& Schult. var. *cordata*	Chase 6049
**Sagina apetala* Ard.	FoZ #1808
Silene burchellii DC. var. *angustifolia* Sond.	Chase 7224
Stellaria mannii Hook.f.	Müller plot 68
**Stellaria media* (L.) Vill.	FoZ #79972
Celastraceae	
Allocassine laurifolia (Harv.) N.Robson	Chase 7199
Catha edulis (Vahl) Endl.	Chase 784
Elaeodendron croceum (Thunb.) DC.	Müller plot 150
Gymnosporia buxifolia (L.) Szyszyl.	Chase 5571
Gymnosporia harveyana Loes. subsp. *harveyana*	FoZ #15259
Gymnosporia mossambicensis (Klotzsch) Loes. subsp. *mossambicensis*	Chase 6279
Gymnosporia senegalensis (Lam.) Loes.	FoZ #15183
Hippocratea africana (Willd.) Loes. var. *richardiana* (Cambess.) N.Robson	Müller 3149
Maytenus acuminata (L.f.) Loes. var. *acuminata*	Chase 4416
Maytenus chasei N.Robson	Chase 5634
Maytenus undata (Thunb.) Blakelock	Müller 2803
Chrysobalanaceae	
Parinari curatellifolia Benth.	FoZ #2039
Clusiaceae	
Garcinia buchananii Baker	Chase 5296
Garcinia kingaensis Engl.	Müller plot 74
Harungana madagascariensis Poir.	Chase 1970
Hypericum aethiopicum Thunb. subsp. *sonderi* (Bredell) N.Robson	FoZ #15321
Hypericum peplidifolium A.Rich.	FoZ #15310
Hypericum revolutum Vahl	Chase 1181
Hypericum roeperianum A.Rich.	Whellan 1138
Psorospermum febrifugum Spach	FoZ #15157
Combretaceae	
Combretum molle G.Don	FoZ #23920
Combretum psidioides Welw. subsp. *psidioides*	West 6373
Connaraceae	
Agelaea pentagyna (Lam.) Baill.	Drummond 5079
Convolvulaceae	
**Dichondra micrantha* Urb.	FoZ #929
Hewittia malabarica (L.) Suresh	FoZ #18123
**Ipomoea cairica* (L.) Sweet var. *cairica*	FoZ #1404
Ipomoea involucrata P.Beauv. var. *involucrata*	Chase 2163
Ipomoea obscura (L.) Ker Gawl. var. *obscura*	FoZ #4128
Turbina holubii (Baker) A.Meeuse	Chase 8589
Cornaceae	
Curtisia dentata (Burm.f.) C.A.Sm.	Chase 4168
Crassulaceae	
**Bryophyllum pinnatum* (Lam.) Oken	FoZ #25790
**Bryophyllum tubiflorum* Harv.	FoZ #3407
Crassula alsinoides (Hook.f.) Engl.	Mavi 1558
Crassula alticola R.Fern.	FoZ #39862
Crassula capitella Thunb. subsp. *nodulosa* (Schönland) Toelken	FoZ #7384
Crassula expansa Dryand. subsp. *expansa*	FoZ #79967
Crassula lanceolata (Eckl.& Zeyh) Walp. subsp. *transvaalensis* (Kuntze) Toelken	FoZ #3494
Crassula sarcocaulis Eckl.& Zeyh. subsp. *sarcocaulis*	Ferrar s.n.
Crassula sarmentosa Harv.	FoZ #3499
Crassula setulosa Harv. var. *setulosa*	Chase 6134
Crassula swaziensis Schönland subsp. *swaziensis* var. *swaziensis*	Chase 6149
Kalanchoe crenata (Andrews) Haw.	Chase 8445
Kalanchoe lanceolata (Forssk.) Pers.	FoZ #1620
Kalanchoe luciae Raym.-Hamet subsp. *luciae*	FoZ #4061
Cucurbitaceae	
Coccinia adoensis (A.Rich.) Cogn.	Chase 7388
Cucumis zeyheri Sond.	Chase 8485
Momordica foetida Schumach.	Wild 14218
Oreosyce africana Hook.f.	Chase 6222
Peponium chirindense (Baker f.) Cogn.	Müller 3486

Name / authority	Voucher
Zehneria minutiflora (Cogn.) C.Jeffrey	Ferrar 4020
Zehneria scabra (L.f.) Sond. subsp. *scabra*	Müller plot 169
Zehneria thwaitesii (Schweinf.) C.Jeffrey	Chase 5550
Dipsacaceae	
Scabiosa columbaria L.	FoZ #556
Dipterocarpaceae	
Monotes engleri Gilg	FoZ #557
Droseraceae	
Drosera burkeana Planch.	Carly 467
Drosera dielsiana Exell & J.R.Laundon	FoZ #644
Ebenaceae	
Diospyros abyssinica (Hiern) F.White subsp. *abyssinica*	Müller 3043
Diospyros lycioides Desf. subsp. *sericea* (Bernh.) De Winter	Bamps 626
Diospyros natalensis (Harv.) Brenan subsp. *nummularia* (Brenan) Jordaan	Müller 2556
Diospyros whyteana (Hiern) F.White	Chase 1495
Ericaceae	
Erica hexandra (S.Moore) E.G.H.Oliv.	van der Berghen 623
Erica johnstoniana Britten	Galpin 9267
Erythroxylaceae	
Erythroxylum emarginatum Thonn.	Bamps et al. 648
Euphorbiaceae	
Adenocline acuta (Thunb.) Baill.	Chase 8491
Croton sylvaticus C.Krauss	Drummond 5090
Euphorbia benthamii Hiern	Chase 5539
**Euphorbia peplus* L.	FoZ #581
**Euphorbia prostrata* Aiton	FoZ #3742
**Euphorbia tirucalli* L.	Chase 5161
**Homalanthus populifolius* Graham	FoZ #3728
Leidesia procumbens (L.) Prain	Wild 6447
Macaranga capensis (Baill.) Sim	Chase 5565
Macaranga mellifera Prain	Chase 5455
Neoboutonia macrocalyx Pax	FoZ #7425
**Ricinus communis* L. var. *communis*	FoZ #25729
Shirakiopsis elliptica (Hochst.) Esser (=*Sapium ellipticum* (Krauss) Pax)	Chase 7115
Suregada procera (Prain) Croizat	Müller 2557
Tannodia swynnertonii (S.Moore) Prain	Müller plot 172
**Vernicia montana* Lour.	FoZ #3799
Fabaceae: Caesalpinioideae	
Bauhinia galpinii N.E.Br.	FoZ #506
Bauhinia petersiana Bolle	FoZ #1030
**Bauhinia variegata* L. var. *variegata*	FoZ #17371
Brachystegia spiciformis Benth.	Chase 4153
Brachystegia utilis Hutch.& Burtt Davy	Chase 4154
Chamaecrista kirkii (Oliv.) Standl. var. *kirkii*	Chase 5489
Chamaecrista parva (Steyaert) Lock	Ferrar s.n.
Chamaecrista wittei (Ghesq.) Lock	Chase 8493
Julbernardia globiflora (Benth.) Troupin	FoZ #1040
**Senna didymobotrya* (Fresen.) H.S.Irwin & Barneby	Methuen 43
Senna petersiana (Bolle) Lock	FoZ #3923
**Senna septemtrionalis* (Viv.) H.S.Irwin & Barneby	Grosvenor 11
Fabaceae: Mimosoideae	
Acacia abyssinica Benth.	Chase 7796
Acacia amythethophylla A.Rich.	FoZ #15446
Acacia cornigera (L.) Willd. (=*A. spadicigera* Schltr. & Cham.)	Obermeyer 2061
**Acacia mearnsii* De Wild.	FoZ #3591
**Acacia melanoxylon* R.Br.	Biegel 2431
**Acacia podalyriifolia* G.Don	FoZ #3800
Acacia sieberiana DC. var. *woodii* (Burtt Davy) Keay & Brenan	Biegel 2430
Albizia adianthifolia (Schumach.) W.Wight	Müller 3383
Albizia antunesiana Harms	FoZ #15145
Albizia glaberrima (Schumach.& Thonn.) Benth. var. *glabrescens* (Oliv.) Brenan	Müller 3097
Albizia gummifera (J.F.Gmel.) C.A.Sm.	Wild 1596
Albizia schimperiana Oliv. var. *schimperiana*	Chase 6223
Dichrostachys cinerea (L.) Wight & Arn.	FoZ #15202
Entada abyssinica A.Rich.	Chase 5554

