

# Three new caespitose species of *Senecio* (Asteraceae, Senecioneae) from South Peru

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## Abstract

Three new species of the genus *Senecio* (Asteraceae, Senecioneae) belonging to *S.* ser. *Suffruticosi* subser. *Caespitosi* were discovered in the tributaries of the upper Tambo River, Moquegua Department, South Peru. Descriptions, diagnoses and discussions about their distribution, a table with the morphological similarities with other species of *Senecio*, a distribution map, conservation status assessments, and a key to the caespitose Peruvian species of *S.* subser. *Caespitosi* are provided. The new species are *Senecio moqueguensis* Montesinos, **sp. nov.** (Critically Endangered) which most closely resembles *Senecio pupacampaensis* Beltrán, *Senecio sykorae* Montesinos, **sp. nov.** (Critically Endangered) which most closely resembles *Senecio gamolepis* Cabrera, and *Senecio tassaensis* Montesinos, **sp. nov.** (Critically Endangered) which most closely resembles *Senecio moqueguensis* Montesinos.

## Resumen

Tres nuevas especies del género *Senecio* (Asteraceae, Senecioneae) pertenecientes a *S.* ser. *Suffruticosi* subser. *Caespitosi* fueron descubiertas en las alturas de la cuenca del río Alto Tambo, Departamento Moquegua, Sur de Perú. Las especies se describen y tipifican, una diagnosis y discusión acerca de su distribución, una tabla con las similitudes morfológicas con otras especies de *Senecio*, un mapa de distribución, el estatus de conservación y una clave para las especies peruanas cespitosas de *S.* subser. *Caespitosi* son presentadas. Las nuevas especies son *Senecio moqueguensis* Montesinos, **sp. nov.** (En Peligro Crítico) el cual se asemeja más a *Senecio pupacampaensis* Beltrán, *Senecio sykorae* Montesinos, **sp. nov.** (En Peligro Crítico) el cual se asemeja más a *Senecio gamolepis* Cabrera, y *Senecio tassaensis* Montesinos, **sp. nov.** (En Peligro Crítico) el cual se asemeja más a *Senecio moqueguensis* Montesinos.

**Keywords**

Compositae, new species, *Senecio* subser. *Caespitosi*, South America, taxonomy

**Palabras clave**

Compositae, nuevas especies, *Senecio* subser. *Caespitosi*, Sudamérica, taxonomía

**Introduction**

*Senecio* contains about 175 species in Peru (Brako and Zaruchi 1993, Vision and Dillon 1996) including several recently described new species (Beltrán 2009). The genus has 94 species endemic to Peru which have been evaluated and classified according to IUCN criteria (Beltrán et al. 2007). In the Department of Moquegua, 30 species have been recorded (Arakaki and Cano 2003, Montesinos 2012). The species of *Senecio* described here were discovered in the tributaries of the upper Tambo River in southern Peru, an area of extraordinary species richness and a high level of endemism (Montesinos 2011, 2012).

*Senecio* ser. *Suffruticosi* Cabrera accounts for 143 species occurring on the American continent, especially in the Andes and Patagonia (Cabrera 1949, Cabrera 1985, Cabrera et al. 1999). Cabrera et al. (1999) divided *S.* ser. *Suffruticosi* into five subseries and described it as embracing suffruticose or perennial herbs, glabrous or glandulose, with entire leaves which are dentate or, more rarely, incised, involucre discoid, and capitula isomorphic. Among those subseries, *S.* subser. *Caespitosi* Cabrera contains 50 species (Cabrera et al. 1999), of which thirteen occur in Peru at altitudes between 3500 m and 5000 m (Brako and Zaruchi 1993, Beltrán et al. 2007): *S. adenophyllus* Meyen & Walp., *S. algens* Wedd., *S. scorzonnerifolius* Meyen & Walp. and *S. trifurcifolius* Hieron. also distributed in northwestern Argentina, Bolivia and north of Chile, *S. danai* A. Gray and *S. pucapampaensis* Beltrán occurring only in central Peru (Beltrán 2007), *S. evacoides* Sch. Bip., *S. expansus* Wedd. and *S. humillimus* Sch. Bip. also distributed in northwestern Argentina and Bolivia, *S. gamolepis* Cabrera, endemic to central and southern Peru, *S. rufescens* DC. distributed from Colombia to northwestern Argentina, *S. repens* Stokes distributed from south Ecuador through Peru and northwestern Bolivia, and *S. vegetus* (Wedd.) Cabrera, also distributed in Bolivia. In *S.* subser. *Caespitosi* plants are characterized as suffruticose (or herbaceous), glabrous or glandulose; leaves entire, dentate or, more rarely, incised; capitula discoid, medium or small; and flowers isomorphic (Cabrera et al. 1999).

Notwithstanding the progress in taxonomical and molecular studies (Nordenstam 1977, Cabrera 1949, 1985, Cabrera et al. 1999, Pelsner et al. 2007, Nordenstam et al. 2009), there are more species of the tribe *Senecioneae* occurring in the Andes which remain poorly understood and are awaiting discovery. Intergeneric relationships within *Senecioneae* are still largely unknown (Pelsner et al. 2007); furthermore, the lack of knowledge about generic-level evolutionary relationships in *Senecioneae* remains the largest taxonomic problem on the way to obtaining a monophyletic delimitation of

*Senecio* (Bremer 1994, Pelser et al. 2007). Phylogenetic positions for the members of *S.* subser. *Caespitosi* are still largely unknown, except for *S. algens*, *S. humillimus* and *S. rufescens* (Pelser et al. 2007), of which *S. algens* belongs to the *Aetheolaena involucrata*-*A. patens* clade and *S. humillimus* and *S. rufescens* to the *Senecio glaber*-*S. donianus* clade. Numerous new collections from Moquegua have been made in recent years (Montesinos 2011, 2012). A comparison with herbarium specimens, together with a review of the literature and taxonomic keys, has shown that these collections include three new species of *S.* subser. *Caespitosi* which are described below. These new species were separated from the other species of this subseries on the basis of a set of characters such as habit, the presence or absence of trichomes, flower color, the number of phyllaries and involucre bracts, the involucre length and the achene type (Cabrera 1955, 1985, Cabrera et al. 1999). The new species can be found at elevations above 4500 m as terrestrial plants on bare rocky soils on the summits of high mountains in the north of Moquegua department, where they co-occur with several other acaulescent *Senecioneae* from *S.* subser. *Caespitosi* such as *S. gamolepis*, *S. evacoides*, and *S. algens*.

## Methods

Based on morphological characters, an overview of the genus *Senecio* with an emphasis on *S.* subser. *Caespitosi* from Peru and adjacent areas (Ecuador, Bolivia, Argentina and northern Chile) has been prepared, based on Cabrera (1955, 1985) and Cabrera et al. (1999). Since 2009 I have examined more than 450 specimens of *S.* subser. *Caespitosi* housed in Peruvian herbaria (CUZ, HSP, HUPCH, HUSA, MOL, USM), relevant collections from institutions abroad (B, BR, F, L, LPB, MO, P, WAG), and material from my recent fieldwork. Digitised specimens were viewed via online herbarium catalogues (<http://tropicos.org> and <http://fm1.fieldmuseum.org/vrrc/>) or via JSTOR (2013). All morphological characters were studied under a NSZ-405 1X-4.5X stereo microscope and an AmScope M100C-LED 40x-1000x compound microscope. The descriptions were made using the terminology presented by Cabrera (1955, 1985), Cabrera et al. (1999), Vision and Dillon (1996), Beltrán (2009), Nordenstam et al. (2009) and Roque et al. (2009). Conservation assessments were undertaken using the IUCN criteria (IUCN 2001).

## Taxonomy

### *Senecio moqueguensis* Montesinos, sp. nov.

urn:lsid:ipni.org:names:77140249-1

Figs 1, 4A, 5

**Diagnosis.** The new species is morphologically similar to *Senecio pucapampaensis* but is clearly distinguished by the leaf lamina oblong-spathulate (vs. cuneiform), leaf surface

covered by thin trichomes (vs. glabrous), corolla yellow (vs. white), calycular bracts linear-oblong, 6–9 mm long (vs. linear, 6–7 mm long), and phyllaries 9–12 (vs. 12–14).

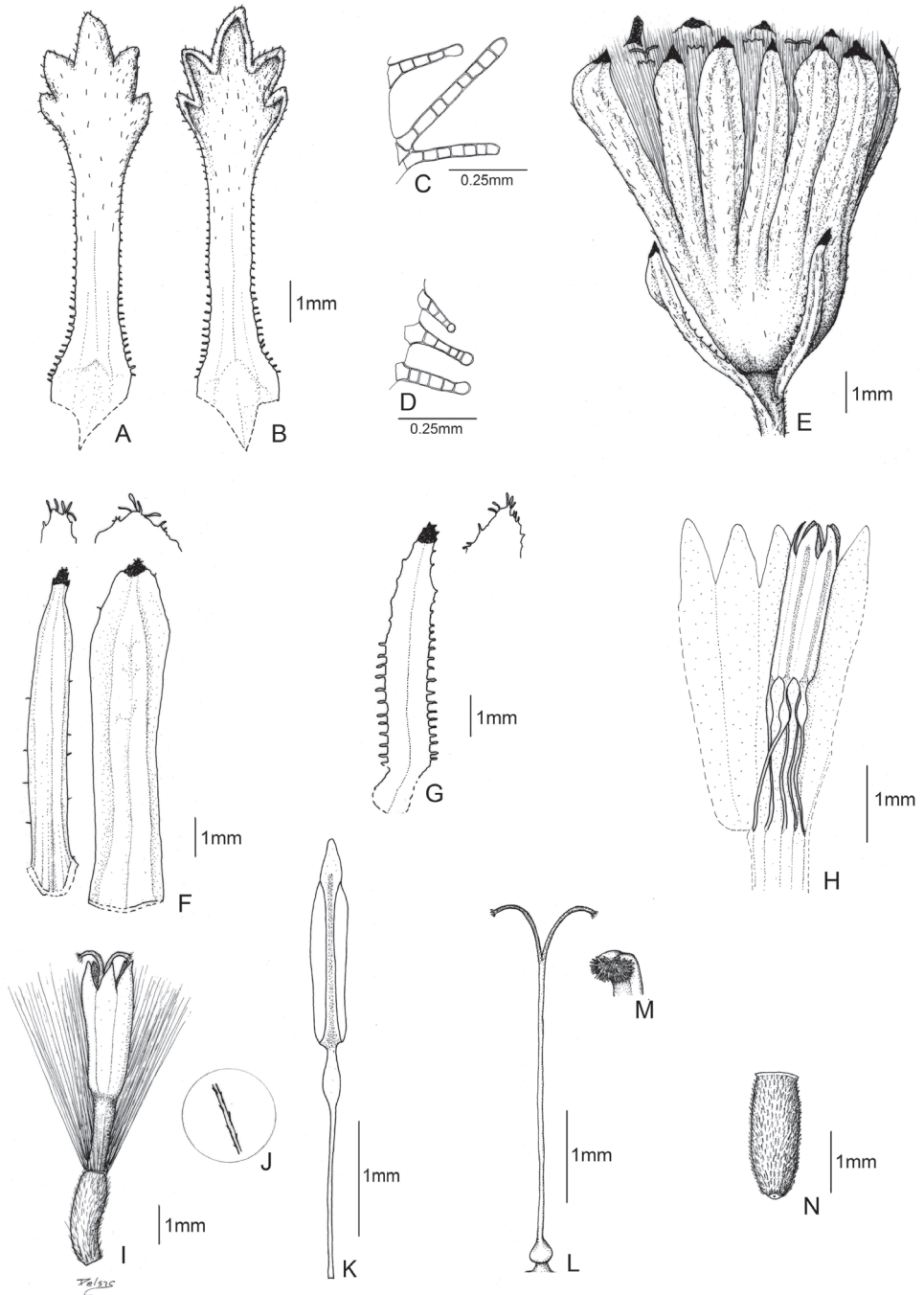
**Type.** PERU. Moquegua Region, General Sánchez Cerro Province, Ubinas District, NW of Tassa, terrestrial on clayey rocky soils on the plateau peaks near Lake Pacosani, elevation 4653 m, 16°06'43"S, 70°44'45"W, 3 April 2009, *Montezinos 2400* (holotype USM!, isotypes MO 2383567, HUPCH 4185, CPUN, WAG 0246107).

**Description.** *Perennial* herb, rhizomatous, creeping, low-growing, forming mats 2–4 cm tall and up to 60 cm in diam. *Trichomes* glandular, somewhat dense and irregularly distributed, multicellular, whitish transparent, 0.1–0.3 mm long and 0.05–0.1 mm wide and composed of 4–8 subrotund cells (each 30–50 µm long), apical cell rotund. *Stems* 1–3 cm long, often densely branched and leafy in the central part, rooting. *Leaves* cauline, lamina oblong-spathulate, 8–12 mm × 1–2.5 mm, sparsely covered by thin trichomes on the margins, lower and upper surfaces except at the base; base truncated, apex subpinnatifid; young leaves dark green with yellowish margins, turning light green-greyish with age. *Synflorescences* of solitary sessile or subsessile terminal capitula. *Capitula* homogamous, discoid. *Involucres* at first broadly cylindrical, gradually turning campanulate with age, ca. 7–10 mm long × 6–8.5 mm wide). *Calycular bracts* linear-oblong (6–9 mm × 1–2.5 mm), whitish green on the surface and whitish along the margins, with scarce trichomes near the midrib and margins, apex dark brown covered with short light-brown trichomes. *Phyllaries* 9–12, connate, 5–8 mm long × 0.7–1.2 mm wide, oblong-lanceolate, covered with thin trichomes sparsely on the surface and densely along the margins, apex greenish grey and dark brown with short white multicellular trichomes. *Florets* 24–28; corolla tubular, abruptly constricted near the base, 5-lobed, each lobe 0.5 mm long, bright yellow, tube 3–5 mm long × 0.8–1 mm wide; anthers linear-lanceolate, 1.5–2.5 mm long, 0.2–0.4 mm wide, ecalcarate, terminal appendages lanceolate, obtuse, margin whitish transparent and becoming yellow towards the centre; style dark yellow, truncate, papillae covering the whole surface of the apex. *Achenes* cylindrical, covered with trichomes, 1.8–2.5 mm long and 0.4–0.8 mm wide, light brown; carpodium symmetrical in a small ring; pappus of smooth bristles, white, silky, 5–6 mm long, with fine single setulae.

**Ecology and distribution.** Terrestrial plant on clayey rocky soils on the peaks of the highland summits and grasslands in the north of Moquegua Region, at elevations of ca. 4500 to 4800 m. Co-occurring species include *Azorella compacta* Phil., *Calamagrostis vicunarum* (Wedd.) Pilg., *Pycnophyllum molle* Remy, and *Festuca* spp. Flowers and fruits between March and April.

**Etymology.** The specific epithet refers to Moquegua, where the only three collections are known from the north of the department.

**Additional material examined (paratypes).** PERU. Moquegua Region, General Sánchez Cerro Province, Ubinas District, terrestrial on bare clayey soils in the verges of the road east Pillone town, elevation 4584 m, 16°10'02"S, 70°49'56"W, 24 March 2013, *Montezinos 4022* (USM, HUSA). Moquegua Region, General Sánchez Cerro Province, Ubinas District, NW of Tassa, terrestrial on bare clayey soils in the verges of



**Figure 1.** *Senecio moqueguensis* Montesinos. **A** Leaf (upper side) **B** Leaf (underside) **C** Phyllary trichomes **D** Leaf trichomes **E** Capitulum **F** Calycular bracts **G** Phyllary **H** Stamens arrangement in a floret **I** Floret **J** Pappus bristles **K** Stamens **L** Style **M** Papillose stigma **N** Achene

the road to Lake Cochapata, elevation 4687 m, 16°08'56"S, 70°43'0.30"W, 9 December 2013, *Montezinos 4200* (CUZ).

**Discussion.** A comparison of the material has shown that *S. moqueguensis* is most similar to *S. pucapampaensis* and *S. tassaensis* sp. nov. Together with *S. evacoides*, *S. expansus*, *S. repens* and *S. humillimus*, it forms a coherent morphological and geographical group within *S.* subser. *Caespitosi* which occurs from central Peru to northwest Argentina and is characterized by the presence of trichomes on stems, leaves and involucres. *Senecio moqueguensis* can be distinguished from *S. pucapampaensis* by the dense caespitose mat habit, leaves, calycular bracts, corolla color, involucres and achene morphology as summarised in Table 1. *Senecio moqueguensis* can be distinguished from *S. evacoides*, *S. expansus* and *S. repens* by the habit, density of trichomes, leaf shape and length, as well as by the calycular bracts and phyllary length and form.

**Conservation status.** Following the criteria and categories of IUCN (2001), a preliminary status of Critically Endangered (CR) is assigned. The new species deserves protection because its total area of occupancy is less than 100 km<sup>2</sup> (ca. 50 km<sup>2</sup>) (B1); only three populations are known (B1b); habitat inferred to be continuing to decline (B1b(i-iii)); population estimated to number fewer than 300 individuals (D). The suitable habitats for *S. moqueguensis* on the mountain summits near the set of lakes in the Ubinas district are regarded as endangered because overgrazing of grasslands, changes in annual rainfall, volcanic activity, and exploitation of natural resources may all potentially reduce their extent.

***Senecio sykorae* Montezinos, sp. nov.**

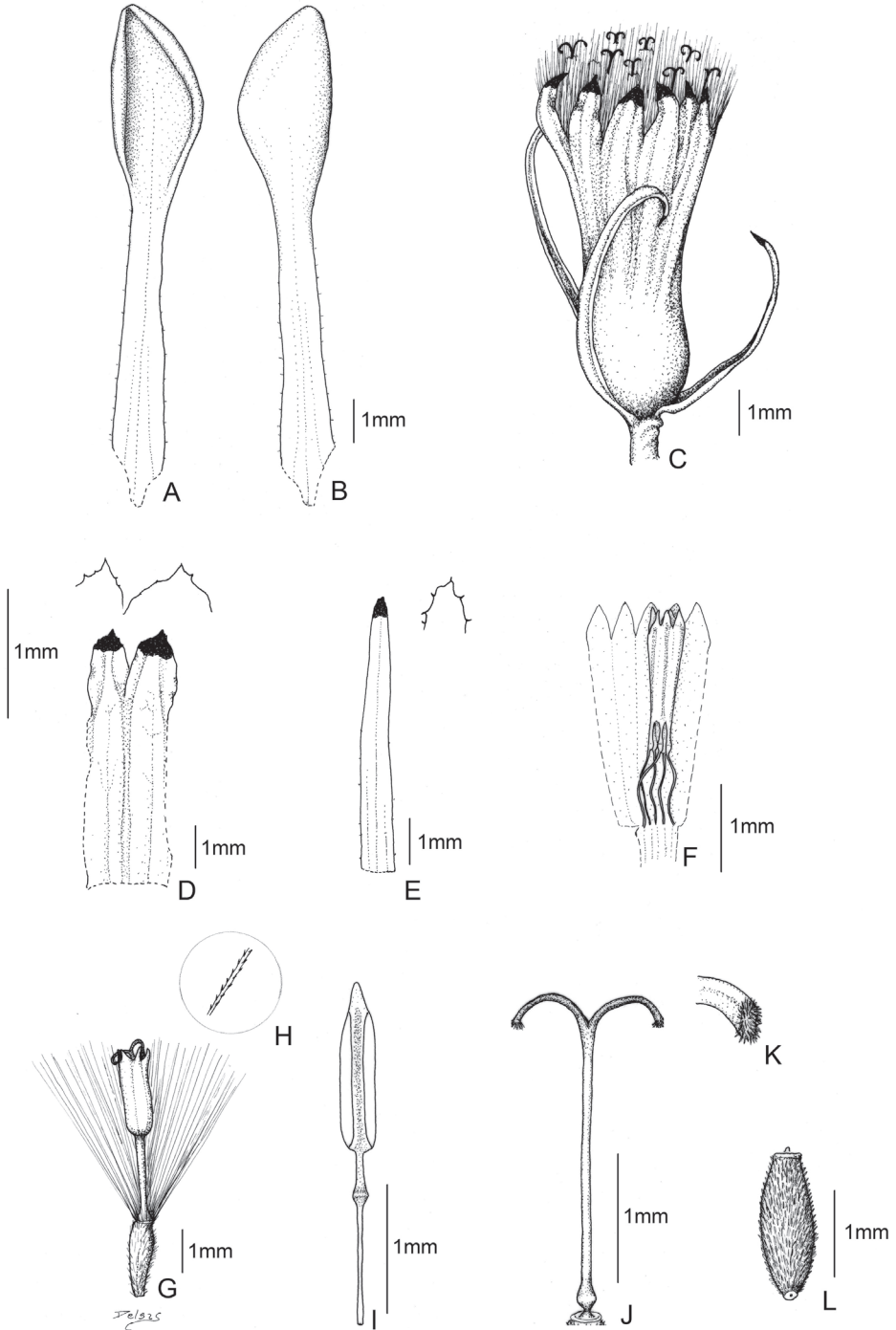
urn:lsid:ipni.org:names:77140250-1

Figs 2, 4B, 5

**Diagnosis.** Morphologically similar to *Senecio gamolepis* but clearly distinguished by the tuft mat habit (vs. cushion mats), the leaf shape being obovate-spathulate (vs. linear-lanceolate), corolla white (vs. yellow), phyllaries 12–14 (vs. 7–9), disc length 7–9 mm (vs. 8–12 mm), and achene length 1.5–2 mm (vs. 1–1.3 mm).

**Type.** PERU: Moquegua Region, General Sánchez Cerro Province, Yunga District, E of Yunga, terrestrial on bare clayey soils on the peaks of Perusa mountain, elevation 4802 m, 16°11'08"S, 70°38'14"W, 13 April 2012, *Montezinos & Calisaya 3805* (holotype USM!, isotype HUSA!).

**Description.** *Perennial* herb, decumbent, low-growing and forming small tuft mats 4–6 cm high and up to 6 cm in diam. *Trichomes* absent. *Stems* 3–5 cm long, densely leafy, woody and branched at the base. *Leaves* cauline, alternate, lamina obovate-spathulate, 9–14 mm long × 1–2.2 mm wide, glabrous on surface and margins except at the base (scarcely covered by thin, short trichomes), base truncate to auriculate, apex obtuse, entire, margin involute; young leaves pale green with yellowish margins turning dark green with age. *Synflorescences* of solitary, terminal capitula. *Capitula*



**Figure 2.** *Senecio sykoraе* Montesinos. **A** Leaf (upper side) **B** Leaf (underside) **C** Capitulum **D** Calycular bracts **E** Phyllary **F** Stamens arrangement in a floret **G** Floret **H** Pappus bristles **I** Stamens **J** Style **K** Papillose stigma **L** Achene

**Table 1.** Comparison between *Senecio moqueguensis*, *S. sykora*, *S. tassaensis* and their closest relatives.

	<i>S. moqueguensis</i>	<i>S. sykora</i>	<i>S. tassaensis</i>	<i>S. puacampaensis</i>	<i>S. gamolepis</i>	<i>S. algens</i>
<b>Distribution</b>	PE (Moquegua)	PE (Moquegua)	PE (Moquegua)	PE (Junin)	PE, CH, AR, BO	PE, BO, AR
<b>Altitude</b>	4500–4800 m	4550–4800 m	4650–4700 m	4500–4600 m	4000–4800 m	4500–5000 m
<b>Habit</b>	dense caespitose mat	turf mat	turf	prostrate, decumbent	dense caespitose mat	caespitose subshrub
<b>Plant dimensions (height, diameter)</b>	2–4 cm, > 60 cm	4–6 cm, > 6 cm	2–4 cm, > 4 cm	5–9 cm, > 8 cm	2–3 cm, > 1 m	4–6 cm, > 6 cm
<b>Indumentum</b>	glandular, multicellular, 0.1–0.3 mm	absent	glandular, multicellular, 0.3–1.2 mm	finely puberulous, <0.1 mm	absent	absent
<b>Leaf shape</b>	oblong-spathulate, subpinnatifid	obovate-spathulate	obovate-spathulate, incised or acuminate	cuneiform-subpinnatifid, incised	linear-lanceolate	spathulate, obtuse
<b>Leaf (length, width)</b>	8–12 × 1–2.5 mm	9–14 × 1–2.2 mm	6–9 × 1–2.5 mm	9–15 × 3–4 mm	8–12 × 2–4 mm	10–35 × 2–5 mm
<b>Leaf pubescence</b>	sparsely covered by thin trichomes	glabrous	densely covered by trichomes	ciliate margins	glabrous	glabrous
<b>Involute (shape; length; width)</b>	cylindrical-campanulate; 7–10 × 6–8.5 mm	cylindrical-campanulate; 7–9 × 3–5 mm	cylindrical-campanulate; 6–8 × 5–7 mm	campanulate; 7–8 × 8–9 mm	cylindrical-campanulate; 8–11 × 4–6 mm	cylindrical-campanulate; 7.5–10 × 8–12 mm
<b>Calycular bracts (shape; margin; size)</b>	linear-oblong; sparse trichomes; 6–9 × 1–2.5 mm	linear-oblong; scarce trichomes; 6–8 × 0.7–1 mm	ovate-oblong; dense trichomes; 4–6 × 1 mm	linear; ciliate; 6–7 × 1 mm	linear; glabrous; 7–10 × 0.8–1.2 mm	linear; glabrous; 6–9 × 0.8–1.1 mm
<b>Phyllaries (shape; size)</b>	oblong-lanceolate; 5–8 × 0.7–1.2 mm	linear-lanceolate; 5–6.5 × 0.6–1 mm	linear-lanceolate; 5–8 × 0.8–1.2 mm	linear; 6–7 × 1.2 mm	oblong; 6–8 × 1.8–2.3 mm	linear; 7–9 × 2–3 mm
<b>Phyllaries (number)</b>	9–12	12–14	12–16	12–14	7–9	10–15
<b>Phyllaries (margin)</b>	densely covered with trichomes	glabrous	densely covered with trichomes	scarious, ciliate	glabrous	glabrous
<b>Corolla (color)</b>	bright yellow	white	purple-pink to pale white	white	yellow	yellow
<b>Achene (shape, texture)</b>	cylindrical, with trichomes	cylindrical, with trichomes	ovate, striate, with trichomes	cylindrical, glabrous	cylindrical, glabrous	cylindrical, glabrous
<b>Pappus (length)</b>	5–6 mm	4–6 mm	3.5–5 mm	5–6 mm	6–9 mm	6–8 mm



Table 1. Continue

	<i>S. euacoides</i>	<i>S. humilimus</i>	<i>S. expansus</i>	<i>S. trifurcifolius</i>	<i>S. repens</i>
<b>Distribution</b>	PE, BO, AR	BO, South Peru	AR, BO, PE	PE, BO, CH	BO, EC, PE
<b>Altitude</b>	4000–4800 m	3500–4500 m	3900–4800 m	4000–4500 m	3000–4600 m
<b>Habit</b>	suffruticose or shrubby	dense caespitose mat	ground rosette herb	suffruticose	ground rosette herb
<b>Plant dimensions (height, diameter)</b>	2 cm, ca. 1 m	2 cm, ca. 70 cm	2–4 cm, 5–8 cm	5–8 cm, > 8 cm	2–4 cm, 6–9 cm
<b>Indumentum</b>	white lanuginose; < 0.2 mm	puberulous, 0.1–0.2 mm	densely lanuginose; < 0.2 mm	absent	puberulous, < 0.2 mm
<b>Leaf shape</b>	obovate-spathulate	linear-spathulate, ovate	ovate, elliptical or circular, crenate	cuneiform-linear, dentate	elliptic-ovate, obovate
<b>Leaf (length, width)</b>	10–20 × 3–6 mm	3–10 × 0.5–1 mm	10–25 × 10–22 mm	10–20 × 1 mm	10–25 × 10–22 mm
<b>Leaf pubescence</b>	densely lanuginose	sparsely puberulous	densely lanuginose	glabrous	glabrous adaxially, puberulous abaxially
<b>Involucre (shape; length; width)</b>	campanulate; 7–8 × 5–6 mm	cylindrical-campanulate; 5 × 3–4 mm	campanulate; 10–25 × 10–22 mm	campanulate; 8–9 × 6 mm	campanulate; 6–7 × 8–10 mm
<b>Calycular bracts (shape; margin; size)</b>	linear; tomentose; 6–7 × 0.8–1.2 mm	linear; glabrous; 3–4 × 0.7–1 mm	linear; tomentose; 9–22 × 2.5–5 mm	linear; glabrous; 7–8 × 0.8–1.2 mm	linear; glabrous; 5–6 × 0.8–1.2 mm
<b>Phyllaries (shape; size)</b>	linear; 5–7 × 0.8–1.1 mm	oblong-lanceolate; 6–8 × 1–1.2 mm	linear; 10–15 × 2–4 mm	lanceolate, attenuate; 6–8 × 1–1.5 mm	linear; 13–20 mm × 1–2 mm
<b>Phyllaries (number)</b>	13–20	8	20–25	8	13–20
<b>Phyllaries (margins)</b>	pubescent	glabrous	glabrous or pubescent	glabrous	glabrous
<b>Corolla (color)</b>	yellow	dark yellow with purple tube	yellow	yellow	yellow
<b>Achene (shape, texture)</b>	cylindrical, glabrous	cylindrical, sericeous	cylindrical, glabrous	cylindrical-ovate, densely sericeous	cylindrical, glabrous
<b>Pappus (length)</b>	4–6 mm	5–7 mm	10–20 mm	6–7 mm	5–6 mm

homogamous, discoid and pedicled (5–10 mm long). *Involucres* at first narrowly cylindrical becoming cylindrical-campanulate with age (7–9 mm long  $\times$  3–5 mm wide). *Calycular bracts* linear-oblong (6–8 mm  $\times$  0.7–1 mm), dark green on the surface and light green along the margins, with dark brown-black apex covered with inconspicuous trichomes or glabrous. *Phyllaries* 12–14, connate, 5–6.5 mm long  $\times$  0.6–1 mm wide, linear-lanceolate, margins glabrous, apex dark brown with short trichomes. *Florets* 13–16; corolla tubular, abruptly constricted near the base, 5-lobed, each lobe 0.2–0.3 mm long, white, tube 2.5–4 mm long  $\times$  0.5–0.8 mm wide; anthers linear-lanceolate, 1.5–2 mm long  $\times$  0.2–0.3 mm wide, truncate, terminal appendages lanceolate, obtuse; margin whitish transparent and becoming darker towards the centre; style dark purple, truncate, apically covered by papillae equally distributed. *Achenes* cylindrical, pale green, finely covered with trichomes, 1.5–2 mm long  $\times$  0.6–0.9 mm wide; carpodium symmetrical in a shallow ring; pappus of smooth fine bristles, white, 4–6 mm long, with fine alternate single setulae.

**Ecology and distribution.** Terrestrial plant on bare clayey soils on the summits of mountain peaks and grassland plateaus in the north of the Moquegua Region at elevations of 4550–4800 m. Co-occurring with *Belloa pickeringii* (A. Gray) Sagást. & M.O. Dillon, *Nototriche obcuneata* (Baker f.) A.W. Hill, *Pycnophyllum molle* Remy, *Senecio candollei* Wedd. and *Xenophyllum ciliolatum* (A. Gray) V.A. Funk. Flowers and fruits between March and April.

**Etymology.** This *Senecio* is named after Karlè Sýkora, a well-known Dutch vegetation scientist who was my mentor in phytosociology.

**Additional material examined (paratypes).** PERU. Moquegua Region, General Sánchez Cerro Province, Ubinas District, S of Pillone, terrestrial on bare clayey soils in the verges of the road to Pillone town, elevation 4584 m, 16°10'02"S, 70°49'56"W, 24 March 2013, *Montezinos 4023* (USM).

**Discussion.** *Senecio sykora* appears to be closely related to *S. gamolepis* which grows at higher elevations but approaches the known range of *S. sykora* within a few hundred metres. While *S. gamolepis* is generally distinctive in the genus for its large size, attaining widths of up to 1 meter in diameter, and for its larger, capitulate form, *S. sykora* is a smaller plant, of about 4–6 cm wide and has shorter corolla, less than 9 mm long. *Senecio sykora* is also distinctive in that it has 12–14 phyllaries per capitulum instead of 7–9 phyllaries in *S. gamolepis*. Likely the leaves of *S. sykora* are distinctive in that they are obovate-spathulate vs. linear-lanceolate. Also, the achenes in *S. sykora* are larger (1.5–2 mm long) vs. 1–1.3 mm long in *S. gamolepis*. *Senecio sykora* also differs from *S. algens* by the leaf and capitula length (shorter in *S. sykora*), and from both species by the corolla colour (white vs. yellow). Less similarity is found in *S. algens*, *S. humillimus*, *S. trifurcifolius*, *S. pucapampaensis* and *S. evacooides*, and from which *S. sykora* can be distinguished on the basis of its habit, trichomes, leaf shape and length, calycular bracts and phyllary length and shape as summarized in Table 1.

**Conservation status.** Following the criteria and categories of IUCN (2001), a preliminary status of Critically Endangered (CR) is assigned. The new species deserves

protection because its total area of occupancy is less than 10 km<sup>2</sup> (ca. 5 km<sup>2</sup>) (B2); only one population known (B2b); habitat inferred to be continuing to decline (B2b(i-iii)); population estimated to number fewer than 150 individuals (D). The suitable habitats for *S. sykora* on the mountain summits of the north of Moquegua are indicated as endangered because of overgrazing of grasslands, changes in annual rainfall, volcanic activity, and exploitation of natural resources, all potentially reducing their extent.

***Senecio tassaensis* Montesinos, sp. nov.**

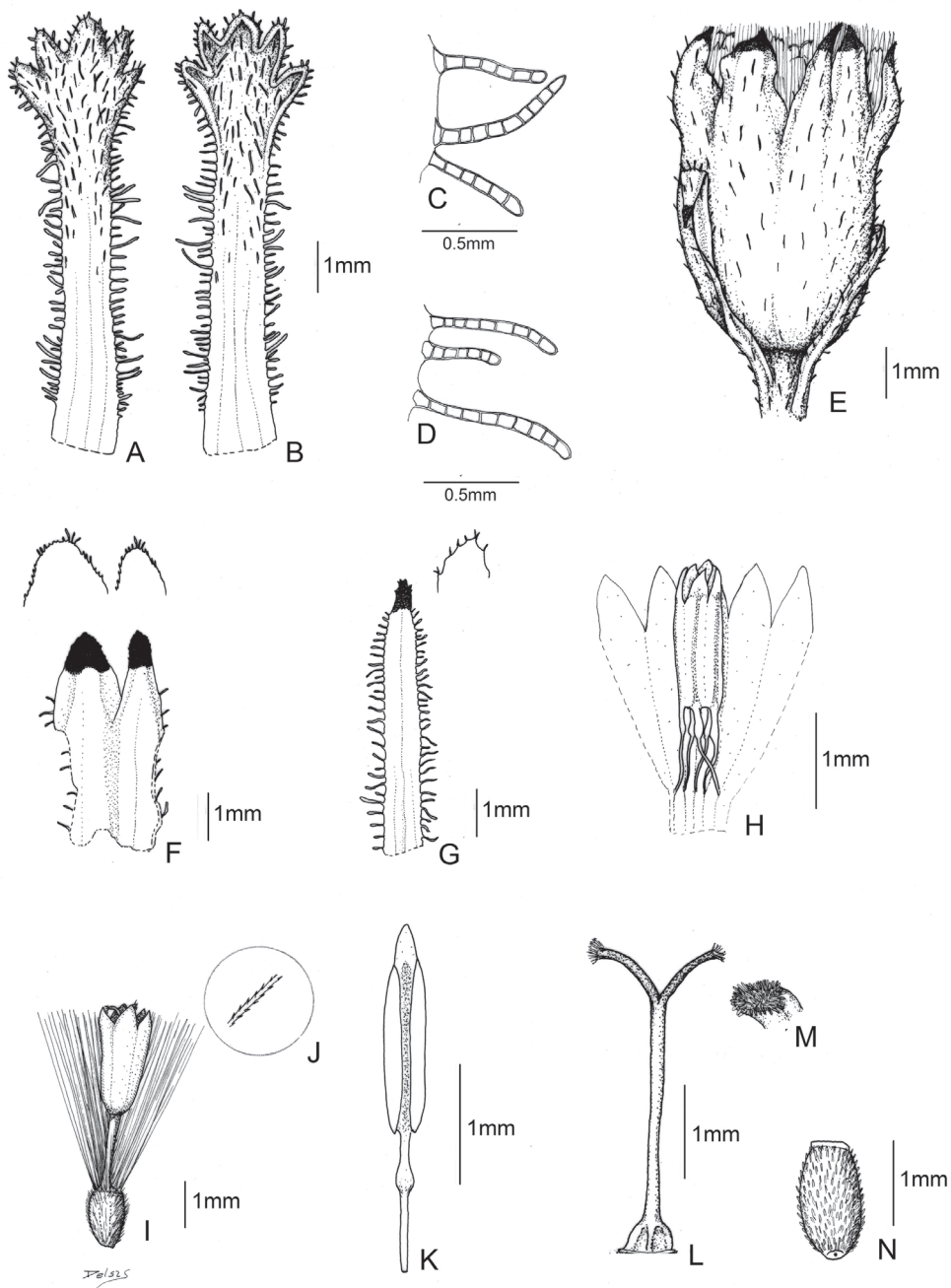
urn:lsid:ipni.org:names:77140251-1

Figs 3, 4C, 5

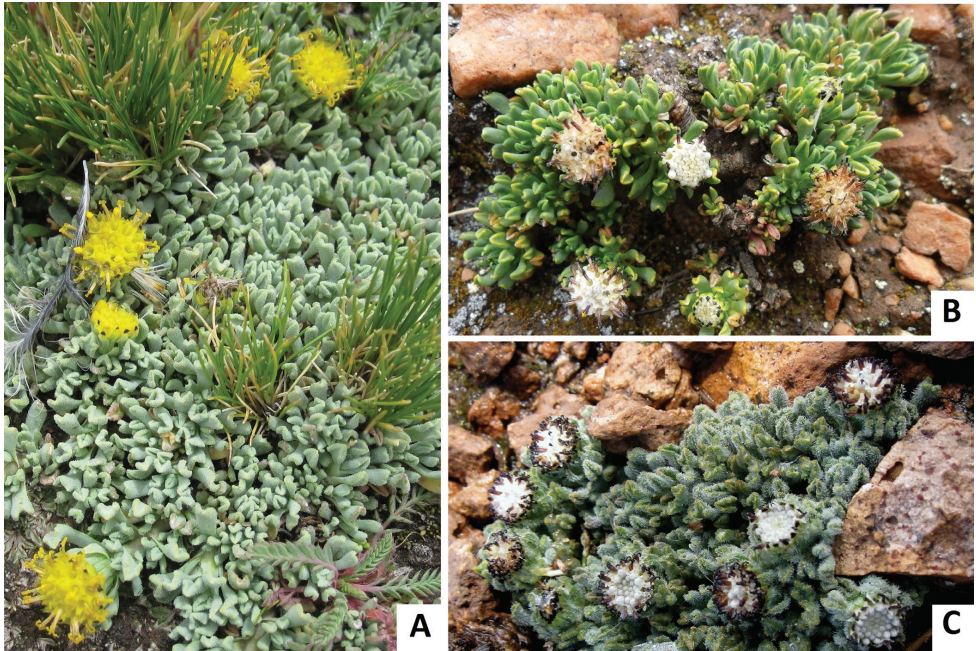
**Diagnosis.** Similar to *Senecio moqueguensis* but clearly distinguished by the leaf lamina obovate-spathulate (vs. oblong-spathulate), leaf length 6–9 mm (vs. 8–12 mm), leaf surface densely covered by trichomes (vs. sparsely covered), trichomes 0.3–1.2 mm long (vs. 0.1–0.3 mm long), corolla white (vs. yellow), calycular bracts 4–6 mm long (vs. 6–9 mm), phyllaries 12–16 (vs. 9–12), involucre length 6–8 mm (vs. 7–10 mm), and achene length 1–1.2 mm (vs. 1.8–2.5 mm).

**Type.** PERU. Moquegua Region, General Sánchez Cerro Province, Ubinas District, NW of Tassa, terrestrial on clayey rocky soils on the summits of Pirhuani peak, elevation 4657 m, 16°09'58"S, 70°43'49"W, 07 April 2011, *Montesinos 3103* (holotype HUSA!, isotypes MOL, USM).

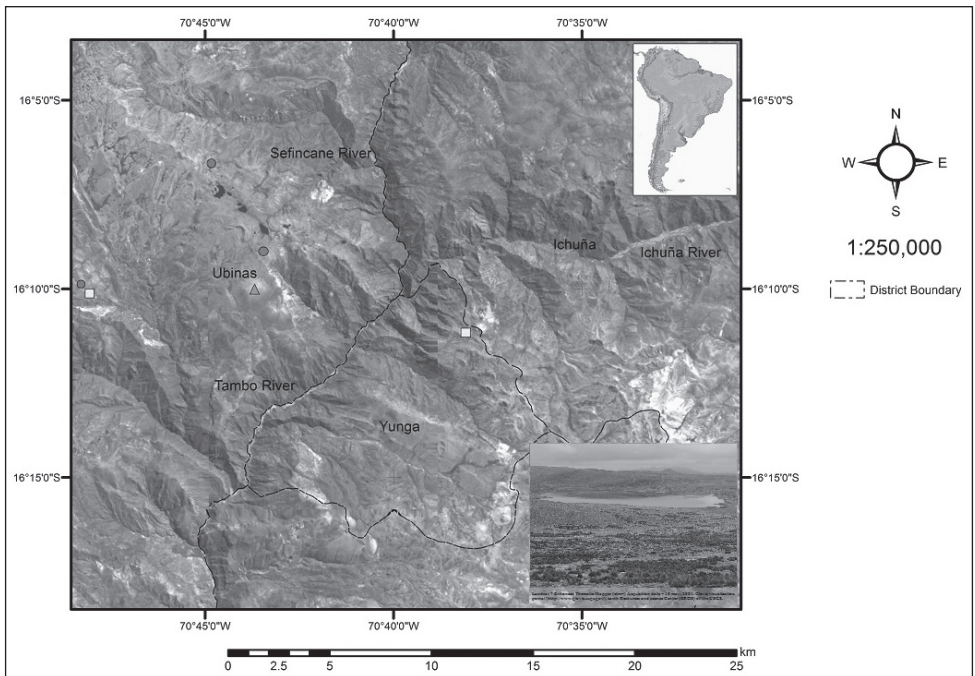
**Description.** *Perennial* herb, tufted, up to 2–4 cm high and up to 4 cm in diam. *Trichomes* glandular, densely covering the plant, multicellular, whitish transparent, 0.3–1.2 mm long × 0.1–0.2 mm wide, composed of 6–10 ovate or elongate cells (each 60–80 µm long), apical cell rotund. *Stems* thick, < 1 cm long, often densely branched and leafy in the central portion. *Leaves* arranged in irregular rosettes, lamina obovate-spathulate, 6–9 mm × 1–2.5 mm, densely covered by thin trichomes on the margins; base truncated and apex pinnatifid; lower and upper surface of the leaves gradually becoming shorter towards the tip; margin incised with 5–7 obtuse lobes or rarely acuminate; mature leaves with involute margins; young leaves green yellow turning greenish grey with age. *Synflorescences* of solitary sessile or subsessile terminal capitula. *Capitula* homogamous, discoid. *Involucre*s at first cylindrical, turning campanulate with age (ca. 6–8 mm long × 5–7 mm wide). *Calycular bracts* ovate-oblong (4–6 mm × 1 mm), greyish green on the surface and covered with trichomes on the margins, dark brown apex covered apically with short brown multicellular trichomes. *Phyllaries* 12–16, connate, 5–8 mm long × 0.8–1.2 mm wide, linear-lanceolate, covered with thin trichomes scarcely on the surface and densely along the margins, apex dark brown and covered with short multicellular trichomes. *Florets* 18–21, corolla tubular, abruptly constricted near the base, 5-lobed, each lobe 0.2–0.4 mm long, purple pink gradually becoming pale white towards the tip, tube 2–2.5 mm long × 1 mm wide; anthers linear-lanceolate, 1.5–2 × 0.3–0.4 mm, terminal appendages lanceolate, acute to somewhat protuberant, bases ecalcarate; anthers margin white becoming dark yellow towards



**Figure 3.** *Senecio tassaensis* Montesinos. **A** Leaf (upper side) **B** Leaf (underside) **C** Phyllaries trichomes **D** Leaf trichomes **E** Capitulum **F** Calycular bracts **G** Phyllary **H** Stamens arrangement in a floret **I** Floret **J** Pappus bristles **K** Stamens **L** Style **M** Papillose stigma **N** Achene.



**Figure 4.** Habit photographs of: **A** *Senecio moqueguensis* **B** *Senecio sykoraе* **C** *Senecio tasaensis*.



**Figure 5.** Distribution map showing collection and recorded sites for *Senecio moqueguensis* (red circles), *S. sykoraе* (yellow squares) and *S. tasaensis* (green triangles). Inset: Photograph of the highland plains of Tassa, Moquegua, where populations of *S. moqueguensis* occur.

the centre; style dark purple, truncate, papillae covering the whole surface of the apex. *Achenes* ovate, striate, covered with trichomes, 1–1.2 mm long and 0.6–0.8 mm wide, pale yellow; carpodium symmetrical in a shallow ring; pappus of smooth bristles, white, silky, 3.5–5 mm long, with fine single setulae.

**Ecology and distribution.** Terrestrial plant on clayey rocky soils on the peaks of the highland summits of the Pirhuani peak, near Tassa town, Moquegua Region, at elevations of 4650–4700 m. It occurs with *Azorella*, *Calamagrostis*, *Pycnophyllum*, *Mniodes*, *Senecio*, and *Xenophyllum*. Flowers and fruits between March and April.

**Etymology.** This *Senecio* is named after the town of Tassa (Moquegua Region), downslope of Pirhuani peak where the species was found.

**Discussion.** *Senecio tassaensis* appears to be closely related to *S. moqueguensis* which grows at the same elevational range but approaches the known range of *S. tassaensis* within a few hundred metres. *Senecio moqueguensis* is generally distinctive in the series for its larger size, attaining dense ground mats, and for its yellow corolla. *Senecio tassaensis* has 12–16 phyllaries (vs. 9–12), an involucre length of 6–8 mm and achene length of 1–1.2 mm, being much shorter than in *S. moqueguensis*. *Senecio tassaensis* is relatively a very rare species with an estimated 100 individuals known. It is less similar to *S. pucapampaensis*, *S. evacooides*, *S. expansus* and *S. repens*, and can be distinguished on the basis of the habit, trichomes, leaf shape and length, calycular bracts and phyllaries length and shape as summarized in Table 1.

**Conservation status.** Following the criteria and categories of IUCN (2001), a preliminary status of Critically Endangered (CR) is assigned. The new species deserves protection because its total area of occupancy is less than 10 km<sup>2</sup> (ca. 5 km<sup>2</sup>) (B2); only one population is known (B2b); habitat inferred to be continuing to decline (B2b(i–iii)); population estimated to number fewer than 100 individuals (D). The suitable habitats for *S. tassaensis* on the mountain summits of Pirhuani peak in the Ubinas district are indicated as endangered, because changes in the annual rainfall, volcanic activity and exploitation of natural resources, may all reduce their extent.

### Key to the species of *Senecio* ser. *Suffruticosi* subser. *Caespitosi* in Peru

(adapted from Cabrera 1985, Cabrera et al. 1999)

- |    |  |                          |
|----|--|--------------------------|
| 1a | Plants shrubby; involucre longer than 11 mm .....                                    | 2                        |
| 1b | Plants caespitose; involucre shorter than 11 mm long.....                            | 5                        |
| 2a | Achenes densely pubescent; leaves 1–2 cm long, deeply dentate or lobulate..<br>..... | <i>S. adenophyllum</i>   |
| 2b | Achenes glabrous; leaves 1–3.5 cm long, entire .....                                 | 3                        |
| 3a | Leaves 3–5 mm wide; involucre bracts oblong .....                                    | <i>S. rufescens</i>      |
| 3b | Leaves 0.7–2 mm wide; involucre bracts linear .....                                  | 4                        |
| 4a | Leaves 25–80 mm long; phyllaries 13–18 .....   | <i>S. scorzonifolius</i> |
| 4b | Leaves 15–25 mm long; phyllaries 15–20 .....   | <i>S. danai</i>          |

5a	Capitulum small; involucre shorter than 5 mm.....	6
5b	Capitulum larger; involucre shorter than 11 mm.....	7
6a	Leaves entire, glabrous and fleshy; phyllaries 8.....	<i>S. humillimus</i>
6b	Leaves entire or dentate, glabrous or lanuginose; phyllaries 13.....	<i>S. vegetus</i>
7a	Plants tomentose, at least on the underside of leaves.....	8
7b	Plants glabrous.....	13
8a	Plants with dense pubescence covering all plant parts.....	9
8b	Plants with sparse pubescence not covering all plant parts.....	11
9a	Leaves spatulate, 10–20 mm long; involucre 7–8 mm tall; phyllaries 13–20.....	<i>S. evacoides</i>
9b	Leaves ovate, elliptic or circular, crenate, 10–65 mm long; involucre 6–10 mm tall; phyllaries 13–25.....	10
10a	Involucre 10–25 mm long; phyllaries 20–25.....	<i>S. expansus</i>
10b	Involucre 6–7 mm long; phyllaries 13–20.....	<i>S. repens</i>
11a	Leaves cuneiform, lamina glabrous except puberulous margins.....	<i>S. pucapampaensis</i>
11b	Leaves oblong, lamina with trichomes on surfaces and margins.....	12
12a	Leaves 8–12 mm long, lamina oblong-spathulate; involucre 7–10 mm; phyllaries 9–12.....	<i>S. moqueguensis</i>
12b	Leaves 6–9 mm long, lamina obovate-spathulate; involucre 6–8 mm; phyllaries 12–16.....	<i>S. tassaensis</i>
13a	Leaves dentate, linear-cuneiform.....	<i>S. trifurcifolius</i>
13b	Leaves entire.....	14
14a	Leaves 10–35 mm long.....	<i>S. algens</i>
14b	Leaves less than 14 mm long.....	15
15a	Leaves 8–12 mm, linear-lanceolate; involucre 8–11 mm; phyllaries 6–8.....	<i>S. gamolepis</i>
15b	Leaves 9–14 mm, obovate-spathulate; involucre 7–9 mm; phyllaries 12–14.....	<i>S. sykoraie</i>

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# *Hieracium sinoaestivum* (Asteraceae), a new species from North China

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## Abstract

*Hieracium sinoaestivum* Sennikov **sp. nov.** is described as new to science and illustrated. This presumably apomictic species is solely known from two old collections made in a single locality in the Shanxi Province of China. It belongs to the hybridogenous group *H.* sect. *Aestiva* (*H.* sect. *Prenanthoidea* × *H.* sect. *Umbellata*) and is most similar to *H. veresczaginii* from southern Siberia. The new species occurs at low altitudes in the forest belt of Liliian Mts. and belongs to taiga forest elements.

## Keywords

Apomictic species, boreal forest, Compositae, Shanxi, Siberia, taiga

## Introduction

The genus *Hieracium* L. with its ca. 10000 species (Sell and Murrell 2006), the majority of which are presumably apomictic (Chrtek et al. 2007), has the greatest diversity in the mountains of Europe and the Caucasus (Zahn 1921–1922). In China the genus is on the very margin of its distribution and is represented by a few taxonomic groups and species, mostly found in the mountains of Central Asia (Sennikov 2008, Shih and Gottschlich 2011).

In spite of the very low number of species, the genus is still quite poorly studied in China. The latest authoritative sources give different statistics. The Chinese edition of the *Flora of China* (Shih 1997) accepted four species which are referable to the present-day *Hieracium* (excluding *Pilosella* Vaill., *Hololeion* Kitam. and one misplaced species of *Crepis*). A revised treatment of *Hieracium* in Central Asia (Sennikov 2008) included eight species, of which four (*H. kirghizorum* Üksip, *H. krylovii* Nevski ex Schljakov, *H. robustum* Fr., *H. subramosum* Lönnr.) were new to China. The English edition of the *Flora of China* (Shih and Gottschlich 2011) revised the old treatment, recognizing *H. robustum* and *H. morii* Hayata from Taiwan and adding *Crepis shawanensis* C. Shih to the synonymy of *H. korshinskyi* Zahn, but they kept the number of species low. Shih and Gottschlich's treatment accepted only six species, probably because the authors had little access to the material from Central Asia.

During my revision of assorted *Hieracium* specimens collected in Asia and kept in the Swedish Museum of Natural History, Stockholm (S), I recovered two gatherings of a plant which was recognised as a new species many years ago by the prominent Swedish *Hieracium* expert Karl Johansson (1856–1928). Johansson compiled a detailed species description that was attached to one of the specimens, both handwritten and in typescript, and it was obviously his death that prevented him from publication of this novelty.

This species is highly dissimilar from any species of *Hieracium* hitherto known from China, and therefore is here described as new to science. The species name suggested by Johansson, "*H. chinense* Johanss.", may not be used because of the earlier near-homonym *H. sinense* Vaniot (1903); the use of such near-homonyms is explicitly precluded by Art. 53.3 with Ex. 11 (McNeill et al. 2012).