Name / authority	Voucher
Newtonia buchananii (Baker f.) G.C.C.Gilbert & Boutique	Chase 878
Fabaceae: Papilionoideae	
Aeschynomene nodulosa (Baker) Baker f. var. *nodulosa*	FoZ #2041
Argyrolobium rupestre (E.Mey.) Walp. subsp. *rupestre*	Bamps et al. s.n.
Argyrolobium tomentosum (Andrews) Druce	FoZ #41255
Craibia brevicaudata (Vatke) Dunn subsp. *baptistarum* (Büttner) J.B.Gillett	Wild 1586
Crotalaria capensis Jacq.	Corby 1582
Crotalaria cephalotes A.Rich.	Chase 8565
Crotalaria chirindae Baker f.	Hopkins 8033
Crotalaria gazensis Baker f. subsp. *gazensis*	Müller 6684
Crotalaria hyssopifolia Klotzsch	Chase 7055
Crotalaria laburnifolia L. subsp. *australis* (Baker f.) Polhill	Corby 1445
Crotalaria lachnophora A.Rich.	Chase 7449
Crotalaria lanceolata E.Mey. subsp. *lanceolata*	Chase 7469
Crotalaria pallida Aiton var. *pallida*	FoZ #5617
Crotalaria variegata Baker (=*C. sericifolia* Harms)	Chase 6366
Dalbergia lactea Vatke	Müller plot 149
Dalbergia nitidula Baker	Chase 168
Desmodium adscendens (Sw.) DC. var. *robustum* B.G.Schub.	FoZ #35168
Desmodium barbatum (L.) Benth. var. *dimorphum* (Baker) B.G.Schub.	Staples 183
Desmodium repandum (Vahl) DC.	Chase 580
Desmodium setigerum (E.Mey.) Harv.	Chase 8557
**Desmodium uncinatum* (Jacq.) DC.	FoZ #3543
Dolichos kilimandscharicus Taub. subsp. *kilimandscharicus*	FoZ #15323
Dolichos sericeus E.Mey. subsp. *sericeus*	Chase 6930
Dumasia villosa DC. var. *villosa*	Whellan 1598
Eriosema buchananii Baker f. var. *buchananii*	FoZ #52033
Eriosema burkei Harv.	Corby 266
Eriosema chrysadenium Taub. var. *chrysadenium*	FoZ #6264
Eriosema ellipticum Baker subsp. *ellipticum*	FoZ #1617
Eriosema psoraleoides (Lam.) G.Don	FoZ #1697
Erythrina lysistemon Hutch.	FoZ #1688
Flemingia grahamiana Wight & Arn.	Chase 1739
Indigofera arrecta A.Rich.	FoZ #40764
Indigofera cecilii N.E.Br.	FoZ #7519
Indigofera hilaris Eckl.& Zeyh.	Jacobsen 1488
Indigofera lyallii Baker subsp. *lyallii*	FoZ #5628
Indigofera paniculata Pers. subsp. *gazensis* (Baker f.) J.B.Gillett	Chase 6109
Indigofera setiflora Baker var. *setifera*	Hopkins 7080
Kotschya strigosa (Benth.) Dewit & P.A.Duvign. var. *strigosa*	Chase 3732
Lablab purpureus (L.) Sw. subsp. *uncinatus* Verdc. var. *uncinatus*	Chase 8292
Lotononis listii Polhill	FoZ #73221
Lotus arabicus L.	Bamps et al. 676
Lotus discolor E.Mey. subsp. *mollis* J.B.Gillett	Chase 3107
Lotus namulensis Brand	Chase 3106
Macrotyloma densiflorum (Baker) Verdc. var. *densiflorum*	Carter 2128
Mucuna coriacea Baker subsp. *irritans* (Burtt Davy) Verdc.	FoZ #1699
Ormocarpum kirkii S.Moore	Carter 2129
Otholobium foliosum (Oliv.) C.H.Stirt. subsp. *gazense* (Baker f.) Verdc.	FoZ #2366
Philenoptera violacea (Klotzsch) Schrire (=*Lonchocarpus capassa* Rolfe)	Chase 60
Pseudarthria hookeri Wight & Arn. var. *hookeri*	FoZ #2457
Pterocarpus angolensis DC.	FoZ #15141
Pterocarpus rotundifolius (Sond.) Druce subsp. *rotundifolius*	FoZ #98755
Rhynchosia clivorum S.Moore subsp. *pycnantha* (Harms) Verdc.	Fischer 1313
Rhynchosia monophylla Schltr.	FoZ #3749
Rhynchosia swynnertonii Baker f.	Chase 8004
Sphenostylis zimbabweensis Mithen	Chase 1530
Stylosanthes fruticosa (Retz.) Alston	Staples 185
Tephrosia dasyphylla Baker subsp. *dasyphylla*	Chase 1964
Tephrosia festina Brummitt	Biegel 2432
Tephrosia meisneri Hutch.& Burtt Davy (=*T. glomeruliflora* Meisn. subsp. *meisneri* (Hutch.& Burtt Davy) Schrire)	Chase 8151
Tephrosia paniculata Baker subsp. *paniculata*	Chase 7318
Tephrosia rhodesica Baker f. var. *polystachyoides* (Baker f.) Brummitt	Chase 1966
Tylosema fassoglensis (Schweinf.) Torre & Hillc.	FoZ #3927

Name / authority	Voucher
Vigna gazensis Baker f.	Chase 6510
Vigna schlechteri Harms	Wild 2844
Vigna vexillata (L.) A.Rich. var. *vexillata*	FoZ #24719
Zornia milneana Mohlenbr.	FoZ #41451
Gelsemiaceae	
Mostuea brunonis Didr. var. *brunonis*	Chase 6745
Gentianaceae	
Sebaea leiostyla Gilg	Hopkins 7257
Geraniaceae	
Geranium arabicum Forssk. subsp. *arabicum*	FoZ #25127
Geranium incanum Burm.f. subsp. *nyassense* (R.Knuth) J.R.Laundon	Drummond 5093
Pelargonium luridum (Andrews) Sweet	Chase 7921
Pelargonium mossambicense Engl.	Eyles 9276
Gesneriaceae	
Streptocarpus eylesii S.Moore subsp. *eylesii*	Plowes 2170
Streptocarpus hirticapsa B.L.Burtt	Ferrar s.n.
Streptocarpus michelmorei B.L.Burtt	FoZ #627
Streptocarpus umtaliensis B.L.Burtt **NE**	Chase 1374
Halogoraceae	
**Myriophyllum aquaticum* (Vell.) Verdc.	Denny 1312
Heteropyxidaceae	
Heteropyxis dehniae Suess.	FoZ #3610
Hydrostachyaceae	
Hydrostachys polymorpha A.Braun	Chase 6637
Icacinaceae	
Apodytes dimidiata Arn. subsp. *dimidiata*	Chase 366
Iteaceae	
Choristylis rhamnoides Harv.	Chase 1736
Lamiaceae	
Aeollanthus buchnerianus Briq.	Fisher 1627
Aeollanthus serpiculoides Baker	Whellan 749
Clerodendrum cephalanthum Oliv. subsp. *swynnertonii* (S.Moore) Verdc.	Chase 2164
Haumaniastrum dissitifolium (Baker) A.J.Paton	FoZ #73536
Haumaniastrum sericeum (Briq.) A.J.Paton	Hopkins s.n.
Haumaniastrum villosum (Benth.) A.J.Paton	Chase 6566
Hoslundia opposita Vahl	FoZ #1752
**Hyptis pectinata* (L.) Poit.	FoZ #876
**Hyptis suaveolens* (L.) Poit.	FoZ #27586
Leonotis ocymifolia (Burm.f.) Iwarsson var. *raineriana* (Vis.) Iwarsson	FoZ #34929
Leucas milanjiana Gürke	FoZ #3922
Micromeria imbricata (Forssk.) C.Chr. var. *imbricata* (=*Satureja punctata* (Benth.) Briq.)	Chase 7137
Ocimum obovatum Benth. subsp. *obovatum* var. *obovatum*	FoZ #3364
Plectranthus chimanimanensis S.Moore	Chase 6021
Plectranthus esculentus N.E.Br.	FoZ #7536
Plectranthus hadiensis (Forssk.) Spreng.	FoZ #21128
Plectranthus hereroensis Engl.	Chase 6512
Plectranthus kapatensis (R.E.Fr.) J.K.Morton	Chase 5563
Plectranthus lanuginosus (Benth.) Agnew	FoZ #15345
Plectranthus laxiflorus Benth.	Chase 1999
Plectranthus sanguineus Britten	FoZ #2052
Plectranthus swynnertonii S.Moore	Eyles 7084
Pycnostachys reticulata (E.Mey.) Benth.	Chase 2000
Pycnostachys urticifolia Hook.	FoZ #37502
Rotheca myricoides (Hochst.) D.A.Steane & Mabb.	FoZ #873
**Salvia coccinea* Etl.	FoZ #37444
Tetradenia riparia (Hochst.) Codd	Carter 2131
Vitex doniana Sweet	Masterson 570
Vitex madiensis Oliv. subsp. *milanjiensis* (Britten) F.White	Chase 1965
Lauraceae	
**Cinnamomum camphora* (L.) J.Presl	FoZ #23896
**Cinnamomum verum* J.Presl	FoZ #25873
Cryptocarya liebertiana Engl.	Müller 3382
**Persea americana* Mill.	FoZ #3716
Lentibulariaceae	
Genlisea hispidula Stapf	Philcox et al. 8951

Name / authority	Voucher
Utricularia firmula Oliv.	Philcox et al. 8952
Utricularia livida E.Mey.	Chase 6112
Utricularia scandens Benj.	Chase 5539
Utricularia subulata L.	Philcox et al. 8950
Linderniaceae	
Craterostigma lanceolatum (Engl.) Skan	FoZ #53083
Craterostigma sp. no. 1 cf. *lanceolatum*	FoZ #28553
Linderniella pulchella (Skan) Eb.Fisch., Schäferh.& Kai Müll. (=*Lindernia pulchella* (Skan) Philcox)	Philcox 8971
Linderniella wilmsii (Engl.) Eb.Fisch., Schäferh.& Kai Müll. (=*Lindernia wilmsii* (Engl.) Philcox)	Philcox 8972
Loganiaceae	
Strychnos angolensis Gilg	Müller 3801
Strychnos lucens Baker	FoZ #1306
Strychnos spinosa Lam.	FoZ #15189
Strychnos usambarensis Gilg	FoZ #1308
Loranthaceae	
Agelanthus lancifolius Polhill & Wiens	FoZ #39863
Agelanthus molleri (Engl.) Polhill & Wiens	Polhill & Pope 4746
Agelanthus nyasicus (Baker & Sprague) Polhill & Wiens	Chase 578
Englerina oedostemon (Danser) Polhill & Wiens **NE**	Polhill & Pope 4747
Malvaceae: Byttnerioideae, Helicteroideae & Sterculioideae	
Cola greenwayi Brenan var. *greenwayi*	Drummond 5092
Dombeya burgessiae Harv.	Loveridge 1089
Dombeya rotundifolia (Hochst.) Planch.	FoZ #1785
Melhania randii Baker f.	FoZ #3924
Waltheria indica L.	FoZ #37490
Malvaceae: Grewioideae	
Grewia occidentalis L. var. *occidentalis*	FoZ #3190
Grewia stolzii Ulbr.	FoZ #7353
Sparrmannia ricinocarpa (Eckl.& Zeyh.) Kuntze	Chase 1678
Triumfetta annua L.	FoZ #7392
Triumfetta pilosa Roth var. *pilosa*	FoZ #7393
Triumfetta rhomboidea Jacq.	Wild 500
Malvaceae: Malvoideae	
Abutilon sonneratianum (Cav.) Sweet	Wild 472
Azanza garckeana (F.Hoffm.) Exell & Hillc.	FoZ #98753
Hibiscus fuscus Garcke	Chase 8301
Hibiscus shirensis Sprague & Hutch.	FoZ #7152
Hibiscus surattensis L.	Chase 8558
**Malvastrum coromandelianum* (L.) Garcke	FoZ #4040
Pavonia columella Cav.	Fisher 1601
Pavonia urens Cav.	FoZ #1221
Melastomataceae	
Antherotoma naudinii Hook.f.	Schelpe 365
Dissotis princeps (Kunth) Triana var. *princeps*	Whellan 1980
Meliaceae	
Ekebergia benguelensis C.DC.	FoZ #98848
Ekebergia capensis Sparrm.	Chase 555
Khaya anthotheca (Welw.) C.DC.	FoZ #25861
Trichilia dregeana Sond.	Chase 3506
Melianthaceae	
Bersama abyssinica Fresen. subsp. *nyassae* (Baker f.) F.White	FoZ #98884
Bersama swynnertonii Baker f.	Chase 7020
Menispermaceae	
Cissampelos mucronata A.Rich.	FoZ #37441
Cissampelos torulosa Harv.	Chase 1544
Stephania abyssinica (Quart.-Dill.& A.Rich.) Walp. var. *abyssinica*	Wild 495
Stephania abyssinica (Quart.-Dill.& A.Rich.) Walp. var. *tomentella* (Oliv.) Diels	FoZ #27674
Tiliacora funifera (Miers) Oliv.	Grosvenor 265
Molluginaceae	
Corrigiola drymarioides Baker f.	Chase 1183
Mollugo cerviana (L.) Ser. var. *cerviana*	Chase s.n.
Monimiaceae	
Xymalos monospora (Harv.) Baill.	Chase 6179
Moraceae	
Dorstenia buchananii Engl. var. *buchananii*	Chase 6259

Name / authority	Voucher
Ficus chirindensis C.C.Berg	Müller plot 78
Ficus craterostoma Mildbr.& Burret	Plowes 2184
Ficus exasperata Vahl	Masterson 602
Ficus natalensis Hochst. subsp. *graniticola* J.E.Burrows	Hyde s.n.
Ficus rokko Warb.& Schweinf. (=*F. thonningii* Blume in part)	Biegel 2490
Ficus scassellatii Pamp. subsp. *scassellatii*	FoZ #15572
Ficus sur Forssk.	FoZ #3525
Trilepisium madagascariense DC.	Chase 5625
Myricaceae	
Morella pilulifera (Rendle) Killick	FoZ #3553
Myrothamnaceae	
Myrothamnus flabellifolius Welw.	FoZ #2038
Myrsinaceae	
Embelia schimperi Vatke	Chase 1443
Maesa lanceolata Forssk.	Obermeyer 2053
Myrsine africana L.	Chase 5295
Rapanea melanophloeos (L.) Mez	Chase 6739
Myrtaceae	
Eugenia malangensis (O.Hoffm.) Nied.	FoZ #1226
Eugenia natalitia Sond. (incl. *E. nyassensis* Engl., *E. capensis* (Eckl.& Zeyh.) Sond. subsp. *nyassensis* (Engl.) F.White)	Chase 7219
**Psidium cattleianum* Sabine	FoZ #7397
**Psidium guajava* L.	FoZ #3529
Syzygium cordatum C.Krauss	Bamps et al. 621
Syzygium guineense (Willd.) DC. subsp. *afromontanum* F.White (=*S. gerrardii* (Hook.f.) F.White)	Chase 5626
**Syzygium jambos* (L.) Alston	FoZ #25884
Ochnaceae	
Ochna holstii Engl.	Wild 1594
Oleaceae	
Chionanthus battiscombei (Hutch.) Stearn	Müller 3077
Chionanthus foveolatus (E.Mey.) Stearn subsp. *major* (I.Verd.) Stearn	Müller plot 153
Jasminum abyssinicum DC.	FoZ #15266
Jasminum streptopus E.Mey.	Müller plot 149
Olea capensis L. subsp. *macrocarpa* (C.H.Wright) I.Verd.	Müller plot 152
Schrebera alata (Hochst.) Welw.	FoZ #3586
Opiliaceae	
Opilia amentacea Roxb.	FoZ #6110
Orobanchaceae	
Alectra sessiliflora (Vahl) Kuntze (incl. var. *monticola* (Engl.) Melch. & var. *senegalensis* (Benth.) Hepper)	Chase 6035, Philcox 8953
Buchnera speciosa Skan	Chase 4199
Cycnium adonense Benth. subsp. *adonense*	Chase 611
Sopubia ramosa (Hochst.) Hochst.	Bacon s.n.
Striga bilabiata (Thunb.) Kuntze	Wild 2807
Striga elegans Benth.	FoZ #24937
Oxalidaceae	
Biophytum umbraculum Welw.	Chase 5534
**Oxalis corniculata* L.	FoZ #7
**Oxalis latifolia* Kunth	FoZ #5774
Oxalis semiloba Sond. subsp. *semiloba*	FoZ #15219
Passifloraceae	
Adenia digitata (Harv.) Engl.	FoZ #37462
Adenia gummifera (Harv.) Harms var. *gummifera*	FoZ #98866
Adenia lobata (Jacq.) Engl. subsp. *rumicifolia* (Engl.& Harms) Lye	Müller 3621
Basananthe apetala (Baker f.) W.J.de Wilde	FoZ #22042
**Passiflora edulis* Sims	FoZ #3760
Penaeaceae	
Olinia vanguerioides Baker f.	Fisher 1218
Peraceae	
Clutia abyssinica Jaub.& Spach var. *abyssinica*	Whellan 1599
Clutia paxii Pax	FoZ #40916
Clutia swynnertonii S.Moore	Galpin 9271
Phyllanthaceae	
Antidesma membranaceum Müll.Arg.	Müller 3380
Antidesma venosum Tul.	FoZ #15191

Name / authority	Voucher
Antidesma vogelianum Müll.Arg.	Hyde s.r.
Bridelia micrantha (Hochst.) Baill.	FoZ #3580
Cleistanthus polystachyus Planch. subsp. *milleri* (Dunkley) Radcl.-Sm. (=*C. apetalus* S.Moore)	Wild 5551
Margaritaria discoidea (Baill.) Webster var. *nitida* (Pax) Radcl.-Sm.	Chase 5483
Phyllanthus beillei Hutch.	Chase 5596
Phyllanthus ovalifolius Forssk. (=*P. guineensis* Pax)	Müller plot 79
Uapaca kirkiana Müll.Arg. var. *kirkiana*	FoZ #596
Phytolaccaceae	
Phytolacca dodecandra L'Hér.	Müller 3092
**Phytolacca octandra* L.	FoZ #2561
Piperaceae	
Peperomia bangroana C.DC. (=*P. rotundifolia* sensu FZ)	Müller 3067
Peperomia blanda (Jacq.) Kunth var. *leptostachya* (Hook.& Arn.) Düll	Chase 851
Peperomia retusa (L.f.) A.Dietr.	Wild 2836
Peperomia tetraphylla (G.Forst.) Hook.& Arn.	Müller 3061
Piper capense L.f. var. *capense*	Plowes 2163
Pittosporaceae	
Pittosporum viridiflorum Sims var. *viridiflorum*	Chase 7218
Plantaginaceae	
**Linaria vulgaris* Mill.	FoZ #5438
**Plantago major* L.	Ferrar s.n.
**Veronica javanica* Blume	Wild 1591
Polemoniaceae	
**Cobaea scandens* Cav.	Edwards s.n.
Polygalaceae	
Polygala gazensis Baker f.	Schelpe 374
Polygala ohlendorfiana Eckl.& Zeyh.	Chase 7873
Polygala virgata Thunb. var. *decora* (Sond.) Harv.	FoZ #25783
Polygala wilmsii Chodat	Obermeyer 2048
Securidaca longepedunculata Fresen.	FoZ #3920
Polygonaceae	
Oxygonum dregeanum Meisn. subsp. *canescens* (Sond.) Germish.	Craster s.n.
**Persicaria capitata* (D.Don) H.Gross	FoZ #1294
**Rumex acetosella* L. subsp. *angiocarpus* (Murb.) Murb.	FoZ #2778
**Rumex crispus* L.	FoZ #2781
Rumex sagittatus Thunb.	FoZ #2783
Primulaceae	
Ardisiandra wettsteinii R.Wagner	FoZ #2772
Proteaceae	
Faurea rochetiana (A.Rich.) Pic.Serm.	Fisher 337
Faurea rubriflora Marner	Chase 6045
Faurea saligna Harv.	Hyde s.n.
**Grevillea robusta* R.Br.	FoZ #7595
Protea caffra Meisn. subsp. *gazensis* (Beard) Chisumpa & Brummitt	FoZ #7648
Protea gaguedi J.F.Gmel.	FoZ #4872
Protea petiolaris (Hiern) Baker subsp. *elegans* Chisumpa & Brummitt	Mitchell s.n.
Protea welwitschii Engl.	FoZ #1352
Putranjivaceae	
Drypetes gerrardii Hutch. var. *gerrardii*	Hyde s.n.
Drypetes natalensis (Harv.) Hutch. var. *natalensis*	FoZ #5654
Ranunculaceae	
Clematis brachiata Thunb.	Müller 3403
Clematis simensis Fresen.	Müller 3087
Ranunculus multifidus Forssk.	FoZ #98776
Thalictrum rhynchocarpum Quart.-Dill.& A.Rich.	FoZ #2887
Rhamnaceae	
Gouania longispicata Engl.	Simon 925
Rhamnus prinoides L'Hér.	Fisher 1334
Scutia myrtina (Burm.f.) Kurz	Müller 3391
Ziziphus mucronata Willd.	FoZ #5025
Rhizophoraceae	
Cassipourea gummiflua Tul. var. *verticillata* (N.E.Br.) J.Lewis	Chase 1802
Cassipourea malosana (Baker) Alston (=*C. congoensis* sensu auct.)	Chase 5454
Rosaceae	
Alchemilla kiwuensis Engl.	Chase 1162