## Materials and methods

The new species was described solely on the basis of two dried collections kept at S. Measurements were taken with a light microscope (Leica S4E). The species description follows Sennikov (2002) and Sell and Murrell (2006) with minor modifications. Terminology in the descriptions of pubescence follows Schljakov (1989).

Details of pubescence were photographed with a digital camera (Canon EOS 5D Mark III, lens EF 100 mm 1:2.8L, two extension rings), and the series of images was processed with the Helicon Focus Pro software.

The distribution map was produced using the R software environment for statistical computing and graphics (R Development Core Team 2013). The basemap was compiled from the Digital Chart of the World, Arc/INFO resource provided by the Environmental Systems Research Institute, Inc., the Pennsylvania State University Libraries.

## Taxonomic treatment

### *Hieracium sinoaestivum* Sennikov, sp. nov.

urn:lsid:ipni.org:names:77140258-1

**Type.** China. Shanxi: Lüliang City. “Chiao-ch’eng distr., Pashui-ko-shan”, alpine meadow, 2400 ft., 24.08.1924, *Harry Smith 7172* (S!, holotype; UPS, isotype). Fig. 1.

**Paratypes.** China. Shanxi: Lüliang City. “Chiao-ch’eng distr., Pashui-ko-shan”, meadows in mixed forests, 2100 ft., 28.08.1924, *Harry Smith 7219* (BM 000996241 photo!, S!).

**Diagnosis.** The new species differs from the most similar *H. vereschaginii* Schischk. & Serg. mainly in a greater density of simple hairs (rare to sparse vs. solitary or sometimes absent) on the phyllaries.

**Description.** Evidently aphyllopodous *perennial plant*. Stem 60–70 cm tall, robust, pale green, without simple hairs (paratype) or with abundant simple hairs up to 3 mm long (holotype), with lax stellate pubescence mostly in the lower half. Leaves up to 50, gradually decreasing in size upwards, sessile, clearly bicolor, intensely green on upper surface, pale green beneath, with lax stellate pubescence on both sides and simple hairs 1.5–2 mm long along margins and beneath; the *lower* unknown (withered at anthesis); the lamina of the *median* leaves (most developed) 9–12 cm long, 2.5–4 cm wide (ratio 1:3–3.5), oblong-ovate, widest near basal third, acute at apex, broadly cuneate or rotund at base, with 4–5 pairs of narrow acute teeth up to 5(8) mm long; the lamina of the *upper* leaves up to 6 cm long, 1.5–1.8 cm wide, ovate-lanceolate, widest near base, acute at apex, rotund at base, with 3–4 pairs of small narrow teeth. *Synflorescence* up to 25 cm long, laxly branched with 3–8 branches and 10–35 capitula; branches elongated, without simple and glandular hairs under the capitula, with dense stellate pubescence. *Capitula* cup-shaped, rounded at base. *Phyllaries* (Fig. 2) 9–10 mm long, 1–1.2 mm wide at middle, 1.5–1.7 mm wide at base, oblong-triangular with a gradually narrowed apex, olive green, the inner with paler margins, with simple and glandular hairs along a narrow median line and with stellate hairs over the surface; the inner with rare to sparse (5–15) simple hairs 1–1.2 mm long, dark at base, otherwise whitish, with sparse (up to 20) glandular hairs 0.2–0.5 mm long, thin and rather dark, with lax stellate pubescence, tipped with a few very short cilia at apex. *Florets* 15–18, 16–17 mm long. *Ligules* probably intensely yellow, glabrous-tipped. *Styles* with black spines. *Achenes* ca 4 mm long, brick red. *Pappus* 7–8 mm long, yellowish.

**Affinity.** The new species is attributed to *Hieracium* sect. *Aestiva* (Üksip ex Schljakov) Sennikov which was circumscribed to embrace morphotypes presumably originated from crosses between members of *H.* sect. *Prenanthoidea* W.D.J.Koch s.l. and *H.* sect. *Umbellata* Sendtn. (Sennikov 1999). *Hieracium sinoaestivum* shares the abundant stellate pubescence, habit and largely the shape of leaves with some broad-leaved forms of *H. umbellatum* L. but differs from the latter in its broader phyllaries with straight (vs. reflexed) tips, its leaf base clearly subrotund (vs. broadly cuneate), and a



Figure 1. Holotype of *Hieracium sinoaestivum* Sennikov.



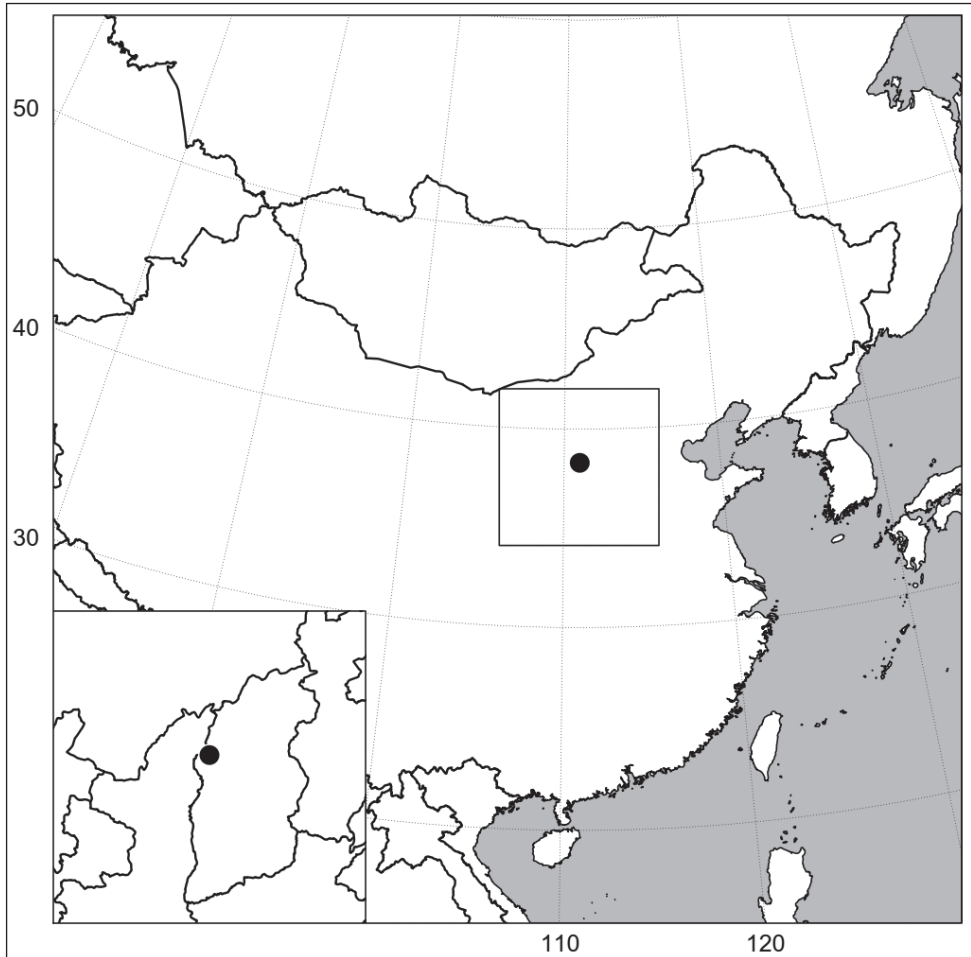
**Figure 2.** Pubescence on the phyllaries of *Hieracium sinoaestivum* Sennikov (Harry Smith 7219, S). Scale bar: 1 mm.

much greater number of simple and glandular hairs on the phyllaries (the phyllaries in *H. umbellatum* may occasionally have solitary to rare glandular hairs only). From *H. sect. Prenanthoidea* the new species borrows a denser indumentum of phyllaries, a broader base of leaves, and the pale green (nearly glaucous) colour of leaves which is untypical of *H. umbellatum*.

Of the presumed parents, *H. umbellatum* is a common component of the boreal vegetation in the mountains of northern and western China (Shih and Gottschlich 2011). In China, the species of *H. sect. Prenanthoidea* s.l. (including hybrids) occur in the Xinjiang Province but not in the northern provinces (Sennikov 2008, 2012, Shih and Gottschlich 2011).

No similar species is known from China (Sennikov 2008, Shih and Gottschlich 2011). In southern Siberia *H. sect. Aestiva* is represented by about 7 species (Tupitzina 2004), of which only *H. nasimovae* Stepanov and *H. vereschaginii* Schischk. & Serg. are said to have the leaf base cuneate or rotund and the synflorescence branches usually without glandular hairs. Unlike *H. sinoaestivum*, *H. nasimovae* is characterized by a large number of glandular hairs (up to 60) on the phyllaries and by the slightly panduriform leaves (Stepanov 1998); this poorly known local taxon may actually be closely related to *H. krylovii* Nevsky ex Schljakov, a species of *H. sect. Aestiva* with a greater expression of characters of *H. sect. Prenanthoidea* s.l.

*Hieracium vereschaginii* occurs in eastern Kazakhstan on the border with Russia (Kotukhov 1971, Abdulina 1999) and in southern Siberia westwards to the Chita



**Figure 3.** Distribution of *Hieracium sinoaestivum* Sennikov.

town (Tupitzina 2004). It is said to be characterized by the phyllaries with sparse glandular hairs 0.2–0.4 mm long (along a median line) and sometimes also with solitary short simple hairs, usually with an abundant stellate pubescence (Tupitzina 2004). My examination of the material of *H. veresczaginii* kept in LE has shown that this species regularly has ovate-lanceolate or oblong-ovate leaves with a rotund base and a coarse dentation, resembling those of large individuals of *H. umbellatum*. In the shape of leaves and the type of pubescence *Hieracium veresczaginii* seems to be the most similar to *H. sinoaestivum*, mainly differing in solitary simple hairs on its phyllaries. It is a species of taiga forest, occurring in spruce, fir, pine, birch and mixed forests of the Altai-Sayan mountain system and its northern extensions (Tupitzina 2004).

**Variability.** The two original collections clearly differ from each other in the pubescence of stems and leaves, although the indumentum of phyllaries is nearly invariable. The robust and hairy plant of *Harry Smith* 7172 also has a much longer dentation



of leaves. This difference is considered taxonomically insignificant but likely indicates genetic variability within this presumably apomictic species.

**Distribution.** The new species is known from a single locality in the Shanxi Province of China, situated approximately at 38.3°N, 111°E in the Lüliang Mountains (Fig. 3).

This locality lies within the distribution area of *H. umbellatum* (Shih and Gottschlich 2011) but at the distance of ca. 600 km from the nearest locality of *H.* sect. *Prenanthoidea* s.l. (including hybrids) in southern Siberia (Tupitzina 2004).

**Ecology.** According to the collector's notes, *H. sinoaestivum* grows on montane meadows in the forest belt at altitudes of 600–750 m a.s.l. The species flowers in August, fruits in August–September.

**Phytogeography.** The only locality of the new species is situated in the subregion of North China Mountains, region of North China, subkingdom of Sino-Japanese Forest, Eastern Asiatic kingdom of Chinese phytogeographers (Sun 2013). This area has a rich indigenous flora, with ca. 300 species endemic to the subregion (Wang 1997, Sun 2013). *Hieracium sinoaestivum* belongs to taiga forest floristic elements and represents a penetration of holarctic elements into the East Asian flora.

**Conservation status.** Data deficient.

**Mode of reproduction.** Not known, presumably apomictic.

**Etymology.** The species epithet is derived from *Sino-*, pertaining to China, and *aestivum*, reflecting the sectional placement of the species.

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# A new species of spiny *Solanum* (Solanaceae) from Peru

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## Abstract

A new species of *Solanum* is described from Peru. *Solanum junctum* S. Stern & M. Nee, **sp nov.** is a member of the Torva clade of the spiny solanums (Leptostemonum clade). The narrow corolla lobes and recurved prickles of *S. junctum* are similar to species in the Micracantha clade, but *S. junctum* differs in its branched inflorescences and upright green fruits. These characteristics are shared with other members the Torva clade; within this section *S. junctum* is morphologically most similar to *S. subinerve* and *S. poinsettiiifolium*. *Solanum subinerve* has larger flowers, longer cauline prickles, and often has long straight prickles on the adaxial leaf surface that are lacking in *S. junctum*. *Solanum poinsettiiifolium* has fewer spines, dense white tomentum on the abaxial leaf surfaces, stout unbranched inflorescences, and more extensive interpetalar corolla tissue than *S. junctum*.

## Keywords

*Solanum*, Peru, new species, Torva clade

## Introduction

The giant genus *Solanum* L. has been the subject of recent systematic studies due to support from the NSF Planetary Biodiversity Inventory program, including phylogenetic study of the Leptostemonum clade (Bohs 2005; Levin et al. 2006; Weese and Bohs 2007; Stern et al. 2010; Stern et al. 2011). This clade includes approximately 350–400 species commonly known as the “spiny solanums” due to their epidermal

prickles. Species in the group also have long, attenuate anthers and stellate hairs and exhibit a variety of habits, from small herbs to large trees.

Various species in the clade are vines or lianas that climb using recurved prickles. Recurved prickles are uncommon in *Solanum* and have been used as a synapomorphy to define the *Solanum lanceifolium* species group (Whalen 1984) also known as sect. *Micracantha* Dunal (Nee 1999). Stern et al. (2011) conducted a large-scale phylogenetic study of the spiny solanums and found that *Solanum* species that climb with recurved prickles belong to several different groups, including the Torva, *Erythrotrichum*, *Micracantha*, and Old World clades (as defined by Stern et al. 2011). Clearly, climbing via recurved prickles is a trait that has evolved multiple times in different lineages.

Revisionary work on the *Micracantha* clade and phylogenetic study of the large Torva clade has led to the identification of the new species described here. It has been widely collected throughout the central and northern Andes in Peru with specimens dating from the 1920's. Macbride (1962) cited some of these in his treatment of *S. heterophyllum* Lam. in the Flora of Peru (now recognized as a synonym of *S. subinerme* Jacq., a species in the Torva clade). He noted that his concept of *S. heterophyllum* included specimens that were variable and indicated that the specimens cited "may be several species." Indeed, these specimens represent at least three different *Solanum* species. Nee et al. (2006) used some of the material that Macbride called *S. heterophyllum*, including *Mexia* 6485 and *Williams* 3448, to describe *S. pedemontanum* M. Nee, a species of the *Micracantha* clade. Another specimen Macbride included under *S. heterophyllum*, *Swingle* 119, is *S. poinsettiifolium* Rusby, a member of the Torva clade. Finally, other specimens Macbride cited, including *Williams* 7678 and *Klug* 3407, are used to describe the new species below. Specimens of the new species have been annotated by Nee as a species "at junction of sect. *Micracantha* with sect. *Erythrotrichum* Whalen ex. A. Child." but morphological and molecular data support its inclusion in the Torva clade.

## Taxonomy

### *Solanum junctum* S. Stern & M. Nee, sp. nov.

urn:lsid:ipni.org:names:77140259-1

Fig. 1

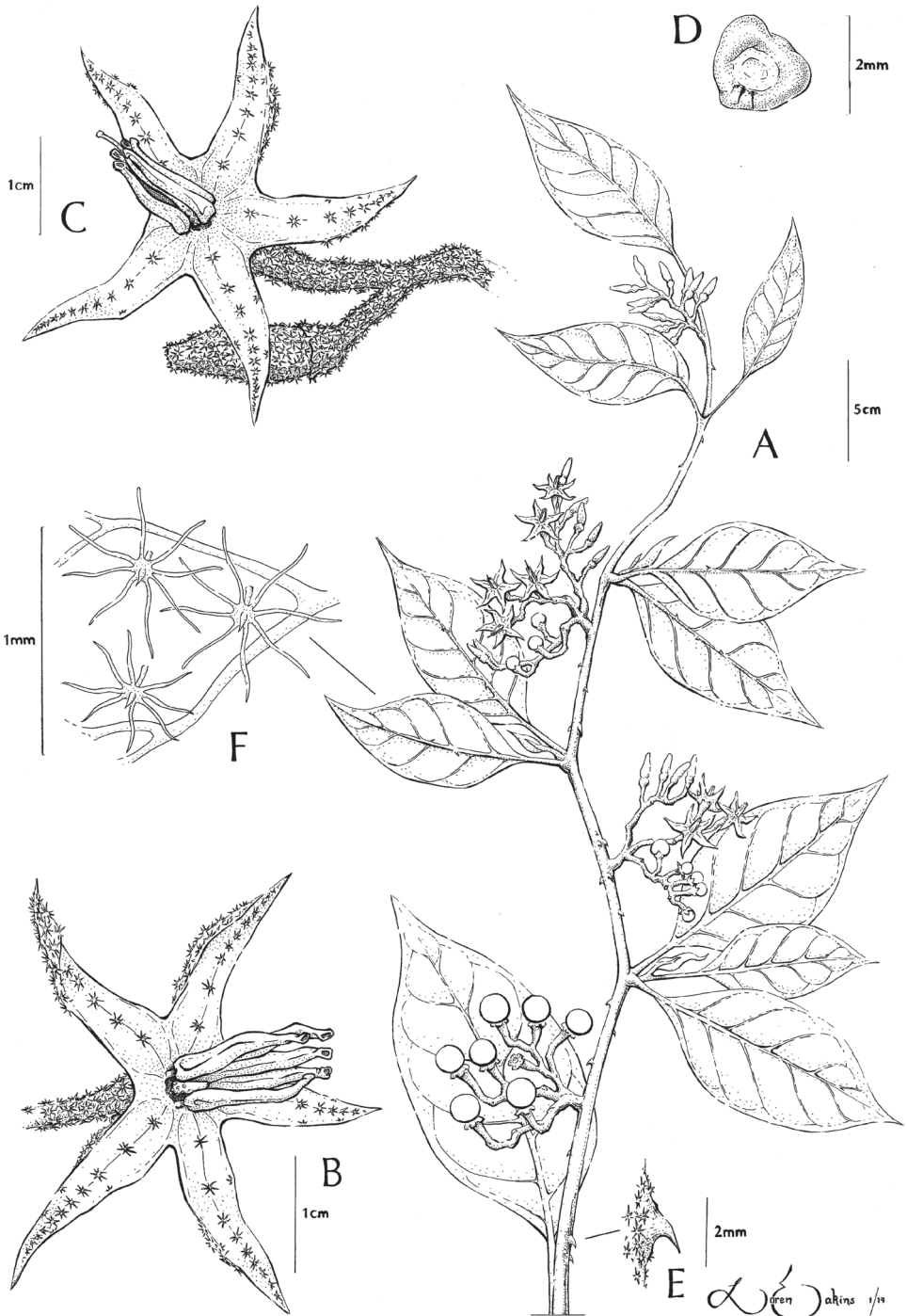
**Type.** PERU. Pasco: Prov. Oxapampa, Dist. Pozuzo, 1 km N del Puente Yulitunqui–Sector Huampal, Parque Nacional Yanachaga-Chemillén, 10°09'47"S, 75°33'58"W, 975–1100 m, 15 Apr 2005 (fl), *E. Ortiz V. & J. Mateo M.* 576 (holotype: NY[NY01802055]!; isotypes: AMAZ, F, HAO, HOXA, HUT, MO!, MOL, USM, NY[NY00854134]!, NY[NY01802056]!)

**Diagnosis.** Similar to *S. subinerme* Jacq. and *S. poinsettiifolium* Rusby. *Solanum junctum* differs from *S. subinerme* in its smaller flowers, shorter cauline prickles and lack of straight prickles on the adaxial leaf surfaces. *Solanum junctum* has branched

inflorescences and lacks the white tomentum on the adaxial leaf surface and the more abundant interpetalar tissue of *S. poinsettiiifolium*.

Erect or scandent shrub, liana, or small tree, 1–20 m. Stems armed with recurved tan to brown prickles to 5 mm long, the base to  $2\text{--}4 \times 0.5\text{--}1$  mm, the young stems moderately to densely pubescent with tan to white stellate hairs, the stalks absent to 1 mm, multiseriate, the rays 6–10, ca. 0.5 mm long, the midpoints absent to 0.5 mm, the older stems becoming sparsely pubescent to nearly glabrous. Flowering portions of stem of difoliate sympodial units, the leaves usually geminate, those of a pair often slightly unequal. Leaves simple, the blades  $8\text{--}12 \times 4\text{--}7$  cm, ovate, chartaceous, green on both surfaces with the adaxial surface typically darker, both surfaces moderately pubescent with hairs like those of the stem, the abaxial surface typically slightly more tomentose and often armed with a few recurved prickles to 2 mm in length on the midrib, abaxial surface with occasional simple glandular hairs below the stellate hairs; venation pinnate, the secondary veins 3–6 on each side of the midvein; base rounded to obtuse, often asymmetrical; margin entire; apex acute to attenuate; petioles 1–3.5 cm, moderately pubescent with hairs like those of the stem, sparsely to moderately armed with prickles like those of the stem. Inflorescence 5–8 (10) cm, extra-axillary, branched with 2–3 (5) main branches, bearing 14–20 flowers, the plants apparently andromonoecious, with male flowers lacking a developed style and hermaphroditic flowers with an elongated style, the axes moderately to densely pubescent with hairs like those of the stem, unarmed; peduncle 2–10 mm; rachis 4–7 (10) cm; pedicels 4–10 mm in flower, 8–14 mm in fruit, spaced 1–3 mm apart, articulated at the base. Flowers 5-merous, appearing actinomorphic on herbarium sheets but slightly zygomorphic in the field due to curved anthers, the flower buds slightly curved. Calyx 0.5–3 mm long in bud through anthesis, cupular with lobes nearly absent, moderately to densely pubescent with hairs like those of the stem, the calyx splitting into lobes during late flowering or early fruiting; fruiting calyx lobes  $2\text{--}3 \times 1\text{--}2$  mm, triangular. Corolla 2–3 cm in diameter, chartaceous, light violet to purple, lobed nearly to the base, the lobes  $8\text{--}12 \times 2\text{--}3.5$  mm, narrowly triangular, densely pubescent on the abaxial surface with hairs like those of the stem, glabrous to sparsely stellate-pubescent on the midvein on the adaxial surface. Stamens 8–12 mm long; filaments ca. 0.5 mm long, glabrous; anthers  $8\text{--}12 \times 1\text{--}1.5$  mm, proximally curving downward with small upward curve at distal end, attenuate, tapering, connivent to weakly spreading, yellow, the base cordate, the apex obtuse, the pores apical, not opening into longitudinal slits with age. Ovary glabrous; style in functionally male flowers  $1\text{--}2 \times \text{ca. } 0.5$  mm, style in hermaphroditic flowers  $12\text{--}14 \times 0.5$  mm, exceeding the anthers by 2–3 mm, cylindrical, glabrous; stigma ca. 0.5 mm wide. Fruit a globose berry 1–1.2 cm in diameter, green, glabrous, held upright, with 3–10 fruits per infructescence. Seeds 75–120 per fruit,  $3\text{--}4 \times 2\text{--}3$  mm, ovate to reniform, brown.

**Distribution and phenology.** Known from Amazonas, Ayacucho, Junín, Pasco, and San Martín Departments in Peru from 600–1800 m in elevation. Flowering specimens were collected in February–May, July, November–December and fruiting specimens in April, July–August, November.



**Figure 1.** *Solanum junctum* S. Stern & M. Nee **A** Habit **B** Functionally male flower; note reduced style **C** Perfect flower **D** Seed **E** Cauline prickle **F** Trichomes on abaxial leaf surface. All from *Ortiz & Mateo 576*.

**Etymology.** *Solanum junctum* is taken from the Latin “*junctus*” for “connect or join,” referring to the morphological similarities of this species with other sections within the spiny solanums. This has been used as an herbarium name on specimen annotations by M. Nee since at least 1995.

**Conservation status.** The conservation status of *S. junctum*, according to the IUCN Red List Categories (IUCN, 2010) is Least Concern due to the large extent of occurrence (~99,000 km<sup>2</sup>) and numerous collections (Bachman et al. 2011).

Since *Solanum* is such a large and diverse group, particularly in the Andes, it is not surprising that many new species and taxonomic difficulties remain. This is particularly true in undercollected areas of the Andes, but recently many inroads have been made (Knapp 2010; Stern and Bohs 2010; Farruggia and Bohs 2010; Tepe et al. 2012; Särkinen et al. 2013). Field collections, revisionary, and phylogenetic study have spurred the description of species that otherwise may remain as “herbarium names”.

Both M. Nee and S. Stern recognized *S. junctum* as a new species from herbarium collections, resulting in the shared authorship of this name. Stern first annotated a specimen as a new species in 2008 (*Rodríguez & Leiva 2121* HAO, subsequently destroyed in an herbarium fire) and Nee has applied the herbarium name *S. junctum* to specimens since at least 1995 (*Schunke 6020* [NY]). The type material for *S. junctum* was selected from the numerous collections made from Prov. Oxapampa in the Department of Pasco, Peru. *Ortiz & Mateo 576* was chosen as the type due to the quality of the specimens and wide distribution in herbaria. The holotype at NY was the highest quality specimen of those seen and contained abundant flowering material and developing fruits.

As with many *Solanum* species with recurved prickles, *S. junctum* has a variable habit and may be an erect or scandent shrub, vine, or even a small tree. The species is unusual in the Torva clade in having flowers with very narrow corolla lobes with sparse interpetalar tissue, but its branched inflorescences and green upright fruits are shared with many other species in this section. DNA sequence data from specimens of *S. junctum* have been added to the dataset of Stern et al. (2011) and indicates that *S. junctum* is a member of the Torva clade but the exact species level relationships remain unclear. Phylogenetic relationships between members of this group are being assessed further using molecular data (S. Stern, in prep.).

Morphologically, the violet to purple flowers with narrow corolla lobes of *S. junctum* are similar to those of *S. subinerme*. Additionally, both species have curved flower buds and slightly zygomorphic flowers due to curved anthers. These species can be differentiated by the larger flowers of *S. subinerme*, with corollas 3.5–4 cm in diameter (versus 2–3 cm in diameter in *S. junctum*), the longer cauline prickles in *S. subinerme*, and presence of long straight prickles on the adaxial leaf surface in *S. subinerme*, which are lacking in *S. junctum*. Finally, *S. subinerme* has thin pedicels that reach 2 cm or more in fruit while those of *S. junctum* are thicker and only reach 14 mm. *Solanum subinerme* has a much broader distribution and is found from the Caribbean through northern South America to the Amazon Basin. It is not known from the higher elevations of Peru where *S. junctum* is found.