Name / authority	Voucher
Cliffortia serpyllifolia Cham.& Schltdl.	Chase 1182
**Cotoneaster pannosus* Franch.	FoZ #3811
**Eriobotrya japonica* (Thunb.) Lindl.	FoZ #18306
Prunus africana (Hook.f.) Kalkman	Chase 6198
**Prunus cerasoides* D.Don	Bannermann s.n.
**Rubus niveus* Thunb.	FoZ #2697
Rubiaceae	
Afrocanthium ngonii (Bridson) Lantz (=*Canthium ngonii* Bridson, *C. pseudoverticillatum* sensu R.B. Drumm.)	Müller 3068
Agathisanthemum bojeri Klotzsch subsp. *bojeri*	FoZ #35444
Aidia micrantha (K.Schum.) F.White var. *msonju* (K.Krause) Petit	Chase 5552
Anthospermum ammanioides S.Moore	FoZ #1592
Anthospermum herbaceum L.f.	FoZ #1907
Anthospermum vallicola S.Moore	Chase 6037
Anthospermum whyteanum Britten	Chase 6038
Anthospermum zimbabwense Puff **NE**	FoZ #2034
Canthium inerme (L.f.) Kuntze	Chase 5351
Cephalanthus natalensis Oliv.	Greenway 8802
**Coffea arabica* L.	FoZ #14119
Coffea mufindiensis Bridson subsp. *australis* Bridson (=*C. ligustroides* sensu Garcia)	Drummond 5088
Conostomium natalense (Hochst.) Bremek.	Chase 6039
Coptosperma supra-axillare (Hemsl.) Degreef (=*Tarenna supra*-axillaris (Hemsl.) Bremek. subsp. *barbertonensis* (Bremek.) Bridson)	Müller 2561
Cremaspora triflora (Thonn.) K.Schum. subsp. *triflora*	FoZ #99093
Fadogia ancylantha Schweinf.	FoZ #786
Fadogia homblei De Wild.	FoZ #2219
Galium chloroionanthum K.Schum.	Müller plot 82
Galopina circaeoides Thunb.	Chase 342
Gardenia imperialis K.Schum. subsp. *imperialis*	Chase 6555
Heinsenia diervilleoides K.Schum. subsp. *diervilleoides*	Chase 1466
Hymenodictyon floribundum (Hochst.& Steud.) B.L.Rob.	FoZ #3505
Keetia gueinzii (Sond.) Bridson (=*Canthium gueinzii* Sond.)	Chase 1810
Kohautia amatymbica Eckl.& Zeyh.	FoZ #4405
Leptactina benguelensis (Benth.& Hook.f.) R.D.Good subsp. *pubescens* Verdc.	FoZ #2042
Mussaenda arcuata Poir.	Wild 552
Oldenlandia affinis (Roem.& Schult.) DC. subsp. *fugax* (Vatke) Verdc.	Chase 2162
Oldenlandia goreensis (DC.) Summerh. var. *goreensis*	FoZ #3350
Oldenlandia herbacea (L.) Roxb. var. *herbacea*	Ballings 1734
Otiophora inyangana N.E.Br. subsp. *inyangana*	Chase 7299
Oxyanthus goetzei K.Schum. subsp. *goetzei*	FoZ #3772
Oxyanthus speciosus DC. subsp. *stenocarpus* (K.Schum.) Bridson	Chase 281
Pavetta comostyla S.Moore subsp. *comostyla* var. *inyangensis* (Bremek.) Bridson	FoZ #7191
Pavetta umtalensis Bremek.	Chase 5490
Pentanisia schweinfurthii Hiern	Obermeyer 2029
Pentas purpurea Oliv. subsp. *purpurea*	Eyles 7081
Psychotria mahonii C.H.Wright	Chase 6280
Psychotria peduncularis (Salisb.) Steyerm.	Masterson 559b
Psychotria zombamontana (Kuntze) E.M.A.Petit	Drummond 5098
Psydrax kraussioides (Hiern) Bridson	Müller 25
Psydrax parviflora (Afzel.) Bridson subsp. *chapmanii* Bridson (=*Canthium vulgare* (K.Schum.) Bullock)	Müller 3050
Pyrostria bibracteata (Baker) Cavaco	Müller 3747
**Richardia brasiliensis* Gomes	FoZ #37438
**Richardia scabra* L.	FoZ #3354
Rothmannia fischeri (K.Schum.) Bullock subsp. *moramballae* (Hiern) Bridson	Chase 6999
Rothmannia urcelliformis (Hiern) Robyns	Chase 6210
Rubia cordifolia L. subsp. *conotricha* (Gand.) Verdc.	Greatrex-SRGH 14938
Rutidea fuscescens Hiern subsp. *fuscescens*	FoZ #15915
Rytigynia macrura Verdc. (=R. sp. 1 of Drummond)	Müller 3595
Sericanthe andongensis (Hiern) Robbr. subsp. *engleri* (K.Krause) Bridson	FoZ #3509
Sericanthe sp. A of FZ	Müller 3082
Spermacoce natalensis Hochst.	Hopkins 7096
Tapiphyllum velutinum (Hiern) Robyns	Chase 4151
Tarenna pavettoides (Harv.) Sim subsp. *affinis* (K.Schum.) Bridson	FoZ #3806
Tricalysia coriacea (Benth.) Hiern subsp. *angustifolia* (J.C.Garcia) Robbr.	Müller plot 68
Tricalysia pallens Hiern	Müller plot 91
Vangueria apiculata K.Schum.	Müller 2425

Name / authority	Voucher
Vangueria esculenta S.Moore	Müller 3054
Vangueria infausta Burch. subsp. *infausta*	FoZ #15143
Rutaceae	
Calodendrum capense (L.f.) Thunb.	Hyde s.r.
**Casimiroa edulis* La Llave	FoZ #21844
**Citrus limon* (L.) Burm.f.	FoZ #4034
Clausena anisata (Willd.) Benth. var. *anisata*	Whellan 761
Toddalia asiatica (L.) Lam.	Bamps et al 625
Vepris bachmannii (Engl.) Mziray (=*Oricia bachmannii* (Engl.) I.Verd.)	Chase s.n.
Vepris nobilis (Delile) Mziray (=*Teclea nobilis* Delile)	Chase 5297
Zanthoxylum davyi (I.Verd.) P.G.Waterman	Müller plot 152
Salicaceae	
Casearia battiscombei R.E.Fr.	Chase 6177
Dovyalis lucida Sim	FoZ #79997
Scolopia stolzii Gilg var. *stolzii*	Chase 5594
Trimeria grandifolia (Hochst.) Warb. subsp. *grandifolia*	Drummond 5095
Santalaceae	
Osyridicarpos schimperianus (A.Rich.) A.DC.	Müller 3594
Osyris lanceolata Hochst.& Steud.	FoZ #955
Thesium ussanguense Engl.	Bamps et al 691
Viscum shirense Sprague	Müller 4744
Sapindaceae	
Alophyllus abyssinicus (Hochst.) Radlk.	Chase 6226
Alophyllus africanus P.Beauv.	Carter 2130
Alophyllus chirindensis Baker f.	Müller 3494
Dodonaea viscosa Jacq. subsp. *angustifolia* (L.f.) J.G.West	Williams 223
Filicium decipiens (Wight & Arn.) Thwaites	Chase 1968
Zanha africana (Radlk.) Exell	FoZ #15195
Zanha golungensis Hiern	Müller 3373
Sapotaceae	
Chrysophyllum gorungosanum Engl.	Chase 7690
Englerophytum magalismontanum (Sond.) T.D.Penn.	FoZ #1383
Englerophytum natalense (Sond.) T.D.Penn.	Müller 3622
Manilkara discolor (Sond.) J.H.Hemsl.	Chase 4559
Mimusops zeyheri Sond.	Chase 1741
Scrophulariaceae	
Buddleja pulchella N.E.Br.	Müller plot 146
Buddleja salviifolia (L.) Lam.	Chase 7798
Diclis ovata Benth.	Mavi 1785
Diclis tenella Hemsl.	Chase 6119
Freylinia tropica S.Moore	FoZ #784
Hebenstretia angolensis Rolfe	Chase 6124
Hebenstretia oatesii Rolfe subsp. *rhodesiana* Roessler	FoZ #24443
Jamesbrittenia carvalhoi (Engl.) Hilliard	Chase 259
Nemesia zimbabwensis Rendle	Whellan 1559
Selago goetzei Rolfe subsp. *ambigua* Hilliard	Whellan 1143
Solanaceae	
**Cestrum aurantiacum* Lindl.	FoZ #18295
**Nicandra physalodes* (L.) Gaertn.	FoZ #114
**Physalis peruviana* L.	FoZ #1201
**Solanum aculeatissimum* Jacq.	Biegel 2429
Solanum anguivi Lam.	Müller 2628
**Solanum betaceum* Cav. (=*Cyphomandra betacea* (Cav.) Sendtn.)	Masterson 1327
Solanum campylacanthum A.Rich. (=*S. panduriforme* E.Mey., *S. incanum* auct.)	FoZ #7241
**Solanum lycopersicum* L. (=*Lycopersicon esculentum* Mill.)	FoZ #21088
**Solanum mauritianum* Scop.	FoZ #7344
Solanum terminale Forssk.	Drummond 5083
Sterculiaceae (see Malvaceae: Byttnerioideae, Helicteroideae & Sterculioideae)	
Stilbaceae	
Halleria lucida L.	Plowes 2503
Nuxia congesta Fresen.	Simon 921
Nuxia floribunda Benth.	Plowes 2183
Thymelaeaceae	
Dais cotinifolia L.	FoZ #4994
Gnidia kraussiana Meisn. var. *kraussiana*	Chase 7368

Name / authority	Voucher
Peddiea africana Harv.	Chase 1969
Synaptolepis alternifolia Oliv.	Chase 6502
Tiliaceae (see Malvaceae: Grewioideae)	
Turneraceae	
Tricliceras longepedunculatum (Mast.) R.Fern. var. *longepedunculatum*	Bamps et al 643
Ulmaceae	
Celtis africana Burm.f.	Chase 7012
Trema orientalis (L.) Blume	Bamps et al 728
Urticaceae	
Boehmeria macrophylla Hornem.	Chase 7135
Droguetia iners (Forssk.) Schweinf.	FoZ #3789
Elatostema monticola Hook.f.	Müller 803
Laportea alatipes Hook.f.	Biegel 3498
Laportea mooreana (Hiern) Chew	Chase 6059
Laportea peduncularis (Wedd.) Chew subsp. *peduncularis*	Müller 3398
Myrianthus holstii Engl.	Chase 5790
**Pilea microphylla* (L.) Liebm.	FoZ #37433
Pilea tetraphylla (Steud.) Blume	Chase 7487
Pouzolzia parasitica (Forssk.) Schweinf.	FoZ #15694
Urera hypselodendron (A.Rich.) Wedd.	Chase 8439
Urera trinervis (Hochst.) Friis & Immelman	Müller 3498
Verbenaceae	
**Lantana camara* L.	FoZ #7593
Lantana swynnertonii Moldenke	FoZ #29009
Lippia javanica (Burm.f.) Spreng.	FoZ #1552
**Verbena bonariensis* L.	FoZ #1582
**Verbena brasiliensis* Vell.	Bamps et al 617
Violaceae	
Rinorea convallarioides (Baker f.) Eyles subsp. *convallarioides*	Müller 3495
Rinorea ferruginea Engl.	Drummond 5081
Viola abyssinica Oliv.	Biegel 2423
Vitaceae	
Cayratia gracilis (Guill.& Perr.) Suess.	Chase 7300
Cissus petiolata Hook.f.	Müller 3093
Cyphostemma buchananii (Planch.) Wild & R.B.Drumm.	Wild 2834
Cyphostemma kilimandscharicum (Gilg) Wild & R.B.Drumm.	Chase 8182
Cyphostemma montanum Wild & R.B.Drumm.	FoZ #1776
Rhoicissus rhomboidea (Harv.) Planch.	Chase 7394
Rhoicissus tomentosa (Lam.) Wild & R.B.Drumm.	FoZ #3574
Rhoicissus tridentata (L.f.) Wild & R.B.Drumm.	FoZ #15342

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Hanceola suffruticosa (Lamiaceae, Nepetoideae), a new species from the Sino-Vietnamese border

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Abstract

Hanceola is a genus of eight herbaceous species previously thought to be endemic to southern China. However, *H. suffruticosa*, a new species described here from China and Vietnam, differs from all other species of *Hanceola* by its subshrubby habit. It is also distinct in its shallowly bicrenate laminae and densely purplish glandular puberulent inflorescences. The morphological description, illustrations, and distribution of the new species are presented. A key to all species of *Hanceola* is also provided.

Keywords

Hanceola, Hanceolinae, new species, Ocimeae, Sino-Vietnamese border

Introduction

Comprising about eight species, the genus *Hanceola* Kudô (Ocimeae, Nepetoideae, Lamiaceae) is endemic to the evergreen and mixed forests in southern China (Wu and Li 1977; Li and Hedge 1994; Harley et al. 2004). It can be distinguished from other genera of Ocimeae based on the following set of characters: cymes pedunculate and bracteolate, calyx 2-lipped (3/2, a 3-toothed posterior lip with median tooth larger, and a 2-toothed anterior lip), corolla 2-lipped (2/3, 2 lobes on the posterior lip and 3 lobes on the anterior) with tube clearly dilating at midpoint, and free filaments inserted near the throat of corolla (Wu and Li 1977; Li and Hedge 1994; Paton and Ryding 1998; Harley et al. 2004).

Hemsley established the genus *Hancea* Hemsl. with type species *H. sinensis* Hemsl. based on two syntypes, Faber 666 and 681, both collected from Mt. Omei of Sichuan Province (Forbes and Hemsley 1890). Considering that *Hancea* Hemsl. was a late homonym of *Hancea* Seem. (Euphorbiaceae), Kudô (1929) proposed a new name *Hanceola* Kudô for *Hancea* Hemsl.. Tribe Hanceoleae was proposed by Wu and Li (1977) in subfamily Ocimoideae sensu Briquet (1895–1897) to accommodate the distinct genus. Based on morphological cladistic analysis, Cantino (1992a, b) assigned all taxa of Ocimoideae to Nepetoideae sensu Cantino et al. (1992) and recognized Ocimoideae as tribe Ocimeae of subfamily Nepetoideae. Cantino et al. (1992) also placed the genus *Siphocranion* Kudô as a synonym under *Hanceola*. Since *Siphocranion* is distinct from *Hanceola* in its sessile and single-flowered cymes, Paton and Ryding (1998) resurrected *Siphocranion* from *Hanceola*, and treated the two genera as *incertae sedis* in Ocimeae together with *Isodon* (Schrad. ex Benth.) Spach. Harley et al. (2003) later established the subtribe Hanceolinae in Ocimeae to accommodate the three genera, which is adopted in the recent classification of Lamiaceae (Harley et al. 2004).

Zhong et al. (2010) first elucidated the phylogenetic relationships within Ocimeae based on molecular phylogenetic analyses. Using the nuclear ribosomal internal transcribed spacer (nrITS) and two plastid DNA regions (*rps16* and *trnL-trnF*), they demonstrated that each of the three genera *Siphocranion*, *Hanceola*, and *Isodon* formed a distinct lineage within Ocimeae; the subtribes Siphocranioninae and Isodoninae were thus described to accommodate *Siphocranion* and *Isodon*, respectively (Zhong et al. 2010), while subtribe Hanceolinae is restricted to include *Hanceola* alone. Their results and treatment were further supported by Chen et al. (2019).

During our recent field investigations in Malipo County of Yunnan Province, southwestern China, an unusual species of *Hanceola* was discovered at the Sino-Vietnamese border. Further morphological studies suggested that it represents an undescribed species. Hereafter, we describe it as *Hanceola suffruticosa* Y.P. Chen, A.J. Paton & C.L. Xiang.

Material and methods

This study was based on comparison of herbarium specimens of *Hanceola* from 13 public herbaria AU, E, FJSI, HHBG, IBK, IBSC, LBG, K, KUN, NAS, PE, SM, and SZ (herbarium acronyms follow Index Herbariorum; Thiers 2020) and our new collections in China (herbarium specimens kept in KUN). Meanwhile, protologues of all published names and other related taxonomic literature (Forbes and Hemsley 1890; Kudô 1929; Sun 1942; Wu and Li 1977; Li and Hedge 1994; Paton and Ryding 1998; Harley et al. 2004) were collated and reviewed. Terminology for the description of the new species followed that of Li and Hedge (1994) and Harley et al. (2004).

Taxonomic treatment

***Hanceola suffruticosa* Y.P. Chen, A.J. Paton & C.L. Xiang, sp. nov.**
urn:lsid:ipni.org:names:77209337-1
Figs 1, 2

Type. China. Yunnan Province: Malipo County, Tianbao Town, Bajiaoping Village, under the evergreen mixed forest, elevation 1140 m, 1 Dec 2018, Y.P. Chen & L.Q. Jiang EM748 (holotype: KUN!; isotypes: K!, KUN!, PE!).

Diagnosis. *Hanceola suffruticosa* differs from other species of *Hanceola* by being a subshrub with woody rather than herbaceous stems, shallowly bicrenate margin of laminae rather than coarsely dentate, and densely purplish glandular puberulent inflorescences rather than subglabrous or with white glandular or eglandular hairs.

Subshrubs 50–100 cm tall. Stems woody, erect, branched, old stems greyish brown, subterete, glabrous, young stems and branchlets obtusely 4-angled, densely purplish puberulent. Leaves opposite; laminae oblong, ovate to ovate-lanceolate, papery, 7–22 × 3–9 cm, apex acute to acuminate, base cuneate, margin shallowly bicrenate, adaxially green, subglabrous to sparsely puberulent, abaxially light green or purple, subglabrous, glandular, puberulent on veins; lateral veins 4–5 paired; petioles 2–8 cm long, densely purplish puberulent. Inflorescence axillary and terminal, to 20 cm long, cymes (1–) 3–7-flowered; peduncles 2–5 mm long, pedicels 5–10 mm long, densely purplish glandular puberulent; bracts lanceolate to linear, 2–5 mm long, bracteoles linear, 1–2 mm long, densely purplish puberulent. Calyx campanulate, ca. 4 mm long, 10-veined, densely purplish glandular puberulent and glandular outside, glandular puberulent inside; 2-lipped to 1/2 its length, posterior lip 3-toothed, teeth broadly triangular, apex acuminate, medium lobe larger, anterior lip 2-toothed, teeth triangular, apex acuminate, fruiting calyx dilated to ca. 1.2 cm long, slightly curved. Corolla light purple to reddish purple, 3–4 cm long, sparsely puberulent outside, tube slightly curved, long exserted, ca. 1–2 mm in diameter at base, gradually dilated to 1 cm at apex, sparsely pubescent inside at base; limb 2-lipped, dotted with purple spots inside, posterior lip 2-lobed, lobes reflexed, orbicular, ca. 3 mm long, anterior lip 3-lobed, lobes oblong, ca. 6 mm long. Stamens 4, inserted at apical 1/3 the length of corolla, unequal, anterior pair longer, slightly exserted, posterior pair included; anthers ovoid, cells 2, divaricate, confluent at apex; filaments puberulent. Style included, apex shallowly 2-cleft; disc 4-lobed, lobes alternating with mericarps, anterior lobe much larger. Mericarps yellowish brown, oblong, ca. 3 × 2 mm, glabrous.

Phenology. Flowering from October to December, fruiting from November to January next year.

Etymology. The epithet of the new species refers to its suffrutescent habit, which is distinct in the genus.

Common name (assigned here). Mu Jing Si Lun Xiang (木茎四轮香; Chinese name).

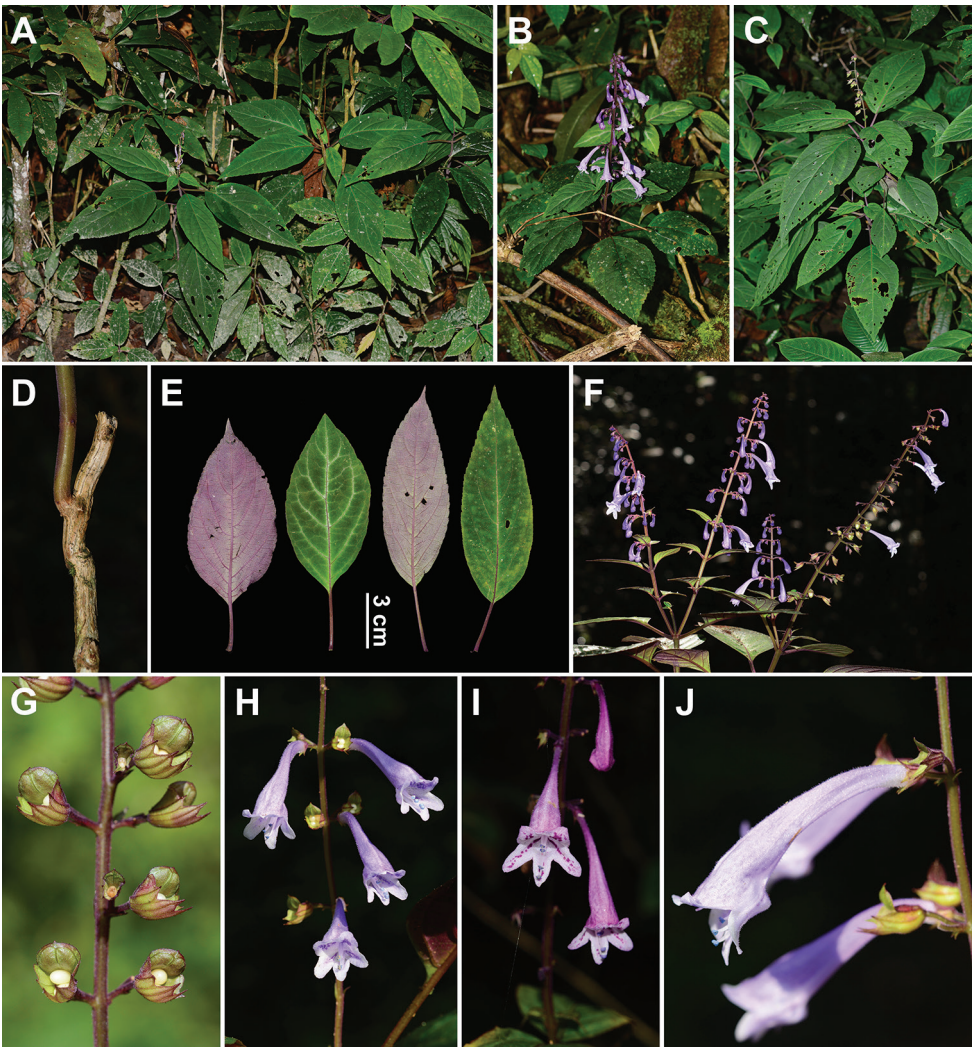

Figure 1. *Hanceola suffruticosa*. **A** Habitat **B, C** plants **D** stem **E** leaves **F** inflorescences **G** post-flowering calyces **H, I** flowers in frontal view **J** flowers in lateral view (Photographs by Ya-Ping Chen).

Distribution and habitat. *Hanceola suffruticosa* is now only known at the Sino-Vietnamese border of Malipo County in Yunnan Province, China and Quan Ba District of Ha Giang Province, Vietnam (Fig. 3). It grows in the evergreen mixed forests at an elevation of 1100–1150 m.