*Solanum junctum* is also similar to *S. poinsettiiifolium*, a species ranging from Dept. Beni, Bolivia along the eastern slope of the Andes to central Peru. *Solanum poinsettiiifolium* is represented by numerous collections from the area where Ucayali, Huánuco, and Loreto Departments intersect. These superficially resemble *S. junctum* as they share similar leaf morphology, flowers and fruits that are a similar size and color, and both species have curved flower buds. These species differ in that *Solanum poinsettiiifolium* specimens are all described as trees or shrubs, have very few spines on the stem and none on the abaxial leaf surface, and have dense white tomentum with a soft, velvety appearance on the abaxial leaf surfaces. The corolla of *S. poinsettiiifolium* has more abundant interpetalar tissue and the inflorescence is stout and unbranched.

Some specimens of *S. ovalifolium* Dunal (another member of the Torva clade) may also resemble *S. junctum*. *Solanum ovalifolium* is a shrub to small tree with much smaller flowers than *S. junctum* (corollas typically under 1 cm in diameter in *S. ovalifolium* vs. 2–3 cm in diameter in *S. junctum*). The inflorescences of *S. ovalifolium* are generally larger and more branched than those of *S. junctum* and may branch further up the rachis, whereas the inflorescences in *S. junctum* branch very near the base. *Solanum ovalifolium* ranges from Venezuela, Colombia, and Ecuador to Depts. Amazonas and Cajamarca in northern Peru, where its distribution appears to terminate at the Amotape-Huancabamba zone (Stern and Bohs 2010).

It is also possible to confuse *S. junctum* with *S. pedemontanum*, a member of the Micracantha clade. At least two specimens of *S. pedemontanum* (Krukoff 8421 and McDaniel & Rimachi 16879 at NY) have been annotated as possible *S. junctum* by M. Nee. Macbride (1962) cited specimens belonging to both *S. junctum* and *S. pedemontanum* in his taxonomic treatment of *S. heterophyllum*. While the habit of *S. junctum* ranges from a vine to shrub, *S. pedemontanum* is nearly always described as a scrambling vine. In Peru, *Solanum pedemontanum* tends to occur at lower elevations (100–450 m) than *S. junctum* (600–1800 m). The corolla in *S. pedemontanum* is white versus the light purple corolla of *S. junctum* and the corolla lobes of *S. pedemontanum* are slightly longer (12–20 mm) than those of *S. junctum* (8–12 mm). The inflorescence in *S. pedemontanum* is unbranched, whereas it branches at the base in *S. junctum*. Finally, fruits in *S. pedemontanum* are orange to red whereas they remain green at maturity in *S. junctum*.

**Paratypes.** PERU. **Amazonas:** Prov. Condorcanqui, Distrito El Cenepa, Región NE del Maraón, Puerto Mori, Río Comaina, 4°23'S, 78°21'W, 800 m, 19 Aug 1994 (fr) *R. Vásquez et al.* 18921 (BM, MO, NY, USM); Bagua Dist., Aramango, Cerros de Nueva Esperanza, 5°28'02"S, 78°23'11"W, 1800 m, 20 Dec 2001 (fl), *R. Vásquez et al.* 27499 (NY, USM). **Ayacucho:** Prov. La Mar, alrededores de Buena Gana, aprox. 8.5 km lineales al WNW de San Antonio, Dist. Anco, 1775 m, 21 Apr 2007 (fl) *J. Roque* 5475 (USM). **Cajamarca:** Prov. San Ignacio, Dist. San José de Lourdes, Caserío Estrella del Oriente, 4°50'S, 78°55'W, 1600–1650 m, 14 Nov 1998 (fl), *E. Rodríguez R. & S. Leiva G.* 2121 (HAO [destroyed], HUT). **Junín:** Track to Chipita, 11°07'70"S, 75°21'19"N, 1400 m, 16 Nov 2002 (fl, fr) *Monro, Pennington, & Diaz* 4005 (BM); Chanchamayo Valley, Mar. 1924–1927 (fl), *Schunke* 264 (F, US). **Pasco:**



Prov. Oxapampa, Dist. Pozuzo, Sector Huampal, 10°10'45"S, 75°34'26"W, 1000–1200 m, 20 Jul 2006 (fl, fr), *Cárdenas & Flores 578* (NY); Dist. Villa Rica, Comunidad Nativa San Pedro de Pichanaz, sector San Francisco, 10°26'24"S, 75°26'07"W, 600 m 17 Apr 2007 (fl) *M. Huamán & R. Rivera 174* (NY); Oxapampa, Dist. Pozuzo, Parque Nacional Yanachaga Chemillén Pozuzo Sector Pan de Azúcar, Zona de Recuperación, 10°15'S, 75°13'W, 1100–1250 m, 10 Apr 2003 (fl, fr), *A. Monteagudo et al. 4912* (NY); Oxapampa, Dist. Villa Rica, Cerro El Ascensor, Bosque de Protección San Matías–San Carlos, 10°45'S, 74°55'W, 1355 m, 3 Jul 2003 (fl), *J. Perea & C. Mateo 137* (NY); Prov. Oxapampa, Dist. Iscosaizín, carretera Chatarra–Puerto Bermúdez, 10°30'25"S, 75°04'06"W, 650 m, 23 Nov 2007 (fl, fr), *Tepe et al. 2264* (NY). **San Martín:** Zepelacio, near Moyobamba, 1200–1600 m, Dec 1933 (fl), *G. Klug 3407* (F, MO, US, WIS); Prov. Lamas, Alonso de Alvarado, carretera a Moyobamba, 800 m, 23 Apr 1973 (fl), *J. Schunke V. 6020* (NY). Prov. Lamas, Dist. Alonso de Alvarado, San Juan de Pacaizapa, km 72 carretera Tarapoto–Moyobamba, 1000–1050 m, 29 May 1977 (fl), *J. Schunke 9536* (MO, NY); San Roque, 1350–1500 m, 3 Feb 1930 (fl), *Ll. Williams 7678* (F, US).

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# *Viola kauaensis* var. *hosakae* (Violaceae), a new variety of endemic Hawaiian violet

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## Abstract

The Hawaiian endemic *Viola kauaensis* A. Gray has a broad distribution in bogs of Kaua`i and a limited distribution on mesic ridges in the Ko`olau Mountains of O`ahu. Based on differences in scale, the O`ahu populations of *V. kauaensis* had previously been described as a distinct taxon. The taxonomic status of the O`ahu populations was reevaluated through a morphometric analysis of all varieties of *V. kauaensis* and the morphologically similar *V. vanroyenii*. Morphological features of historic and freshly collected specimens of all varieties of *V. kauaensis* were analyzed with a principal components analysis. Populations from O`ahu represent a distinct cluster that slightly overlaps with *V. kauaensis* var. *kauaensis*. Lamina width, apex angle, and base angles contribute to the separation of the O`ahu populations from other varieties of *V. kauaensis*. Due to differences in scale, the O`ahu populations are described as *Viola kauaensis* var. *hosakae*, a new critically endangered taxon.

## Keywords

Hawaiian Islands, O`ahu, Violaceae, *Viola kauaensis* var. *hosakae*, cleistogamy

## Introduction

*Viola kauaensis* A. Gray is one of nine species of the monophyletic Hawaiian violets (Violaceae) (Ballard and Sytsma 2000, Havran et al. 2009). The species grows from a creeping rhizome and is notable among endemic Hawaiian *Viola* in being both herbaceous and bears cleistogamous flowers (Wagner et al. 1999). Two varieties of *V. kauaensis* are recognized: *V. kauaensis* var. *kauaensis* possesses rotund to cordate

leaves and is distributed primarily in high elevation bogs and cloud forest margins in central to northwestern Kaua`i (Wagner et al. 1999); *Viola kauaensis* var. *wahiawaensis* Forbes is distributed in the Kanele (Wahiawa) Bog and nearby ridges north of the town of Hanapepe, Kaua`i (Forbes 1920, Wagner et al. 1999). *Viola k. wahiawaensis* can be differentiated from *V. k. var. kauaensis* by cuneate leaf bases (Forbes 1920, Wagner et al. 1999). While *V. k. var. kauaensis* is locally abundant, *V. k. var. wahiawaensis* is a federally listed endangered taxon.

Additional populations of *V. kauaensis* are located in the Ko`olau Range on the neighboring Hawaiian Island of O`ahu. Individuals in the O`ahu populations resemble *V. k. var. kauaensis* but possess smaller leaves, stipules, flowers, and fruits (St. John 1989). *Viola kauaensis* is rare on O`ahu and is distributed on sloping exposed or mossy ground, not in open bogs or forest margins like on Kaua`i. No evidence has been found that the populations on O`ahu produce cleistogamous flowers. Fosberg and Hosaka (1938) mention that “the specimens from O`ahu correspond very well with the dwarf form from the bogs” of Kaua`i. Due to differences in scale, the individuals in the O`ahu populations were named *Viola hosakae* St. John by St. John (1989) in a systematic treatment of all Hawaiian *Viola*. The O`ahu specimens of *V. kauaensis* were not available for study during the drafting of *Manual of the Vascular Plants of Hawai`i* (Wagner et al. 1999) and were therefore not treated in that publication. In *The Flora of the Hawaiian Islands* website, *V. hosakae* is placed in synonymy with *V. k. var. kauaensis* but W. Wagner noted: “probably this should be treated as a third taxon of *V. kauaensis*”.

St. John (1989) named one other violet that is morphologically similar to *Viola kauaensis*. *Viola vanroyenii* St. John represents a population of small herbaceous violets endemic to the summit area of Mt. Wai`ale`ale on Kaua`i. One collection was made from the summit by van Royen and Perlman in 1977 (P. van Royen 11733 [BISH]). The population is represented by one herbarium sheet at BISH containing 14 individual plants and several fragments. The species is distributed within the range of *V. k. var. kauaensis* on Kaua`i and has yet to be rediscovered (Ken Wood and Steve Perlman, personal communication).

In the current study, the taxonomic status of O`ahu populations of *V. kauaensis* was reevaluated through an analysis of vegetative and reproductive traits of all varieties of *V. kauaensis* and of *V. vanroyenii*. We asked three questions: (1) Is variation in morphological traits discontinuous between interisland populations of *Viola kauaensis*?; (2) Do the O`ahu populations of *V. kauaensis* produce cleistogamous flowers?; and (3) Should the O`ahu populations of *V. kauaensis* be treated as a distinct taxon?

## Methods

### Field collection

*Viola kauaensis* has been documented from several sites on O`ahu. The first recorded collection of the species in 1938 was recorded as “Ko`olau Range, divide between head

of Kawainui and Kaipapau Gulches” (*E.Y. Hosaka 2,504* [BISH]). The site has not been relocated since the original collection. Two additional populations are located in the Poamoho region of the Ko`olau Mountains (due to the rarity of the species, the population locations are referred here as sites A and B). Both locations were visited in May 2013 to make new collections and assess the size of populations.

Site A is located near the Poamoho Trail and contains four small subpopulations. Because the species is considered locally threatened only two whole individuals were collected. One additional flower was collected and preserved in 70% ethanol for dissection. The fragmented nature of the populations and their position on nearly vertical cliff faces (which appears typical for individuals on O`ahu) prevented a random assessment of individuals from the site. To obtain a measure of the size of individuals at Site A, the length and width of the largest lamina of several individuals was measured. A 6 m transect was run parallel to the summit of one ridge. A 2 m tape was extended down the slope of the cliff every 1 m. Individuals easily accessed within 50 cm of the tape were measured.

Site B is located along the Ko`olau Summit Trail. The population was discovered in 1986 by John Obata. Information on the population was shared with Clyde Imada of the Bishop Museum Herbarium (personal communication). The site was revisited by Clyde Imada in 1995 who did not observe any *Viola* at that time. In May 2013, Site B was revisited to survey for *Viola kauaensis*. No individuals of *V. kauaensis* were rediscovered at Site B.

Label data from the type of *V. vanroyenii* collected in 1977 (*van Royen 11733*) indicates that all specimens of *V. vanroyenii* were collected from the “summit area of Mt. Wai`ale`ale”. In November 2012, the summit of Mt. Wai`ale`ale was visited by Kyle Kagimoto (The Nature Conservancy of Hawai`i). Five samples of *V. kauaensis* were made from the summit area and are included in the current study.

## Measurements

All specimens representing varieties of *V. kauaensis* and *V. vanroyenii* on deposit at BISH and DUKE herbaria were analyzed. Digital scans of O`ahu specimens of *V. kauaensis* from PTBG were examined. The type specimens of *V. k.* var. *wahiawaensis*, *V. vanroyenii*, and *V. hosakae* were analyzed at BISH. A digital scan of the type of *V. kauaensis* from US was analyzed. Five specimens of *V. kauaensis* collected by Kyle Kagimoto were deposited at CAU. Morphological variables measured include: length and width of the leaf lamina, cauline stipules, rhizome stipules, and sepals; length of petioles and capsule valves; and apex and base angles of the leaf lamina. Very few specimens of *V. kauaensis* from O`ahu possessed intact or fully developed petals. Therefore we restricted our floral measurements to sepal characters only. The largest leaf on each specimen was chosen for measurements of foliar characteristics. If a leaf was folded, damaged, or wrinkled to the extent that it could not be determined if it represented the largest leaf, the next largest leaf was chosen for measurement. All size measurements were made to the nearest 0.5 mm. Apex angle was measured as the angle of two rays running along the margins of the leaf tip with the vertex placed just above (at or within 1 mm) of the leaf tip. Base

angle was measured as the angle of two rays running along the base of the lamina with the vertex placed just below (at or within 1 mm) of the tapered base of the lamina (Ellis et al. 2009). Some specimens of *V. k. var. kauaensis* possessed cordate leaf bases. In these cases, base angle was measured as the angle of two rays running along the inner margins of the left and right portions of the reniform base with a vertex placed at the insertion point of the lamina (Ellis et al. 2009). For one folded leaf of *V. k. var. wahiawaensis*, base angle was estimated based on one half of a folded leaf.

Only one sheet of *V. vanroyenii* exists at BISH. The sheet contains 14 individual stems and several fragments. We attempted to measure as many entire samples from this sheet as possible to obtain a robust estimate of morphological variation in the taxon. Only three individuals on the sheet possessed all traits required for a principal components analysis.

Multiple individuals were measured from herbarium sheets when it appeared that vegetative and reproductive structures were attached to separate rhizomes. Digital images of herbarium specimens were used where possible. ImageJ software (Rasband 2012) was used to analyze digital images.

## Analyses

A principal component analysis (PCA) was used to investigate the morphological variation between interisland populations and varieties of *V. kauaensis*. The PCA was conducted with varimax rotation on untransformed data. Many herbarium specimens contained samples with degraded, fragmented, missing, or not-otherwise obvious characteristics. Therefore, only specimens that had complete measurements for lamina length, lamina width, petiole length, apex angle, base angle, cauline stipule length, and cauline stipule width were included in the analysis. The 49 samples incorporated into the PCA are listed in Table 1. In accordance with the Kaiser rule, principal component (PC) loadings with eigenvalues above 1.0 were retained for further analysis. Analyses were conducted in R version 2.15.1 (R Core Team 2012).

## Floral morphology

Only specimens of *V. k. var. kauaensis* from Kaua`i and *V. k. var. wahiawaensis* possessed open and mature flowers suitable for measuring petals. All specimens of *V. vanroyenii* and *V. kauaensis* from O`ahu possessed either cleistogamous flowers or flowers without fully developed petals. St. John (1989) included a three dimensional sketch of a chasmogamous flower and sketches of dissected floral organs in his description of the type of *V. hosakae*. Due to the degraded nature of the petals in a fragment envelope of the type of *V. hosakae* at BISH we were unable to reassess size and shape of floral organs from O`ahu. St. John's (1989) measurements of floral organs from *V. hosakae* are referenced in discussions of petal size.

**Table 1.** Samples incorporated into Principal components analysis.

Taxon	Samples per sheet	Island	Collection No.	Herbarium
<i>V. k.</i> var. <i>hosakae</i>	3	O`ahu	<i>E.Y. Hosaka 2504</i>	BISH
<i>V. k.</i> var. <i>hosakae</i>	1	O`ahu	<i>E.Y. Hosaka 1927</i>	BISH
<i>V. k.</i> var. <i>hosakae</i>	1	O`ahu	<i>F.R. Fosberg 13973</i>	BISH
<i>V. k.</i> var. <i>hosakae</i>	1	O`ahu	<i>F.R. Fosberg 14229</i>	BISH
<i>V. k.</i> var. <i>hosakae</i>	1	O`ahu	<i>J.C. Havran 2013.4</i>	BISH
<i>V. k.</i> var. <i>hosakae</i>	1	O`ahu	<i>J.C. Havran 2013.5</i>	BISH
<i>V. k.</i> var. <i>hosakae</i>	1	O`ahu	<i>S. Perlman 14704</i>	PTBG
<i>V. k.</i> var. <i>kauaensis</i>	2	Kaua`i	<i>C.N. Forbes 1135K</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>C.J.F. Skottsberg 939</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>J.C.F. Rock 2124</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>J.C.F. Rock 2130</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>C.N. Forbes 906 K</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>D.R. Herbst 2388</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>P. van Royen 11708</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>O. Degener 21747</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	3	Kaua`i	<i>H. St. John 10753</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>C.N. Forbes 406 K</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>J.F.C. Rock 2131</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>O. Degener 21477</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	2	Kaua`i	<i>H. St. John 23038</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	2	Kaua`i	<i>W.N. Takeuchi Alakai_130a</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>P.K. Higashino PKH 9633</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>T.G. Lammers 5382</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>H.F.J. Huber 20</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>W.L. Wagner 5049</i>	BISH
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>K. Kajimoto 1</i>	CAU
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>K. Kajimoto 2</i>	CAU
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>K. Kajimoto 3</i>	CAU
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>K. Kajimoto 4</i>	CAU
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>K. Kajimoto 5</i>	CAU
<i>V. k.</i> var. <i>kauaensis</i>	1	Kaua`i	<i>H. St. John 1347</i>	DUKE
<i>V. k.</i> var. <i>wahiawaensis</i>	1	Kaua`i	<i>H. St. John 10845</i>	BISH
<i>V. k.</i> var. <i>wahiawaensis</i>	1	Kaua`i	<i>H.U. Stauffer 5911</i>	BISH
<i>V. k.</i> var. <i>wahiawaensis</i>	1	Kaua`i	<i>D.R. Herbst 2415</i>	BISH
<i>V. k.</i> var. <i>wahiawaensis</i>	1	Kaua`i	<i>B.C. Stone 1650</i>	BISH
<i>V. k.</i> var. <i>wahiawaensis</i>	1	Kaua`i	<i>L.H. MacDaniels 606</i>	BISH
<i>V. k.</i> var. <i>wahiawaensis</i>	2	Kaua`i	<i>C.N. Forbes 166.K (Holotype)</i>	BISH
<i>V. k.</i> var. <i>wahiawaensis</i>	1	Kaua`i	<i>C.N. Forbes 166.K (Isotype)</i>	BISH
<i>V. vanroyenii</i>	3	Kaua`i	<i>P. van Royen 11733 (Holotype)</i>	BISH

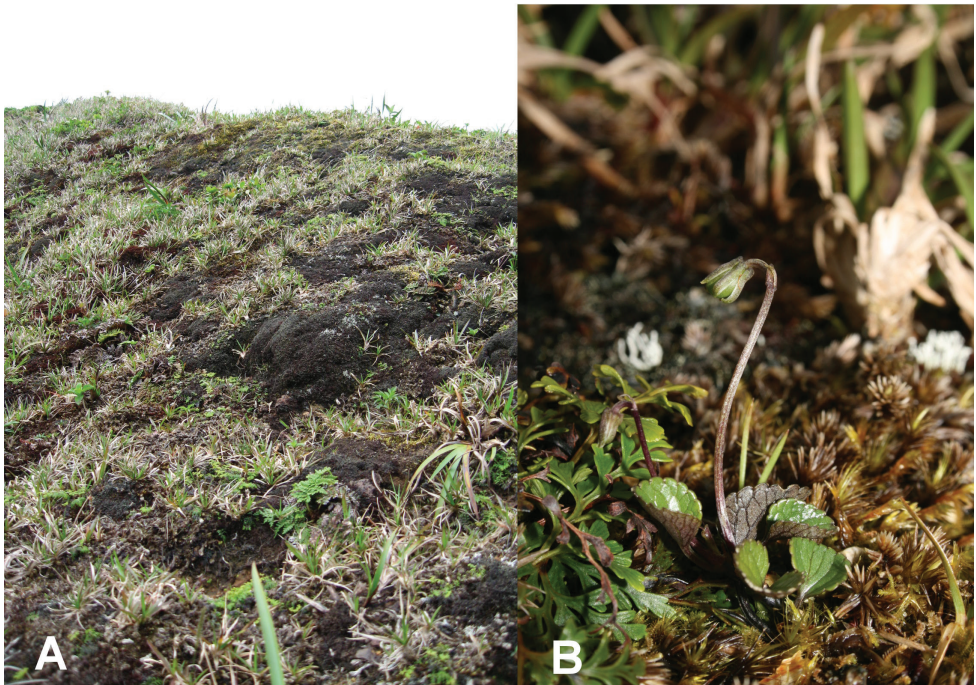
Although no *V. kauaensis* individuals with chasmogamous flowers were observed during the 2013 surveys on O`ahu, several unopened flowers were observed. In the field, it was not obvious if the flowers represented unopened chasmogamous flowers

or fully developed cleistogamous flowers. One flower was collected and preserved in 70% ethanol (multiple flowers were not collected to reduce detrimental impact on the small population). The flower was rehydrated in distilled water prior to dissection. Floral organs were removed and attached to an archival slide. The size and shape of floral organs were compared to Skottsberg's (1940) illustrations of cleistogamous and chasmogamous floral organs from Kaua`i individuals of *V. kauaensis*.

## Results

### Field measurements

Site A contained approximately 70 individuals scattered throughout four isolated patches. The violets grow from a layer of exposed moss on heavily sloped areas (Figure 1). All violets in the area had a small stature, less than 5 cm in height above the moss layer. No conspicuous chasmogamous flowers were observed. Lamina dimensions in the field ranged from 2–16 mm in length to 2–15 mm in width. The average leaf lengths and widths were 11 and 11.5 mm, respectively. Despite a thorough search, no individuals of *V. kauaensis* were observed at site B.



**Figure 1.** *Viola kauaensis* var. *hosakae* on O`ahu. **A** Habitat composed of mossy slope **B** Individual in fruit. (Photo credits: A J. C. H., B Joel Lau).



### Analyses

Data from herbarium specimens show *Viola kauaensis* populations from O`ahu possessed consistently smaller mean values of morphological and reproductive traits when compared to populations on Kaua`i (Table 2). Minimum ranges of morphological values from Kaua`i overlap with maximum values from the O`ahu individuals.

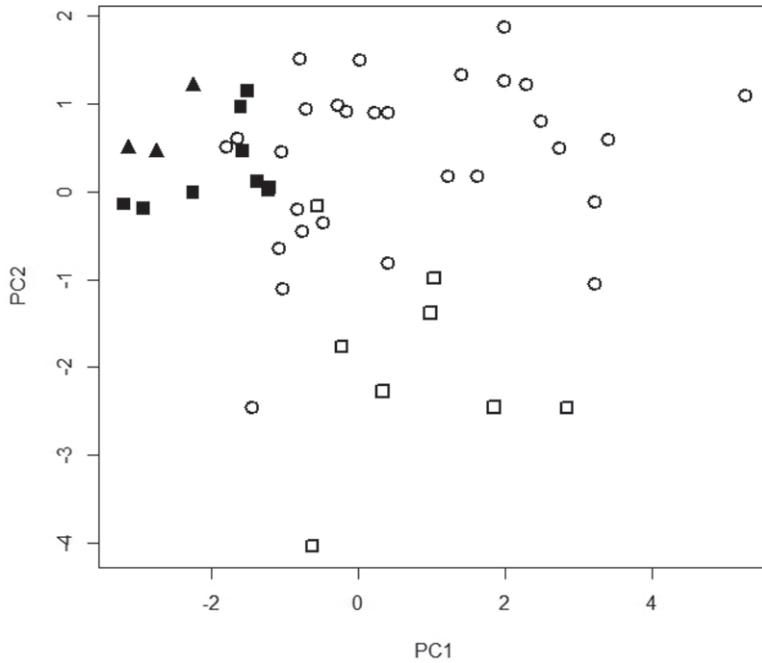
The PCA yielded three principal components (PC) with a cumulative proportion of 0.8831 (Table 3). The first two PCs possessed eigenvalues greater than 1.0 and were retained for the construction of a biplot (Figure 2). The biplot depicts overlap between *V. k.* var. *wahiawaensis* and *V. k.* var. *kauaensis*. These two varieties are primarily separated along PC2, controlled by apex angle and base angle (Table 2). Individuals of *V. kauaensis* from O`ahu cluster together but overlap slightly with individuals of *V. kauaensis* from Kaua`i. *Viola vanroyenii* completely overlaps with individuals of *V. kauaensis* from O`ahu. The O`ahu and Kaua`i populations of *V. kauaensis* are primarily separated along PC1, controlled by lamina width (Table 3).

**Table 2.** Descriptive statistics for select traits quantified for varieties of *Viola kauaensis* and *Viola vanroyenii*. Mean and min-max values are provided. The table includes data from all herbarium specimens analyzed, not just those used for PCA. All measurements in mm.

Trait	<i>V. k.</i> var. <i>kauaensis</i> (Kaua`i)		<i>V. k.</i> var. <i>wahiawaensis</i>		<i>V. kauaensis</i> (O`ahu)		<i>V. vanroyenii</i>	
	mean	min-max	mean	min-max	mean	min-max	mean	min-max
Lamina length	30	11.5–58	36.33	21–52	17.35	8.5–24	6.94	5.5–9
Lamina width	36.37	12.5–77	34.08	14–45	17.27	8–26	8.36	6–11
Petiole length	58.94	9–220	103.17	15–180	33	4–80	8	5–17
Cauline stipule length	7.46	4–14	6.3	3–12	3.18	2–5	3.81	2.5–5
Cauline stipule width	2.75	1.5–5	2.2	1.5–3	1.55	1–2.5	1.62	1–2.5
Sepal length	6.65	5–11	6.86	6–8	4.05	2–6	3.8	3–4.5
Sepal width	2	1–4	1.91	1–3	1.31	0.5–2	1.75	1–3
Capsule valve length	11.1	4.5–17	15	15	7.4	5–9	6.43	5.5–8

**Table 3.** Summary of PCA. Loadings for each variable are presented for the first three Principal Components.

Variable	PC1	PC2	PC3
Lamina length	0.47695396	-0.24381186	0.1296115
Lamina width	0.50188378	0.02178338	0.1166609
Petiole length	0.37770255	-0.23925298	0.5721113
Apex angle	0.08986523	0.61588137	0.4825464
Base angle	0.11415244	0.67522051	-0.1376558
Cauline stipule length	0.40548950	-0.06814306	-0.5148904
Cauline stipule width	0.43867994	0.20727565	-0.3540727
Proportion of variance	0.5362	0.2204	0.1266
Cumulative proportion	0.5362	0.7565	0.8831
Eigenvalue	3.75322839	1.54260388	0.88597604



**Figure 2.** PCA Biplot of PC1 and PC2. Symbols: closed squares = *Viola kavaensis* var. *hosakae*; closed triangles = *Viola vanroyenii*; open circles = *Viola kavaensis* var. *kavaensis*; open squares = *Viola kavaensis* var. *wahiawaensis*.

### Floral morphology

Removal of sepals from the preserved flower (*V. kavaensis* from O`ahu) indicated the presence of several withered petals and only two stamens with anthers. The stamens contained an elongated filament with anthers at their tip. The anther from one of the stamens was in direct contact with the stigmatic surface of the pistil. The style was also relatively short and curved towards the anther. All of these observations were consistent with Skottsberg's (1940) illustrations of cleistogamous floral organs in *V. kavaensis* specimens from Kaua`i.

### Discussion

Herbarium and field data suggest that the herbaceous *Viola* on O`ahu occupy a much more limited range of morphological variation than *V. k.* var. *kavaensis*. Individuals in the O`ahu population, like those individuals on Kaua`i, also produce cleistogamous flowers. The individuals on O`ahu demonstrate a fixed range of variation in the size of leaves, petioles, cauline stipules, and flowers. Although not evidenced in the PCA by contribution of base angle along PC1, individuals on O`ahu do not possess the extreme reniform leaf bases often observed in *V. k.* var. *kavaensis*. This may just be a trait that

is exaggerated in larger leaves. Due to these variations, the O`ahu individuals are best treated at a distinct infraspecific rank within *V. kauaensis*: *V. kauaensis* var. *hosakae*.

Recently collected specimens on O`ahu represent a much smaller range of size than those individuals collected early in the 20<sup>th</sup> century. Leaves of recently collected materials are considerably smaller than those in the type (Figure 3) and represent those individuals more distinct from *V. k* var. *kauaensis* in the PCA biplot. *Viola kauaensis* has been collected from multiple sites on O`ahu, but is now known from just one population. The variety may have existed across the Ko`olau Mountains in a wide range of sizes, but now persists as a solitary population in the smaller extreme of leaf size. The reduction in range size may be associated with interaction with non-native species. The invasive grass *Axonopus fissifolius* (Raddi) Kuhlman has had a negative impact to summit plants on O`ahu and is found growing alongside *V. k.* var. *hosakae*. The action of ungulates along the summit area would also detrimentally impact the survivorship of the variety.

The varieties of *V. kauaensis* on Kaua`i and O`ahu occupy different habitats. On Kaua`i *V. k.* var. *kauaensis* is distributed in the open bog and cloud forest margins of the high-elevation Alakai Swamp. In the bog environments, the species is usually distributed in hummocks of *Metrosideros polymorpha* Gaud., mosses, and lichen, while in bog margins the species can be found growing terrestrially or epiphytically in pockets of moss on tree stems. On O`ahu, the one population of *V. k.* var. *hosakae* contains at least four smaller subpopulations of 4-30 individuals scattered over an area of about 50 m<sup>2</sup>. Each subpopulation is distributed on a moderate to steeply sloping surface with individuals growing directly out of unsaturated exposed soil or from a thin layer of moss (Figure 1). This microhabitat description differs greatly from the typical habitat of *V. k.* var. *kauaensis* on Kaua`i (Wagner et al. 1999), especially with regard to the slope.

Havran et al. (2009) and Ballard (2000) included the O`ahu herbaceous violets in their phylogenies of the endemic Hawaiian *Viola*. In both studies of the Internal Transcribed Spacer (ITS) sequences, the O`ahu populations grouped closely with *V. k.* var. *kauaensis*. Neither study incorporated material from *V. k.* var. *wahiawaensis*. The O`ahu individual possessed four differences in the ITS sequence regions compared with the Kaua`i material. The variation is one of the largest seen when comparing interisland populations of conspecifics in the wet clade of Hawaiian violets. *Viola k.* var. *hosakae* likely diverged from *V. k.* var. *kauaensis* following an interisland dispersal event from Kaua`i to O`ahu.

While it is likely that *V. k.* var. *hosakae* may have been derived through allopatric speciation, the relationship between *V. kauaensis* and *V. vanroyenii* is less clear. *Viola vanroyenii* falls within the range of morphological variation as *V. k.* var. *hosakae*, but outside the range of variation of *V. k.* var. *kauaensis* along PC1. Field observations by Steve Perlman (personal communication) indicate that *V. vanroyenii* is sympatric with *V. k. kauaensis* on Kaua`i. *Viola vanroyenii* may represent *V. k.* var. *kauaensis* at the smaller extreme of its morphological variation, possibly as a result of harsh conditions at the summit area of Mt Waiale`ale. If more individuals are ever found, this relationship should be reevaluated.

## Taxonomic treatment

***Viola kauaensis* A. Gray var. *hosakae* (H.St.John) Havran & Ching Harbin, comb. et. stat. nov.**

urn:lsid:ipni.org:names:77140439-1

Figure 1B, 3. Additional figures: St. John (1989) Bot. Jarb. Syst. 111(2) 165–204 (Figure 4).

**Basionym.** *Viola hosakae* H.St.John, Botanische Jahrbücher für Systematik, 111(2), 173, 1989.

**Type.** Hawai'i, O'ahu Island, Ko'olau Range, divide between head of Kawainui and Kaipapau Gulches, rare in bog, 860 m elev., *E.Y. Hosaka 2504*; July 3, 1938 (holotype: BISH! Sheet no: 72125).

**Description.** *Rhizomatous herb*, rhizome creeping rhizome stipules 1.5–3.0 mm long, 1–2 mm wide, often overlapping and scaly in appearance; vertical stems produced from rhizome, internodes on vertical stem longer than on rhizome, stipules 2.0–5.0 mm long, 1.0–2.5 mm wide. *Flowers* solitary on terminal peduncle, flower subtended by opposite pair of small linear bracts on peduncles. *Chasmogamous flower* characteristics as in St. John (1989): dorsal sepal 5 × 1.4 mm, elliptic; lateral sepal 4.5 × 1.4 mm, obovate elliptic; ventral sepal 5.6 × 1.4 mm, lance elliptic; dorsal petals 15 × 3.3 mm, with a 4 mm claw and an elliptic blade; lateral petals 14 × 2.6 mm, with a broad 4 mm claw and an elliptic blade; ventral petal 16 mm long, with a curved 6 mm channeled claw, and an elliptic blade that is 5 mm wide; dorsal stamen 3.9 mm long, filament 0.5 mm long, stout, oblique, anther 2.5 mm long, narrowly obovoid ellipsoid, sterile tip 1.3 mm long, ovate; lateral stamen 3.9 mm long, filament 0.5 mm long and broad, anther 2.3 mm long, narrowly cuneoid, sterile tip 1.3 mm long, ovate, acute; ventral stamen 3.6 mm long, filament 0.5 mm long and wide, anther 2.3 mm long oblanceoloid, sterile tip 1.5 mm long, lanceolate, nectary 1.5 mm high, 0.8 mm wide, arcuate oblong, basal; pistil 2.8 mm long; style 1 mm long; stigma discoid, divergent at 45°; chasmogamous flowers not seen (see methods). *Cleistogamous flowers* with linear sepals 5, green, 5–6 mm long, 1 mm wide, bases auriculate, apices acuminate, enclosing all other floral organs; petals 5 or fewer, up to 3 mm long, 1 mm wide, white, with withered appearance; stamens 2, 1.5 mm long, filament 1 mm long, anthers 0.5 mm long and at end of filament, anther in direct contact with stigmatic surface of pistil; pistil 2 mm long, ovary 1.5 mm long, style 0.5 mm long, curved at approximately 180° towards ovary. *Fruit* a capsule, capsule valves 7–9 mm long.

**Distribution.** Hawaiian Islands, O'ahu: Poamoho summit region of Ko'olau Mountains.

**Specimens Examined. Hawaiian Islands:** O'ahu: Laie, 19 Dec 1937, *Hosaka 1927* (BISH); Main divide, crest of Ko'olau Mts, above Kaipapau Gulch, 31 May 1937, *Fosberg 13973* (BISH); Main divide, crest of Ko'olau Mts, above Kaipapau Gulch, 24 Jul 1937, *Fosberg 14229* (BISH); About one half mile south of Poamoho trail along the Ko'olau Summit trail, 20 May 2013, *Havran 2013.4* (BISH); About

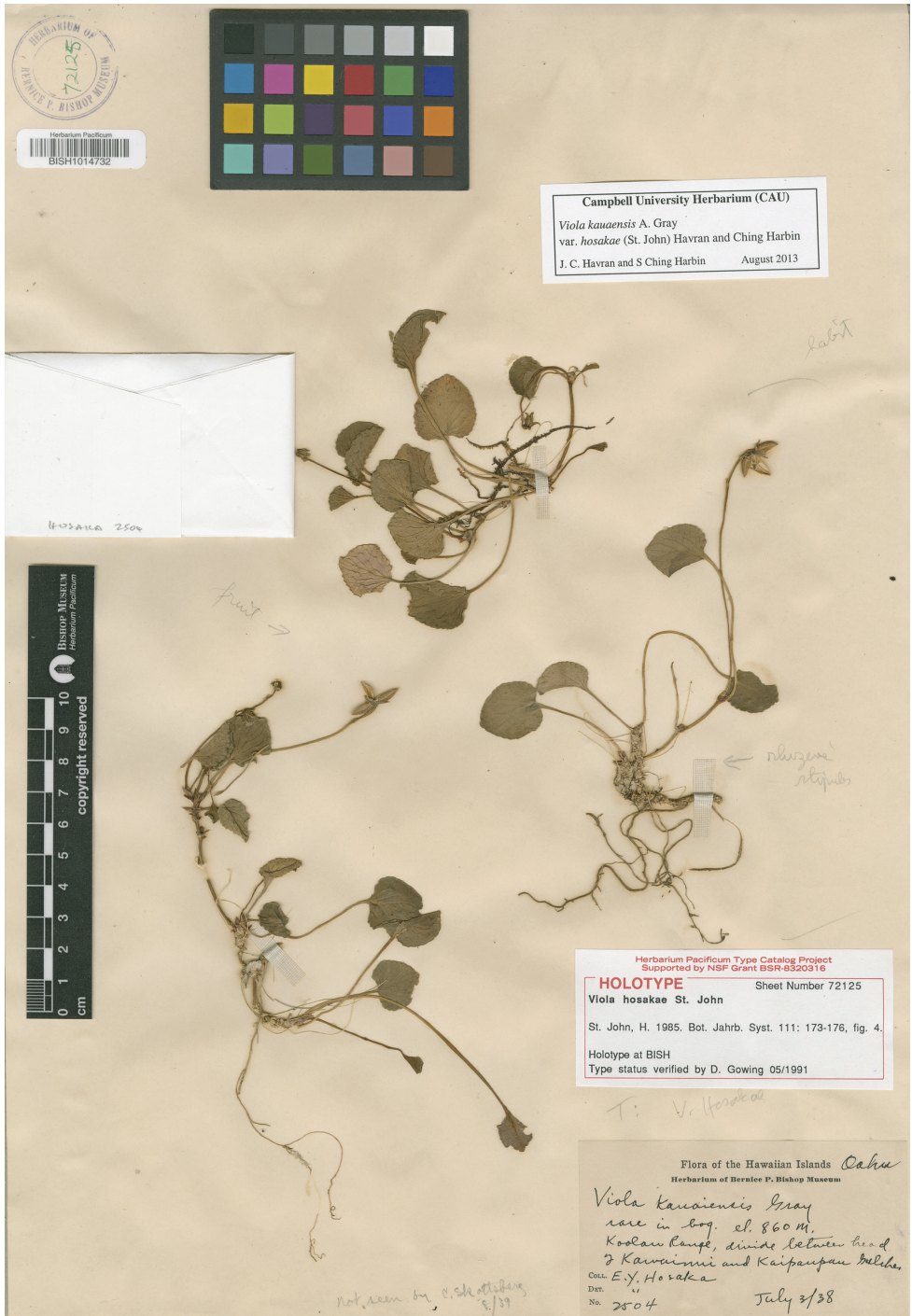


Figure 3. Type of *Viola kauaiensis* var. *hosakae*.

one half mile south of Poamoho trail along the Ko`olau Summit trail, 20 May 2013, *Havran 2013.5* (BISH); Ko`olau Mt summit, on small hill at Puu Pauau, between Poamoho and Schofield-Waikane trail, on west side of Summit trail, about 50 ft. from trail, 12 Mar 1995, *Perlman 14704* (PTBG); Ko`olau Mts. Between summit of Poamoho trail and Schofield trail, along summit crest on small hill, about 0.5 miles south of cabin, 7 Sep 1987, *Perlman 6456* (PTBG).

**Conservation status.** *Viola k.* var. *hosakae* appears very rare on O`ahu. Despite frequent and thorough conservation work by multiple organizations in the summit area of the Ko`olau Mountains, only one population of the variety is known to exist. The population is threatened by grazing ungulates. In addition, island tropical montane environments, like the ones harboring *V. k.* var. *hosakae*, are incredibly susceptible to global climate change (Loope and Giambelluca 1998).

*Viola k.* var. *hosakae* is best classified as Critically Endangered (CR) according to the IUCN Red List Criteria as it meets the following criteria: B. Area of occupancy less than 10 km<sup>2</sup>, number of populations = 1, and continuing decline inferred from extent of occurrence and area of occupancy as indicated from herbarium records and personal communication; C. Number of mature individuals less than 250 and an estimated continuing decline (C2) with less than 50 mature individuals in each subpopulation (C2i).

The Plant Extinction Prevention Program (PEPP) branch on O`ahu will work to preserve this taxon on by collecting and germinating seeds when possible. Efforts are underway to enclose the population within an ungulate fence by the end of 2014. An additional population can be started with propagules from the extant population. The cleistogamous reproduction of the variety should help to facilitate seed production in the absence of pollinators at a new location.

### Key to the varieties of *Viola kauaensis*

- 1 Leaf base cuneate ..... *Viola kauaensis* var. *wahiawaensis*
- Leaf base truncate to cordate..... **2**
- 2 Leaf base truncate to deeply cordate; lamina 13 – 77 mm wide, generally widest in 7 third of lamina, sepals 5–11 mm long; stipules subulate to lanceolate, margins sparsely serrate..... *Viola kauaensis* var. *kauaensis*
- Leaf base rounded, truncate, or shallowly cordate; lamina 8–26 mm wide, generally widest in middle of lamina, sepals 2–6 mm long; stipules linear to lanceolate, margins dentate to erose ..... *Viola kauaensis* var. *hosakae*

### Acknowledgements

Joel Lau, Clyde Imada, Barbara Kennedy, Tim Flynn, and Layne Huiet provided assistance in the field and herbarium. Kyle Kagimoto collected specimens from Mt. Waiale`ale for analysis. Steve Perlman and Ken Wood provided insight into Kaua`i populations. Cliff Morden provided access to lab supplies and herbarium driers. Harvey Ballard provided

analytical advice. An early version of this work was greatly improved by constructive comments from David Lorence. This research was partially funded by a Campbell University Faculty Summer Research Grant.

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## Additional specimens examined

*Viola kauaensis* var. *kauaensis*: **Kaua`i**: Alakai Swamp Trail, 27 Dec 1956, *Stone 1552* (BISH); Wai`ale`ale, 28 Jun 1925, *Brown 1247* (BISH); Kaholuamanu, no date, *Lydgate s.n.* (BISH); Waimea Drainage Basin W side, 3 Jul 1917, *Forbes 1135K* (BISH); Waimea below Kokee on Kilohaua, 27 Oct 1922, *Skottsberg 939* (BISH);

Kokee, “Waineke Swamp”, 28 Jun 1926, *Degener 3351* (BISH); Lehua Makanoe, bogs of Waimea, 3 Mar 1909, *Rock 2124* (BISH); Kaholuamanu, no date, *Rock 2121* (BISH); Lehua Makanoe, 8 Mar 1909, *Rock 2130* (BISH); Alakai Swamp Drainage Basin, W Side, 3 Jul 1917, *Forbes 906K* (BISH); Alakai Swamp, 25 Apr 1372, *Herbst 2388* (BISH); Alakai Swamp in bog areas and on route to Wai`ale`ale, 1 Sep 1977, *van Royen 11708* (BISH); Waimea District, Waimea AHU, Alakai Swamp Tr, 16 May 1981, *Higashino PKH 9679* (BISH); Waimea District, Waimea AHU, Alakai Swamp Tr, 12 May 1981, *Higashino PKH 9643* (BISH); Alakai Swamp, Aipoinui bog, 21 Sep 1985, *Takeuchi s.n.* (BISH); Alakai Swamp, north of Kilohana, near Wainiha rim, TNC survey of Hono O Napali NAR, transect 10, 18 May 1988, *Perlman 9224* (BISH); Alakai Swamp, Aipoinui bog, 19 Jan 1952, *Degener 21747* (BISH); Napali, Kona Forest Reserve NW end of Alakai Swamp, 27 Dec 1930, *St. John 10753* (BISH); Kaholuamanu Lehua Makanoe, E of Waialae, Sep 1909, *Forbes 406K* (BISH); Below Mt. Wai`ale`ale, Mar 1932, *Rogers 1* (BISH); Kaholuamanu, 3 Mar 1909, *Rock 2131* (BISH); Mts above Waimea, no date, *Mann s.n.* (BISH); Lehua Makanoe, 16 Sep 1909, *Rock 5715* (BISH); Kokee, Halemanu, Dec 1951, *Degener 21477* (BISH); Alakai Trail NE of crossing of second n fork of Kawaikoi Stream at B.M. 3638, 25 Dec 1947, *St. John 23038* (BISH, DUKE); Kilohana from the rain gage bog, 31 Jul 1983, *Takeuchi Alakai\_130a* (BISH); Waimea District, Waimea AHU, Alakai Swamp Tr, 12 May 1981, *Higashino PKH 9633* (BISH); Waimea District, Waimea AHU, Alakai Swamp Along trail betw Pihea and Kilohana, 30 Aug 1983, *Lammers 5382* (BISH); Alakai Swamp, 21 Aug 1964, *Huber 20* (BISH); Kokee State Park along Alakai Swamp Trail from jct with Pihea Trail to Kilohana, 30 Aug 1983, *Wagner 5049* (BISH); Mt. Wai`ale`ale, 200 m from summit, 14 Nov 2012, *Kagimoto 1* (CAU); Mt. Wai`ale`ale, 200 m from summit, 14 Nov 2012, *Kagimoto 2* (CAU); Mt. Wai`ale`ale, 200 m from summit, 14 Nov 2012, *Kagimoto 3* (CAU); Mt. Wai`ale`ale, 200 m from summit, 14 Nov 2012, *Kagimoto 4* (CAU); Mt. Wai`ale`ale, 200 m from summit, 14 Nov 2012, *Kagimoto 5* (CAU); Kaua`i, 1838, *Wilkes s.n.* [HOLOTYPE] (US).

*Viola kauaensis* var. *wahiawaensis*: **Kaua`i**: Waimea Bog, 28 Dec 1956, *Wolford 397* (BISH); Wahiawa, Kahili Swamp, 29 Dec 1930, *St. John 10845* (BISH); Wahiawa, Kahili Bog, 24 Dec 1933, *St. John 13555* (BISH); Kola District Wahiawa Swamp near headwaters of Wahiawa Stream, 24 Apr 1964, *Stauffer 5911* (BISH); Wahiawa Swamp, Aug 1909, *Forbes 166.K* [Holotype] (BISH); Wahiawa Bog, 22 May 1972, *Herbst 2415* (BISH); Wahiawa Bog (Kanaele Swamp) W of Kahili Mt, 2 Jan 1957, *Stone 1650* (BISH); Bog above Wahiawa, 8 Feb 1927, *MacDaniels 606* (BISH); Wahiawa Mts, no date, *Lydgate s.n.* (BISH); In Wahiawa Bog (Kanaele Swamp), 22 Dec 1983, *Wagner 5202* (BISH); Wahiawa Swamp, Aug 1909, *Forbes 166.K* [Isotype] (BISH); Wahiawa Swamp, Aug 1909, *Forbes 166.K* [Isotype] (BISH); Koloa District, Wahiawa Swamp near headwaters of Wahiawa Stream, 24 Apr 1964, *Stauffer 5911* (DUKE).

*Viola vanroyenii*: **Kaua`i**: Wai`aleale summit area, Alakai Swamp, 3 Sep 1977, *van Royen 11733* [Holotype] (BISH).



# Two new genera, *Hoffmannanthus* and *Jeffreycia*, mostly from East Africa (Erlangeinae, Vernonieae, Asteraceae)

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## Abstract

Two genera of Vernonieae subtribe Erlangeinae with Type A pollen, 5-ribbed achenes, and blunt-tipped sweeping hairs on the styles are described as new, *Hoffmannanthus* with one species and with *Vernonia brachycalyx* O. Hoffm. as type, and *Jeffreycia* with five known species, with *Vernonia zanzibarensis* Less. as type. *Vernonia abbotiana* O. Hoffm. is neotypified and is an older name for *V. brachycalyx*.

## Keywords

Africa, Compositae, Erlangeinae, *Hoffmannanthus*, *Jeffreycia*, new genera, Vernonieae

## Introduction

The dismantling of the overly broad concept of *Vernonia* Schreb. in the Old World was begun by Robinson (1999a). In that study, the primary point was fully established, that there are no true members of the genus *Vernonia* native to the Eastern Hemisphere. The genus *Vernonia* is almost entirely North American (Robinson 1999b). Still, acceptance of segregate genera would inevitably depend on establishment of a reasonably complete coverage of the tribe, defining properly phyletic segregates, and discovery of reasonable characteristics by which the segregates can be distinguished.

The present effort concentrates on a related group that contains a number of mostly African, woody perennial species of the subtribe Erlangeinae having 5-angled achenes, blunt-tipped sweeping hairs on the styles, and tricolporate type A pollen (Keeley and Jones 1977, 1979), also known as sublophate pollen (Skvarla et al. 2005). Two elements of this group are here described as new genera, *Hoffmannanthus* and *Jeffreycia*.

## Methods

Specimens examined were from the U.S. National Herbarium in Washington, DC. Microscopic structures were examined mostly using material mounted in Hoyer's Solution (Anderson 1954). Preparation of pollen for scanning electron microscopy (SEM) consisted of acetolysis (Erdtman 1960) followed by the osmium-thiocarbohydrazide repeat procedure (Chissoe et al. 1995) and pulse sputter coating with a gold/palladium (60/40) target (Chissoe and Skvarla 1996). Examination was with a JEOL 880 (University of Oklahoma) SEM equipped with lanthanum hexaboride (LaB6) electron sources.

## Results and discussion

The genera *Hoffmannanthus* and *Jeffreycia*, described here as new, are evidently closely related, but of these only *Hoffmannanthus* has had its DNA sequenced (Keeley et al. 2007). The available DNA sequence results place *Vernonia brachycalyx* O. Hoffm., the type of *Hoffmannanthus*, in a subclade within the subtribe Erlangeinae (Keeley and Robinson (2009). According to the DNA sequence, that part of the subtribe contains *Vernoniastrum* H. Rob. (Robinson 1999a), and somewhat more distantly, *Orbivestus* H. Rob. (Robinson 1999a, 2009). Of these, *Vernoniastrum* differs by a more herbaceous habit, pointed sweeping hairs on the style branches, idioblasts of the achenes in transverse bands, and lophate, triporate pollen. *Orbivestus* has the same type of pollen as *Hoffmannanthus*, but the plant is more herbaceous, has heads in seriate or subscorpioid cymes, has nearly sessile T-shaped hairs on the stems, has strictly subimbricate and otherwise undifferentiated bracts in its involucre, has narrowly rhomboid raphids in the walls of the achenes, and has pointed tips on the sweeping hairs of the style branches. The sweeping hairs occur along the entire outer surface of the style branches. Sequence data is lacking for *Jeffreycia*, but on the basis of structural evidence, *Jeffreycia* is considered closer to *Hoffmannanthus* than *Vernoniastrum* or *Orbivestus*. As shown in the review by Herz (1996), *Jeffreycia* (as *Vernonia zanzibarensis*) and *Hoffmannanthus* (as *Vernonia brachycalyx*) also share an unusual type of glaucolide derivative that has otherwise been reported only from *Bothriocline* (as *B. amplifolia*), all three genera evidently members of the Erlangeinae in the strict sense.

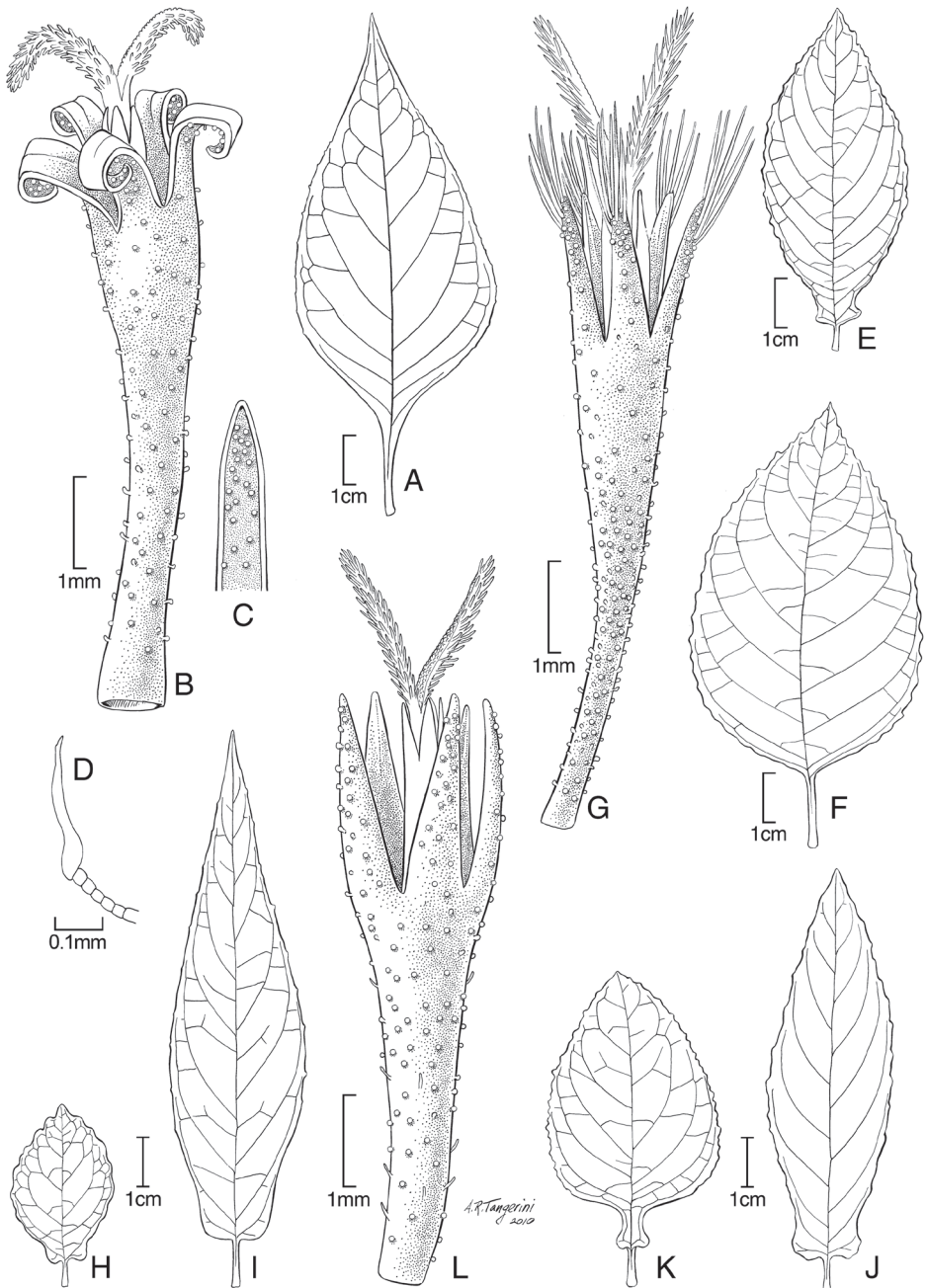
The typical element of the subtribe Erlangeinae with the genera *Erlangea* Sch. Bip., *Bothriocline* Oliv. ex Benth., and *Cyanthillium* Blume consists of herbaceous plants with mostly lophate, triporate pollen, symmetrically T-shaped hairs, and sharply

pointed sweeping hairs on the styles. In contrast, the two genera described herein are shrubbier or weakly arborescent with sublophate, tricolporate pollen having a continuous perforated tectum between the colpi, simple or asymmetrical non-T-shaped hairs, and blunt tips on the sweeping hairs.