Additional specimens examined. Vietnam. Ha Giang Province: Quan Ba District, Can Ti Municipality, vicinities of Sing Xuoi Ho Village, in closed evergreen mixed wet forest along tops of karst remnant limestone ridge at elevation 1100–1150 m, 12 Oct 1999, N.T. Hiep et al. NTH3572 (K000479731!).

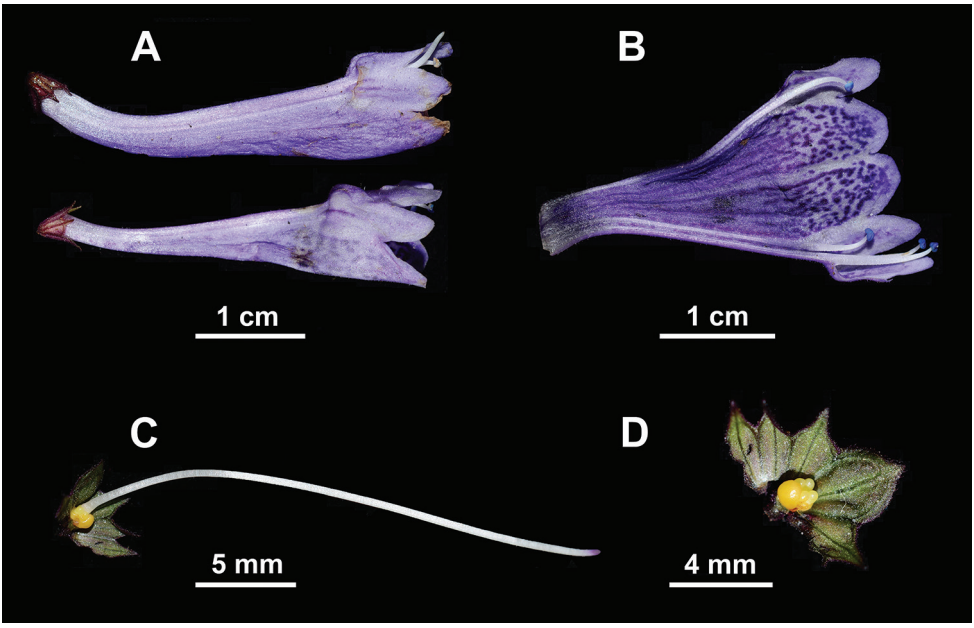

Figure 2. *Hanceola suffruticosa*. **A** Flowers **B** dissected corolla **C** pistil **D** dissected calyx and ovary (Photographs by Ya-Ping Chen).

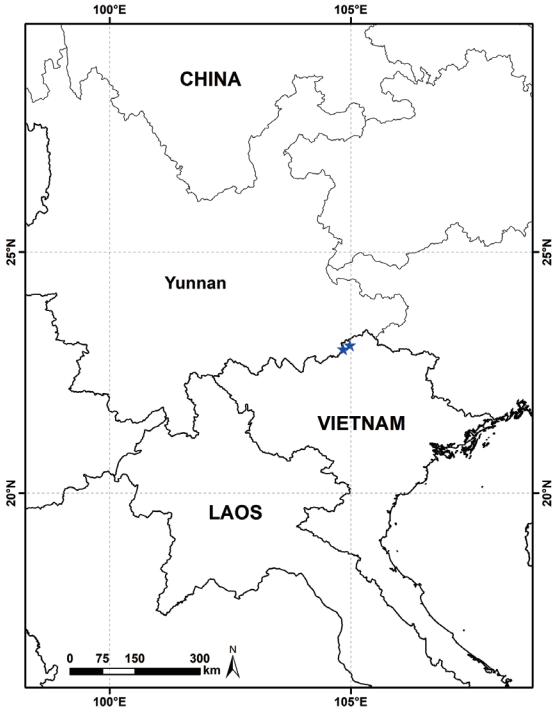

Figure 3. Distribution of *Hanceola suffruticosa* (stars).

Discussion

Hanceola can be distinguished from all other genera of tribe Ocimeae by its pedunculate and bracteolate cymes, 2-lipped (3/2) calyx, 2-lipped (2/3) corolla abruptly dilating toward apex, as well as free filaments inserted near the throat of corolla (Wu and Li 1977; Li and Hedge 1994; Paton and Ryding 1998; Harley et al. 2004). Characterized by all these features, the new species we found at the Sino-Vietnamese border is shown to be a member of *Hanceola*. However, unlike other species of *Hanceola*, which are all perennial herbs, *H. suffruticosa* are subshrubs with woody and robust stems. In addition, the new species is distinct in its morphology of laminae and indumentum of branchlets and inflorescences. Specifically, laminae of most *Hanceola* species are lanceolate with base decurrent on petiole and margin coarsely dentate, whereas that of *H. suffruticosa* are oblong, ovate to ovate-lanceolate, with base not decurrent on petiole and margin shallowly bicrenate. Moreover, *H. suffruticosa* are purplish puberulent all over the branchlets and purplish glandular puberulent all over the inflorescences, while branchlets and inflorescences of other species of *Hanceola* are either subglabrous or with whitish glandular or eglandular hairs.

With all other species of *Hanceola* being endemic to southern China, *H. suffruticosa* is now the only species of the genera to be reported from China and Vietnam (Fig. 3). However, consistent with the habitat of other species, *H. suffruticosa* is also accustomed to the shady and moist evergreen mixed forests.

Though only nine species have been reported from *Hanceola*, most of them are only known from several old specimens. More efforts are needed to further reveal the relationships within these species. Here we provide a key to the nine species of *Hanceola* below.

Key to the species of *Hanceola*

1	Base of lamina not decurrent on petiole	**2**
–	Base of lamina decurrent on petiole	**3**
2	Subshrubs, corolla slightly curved	***H. suffruticosa***
–	Perennial herbs, corolla strongly curved	***H. cordiovata***
3	Stamens exserted	***H. exserta***
–	Stamens included	**4**
4	Stamens subequal, corolla yellow	***H. sinensis***
–	Anterior stamens longer, corolla purple	**5**
5	Corolla longer than 3 cm	**6**
–	Corolla shorter than 2.5 cm	**7**
6	Lamina elliptic, inflorescence glandular puberulent	***H. tuberifera***
–	Lamina lanceolate, inflorescence subglabrous	***H. labordei***
7	Inflorescence subglabrous	***H. cavaleriei***
–	Inflorescence densely glandular puberulent	**8**
8	Stems ascending, flexuous	***H. flexuosa***
–	Stems erect, straight	***H. mairei***

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RESEARCH ARTICLE

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Two new species of *Ardisia* subgenus *Tetrardisia* (Primulaceae-Myrsinoideae) from Borneo

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Abstract

Ardisia argentiana and *A. nagaensis* from subgenus *Tetrardisia* are herein described and illustrated as new species. They are endemic to Borneo and the Indonesian province of Central Kalimantan and to the Malaysian state of Sarawak, respectively. *Ardisia argentiana* is unique in its linear-oblong leaves, with a long, acuminate-caudate apex, and finely serrulate margins, while *A. nagaensis* can be easily recognized by its elliptic-lanceolate leaves.

Keywords

Conservation, endemic, key, Malesia, Myrsinaceae, South-East Asia, taxonomy

Introduction

Ardisia Sw. with ca. 450 to over 1000 species (Stevens 2001 onwards; Frodin 2004), is the largest tropical genus in subfamily Myrsinoideae of the enlarged Primulaceae (as circumscribed by the Angiosperm Phylogeny Group, APG 2009). The genus

was last revised by Mez (1902) within his monograph of the Myrsinaceae, but there are no modern species level treatments. In South-East Asia, contemporary work on the genus has resulted in publication of several species (e.g. Stone 1989a, Stone 1990; Julius et al. 2017), and regional accounts for New Guinea (Sleumer 1988) and Peninsular Malaysia (as an annotated key in Stone 1989a). For Borneo, there is no recent detailed treatment of the genus from the island, but Stone (1989b) published a provisional checklist of *Ardisia* with 80 species, and an additional 14 species were added to these by Hu (2002: 13 species) and Utteridge et al. (2014: 1 species).

Ardisia is classified into subgenera on characters of habit, leaf morphology, disposition of flowers at inflorescence branch apices (racemes, umbels, corymbs), inflorescence position and floral morphology (see Mez 1902), and the two new species described here are members of subgenus *Tetrardisia* (Mez) K. Larsen & C.M. Hu (Larsen and Hu 1995). Originally described as a monotypic genus by Mez (1902), based on the four-merous corolla and the low ovule number, *Tetrardisia* was reduced to a subgenus of *Ardisia* by Larsen and Hu (1995) due to a better understanding of character variation within *Ardisia* - both merosity and ovule number are now known to vary within previously described subgenera. Ståhl and Anderberg (2004) subsequently recognized it as a valid genus, using characters of merosity and ovules in their key to genera but did not discuss this opinion noting only that *Tetrardisia* was "treated as subgenus of *Ardisia* by Larsen and Hu (1995)." Initial molecular findings, however, have shown that species of *Tetrardisia* are nested within *Ardisia* (Julius et al. 2016; Julius 2019), and the classification of Larsen and Hu (1995) is followed here.

The subgenus is defined by the combination of the small, woody shrub habit, leaves lacking bacterial nodules with a finely serrulate-denticulate leaf margin, and the usually tetramerous flowers with few ovules. During study of *Ardisia* specimens from Borneo deposited at KEP and E, two unidentified specimens with tetramerous flowers were encountered and suspected to be undescribed taxa. After close scrutiny of the relevant literature (e.g. Furtado 1959; Larsen and Hu 1991; Stone 1992), and comparison with all other *Tetrardisia* species, we found the specimens do not match any of those known species. Thus, the unidentified specimens collected from Kalimantan and Sarawak are apparently new and described here as new species.

There are very few species of *Ardisia* with tetramerous flowers, and with few occurring in Malesia and surrounding regions: only a single taxon is recognized each from Java and Thailand, and three are known from Peninsular Malaysia, with none currently described from Borneo. With the publication of the two new species here, subgenus *Tetrardisia* now has six species, the previously described species, *A. denticulata* Blume (Blume 1826: 691), *A. porosa* C.B. Clarke (Clark 1882), *A. tetramera* K. Larsen & C.M. Hu (Larsen and Hu 1991), *A. tetrasepala* King & Gamble (King and Gamble 1905, plus the new species herein: *A. argentiana* Julius & Utteridge sp. nov. and *A. nagaensis* Julius, T. Kajita & Utteridge sp. nov.

Materials and methods

This study was based on examination of herbarium specimens at E, K and KEP and the relevant taxonomic literature (e.g. Furtado 1959; Larsen and Hu 1991; Stone 1992); in addition, specimen images from Global Plants JSTOR (http://plants.jstor.org/) and the BioPortal of Naturalis Biodiversity Center (http://bioportal.naturalis.nl/) were consulted. Herbaria are abbreviated according to the Index Herbariorum (Thiers 2016). All measurements were taken from herbarium specimens and rehydrated material for floral description, shape terminology follows Systematics Association Committee (1962). The conservation status was assessed using the IUCN criteria (IUCN 2012).