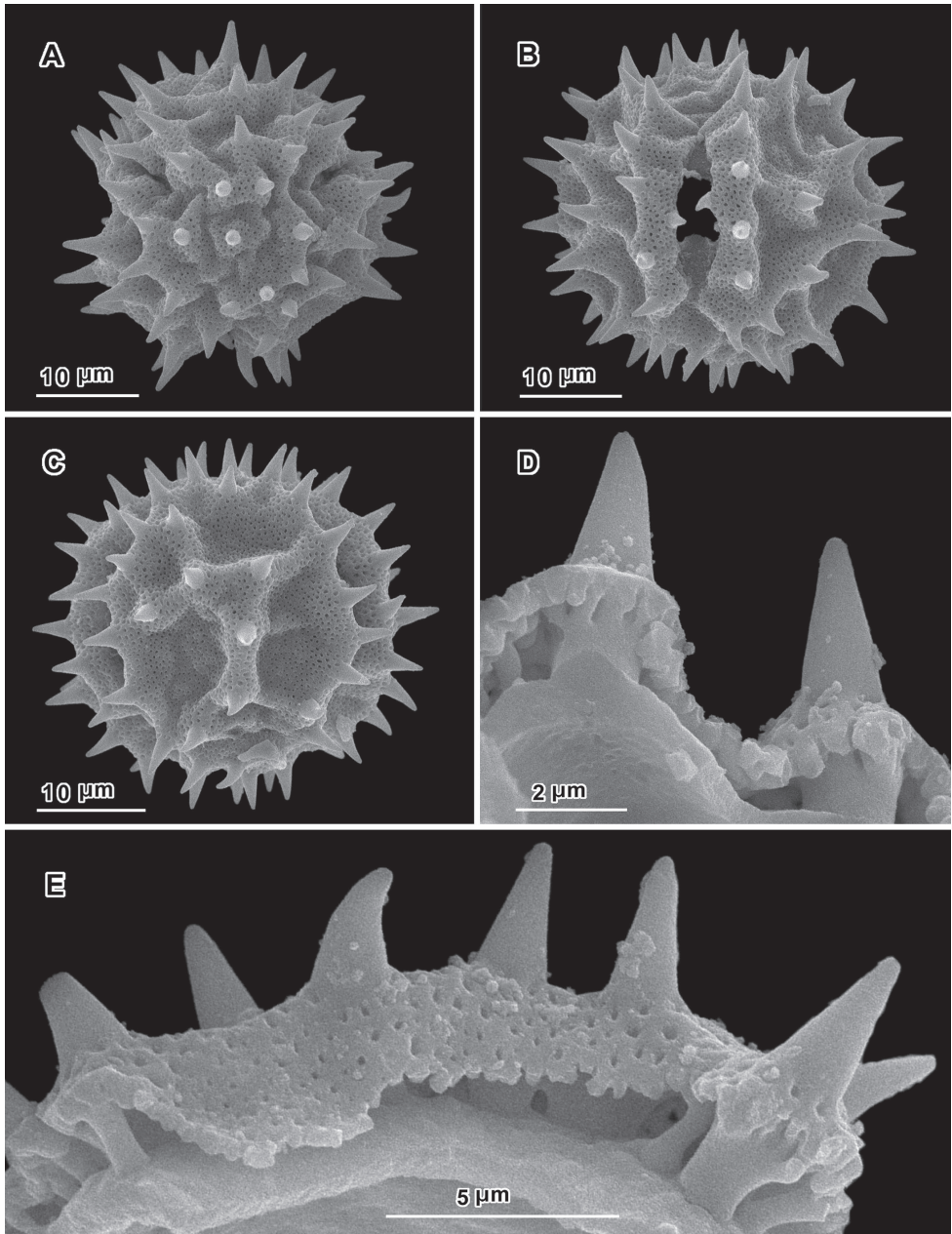
The two new genera, *Hoffmannanthus* and *Jeffreycia* (Fig. 1), share one feature found in many Old World Vernoniae, namely the sweeping hairs which are restricted to the branches of the style and do not extend onto the upper shaft, a feature otherwise a defining characteristic of the tribe Vernoniae and the subfamily Cichorioideae. *Jeffreycia* may be the most extreme in this character, with the sweeping hairs usually failing to even reach the bases of the style branches.

These genera are treated here together to allow a more effective direct comparison. The most obvious differences between *Hoffmannanthus* and *Jeffreycia* are found in the hairs of the stems, the shape of the leaves, and in details of the corolla lobes. The hairs on the stems of *Hoffmannanthus* have a rather long, uniseriate multicellular stalk with an elongate, asymmetrically mounted horizontal cap cell at the tip, these hairs being what could be called L-shaped (Fig. 1D). In contrast, the hairs on the stems of *Jeffreycia* species are simple and unbranched. The leaves of *Hoffmannanthus* have long petioles below the distinct basal acumination of the blade, and have no auricles on the blades (Fig. 1A). The leaves of all *Jeffreycia* except the typical variant of the type species, *J. zanzibarensis* (Less.) H. Rob., S. Keeley & Skvarla have short petioles and blades with auricles projecting laterally at the base (Fig. 1E, F, I–K). The corolla lobes in *Hoffmannanthus* are oblong-triangular, and usually recurved at maturity (Fig. 1B, C). *Jeffreycia* has corolla lobes that are strictly lanceolate, the sides not parallel in any part, but evenly convergent from the base to the tip (Fig. 1G, L). The lobes are erect though sometimes withered when dry, but never recurved. A less obvious difference is the tendency for the pappus bristles in *Hoffmannanthus* to be sordid or even rufous and broader in the distal half, while those of *Jeffreycia* tend to be white and narrowed above.

Jones (1981) placed the type species of *Hoffmannanthus*, *Vernonia brachycalyx* O. Hoffm., in his *Vernonia* subsect. *Strobocalyx* S.B. Jones, among species now placed in the mostly African *Gymnanthemum* Cass. and in the mostly Asiatic and Malaysian genus *Strobocalyx* (Blume ex DC.) Spach. Jeffrey (1988) placed the species in his group 2 subgroup B, in an aggregate 3, distinguished by its persistent involucre bracts, 5-angled achenes, and ovate to cordate, non-panduriform leaves. *Vernonia brachycalyx* was not treated in the first effort to resolve palaeotropical Vernoniae by Robinson (1999a). Relationships of the species of *Hoffmannanthus* are considered to be particularly close to *Jeffreycia* which was placed by Jeffrey (1988) in his group 2, subsection B, aggregate 2. The present study shows that the two genera share Type A sublophate pollen, 5-angled achenes with short raphids, and blunt sweeping hairs on the style branches. Like many of the Old World Vernoniae, the sweeping hairs in *Hoffmannanthus* are lacking on the upper shaft of the style, but unlike most *Jeffreycia*, are not lacking on the bases of the style branches. Both genera are most common in east Africa. It is concluded that the two genera described here as new are closely related to each other but distinct.

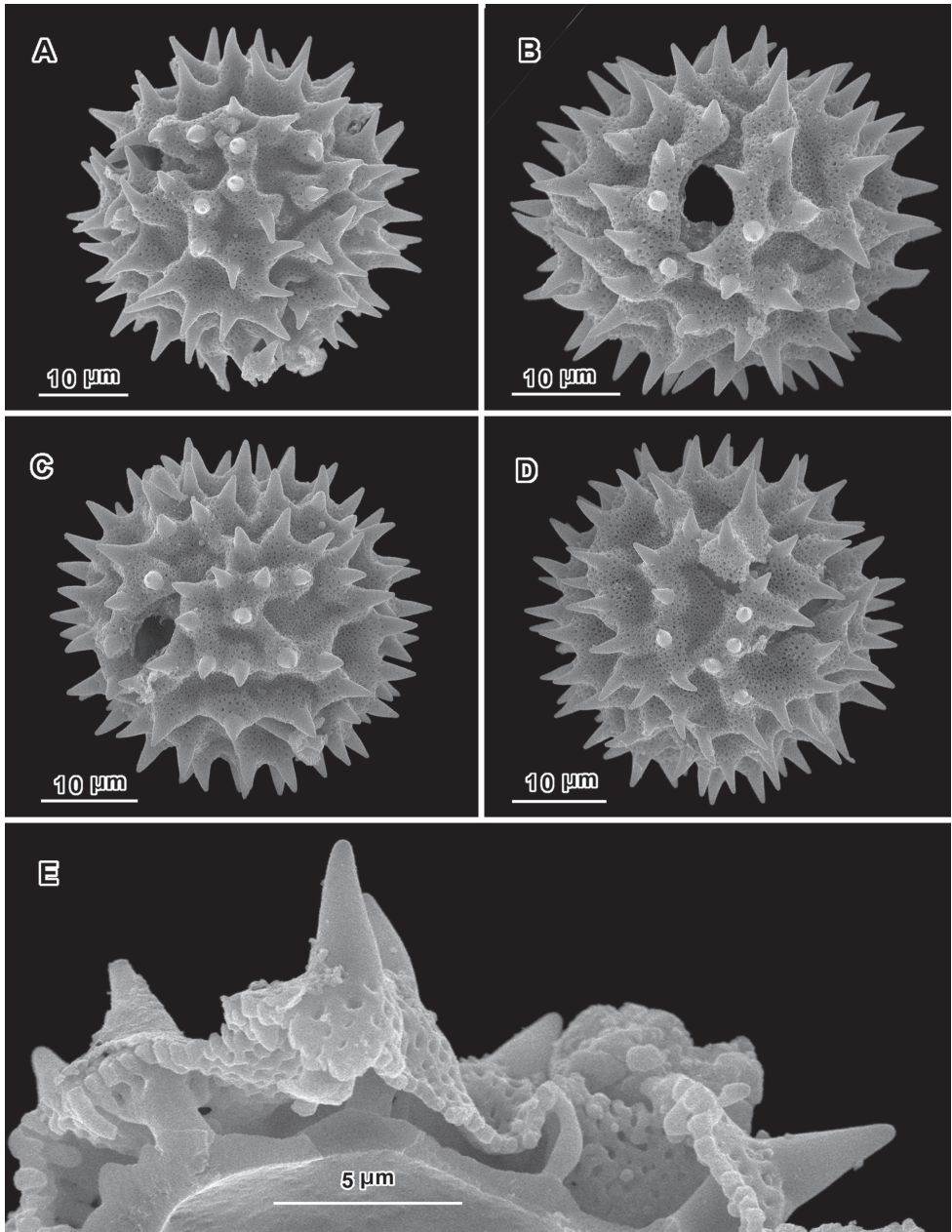


**Figure 1.** **A–D** *Hoffmannanthus abottianus* O. Hoffm. **E–G** *Jeffreyia zanzibarens* (**E** form with panduriform leaves **F, G** typical form) **H–K** *Hildebrandtia hildebrandtii* **I** *J. amaniensis* **J** *J. usambarensis* **K, L** *J. zeylanica*. **A, F, H–K** leaf **B, G, L** corolla **C** lobe of corolla **D** stem hair (**A, D** from Kenya, *Gichuon* 10, US **B, C** from Ethiopia, *Burger* 1816, US **E** from *Rulangaranga et al.* 83, US **F, G** from Tanzania, *Faulkner* 3866, US **H** from Tanzania, *Stuhmann* 7537, US **I** from Tanzania, *Peter O III* 7, US **J** from Tanzania, *Peter O IV* 15, US **K, L** from Sri Lanka, *Silva* 4, US).



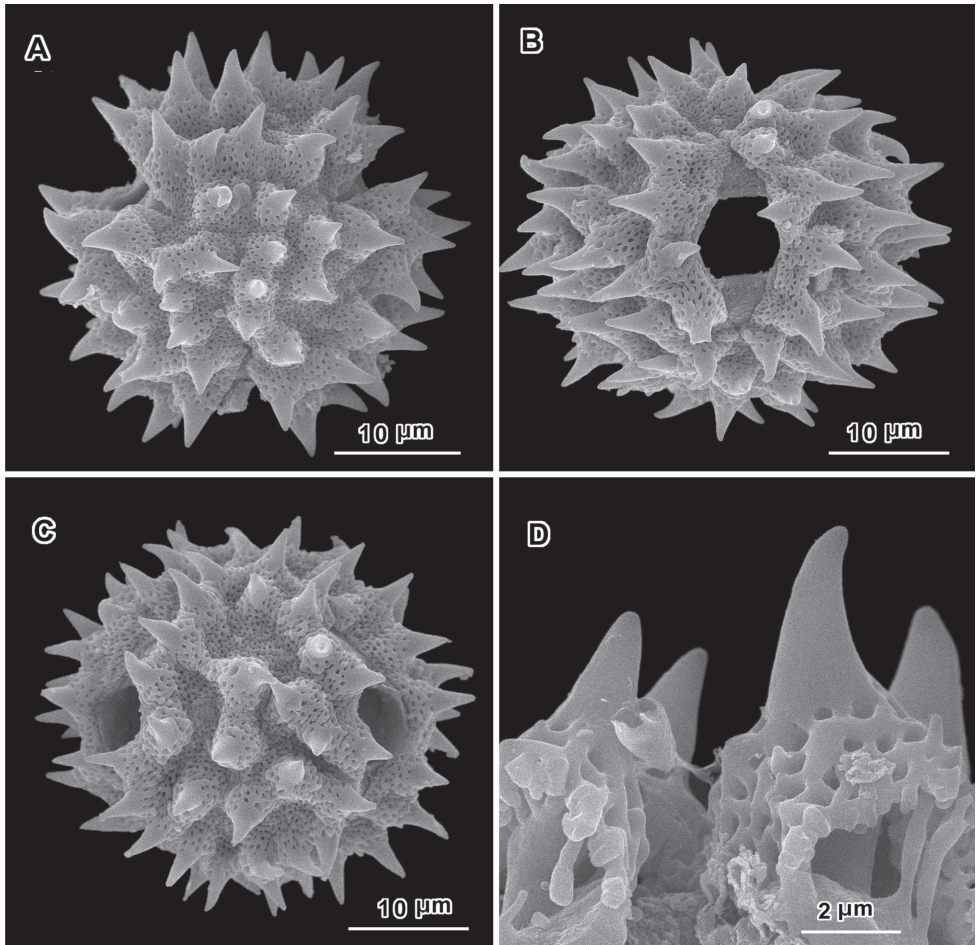
**Figure 2.** Scanning electron micrographs of *Hoffmannanthus abbotianus* pollen (Kenya, *Gichuon 10*, US). **A** polar view **B** equatorial view **C** lateral view **D, E** views of fractured grains.

The second genus treated here, *Jeffreyia*, includes three of the species mistakenly placed in *Gymnanthemum* in the subtribe Gymnantheminae by Robinson (1999a), a genus from which the present group is now seen to be subtribally distinct. Among the



**Figure 3.** Scanning electron micrographs of *Jeffreyia zanzibarensis* pollen (Tanzania, *Faulkner 3866*, US). **A** polar view **B** equatorial view **C** oblique lateral view **D** lateral view **E** view of fractured grain.

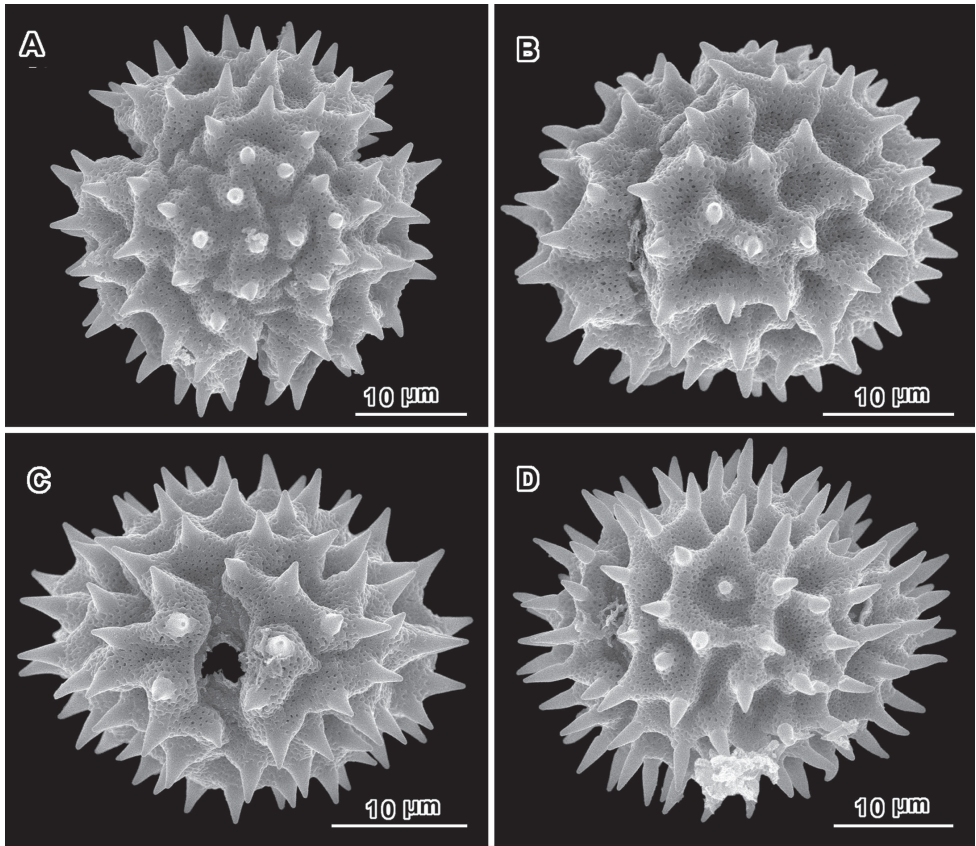
most obvious differences are the presence in *Gymnanthemum* of a broad abaxial shield in the involucre bracts and the tendency for the inner involucre bracts to be deciduous in *Gymnanthemum*, instead of persistent as in *Jeffreyia*.



**Figure 4.** Scanning electron micrographs of *Jeffreyia zeylanica* pollen (Ceylon, *K. Wirawan* 695, US). **A** polar view **B** equatorial view **C** lateral view **D** fractured grain.

A genus that is possibly closely related to *Jeffreyia* is the recently described *Uniyala* H. Rob. & Skvarla of India and Sri Lanka (Robinson and Skvarla 2009) with which *Jeffreyia* scarcely overlaps geographically, only through its one species in Sri Lanka. While superficially similar, *Uniyala* has a shrubbier habit with closely spirally inserted leaves, non-panduriform bases of the blades, elongate raphids and thinner walled cells in the achene wall, and short tubes on the corollas and corolla lobes that are not strictly triangular.

An apparent additional distinction between *Uniyala* and both *Jeffreyia* and *Hoffmannanthus* is the pollen. In all three genera, the pollen is approximately the same size, ca. 30 µm in diam. when dry, up to 50 µm in diam. in fluid, type A tricolporate or sublophate with a continuous perforated tectum between the colpi. However, in *Uniyala* the pollen has incipient muri more defined with fewer, larger incipient lacunae (Robinson and Skvarla 2009) than in the present group, where muri are obscure and the incipient lacunae are small and more numerous (Figs 2–5).



**Figure 5.** Scanning electron micrographs of *Jeffreyia* pollen: **A, B** *J. usambarensis* (Ost-Africa, *A. Peter 0 IV 15*, US) **C, D** *J. hildebrandtii* (Kenya, *J. Lauranos 12468*, US). **A** polar view **B, D** lateral view **C** equatorial view.

The generic segregates of *Vernonia* in tropical Africa are only partially resolved. A treatment of all but two species in Southern Africa is nearly complete, but it does not include any close relatives of the two genera described here. Nevertheless, the presently recognized tropical African genera that have previously been placed in *Vernonia* can be partially distinguished by the following key. Its utility is limited by the number of segregates of tropical African Vernonieae that remain untreated.

**Identification key to the segregate genera of Vernonieae of East Africa**

- 1        Leaves triplinervate; corollas sometimes yellow ..... ***Distephanus* Cass.**
- Leaves with pinnate venation; corollas only purplish, bluish or white ..... **2**
- 2        Strictly herbaceous ..... **3**
- Weakly to strongly woody, prostrate shrubs to small trees ..... **7**



- 3 Perennial herbs with root crown with densely pilose apex; often flowering before leaves appear ..... ***Vernonella* Sond.**
- Annual or perennial herbs with rootstock not densely pilose at apex; flowers usually appearing after leaves ..... **4**
- 4 Mostly small herbs with pollen either sublophate, triporate or pantoporate ..... **(most Erlangeinae and Centrapalinae) *Cabobanthus* H. Rob., *Centrapalus* Cass., *Cyanthillium* Blume, *Lettowia* H. Rob. & Skvarla, *Oocephala* (S.B. Jones) H. Rob., *Orbivestus* H. Rob., *Parapolydora* H. Rob., *Polydora* Fenzl, *Vernoniastrum* H. Rob.**
- Pollen lophate with three fully developed colpi ..... **5**
- 5 Weak herbs with involucre bracts bearing smooth broad shields abaxially, not marginally toothed or apically appendaged ..... ***Anathura* H. Rob. & Skvarla**
- Coarse herbs to shrubs; involucre bracts marginally toothed or apically appendaged ..... **(Linziinae) 6**
- 6 Corollas with lobes not longer than the throat; pappus segments flattened; muri of pollen echinate ..... ***Baccharoides* Moench**
- Corollas with lobes longer than throat; pappus of capillary segments; muri of pollen psilate ..... ***Linzia* Sch.Bip. ex Walp.**
- 7 Involucre bracts broad, smooth abaxially with broad median shield; inner bracts often deciduous ..... ***Gymnanthemum***
- Involucre bracts oblong-lanceolate to linear-lanceolate, without broad smooth shield abaxially; inner bracts persistent ..... **8**
- 8 Pollen lophate, with little or no perforated tectum ..... ***Ambassa* Steetz**
- Pollen sublophate, with continuous perforated tectum in intercolpi ..... **9**
- 9 Leaf blades tapering into petiole at base; corolla lobes oblong-lanceolate, recurved; hairs of stems with asymmetric cap cells ..... ***Hoffmannanthus***
- Leaf blades usually with basal auricles; corollas with erect lanceolate lobes; hairs of stems simple ..... ***Jeffreyia***

## Taxonomic treatment

***Hoffmannanthus* H. Rob., S.C. Keeley & Skvarla, gen. nov.**

urn:lsid:ipni.org:names:77140770-1

**Type.** *Vernonia brachycalyx* O. Hoffm.

Scrambling shrubs; stems slender with solid pith, somewhat deflected at nodes in upper part of vegetative plant and in inflorescence; hairs of stems L-shaped, with long, multicellular, uniseriate stalk and elongate, horizontal cap cell mounted near one end. Leaves alternate, petioles slender and 7–15 mm long below basal acumination of blade; blades ovate, 6–7 times longer than petiole, 5–10 cm long, 1.5–5.0 cm wide, base broadly obtuse to short-acute, narrowly acuminate at petiole, margins remotely denticulate to nearly entire, apex scarcely to gradually acuminate, surfaces pilosulous and

with glandular dots, hairs sparser above, dense on larger veins; secondary veins pinnate, with ca. 6 weak secondary veins on each side of midrib, spreading at ca. 40–45° angles. Inflorescences broadly corymbiform, with branches elongate, mostly with small or insignificant bracteoles at bases; peduncles 2–30 mm long. Heads campanulate; involucre much shorter than florets at maturity; involucre bracts in 2–3 series, persistent, oblong-lanceolate, with acute to short-acuminate tips, puberulous outside, pale at base, midvein broadly greenish, percurrent at tip, lateral margins thinly membranous; receptacle scarcely convex, epaleate, pilose. Florets ca. 15 in a head, homogamous, bisexual; corollas violet to purple, narrowly funnellform, with long basal tube, throat short, lobes narrowly oblong-lanceolate, with glandular dots outside; anthers with triangular apical appendages; base of style slightly enlarged, style shaft glabrous, sweeping hairs on style branches elongate with rounded or blunt tips. Achenes 5-angled, with some glandular dots and short setulae, surface with sparse idioblasts and inner layer with small subquadrate or rounded raphids; pappus pale to sordid or rufous, 2 series, inner pappus of many capillary bristles that are slightly broader in distal half, outer pappus of short narrow scales. Pollen grains 40 µm in diam., Type A, sublophate.  $2n = 20$  (Jones 1982, as *Vernonia brachycalyx*).

**Etymology.** The name *Hoffmannanthus* is considered appropriate, since both of the older species names featured here were published by Hoffmann (1894, 1895).