Taxonomic treatment

Ardisia argentiana **Julius & Utteridge, sp. nov.**
urn:lsid:ipni.org:names:77209338-1
Figure 1

Diagnosis. Differs from other members of the subgenus *Tetrardisia* in having linear-oblong leaves, with a long, acuminate-caudate apex, and finely serrulate margins.

Type. INDONESIA. Borneo: Central Kalimantan, Kotawaringan [Kotawaringin] Timur, S. Mentaya, km 92 from Sangai, Plot 8, [1°18'S, 112°32'E], 100 m elevation, 18 May 1993, *Argent et al. 93187* (holotype E!; iso: BO).

Description. Shrub ca. 1 m high; stems sparsely scaly when young, soon glabrous, slightly flexuous, winged between the nodes with raised lines running along the internodes between the petiole bases. *Indumentum* of sessile, circular, peltate scales up to 0.05 mm in diameter, on young parts, leaves and inflorescence. *Leaves* alternate; petioles 3–5 mm long, winged by the decurrent leaf base, glabrous; lamina chartaceous, linear-oblong, (7–)10–11.5 × 1–2 cm, with dense gland-dots throughout apex acuminate-caudate, acumen 1–2.5 cm long; base cuneate, between the higher order venation, lacking hairs, sparsely scaly on the lower midrib, glabrous above, midrib sunken above, raised beneath; lateral veins ca. 48 pairs, semicraspedodromus, and with 1–2 intersecondary veins within each pair; intercostal veins obscure. *Inflorescences* terminal on lateral branches, proximally laxly paniculate with subumbellate branches with 2-flowers distally racemose; peduncle and rachis (1.5–)2.5–4 cm long, slightly flexuose, sparsely scaly; bracts linear-lanceolate, (0.4–)1.5–1.7 × 0.4 mm, very sparsely ciliate with few scattered hairs. *Flowers* ca. 8; pedicels slender, ca. 1.5 cm long, sparsely scaly; calyx-lobes 4, green, gland-dotted, lacking hairs, sparsely scaly outside, ovate, ca. 1 × 0.8 mm, apex acute, margin very sparsely ciliate with few scattered short hairs; corolla-lobes 4, reflexed, twisted apically, white with orange-brown elongated-dots, lanceolate, 6.4–7 × 1.7–2.3 mm, glabrous on both surfaces; stamens 4, spreading upright (in open flower), filament ±sessile, anthers twisted apically, lanceolate, ca. 5–6.2

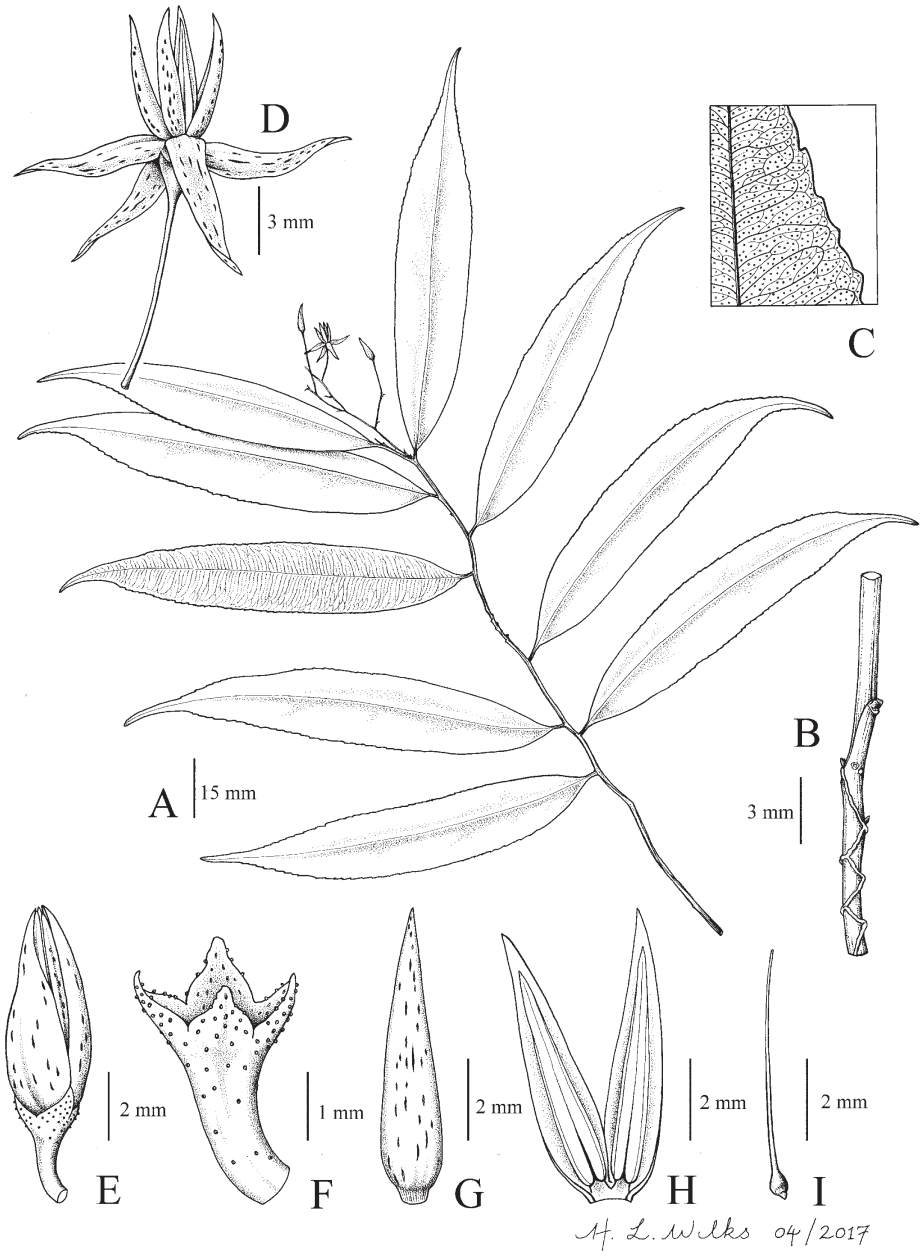

Figure 1. *Ardisia argentiana* Julius & Utteridge, sp. nov. **A** habit **B** stem with flexuose line **C** venation details on lower surface **D** mature flower **E** flower bud **F** calyx **G** corolla lobe, abaxial view **H** open corolla and stamen **I** ovary and pistil. (Drawn by Hazel Wilks from *Argent et al. 93187*).

× 0.8 mm, apex elongated into a hyaline tip, thecae open by longitudinal-slits, with scattered, lineate, orange brown dots behind, glabrous; ovary ovoid, ca. 7 × 6 mm, style and stigma filiform, ca. 6.8 mm long, ovules ca. 6 in 1-series. *Fruits* n.v.

Distribution. Endemic to Borneo; known only from Sungai Mentaya, Kotawaringin Timur, Central Kalimantan.

Etymology. The species epithet commemorates Graham Charles George Argent (1941–2019), a prominent botanist on tropical botany in South-East Asia and a leading expert on Ericaceae, especially the tropical 'Vireya' rhododendrons, and collector of the type material.

Conservation status. Data deficient (DD). The only specimen available was collected in 1993 and the species is known only from a single collection location south of Bukit Raya in Central Kalimantan, and thus meets the B1a criterion for Critically Endangered (CR) status. The species was found to the south of the Bukit Baka – Bukit Raya National Park, and, to date, there are no further collections of the species from inside this protected area. Satellite imagery in Google Earth from 2015 shows that the collection locality still has some forest coverage and was not penetrated with roads or logging tracks, and it also appears to not have been converted for agricultural use such as oil palm plantations. However, lack of collections and field observations of the species do not allow inference of decline or fluctuation in population size or EOO and AOO, and we are unable to fulfil the criteria to preliminary assess this species as Critically Endangered.

Notes. *Ardisia argentiana* is a distinct species on account of the combination of branches with wing-like raised lines running between the petiole bases, linear-oblong leaves less than 2 cm wide with finely serrulate margins, the terminal, laxly paniculate inflorescence with a hairy scaly rachis and few, tetramerous flowers. This new species is morphologically similar to *Ardisia nagaensis*, but differs from that species in leaf morphology, especially the shorter pedicels (*A. argentiana* 3–5 mm long; *A. nagaensis* 1.5–3 cm long), linear-oblong leaves less than 2 cm wide (*A. nagaensis* elliptic-lanceolate to 5.5 cm wide) and the fewer flowered inflorescence (*A. argentiana* with 8 flowers vs. *A. nagaensis* with 24).

The flower is described as 'white' in the specimen label which probably refers to the corolla and anthers. The leaf resembles *Ardisia mystica.* B.C. Stone (Stone 1982), a member of subgenus *Pimelandra*, but all members of that subgenus have short, axillary inflorescences. Similar wing-like ridges along the internodes are found in species of *Systellantha*, a genus of three species endemic to northern Borneo (Drinkell and Utteridge 2015). Members of *Systellantha* are understorey small trees or shrubs to only 3 m, are also tetramerous but have unisexual flowers with the plants being monoecious. The wing-like ridges may be a response to ecological conditions, such as high humidity, in the rainforest understorey.

Ardisia nagaensis **Julius, T. Kajita & Utteridge, sp. nov.**
urn:lsid:ipni.org:names:77209339-1
Figure 2

Diagnosis. Similar to *Ardisia tetrasepala* in its simple and compact inflorescence with corymbose flowers but differs mainly vegetatively in having leaves laxly arranged, long-

er petioles that are covered with glandular hairs, a chartaceous lamina without marginal secondary veins, surface with scattered stellate hairs near the margin beneath and leaf base obtuse or ±cuneate. The corolla lobes are smooth without lepidote scales (vs. lepidote scales present in *A. tetrasepala*).