**Number of species.** The genus contains the single species.

***Hoffmannanthus abbotianus* (O. Hoffm.) H. Rob., S.C. Keeley & Skvarla, comb. nov.**  
urn:lsid:ipni.org:names:77140772-1

*Vernonia abbotiana* O. Hoffm., Bot. Jahrb. Syst. 20: 221. 1894. Type: Tanzania, Kilimanjaro, *Abbot 1890* (holotype B destroyed). Neotype (selected here): Tanzania, Kwa Mshusa, May 1893, *Holst 9096* (US, lectotype of *Vernonia brachycalyx* O. Hoffm.).

*Vernonia brachycalyx* O. Hoffm. in Engler, Pflanzenw. Ost-Afr. C: 405. 1895. Type: Tanzania Kwa Mshusa, *Holst 9096* (syntype B destroyed; lectotype US, selected here, isolectotypes BM, K).

*Vernonia meiocalyx* S. Moore, J. Bot. 38: 155. 1900. Type: Kenya, *Delamere s.n.* (syntypes BM).

*Vernonia hoffmanniana* S. Moore, J. Bot. 38: 156. 1900, nom. nud.

*Vernonia jodopappa* Chiov., Racc. Bot. Miss. Concol.: 60. 1935, nom. illeg., non Sch. Bip. 1845. *Vernonia jodopapposa* Lanza, Miss. Biol. Borana, Racc. Bot. Angiosp.-Gymnosp.: 244. 1939. Type: Kenya, Nyeri, *Balbo 428* (holotype TOM, isotype FI).

**Distribution.** The species occurs from Ethiopia, Congo and Uganda in the north to Angola, Malawi and Zambia to the south.

**Notes.** The type specimen of *Vernonia abbotiana* O. Hoffm. was destroyed in Berlin during the Second World War, and the species was treated by Jeffrey (1988) as

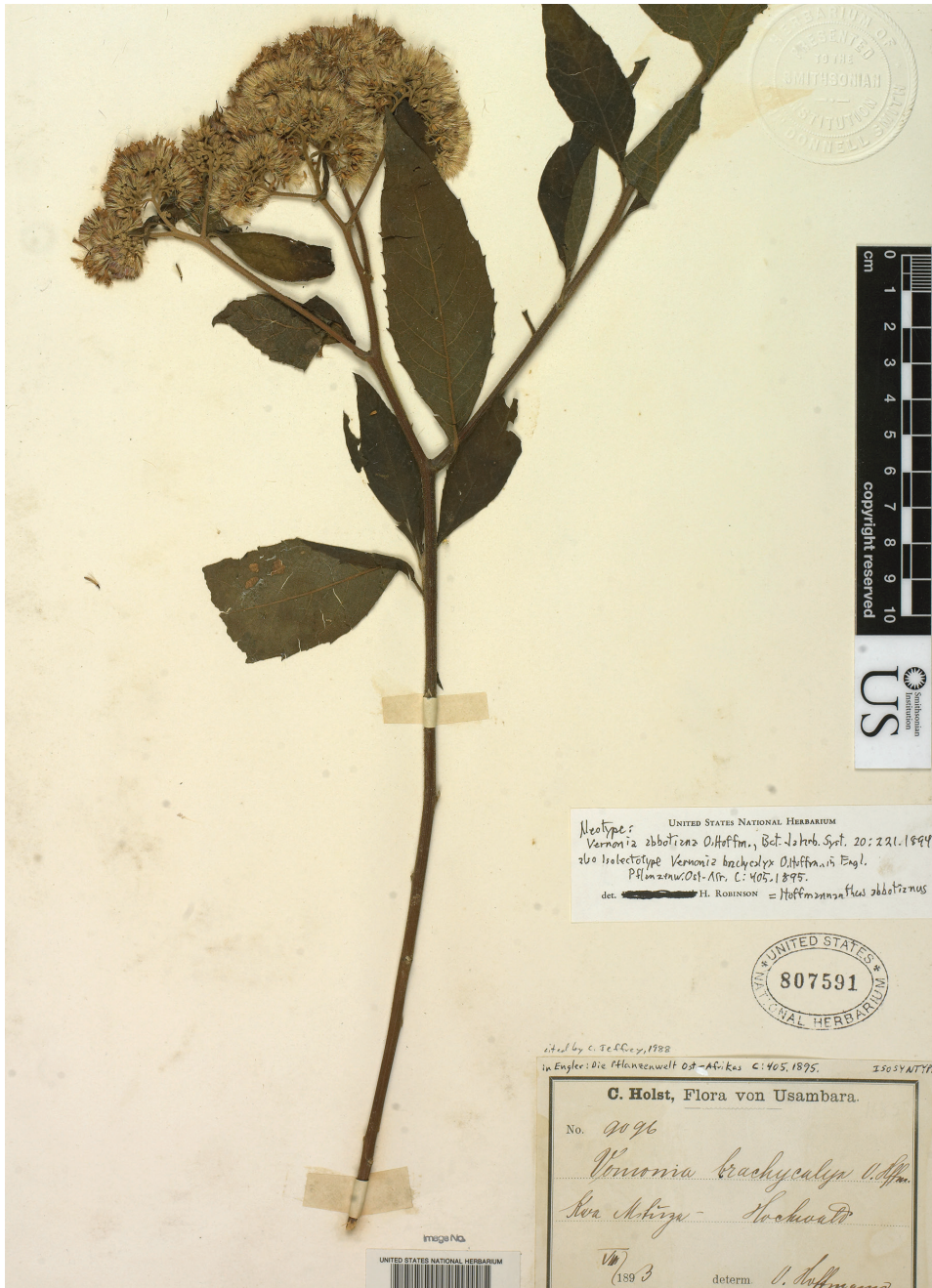
one of group titled, “taxa insufficiently known”. No duplicates of the type are known. Nevertheless, a specimen, *A. Peter OI 119*, from Tanzania, Usambara, collected May 25, 1914, identified as *V. abbotiana*, was deposited in the US. National Herbarium. Although not a type, the specimen led to a careful comparison with the original description of the species (Hoffmann 1894). The specimen was finally recognized as a *Vernonia brachycalyx* with unusually long peduncles, but almost certainly fitting the description of *V. abbotiana* in all details except the peduncles and the supposedly deciduous inner involucre bracts. The inner involucre bracts of *Vernonia brachycalyx* are not deciduous, but the involucre is short, giving the appearance of a missing inner series. As for the density of the inflorescence in *V. abbotiana*, the original author, Hoffmann (1894) compared his species with *Vernonia livingstoniana* Oliv. & Hiern, which is a synonym of *Gymnanthemum thomsonianum* (Oliv. & Hiern) H. Rob. The latter species is not a close relative, but the reference to it in the original description indicates the kind of dense inflorescence. Such a dense inflorescence is unlike that in the Peter specimen, but it is very like typical material of *Vernonia brachycalyx* with which the Peter specimen is now identified. The identification might never have been made without the advent of the Peter specimen, but names such as *V. abbotiana*, dating from comparatively early in the study of tropical Africa, do need to have their identity resolved by some means, in this case by neotypification. Personally, there is no doubt of the identification provided here, and a neotype, that is an isoelectotype of *V. brachycalyx* at the US National Herbarium is selected (Fig. 6), a specimen that matches the denser form of the inflorescence that is indicated by Hoffmann (1894).

***Jeffreyia* H. Rob., S.C. Keeley & Skvarla, gen. nov.**

urn:lsid:ipni.org:names:77140771-1

**Type.** *Vernonia zanzibarensis* Less.

Small to moderate-sized; branching, often scrambling shrubs; stems woody, with narrow solid pith; hairs simple, without cap-cells, sometimes forming loose tomentum. Leaves alternate; petioles distinct, short to elongate; blades ovate to elliptic or panduriform usually with basal auricles, abruptly delimited from petiole at the base, 2.5 to ca. 11 cm long, ca. 1.5–7.5 cm wide, margins crenate or serrate, apices acute to scarcely acuminate, rarely obtuse, upper surface sparsely pilosulous to hispidulous, lower surface sparsely pilosulous to tomentellous, with many glandular dots; secondary veins 4–6 on each side, with unusual somewhat meandering course, spreading at 45–60° angles. Inflorescences terminal, with branches alternate and usually ascending at 30° angles or less, usually with minute bracteoles, sometimes primary bracteoles larger and foliiform; heads crowded at ends of longer branches, with distinct short peduncles; involucre bracts persistent, subimbricate in ca. 4–5 series or with differentiated long, linear-lanceolate basal bracts, bracts, except at base, smooth outside, without median keel; receptacle scarcely convex, epaleate, epilose, with protuberant scars; florets 5–40 in a head; corollas purplish, 5–11 mm long, with some glandular dots outside, few or no hairs below tips, basal tube slender, half as long as the



**Figure 6.** Neotype of *Vernonia abbotiana* O. Hoffm. and lectotype of *Vernonia brachycalyx* O. Hoffm.

corolla, throat half as long as the limb, ca. as long as the lobes, lobes strictly narrowly lanceolate, with sides straight from base to apex, erect, not recurving, sometimes with stiff hairs at tip; anther thecae without glands, calcarate at base, with narrow tails; endothelial cells with-

out obvious nodes; apical appendages narrowly lanceolate; style with basal node; sweeping hairs with blunt tips, restricted to branches, often lacking for some distance above bases of branches. Achenes 2–4 mm long, with 4 or 5 poorly differentiated angles, with or without glands or setulae, with scattered idioblasts on surface sometimes in vertical series, inner cells of achene wall with distinct firm cell walls, containing small subquadrate raphids; carpodium stopper-shaped or somewhat turbinate and asymmetrical, with many series of subquadrate, thick-walled cells; pappus white, with inner series capillary, often deciduous, 4.5–7.0 mm long, gradually narrowed to tips, somewhat flattened on outer surface; outer series of short persistent scales, minute to 0.5 mm long. Pollen ca. 40 µm in diam. in fluid, sublophate, tricolporate, with perforated tectum continuous between colpi.

**Etymology.** The new genus, *Jeffreyia*, honors the author of the study of the *Vernoniae* of East Tropical Africa (Jeffrey 1988) whose work has been one of the most helpful in resolving the tribe in Africa.

**Number of species.** Five species are currently placed in the genus.

In addition to the species listed below, Jeffrey (1988) included another three species in his aggregate, *Vernonia Bruceae* C. Jeffrey, *V. stuhlmanii* O. Hoffm., and *V. fischeri* O. Hoffm., but these have not been seen in this study and therefore are not included in the new genus. Of these, *V. fischeri* O. Hoffm. (1895) and *V. stuhlmanii* O. Hoffm. (1898) are described with leaf bases truncate to subcordate, and both species are probably members of *Jeffreyia*, distinguished from the others by the appendages on the tips of their involucre bracts. However, *V. Bruceae* is described with “foliis ellipticis vel lanceolatis basi late cuneatis vel rotundatis“. Not stated is whether that leaf base is as abrupt at the insertion on the petiole as in all the species of *Jeffreyia* recognized here, and any close relationship to *Jeffreyia* is doubtful.

**Notes on morphology.** Regarding the shape of the leaf base, while it is similar to cordate, Jeffrey (1988) refers to it as panduriform. The auricles result mostly from a constriction above the base of the leaf blade. This character is lacking only in those specimens of *Vernonia zanzibarensis* Less. that have longer petioles. Some specimens combine long hairs at the apices of the corolla lobes as in *V. zanzibarensis* with panduriform bases on short-petiolate leaves, and it is apparently plants like these that have been interpreted by Jeffrey (1988) as hybrids between that species and *Vernonia hildebrandtii* Vatke. However, it is possible that such leaf blades are just a variant of *V. zanzibarensis* that has reverted to or retained the leaf form that is characteristic of all the other members of the genus.

***Jeffreyia amaniensis* (Muschl.) H. Rob., S.C. Keeley & Skvarla, comb. nov.**

urn:lsid:ipni.org:names:77140773-1

*Vernonia amaniensis* Muschl., Bot. Jahrb. Syst. 46: 78. 1911. Type: Tanzania, Amani, Zimmerman & Warnecke 90 (B destroyed, isotypes BM, K).

**Distribution.** Tanzania.

***Jeffreyia hildebrandtii* (Vatke) H. Rob., S.C. Keeley & Skvarla, comb. nov.**

urn:lsid:ipni.org:names:77140774-1

*Vernonia hildebrandtii* Vatke, Oesterr. Bot. Z. 25: 323. 1875. *Gymnanthemum hildebrandtii* (Vatke) H. Rob., Proc. Biol. Soc. Washington 112(1): 241. 1999. Type: Tanzania, Zanzibar, *Hildebrandt 1020* (B destroyed, isotype K).

*Vernonia taylorii* S. Moore, J. Bot. 38: 154. 1900. Type: Kenya, Rabai Hill, *Taylor s.n.* (holotype BM).

**Distribution.** Kenya, Somalia, Tanzania.

***Jeffreyia usambarensis* (O. Hoffm.) H. Rob., S.C. Keeley & Skvarla, comb. nov.**

urn:lsid:ipni.org:names:77140775-1

*Vernonia usambarensis* O. Hoffm., Bot. Jahrb. Syst. 20: 220. 1894. Type: Tanzania, Kwa Mshusa, *Holst 9146* (syntype B destroyed, isosyntype K) & Tanzania, Mlalo, *Holst 129, 203* (syntypes B destroyed).

**Distribution.** Tanzania.

***Jeffreyia zanzibarensis* (Less.) H. Rob., S.C. Keeley & Skvarla, comb. nov.**

urn:lsid:ipni.org:names:77140776-1

*Vernonia zanzibarensis* Less., Linnaea 6: 637. 1831. *Gymnanthemum zanzibarensis* (Less.) H. Rob., Proc. Biol. Soc. Washington 112(1): 243. 1999. Type: “Bojer in insula Zanzebar (v. sp. in hrb. Horn.)” (Lessing 1831).

**Distribution.** Kenya, Tanzania.

***Jeffreyia zeylanica* (L.) H. Rob., S.C. Keeley & Skvarla, comb. nov.**

urn:lsid:ipni.org:names:77140777-1

*Eupatorium zeylanicum* L., Sp. Pl.: 837. 1753. *Vernonia zeylanica* (L.) Less., Linnaea 4: 344. 1829. *Gymnanthemum zeylanicum* (L.) H. Rob., Proc. Biol. Soc. Washington 112(1): 243. 1999. Type: Herb. Hermann 4: 22 (lectotype BM000628096, selected here). The previous lectotype designation (Grierson 1980: 131) refers to at least three (possibly five) specimens, and this choice is narrowed here.

**Distribution.** Sri Lanka.

Key to the five species presently placed in the genus *Jeffreyia*

- 1 Heads with 5–10 florets; with only rather short involucre bracts at base; corollas 5–6 mm long; leaf blades with crenate margins ..... **2**
- Heads with 20–40 florets; with elongate filiform bracts at base; corollas 7–11 mm long; leaf blades with serrate margins ..... **3**
- 2 Undersurfaces of leaves and branches of inflorescence with short hispidulous pubescence; heads with ca. 10 florets ..... *J. hildebrandtii*
- Undersurfaces of leaves and branches of inflorescence with long hairs forming tomentum; heads with ca. 5 florets ..... *J. zeylanica*
- 3 Corollas with cluster of long stiff hairs at tips of lobes; leaf blades usually ovate with margins closely serrate; with small bracteoles in the inflorescences ..... *J. zanzibarensis*
- Corollas lacking cluster of long hairs at tips of lobes; leaf blades oblong or elliptical; with remotely serrate margins; inflorescences with large foliiform primary bracteoles ..... **4**
- 4 Peduncles with appressed stiff hairs; leaf blades shortly pubescent below; inner involucre bracts to ca. 8 mm long ..... *J. amaniensis*
- Peduncles with mostly spreading, crisped hairs; leaf blades crispate pubescent below, somewhat obscurely pubescent on lamina surface; inner involucre bracts ca. 6 mm long ..... *J. usambarensis*

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We wish to thank Alice Tangerini, Staff illustrator of the Department of Botany, National Museum of Natural History for the line drawings of the leaves and corollas of *Hoffmannanthus* and *Jeffreyia*. We also thank Ingrid Pol-yin Lin of the Department of Botany for the scan of the isoelectotype of *Vernonia brachycalyx* O. Hoffm. designated here as the neotype of *Vernonia abbotiana* O. Hoffm. Thanks also to the editor, Alexander Sennikov, for many careful observations and corrections.

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# A new species of *Hibiscadelphus* Rock (Malvaceae, Hibisceae) from Maui, Hawaiian Islands

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## Abstract

*Hibiscadelphus stellatus* H. Oppenheimer, Bustamente, & Perlman, **sp. nov.**, a new, narrowly endemic species from West Maui, Hawaiian Islands is described, illustrated and its affinities and conservation status are discussed. It is currently known from three populations totaling 99 plants in Kaula valley on leeward western Maui. It differs from *H. wilderianus*, its nearest congener, in its denser white or tan stellate pubescence on most parts; larger externally purple colored corollas that are 5–6.5 cm long; linear-subulate to lanceolate, acute to acuminate involucre bracts; globose-cuboid to ovoid capsules; and endocarp with scattered hairs.

## Keywords

Malvaceae, *Hibiscadelphus*, Hawaiian Islands, Maui, conservation, IUCN Red List

## Introduction

Joseph Rock described the endemic Hawaiian genus *Hibiscadelphus* Rock in 1911 based on *H. giffardianus* Rock (Radlkoffer and Rock 1911). The genus is extremely rare, with seven previously described species from the main Hawaiian Islands, four of which are now extinct, two only persisting in cultivation (including restoration plant-

ings), and a single species remaining in its natural habitat. The genus belongs to the tribe Hibisceae (Malvaceae), and it appears to form a distinct monophyletic group based on its curved and narrowly zygomorphic corollas forming a tubular structure with the petals unequal in length (the lower two shorter than the upper three). In contrast, in *Hibiscus* the corollas are actinomorphic with spreading petals of equal length (Lorence and Wagner 1995). In most species of *Hibiscus* the calyx is not circumscissile in fruit but persists, splitting along one side.

In addition to establishing the genus, Rock described three species: *Hibiscadelphus giffardianus* Rock from Mauna Kea, *H. hualalaiensis* Rock from Hualalai, both on Hawai'i Island, and *H. wilderianus* Rock from Auwahi on the island of Maui (Rock 1913). After Rock's initial treatment, Forbes (1920) described a fourth species (*H. bombycinus* C.N. Forbes) based on a specimen collected in the mid 1800's by Hillebrand and Lydgate at Kawaihae in the Kohala Mountains of Hawai'i Island. Over the next 75 years three additional species were subsequently discovered and described: *H. distans* L.E. Bishop & D. R. Herbst on Kaua'i (Bishop and Herbst 1973); *H. crucibracteatus* Hobdy on Lana'i (Hobdy 1984), and *H. woodii* Lorence & W.L. Wagner on Kaua'i (Lorence and Wagner 1995). The last authors published a key to the seven taxa known at that time. Presently, six species are extinct in the wild, but two of these persist in cultivation (including restoration outplantings), and two others, including this new species, occur as natural populations (Table 1). The eight described species are all mostly single volcano endemics. The two Kaua'i species are separated by a distance of 8 km. *Hibiscadelphus woodii* was known from Kalalau Valley on the islands northern coast and *H. distans* is known from Koaie Stream in Waimea Canyon, whose outlet is along the southern shore

During the course of field work on west Maui in 2012 the authors discovered two populations (25 and 51 plants) over 400 m apart of a previously unknown *Hibiscadelphus* species on the steep slopes of Kaua'ula Valley on leeward, western Maui. A year later a third colony was found between the first two locations with 23 plants. *Hibiscadelphus* had not been observed, reported or documented previously on west Maui. Study of the collected specimens and comparison with collections of other known species at the BISH and PTBG herbaria, and images on JSTOR Global Plants revealed they represent an undescribed species.

**Table 1.** Current status of *Hibiscadelphus*.

	Extinct	Cultivation only	Extant in wild	USFWS status	IUCN status
<i>H. bombycinus</i>	X			Species of Concern	EX
<i>H. crucibracteatus</i>	X			Species of Concern	EX
<i>H. distans</i>			X	Endangered	CR
<i>H. giffardianus</i>		X		Endangered	CR
<i>H. hualalaiensis</i>		X		Endangered	CR
<i>H. stellatus</i>			X		EN
<i>H. wilderianus</i>	X			Species of Concern	EX
<i>H. woodii</i>	X			Endangered	CR

## Taxonomy

### *Hibiscadelphus stellatus* H. Oppenheimer, Bustamente, & Perlman, sp. nov.

urn:lsid:ipni.org:names:77140885-1

Figs 1, 2

**Note.** Differs from *H. wilderianus* in its denser pubescence especially on leaves, petioles, peduncles, involucre bracts, and corolla; linear-subulate to lanceolate involucre bracts, with acute to acuminate apices; evenly 5-lobed calyx; wider, densely pubescent, externally purple, internally yellow corolla lobes; and ovate to sub-globose capsules, 2.5–3.5 × 2.2–3.2 cm with scattered long hairs on the endocarp.

**Type. USA. HAWAIIAN ISLANDS:** West Maui, Lahaina District, Kaua`ula Valley, south slope, 841 m, 13 Feb 2014, Oppenheimer, Bustamente & Perlman H21404 (holotype: BISH; isotypes: MO, NY, PTBG, US).

**Description.** Small trees 3–6 m tall, many branched, trunks to 30 cm dbh, bark smooth, light tan to gray, young branchlets densely white to tan pubescent with 8–12-rayed stellate trichomes 0.3–0.4 mm in diam., surface scurfy-waxy, glabrescent with age; petiole scars prominent, subcircular, 2.5–4 mm in diam. Leaves chartaceous, new growth densely stellate-pubescent, mature leaves with blades broadly-ovate to sub-orbicular or subreniform in outline, occasionally shallowly 3-lobed, 7.5–16(–18) cm long, (8)9.5–13.5(–18) cm wide, veins prominulous, primary veins 7–9 radiate from base, midvein with 3–4 pairs of secondary veins arising along midrib, light green to occasionally red tinged when fresh, higher order venation prominulous on both surfaces, margins irregularly broadly crenate, base cordate, with a wide to narrow but usually open sinus, apex acute to obtuse or rounded, green when fresh with scattered tan stellate pubescence on both surfaces, densely so along veins and adaxial surface, trichomes 0.2–0.4 mm in diam. with (2–)8–16 rays, abaxial surface with principal vein axils domatiate with dense tufts of tan to white trichomes 0.2–0.3 mm long; petioles 3.5–6 cm long, green or sometimes red-tinged, pubescent with dense white to tan stellate trichomes as on branchlets; stipules lanceolate to subulate, 2–3.5 mm long, apex acute, green, sparsely to densely tan or white stellate pubescent, soon caducous. Flowers solitary, axillary, erect to spreading, pedicels 22–30 mm long, green or sometimes red-tinged, densely white to tan stellate pubescent as in petioles, involucre bracts 5–6 (–7), linear-subulate to lanceolate (rarely spatulate), acute to acuminate apically, connate only at base, 9–22 mm long, 1–2 mm wide at base, erect, appressed or spreading perpendicular to the floral axis in anthesis, green, densely tan or white stellate pubescent with trichomes 0.2–0.3 mm in diam. Calyx tubular-saccate, mostly 5-lobed, tube 22–30 mm long, 19–20 mm wide, the lobes triangular, acute to short acuminate 5–10 mm long, 7–8 mm wide, green, surface obscured by dense tan stellate pubescence as in bracts, in mature fruit splitting along one side but persistent. Corolla zygomorphic, adaxially curved, 5–6.5 cm long, lobed nearly to base, lobes coalescent, 6–6.5 cm long, 3.5–4 cm wide, obovate-spatulate, apex obtuse, tips and outer margins slightly reflexing with age, outer exposed portion purple, purple-green or purple-yellow, inner



**Figure 1.** *Hibiscadelphus stellatus*. **A** Habit **B** Flowers and leaves (from the holotype) **C** View of bracts illustrating stellate arrangement **D** Close-up of flower. (from the holotype). All photos by the authors.

concealed portion yellow, conspicuously veined, densely covered with gray or tan stellate trichomes especially along veins, internally yellow or purple-tinged distally, purple toward base, corolla usually becoming purplish with age, staminal column and apex of the style exerted for 1.5–2.5 cm; staminal column 8–8.5 cm long, antheriferous in distal 3.5 cm, maroon-purple, antheriferous in distal 3.5 cm, stamens c. 100, anthers reniform-curved, 0.8–1.5 mm long, purple, filaments 6–12 mm long, purple, pollen grains purple turning golden yellow after anther dehiscence; style 8.5–9 cm long, style branches 3–5 mm long, villose, stigmas rounded, c. 1 mm long, yellow, ovary dome-shaped, 8 mm long and wide. Fruit a woody capsule, globose-cuboid to -ovoid,

5-locular, 5-valved, 2.5–3.5 (–4) cm long, 2.2–3.3 cm in diameter, surface yellowish brown, rough densely covered with dense tan stellate hair clusters, appearing tuberculate, mericarps 10, mesocarp well developed, reticulate, endocarp chartaceous, loose, with scattered long hairs, testa brown. Seeds 1–2 per mericarp, reniform, 8–10 mm long, 6–8 mm wide including the dense, lanate yellowish-tan hairs 0.4–1 mm long.