Type. MALAYSIA. Borneo: Sarawak, Tatau District, Ulu Merirai, Gua Naga, [02°39'12"N, 113°03'05"E], 11 July 2005, *Julia et al. S95726* (holotype KEP!; iso: SAR, SING)

Description. A small shrub, less than 1 m high; stems glabrescent, slightly flexuous, winged between the nodes with obscure raised lines running along the internodes between the petiole bases. *Indumentum* of simple, short (stalked), glandular, or stellate (star-liked), pale brown to rusty hairs (visible under microscope). *Leaves* alternate; petioles 1.5–3 cm long, sparsely to densely hairy towards midrib, simple, short, glandular hairs; lamina chartaceous, with dense gland-dots throughout the leaf, glabrous on both surfaces except for margin with scattered stellate hairs beneath, elliptic-lanceolate, 17–19 × 5–5.5 cm, apex long acuminate and slightly caudate with acumen 1.5–2.0 cm long; base obtuse or ±cuneate, margin obscurely denticulate being entire in appearance, midrib flat or slightly sunken above, raised beneath, glabrous except hairy with glandular hairs beneath, denser near leaf base; lateral veins 13–15 pairs, distinct above, prominent beneath, inter-secondary veins present in between; intercostal veins percurrent, distinct beneath. *Inflorescence* terminal on lateral branches, simple with flowers arranged in corymbs; peduncle and rachis 4–5 cm long, densely hairy with glandular hairs; bracts ovate to elliptic, 0.5–1.5 mm long, hairy with glandular hairs. *Flowers* ca. 24; pedicels slender, 1.2–1.8 cm long, up to 2 cm long in fruiting, covered with dense, glandular hairs; calyx-lobes 4, purplish, gland-dotted, lacking hairs, broadly ovate, 1–1.5 × 1–1.5 mm, apex obtuse, margin incised, sparsely ciliate with short, thick hairs; corolla-lobes 4, reflexed, twisted apically, purplish with transparent margin, lanceolate, ca. 8 × 2.5 mm, glabrous on both surfaces; stamens 4, spreading upright (in open flower), filament ±sessile, anthers twisted apically, lanceolate, ca. 6 × 1 mm, apex without a prolonged hyaline tip, thecae opening by longitudinal slits, with lineate, black dots behind, glabrous; ovary globose, ca. 1 × 0.8 mm, style and stigma filiform, ca. 6 mm long, ovules 4–6 in 1-series. *Fruits* ripe bright red, globose, ca. 6 × 5 mm.

Distribution. Endemic in Borneo, Sarawak; known only from Gua Naga, Ulu Merirai area, Tatau District.

Etymology. *Ardisia nagaensis* is very local and was found at only one locality, Gua Naga, for which it is named.

Conservation status. Data deficient (DD). The only specimen available was collected in 2005 and the species is known only from a single collection location from Ulu Merirai in Central Sarawak, and thus meets the B1a criterion for Critically Endangered (CR) status. The Ulu Merirai region is an area of sandstone with limestone cliffs, and supports several point endemics, including several newly described species of *Begonia* L. (Kiew and Sang 2009) and *Monophyllea* R. Br. (Kiew and Sang 2013). The species was found outside of any protected area, but satellite imagery in Google Earth from 2017 shows that the collection locality has undisturbed forest coverage and was

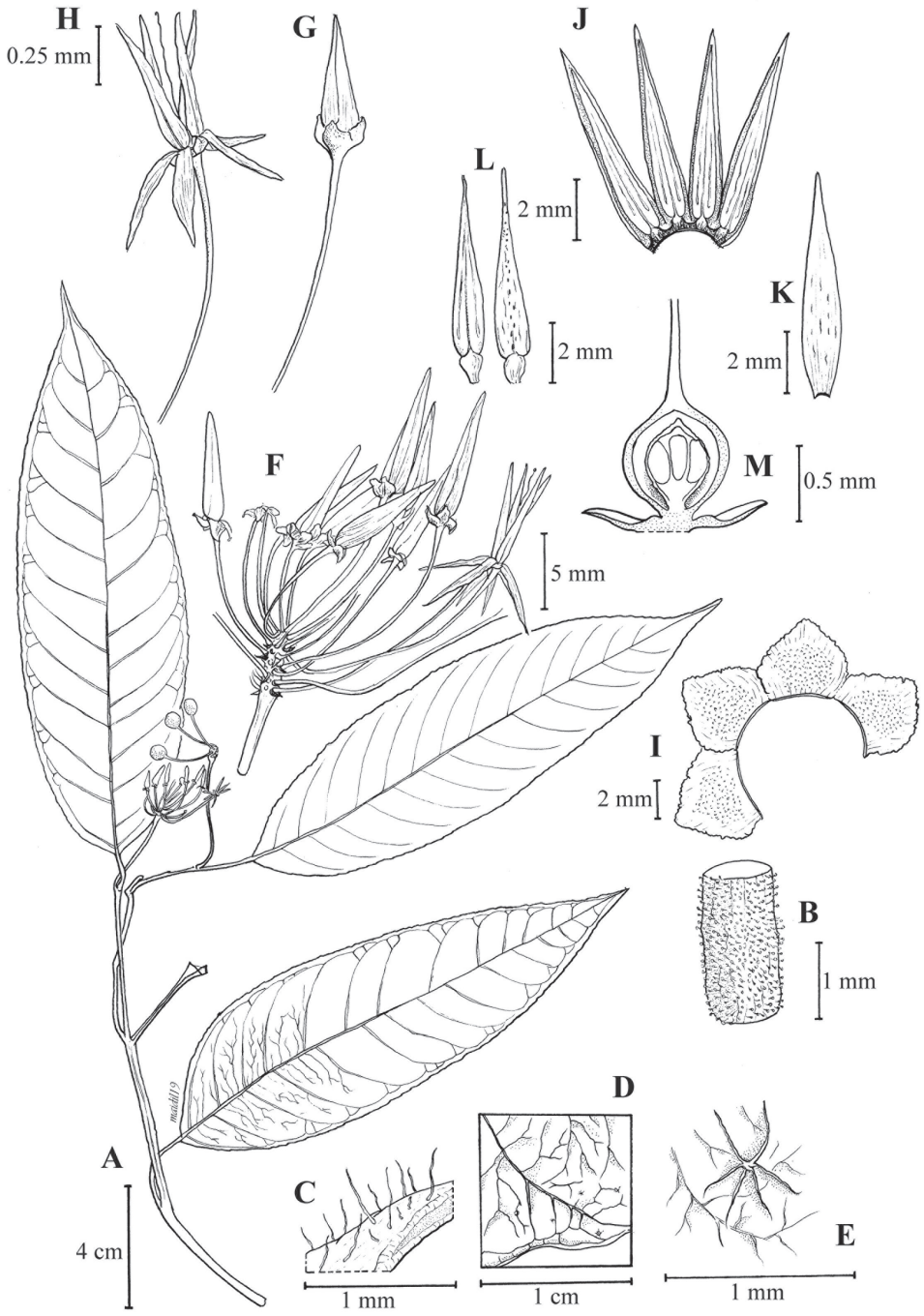

Figure 2. *Ardisia nagaensis* Julius, T. Kajita & Utteridge, sp. nov. **A** habit **B** glandular hairs on stem **C** erect, simple hairs on petiole **D** the venation close-up **E** stellate hairs close-up **F** enlarged inflorescence **G** flower bud **H** mature flower **I** open calyx **J** open corolla with stamen **K** corolla lobe **L** stamen, front and back view **M** placenta and ovules. (Drawn by Mohamad Aidil Noordin from *Julia et al. S95726*).

not penetrated with roads or logging tracks. However, lack of collections and field observations of the species do not allow inference of decline or fluctuation in population size or EOO and AOO, and we are unable to fulfil the criteria to preliminary assess this species as Critically Endangered.

Notes. Compared to the other members of subgenus *Tetrardisia*, this new species described here has an affinity with *A. tetrasepala*, endemic to Peninsular Malaysia [Johor, Gunung Pulai]. This is because both are characterized by a simple and compact inflorescence, whereas other taxa in subgenus *Tetrardisia* have compound and laxly flowers arranged. *Ardisia nagaensis* differs from *A. tetrasepala* by the leaf characters viz. the petiole length (*A. nagaensis* with 1.5–3 cm long vs. *A. tetrasepala* with 0.5–0.8 cm long), the leaf base (*A. nagaensis* with obtuse or ±cuneate leaf base vs. *A. tetrasepala* with cordate-rounded) and the venation (*A. nagaensis* without marginal secondary veins vs. *A. tetrasepala* with marginal secondary veins). Further morphological comparison between these two species is given in the Table 1.

The calyx is described as 'purplish' in the specimen label which probably refers to both the calyx and corolla. The corolla margin on one side is transparent as observed in *A. denticulata*.

Table 1. Morphological comparison of *Ardisia nagaensis* and *A. tetrasepala*.

	Ardisia nagaensis	***A. tetrasepala***
Leaf texture	Chartaceous	Subcoriaceous
Leaf shape and size	Elliptic-lanceolate, 17–19 × 5–5.5 cm	Oblong-elliptic, 10–19.5 × 2.5–5 cm
Leaf base	Obtuse or ±cuneate	Cordate-rounded
Leaf margin	Obscurely denticulate being entire in appearance	Seemingly entire immature but finely crenulate when mature
Leaf apex	Long acuminate and slightly caudate with acumen 1.5–2.0 cm long	Acuminate-caudate, acumen 1.5–2.5 cm long
Leaf surface	Glabrous on both surfaces except for margin with scattered stellate hairs beneath	Glabrous above except sparsely hairy to glabrescent on midrib Beneath
Lateral veins	Lateral veins 13–15 pairs, distinct above, prominent beneath, inter-secondary veins present in between	Lateral veins 20–24, distinct and slightly prominent on both surfaces, brochidodromus with secondary veins looping and joining 0.2–0.5 mm in from the margin with distinct secondary loops
Intercostal veins	Percurrent, distinct beneath	Reticulate, distinct and slightly prominent on both surfaces
Flowers	ca. 24	8–13
Pedicel	12–18 mm long	5–10 mm long
Calyx lobes	Purplish, lacking hairs, broadly ovate, 1–1.5 × 1–1.5 mm	Green, glabrous inside, sparsely hairy outside, ovate, ca. 1 × 1 mm

Key to species of *Ardisia* subgenus *Tetrardisia*

1 Leaves entire or obscurely undulate or obscurely crenulate **2**
– Leaves distinctly crenulate-denticulate..... **5**
2 Inflorescences paniculate, 15–20 cm long. Thailand and Malay Peninsula....***A. porosa***
– Inflorescences subumbullate or racemose, 3–5 cm long..... **3**
3 Leaf lamina linear-oblong, 1–2 cm wide, margin distinctly finely serrulate in the distal half. Inflorescence branched and flowers loosely arranged in racemes. Borneo.....***A. argentiana***
– Leaf lamina elliptic, elliptic-lanceolate or elliptic-oblong, 3.5–7 cm wide..... **4**

4 Leaves with scattered stellate hairs near the margin abaxially, margin obscurely serrulate being entire in appearance; petioles 1.5–3 cm long. Inflorescence with ca. 24 flowers. Borneo ..... ***A. nagaensis***
– Leaves puberulent along the midrib abaxially, margins entire proximally becoming faintly crenulate distally; petioles 5–8 mm long. Inflorescences with 8–20 flowers. Malay Peninsula ..... ***A. tetrasepala***
5 Leaves somewhat bullate, lateral nerves 12–20 pairs; pedicels puberulous. Malay Peninsula and Java..... ***A. denticulata***
– Leaves not bullate, lateral nerves numerous; pedicels glabrous. Thailand .... ***A. tetramera***

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