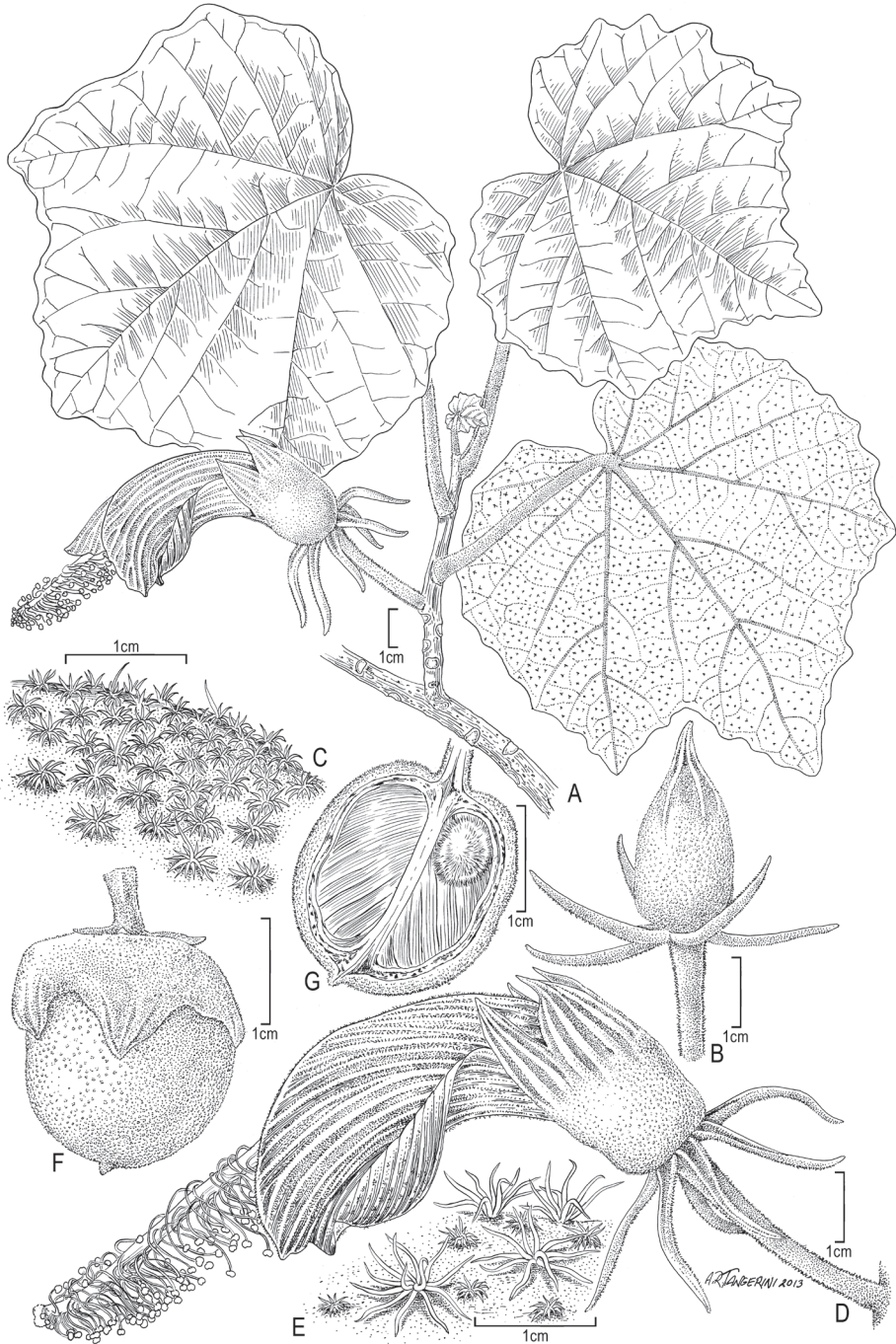
**Distribution.** Known only from west Maui, Hawaiian Islands at 20.87°N, 156.62° (Fig. 3).

**Habitat and ecology.** *Hibiscadelphus stellatus* occurs on very steep, rocky slopes between 800 and 900 m elevation. These sites have a windward aspect and are situated mid-slope between the upper rim of a deep valley and a perennial stream below. Soils at these sites are of typical volcanic, basalt origin, from the Wailuku Series of original shield building flows. The vegetation where *H. stellatus* grows forms a mosaic of trees and shrublands with an open canopy, best characterized as Lowland Mesic Forest (Wagner et al. 1999). Rainfall averages from 12 to 1400 mm annually and the substrate is well-drained.

Associated tree species include: *Alectryon macrococcus* Radlk., *Antidesma pulvinatum* Hillebr., *Coprosma foliosa* A. Gray, *Diospyros sandwicensis* (A. DC) Fosberg, *Dodonaea viscosa* Jacq., *Metrosideros polymorpha* Gaudich. var. *glaberrima* (H. Lév.) H. St. John, *Myoporum sandwicense* A. Gray, *Myrsine lanaiensis* Hillebr., *M. lessertiana* A. DC., *Nestegis sandwicensis* (A. Gray) O. Deg, I. Deg, & L.A.S. Johnson, *Pisonia sandwicensis* Hillebr., *Pittosporum confertiflorum* A. Gray, *Pouteria sandwicensis* (A. Gray) Baehni & O. Deg., *Psychotria kaduana* (Cham. & Schltld.) Fosberg, *Psydrax odorata* (G. Forst.) A.C. Smith & S.P. Darwin, *Santalum ellipticum* Gaudich., *Sophora chrysophylla* (Salisb.) Seem., *Streblus pendulinus* (Endl.) F. Muell., *Zanthoxylum dipetalum* H. Mann, and *Z. hawaiiense* Hillebr. Understory species include: *Achyranthes splendens* Mart. ex Moq., *Bidens micrantha* Gaudich., *Charpentiera ovata* Gaudich., *Euphorbia multiformis* Gaudich. ex Hook. & Arn., *Osteomeles anthyllidifolia* (Sm.) Lindl., *Pipturus albidus* (Hook. & Arn.) A. Gray, *Pleomele auwahiensis* H. St. John, *Remya mauiensis* Hillebr., *Urera glabra* (Hook. & Arn.) Wedd., and *Wikstroemia oahuensis* (A. Gray) Rock. Ferns are locally common in the understory and include: *Asplenium nidus* L., *Doodia kunthiana* Gaudich., *Dryopteris sandwicensis* (Hook. & Arn.) C. Chr., *Lepisorus thunbergianus* (Kaulf.) Ching, and *Microlepia strigosa* (Thunb.) C. Presl. Vines are represented by *Alyxia stellata* (J.R. Forst. & G. Forst.) Roem. & Schult., *Ipomoea tuboides* O. Deg. & Ooststr., *Lipochaeta connata* (Gaudich.) DC, *Sicyos pachycarpus* Hook. & Arn., and *Smilax melastomifolia* Sm. Grasses and sedges are sparse and include: *Eragrostis variabilis* (Gaudich.) Steud., *Panicum nephelophilum* Gaudich., *Trisetum inaequale* Whitney, *Carex meyenii* Nees, and *C. wahuensis* C.A. Mey.

**Phenology.** *Hibiscadelphus stellatus* has been observed with buds, flowers and immature and mature fruit capsules in February and April. Flowers open mid-day and produce abundant nectar.

**Etymology.** *Stellatus* – Latin, star shaped, alluding to the stellate pubescence that characterizes the Malvaceae in general, including *Hibiscadelphus*. The name also refers to the “star-shaped” pattern formed by the five involucre bracts, which contrasts with



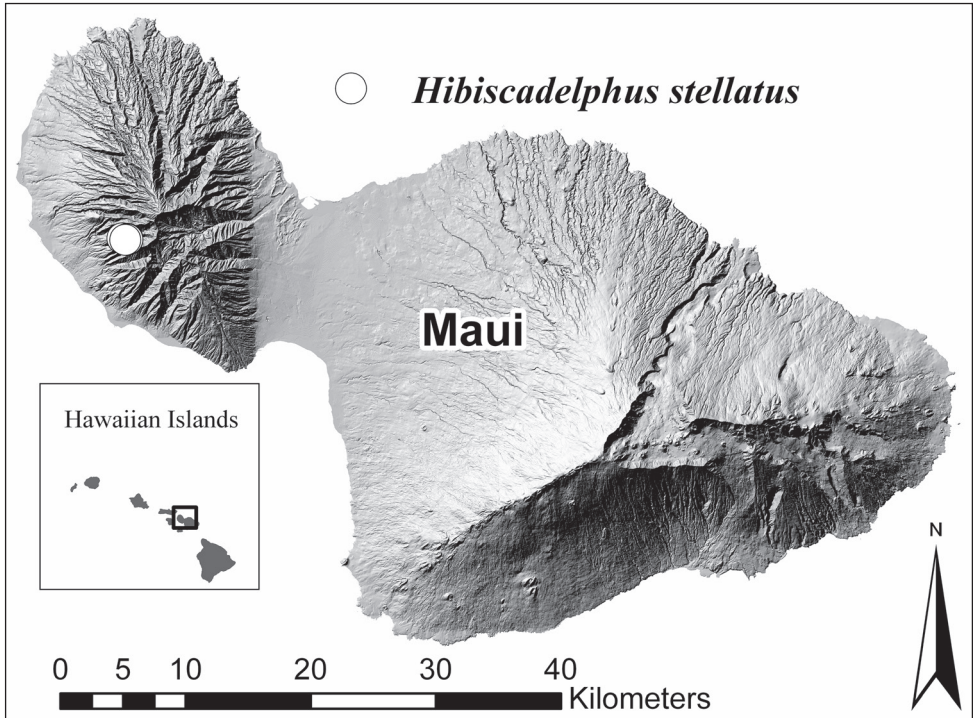
**Figure 2.** *Hibiscadelphus stellatus* H. Oppenh., Bustamente, & Perlman. **A** Habit **B** Flower bud **C** Surface of calyx showing stellate hairs **D** Flower **E** Surface of corolla showing two sizes of stellate hairs **F** Fruit **G** Longitudinal section of fruit showing seed. Drawn from Oppenheimer et al. H41337 (US) and field photographs by the authors.

the cruciform pattern formed by the four bracts in *H. crucibracteatus*. Additionally, *stellatus* acknowledges the beautiful and stellar (outstanding) flowers of this species. The Hawaiian name *hau kuahiwi* has been applied to other species of the genus (Rock 1913). *Hau* (*Hibiscus tiliaceus* L.), a lowland tree; *kuahiwi*—*lit.* mountain or high hill (Pukui and Elbert 1986). Hawaiians recognized the similarities of the taxa while observing that *Hibiscadelphus* grows at higher elevations.

**Conservation efforts.** The conservation status of *Hibiscadelphus* is precarious at best. Three species (*H. crucibracteatus*, *H. giffardianus*, and *H. wilderianus*) were each only known from a single naturally occurring tree (Hobdy 1984; Rock 1913). However, *H. giffardianus* survives in cultivation and is planted within the type locality at Kipuka Puauulu in what is now Hawai'i Volcanoes National Park. Hillebrand provided no information on the abundance or scarcity of *H. bombycinus* when he first collected it but the species is presumed extinct. *Hibiscadelphus crucibracteatus* is presumed extinct in the wild since the single known tree died a few years after its discovery from damage by introduced axis deer (*Axis axis*) despite it being fenced; there is no ex situ material although there were several attempts at propagation (R. Hobdy, pers. comm.). *Hibiscadelphus woodii* was known from four individuals, but evidently has recently gone extinct (Wood 2012). There are no plants in cultivation despite attempts to propagate it. *Hibiscadelphus hualalaiensis* is considered extinct in the wild as of 1992 but is in cultivation. *Hibiscadelphus wilderianus* is also presumed extinct. Although Rock mentioned that Wilder (who discovered the species with Rock, later returning and making several additional collections from the only known tree) had succeeded in raising a single seedling (Rock 1913) no surviving material is known. *Hibiscadelphus distans* is known from two wild populations of approximately 15–20 individuals total on Kaua'i, and over 100 ex situ collections at the McBryde and Limahuli gardens of the National Tropical Botanical Garden (NTBG). With 99 known plants, *H. stellatus* has the largest known wild populations plus the only known naturally occurring seedlings of any species in the genus.

Seeds were collected from 12 individuals of *H. stellatus* representing the three known subpopulations. The subpopulations were mapped with GPS and each individual plant numbered and tagged. Cuttings from three plants were also made although these failed to take root. Material is being propagated at the Olinda Rare Plant Facility on Maui, NTBG on Kaua'i and the Lyon Arboretum on O'ahu. The first seeds germinated in conventional propagation approximately 50 days after sowing and under three weeks in tissue culture. As of May 2013 four parent trees from two sites are represented ex situ, with seeds from four additional trees in the third site now in propagation at Olinda and Lyon.

Threats to the existence of *Hibiscadelphus stellatus* include habitat erosion, fire, weeds, drought, probably rats (*Rattus rattus*, *R. exulans*) (Baker and Allen 1978) and mice, (*Mus domesticus*), slugs such as *Derocerus* and *Limax* or other invertebrates such as seed weevils (Giffard 1920) and caterpillars (Lorence and Wagner 1995), and potentially feral goats (*Capra hircus*) and/or pigs (*Sus scrofa*). Small populations of feral goats and pigs are encroaching in surrounding areas, although the West Maui Moun-



**Figure 3.** Distribution map showing known locations of *Hibiscadelphus stellatus* on West Maui.

tains Watershed Partnership is constructing strategic fencing. In 2007 a large wild fire burned within 180 m of the plants; succession of its habitat presently includes non-native fire-adapted grasses that were absent before the fire. Erosion is a natural process but is exacerbated by invasion by weeds and ungulates and the destruction of vegetation by fire. Woody non-native plants are currently low in diversity and number, but are represented by known aggressive, habitat – modifying species such as *Grevillea robusta* A. Cunn. ex R. Br., *Lantana camara* L., *Psidium guajava* L., and *Schinus terebinthifolius* Raddi. Herbaceous understory weeds are similarly low in number of taxa but include serious habitat modifiers such as *Adiantum hispidulum* Sw., *Ageratina adenophora* (Spreng.) R.M. King & H. Rob., *A. riparia* (Regel) R.M. King & H. Rob., *Buddleia asiatica* Lour., *Erigeron karvinskianus* DC., and *Oplismenus hirtellus* (L.) P. Beauv., all of which may hinder establishment of seedlings.

**Conservation status.** When evaluated using the IUCN Red List criteria (IUCN 2013) *Hibiscadelphus stellatus* falls into the Endangered (EN) category, a designation for taxa facing a very high risk for extinction in the wild. The species merits this designation by meeting the following criteria: B2(a)(biii, v) + D, where the area of occupancy (AOO) is less than 500km<sup>2</sup> (B2), with severely fragmented or number of locations <5 (a), and a continuing decline observed, estimated, inferred or projected in (biii) quality of habitat and (bv) number of mature individuals; and D: <250 mature individuals. Although there is some reproduction observed, there is not a sufficient



population structure that will allow enough immature plants to replace mature individuals as they perish, therefore a decline is almost a certainty under current conditions. The AOO is 2.28 hectares (5.63 acres) much less than the threshold. The habitat is inferred to be in decline due to the effects of introduced taxa such as invasive plants and rats, as well as the effects of introduced rats and diseases on pollinators. Continued monitoring over the next five years will possibly lead to an updated assessment to CR. Furthermore we recommend that the U.S. Fish & Wildlife Service list this new species as Endangered under the Endangered Species Act of 1973 and that the Service prepare and fund a recovery plan.

**Specimens examined. USA.** Hawaiian Islands: Maui: west Maui, Lahaina District, Kaua`ula Valley, south side slope, 807 m, 17 Apr 2012, *Oppenheimer et al. H41214* (BISH), 841 m, 24 Apr 2013, *Oppenheimer et al. H41337* (US), 13 Feb 2014, *Oppenheimer et al. H21403* (BISH), *H21406* (BISH), *H21407* (BISH), 820 m, *Perlman, et al. 23853* (PTBG); Kaua`ula valley, below Helu, 817 m, 17 Apr 2012, *Perlman et al. 22834* (PTBG, 2 sheets), Kaua`ula valley, south slope below Helu summit, 817 m, 18 Apr 2012, *Perlman et al. 22837* (PTBG).

**Discussion.** This new species clearly belongs to *Hibiscadelphus* based on its flowers that have their corolla lobes coalescent into a curved, tubular zygomorphic structure. *Hibiscadelphus stellatus* differs from its congeners in the following combination of characters: moderate to dense stellate pubescence on all parts; involucre bracts 5 (–7) in number that are linear-subulate to lanceolate, 9–22 mm long, and acute to acuminate apically; 5-lobed calyx with tube 22–25 mm long and lobes 5–8 mm x 7–8 mm; externally purplish-colored corolla 5–6.5 cm long; and globose-cuboid to ovoid capsules with scattered hairs on the endocarp. The species of *Hibiscadelphus* can be separated by the following key.

### Key to the species of *Hibiscadelphus*

- 1a Involucre bracts connate ca. ½ of their length; mesocarp weakly developed and usually adnate to the exocarp; endocarp segments 5 ..... *H. distans*
- 1b Involucre bracts free or slightly connate at base; reticulate mesocarp strongly developed; endocarp segments 10 ..... **2**
- 2a Involucre bracts filiform or obsolete; up to 1.1 mm wide toward base..... **3**
- 2b Involucre bracts linear-subulate to spatulate, 1–7 mm wide toward base ... **4**
- 3a Involucre bracts 0.5–2(–3) mm long; corolla greenish yellow externally, fading to purplish internally, 2–5(–5.5) cm long; Hualalai, Hawai`i.....  
..... *H. hualalaiensis*
- 3b Involucre bracts 18–35 mm long; corolla grayish green externally, dark magenta internally, (5–)6–7 cm long; Mauna Loa, Hawai`i..... *H. giffardianus*
- 4a Involucre bracts mostly 4(–5), (20–)23–27(–30) mm long.....  
..... *H. crucibracteatus*
- 4b Involucre bracts 5–7, 9–22 mm long. .... **5**

- 5a Leaf lamina glabrate on both surfaces or with minute, scattered stellate trichomes only on principal veins, the trichomes sparsely tufted in principal vein axils; Kalalau Valley, Kaua`i ..... *H. woodii*
- 5b Leaf lamina sparsely stellate pubescent adaxially, sparsely to densely stellate pubescent abaxially; Maui, Hawai`i ..... **6**
- 6a Calyx ca. 1.2 cm long; Kohala Mts., Hawai`i ..... *H. bombycinus*
- 6b Calyx 2.2–2.5 cm long; Maui ..... **7**
- 7a Plants mostly sparsely pubescent; bracts linear to ligulate or spatulate, apex obtuse to rounded; capsulae ovoid; Auwahi, East Maui ..... *H. wilderianus*
- 7b Plants mostly densely pubescent; bracts linear-subulate to lanceolate, apex acute to acuminate, capsulae globose-cuboid to ovoid; Kaua`ula, West Maui ...  
..... *H. stellatus*

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The authors extend our deepest gratitude to Makila Land Co. and the Maui District of the Hawai`i Division of Forestry and Wildlife for permission to access the study area; the West Maui Mountains Watershed Partnership for logistical support; Windward Aviation, Inc. for their skilled helicopter pilots; Anna Palomino at the Olinda Rare Plant Facility on Maui, Ashley Trask at the National Tropical Botanical Garden (NTBG) on Kaua`i, and Nellie Sugii, Tim Kroessig, and Doug Okamoto at the Lyon Arboretum, O`ahu for the processing, propagation and storage of seeds. Bob Hobdy (DOFAW) and David Lorence (NTBG) provided useful discussions and insights, as well as reviews of earlier drafts. The staff at BISH was extremely helpful, especially Barbara Kennedy for providing high-resolution scans of many specimens in their herbarium, and we appreciate the access to type specimens; thanks also are extended to Tim Flynn (PTBG) and Warren L. Wagner (US). This manuscript was greatly improved with reviews by Lorence and Wagner, as well as an anonymous reviewer. We sincerely appreciate the beautiful illustration by Alice Tangerini (US). The Plant Extinction Prevention Program is funded in part by the U.S. Fish & Wildlife Service and the State of Hawaii Dept. of Land & Natural Resources, Division of Forestry and Wildlife.

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# *Melicope balgooyi* Appelhans, W.L. Wagner & K.R. Wood, a new species and new record in *Melicope* section *Melicope* (Rutaceae) for the Austral Islands

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## Abstract

*Melicope balgooyi*, a new species of *Melicope* (Rutaceae) is described. It is known only from the Austral Islands in the South Pacific (French Polynesia). However, it is not closely related to the other two species previously known from the Austral Islands, which are part of *Melicope* section *Vitiflorae*. The new species belongs to *Melicope* section *Melicope* and is most closely related to species from New Zealand, the Kermadec Islands, and the Society Islands. The new species has alternate to sub-opposite leaves, which is a very rare arrangement in *Melicope* and has only been described for two other species of the genus so far.

## Keywords

Austral Islands, Bass Islands, *Melicope*, French Polynesia, Pacific biogeography, Rapa Iti, Rutaceae, IUCN Red List Category

## Introduction

In the course of phylogenetic and revisionary studies in *Melicope* J.R. Forst. & G. Forst., a new species was found, and along with its description, we discuss its biogeography and sectional placement. *Melicope* is the largest genus in Rutaceae, consisting of

about 235 species divided into the four sections *Lepta* (Lour.) T.G. Hartley, *Melicope*, *Pelea* (A. Gray) Hook. f., and *Vitiflorae* T.G. Hartley (Hartley 2001). Molecular phylogenetic work (Appelhans et al. 2014a) supported Hartley's (Hartley 1981, Hartley and Stone 1989, Hartley 2001) revisionary work in many ways, however, some of the taxa that were described at the genus level, namely *Comptonella* Baker f., *Dutaillyea* Baill., *Picrella* Baill., *Platydesma* H. Mann, and *Sarcomelicope* Engl., have been shown to belong in *Melicope* (Harbaugh et al. 2009, Appelhans et al. 2014a, 2014b). Also, *Melicope* section *Melicope* has been inferred as non-monophyletic (Appelhans et al. 2014a; Fig. 1). *Melicope* section *Melicope* sensu Hartley (2001) consists of 38 species with a distribution that ranges from India to the Society Islands in the South Pacific (Fig. 2). The section occurs on several Pacific island groups among which are the Bismarck Archipelago, the Salomon Islands, Vanuatu, Fiji, the Society Islands, Lord Howe Island, the Kermadec Islands, and New Zealand. Appelhans et al. (2014a) have found that species in section *Melicope* from Australia, New Guinea, and Borneo do not cluster together with the clade that contains the type species *M. ternata* J.R. Forst. & G. Forst. from New Zealand (Fig. 1). Instead, the species from Australia, New Guinea, and Borneo are the closest relatives of *Melicope* section *Pelea* (Appelhans et al. 2014a; Fig. 1). The few species from India, the Malay Peninsula, and Hainan Island (China) were not sampled by Appelhans et al. (2014a), but Hartley (2001) regarded these species as close relatives of the Bornean species. Species from the Bismarck Archipelago, the Salomon Islands, Vanuatu, and Fiji were also not sampled in the study of Appelhans et al. (2014a). Hartley (2001) regarded these species as a closely related group with affinities to species from New Guinea. According to the phylogenetic study by Appelhans et al. (2014a) and the relationships that can be inferred from Hartley's (2001) revisionary work, the abovementioned taxa have to be excluded from *Melicope* section *Melicope*. A monophyletic section *Melicope* consists only of two species from New Zealand (*M. mantellii* Buchanan, *M. simplex* A. Cunn.), one species from New Zealand and the Kermadec Islands (*M. ternata*), two species from Tahiti (Society Islands; *M. lucida* (A. Gray) A.C. Sm., *M. tahitiensis* Nadeaud), and the new species described here. All except one of these species were sampled by Appelhans et al. (2014a) and they formed a clade together with two specimens of an undescribed species from Rapa (Rapa Iti, Austral Islands; French Polynesia). *Melicope* section *Melicope* is thus reduced from 38 to six species (Figs 1 and 2).

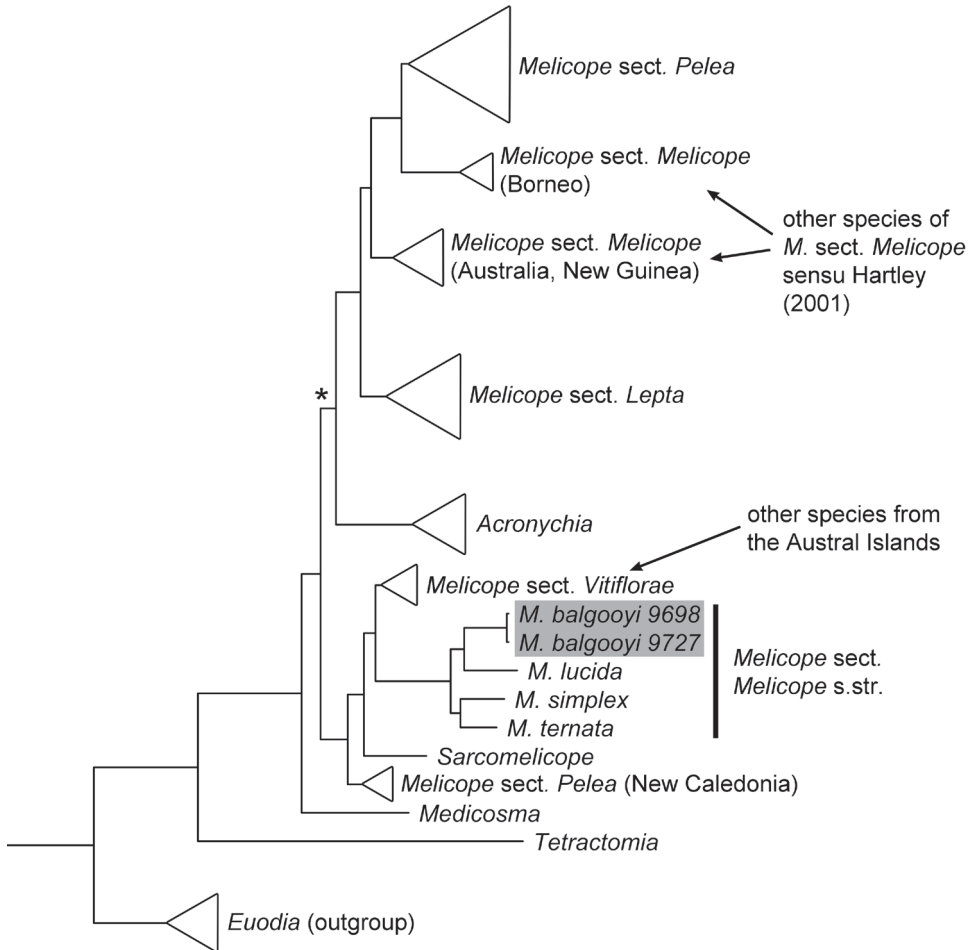
## Taxonomic treatment

### *Melicope balgooyi* Appelhans, W.L. Wagner & K.R. Wood, sp. nov.

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Figs 3, 4a

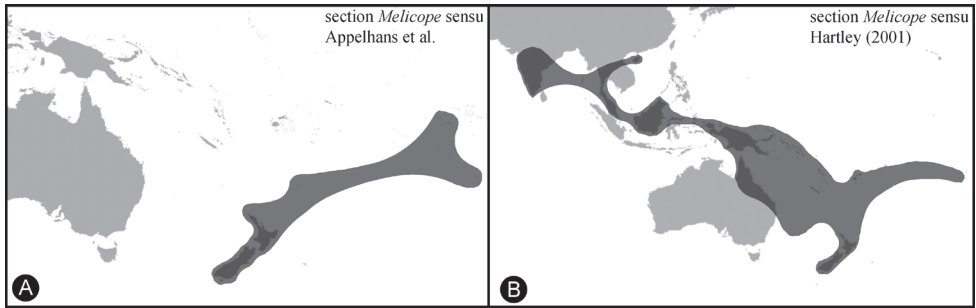
**Type.** AUSTRAL ISLANDS: Rapa Iti, Maii, below rim near Pokumarū, 29 Apr 2002, K.R. Wood 9727 (holotype: PTBG-041326!, isotype: NY!).



**Figure 1.** Phylogenetic placement of the newly described *Melicope balgooyi* Appelhans, W.L. Wagner & K.R. Wood is based on an analysis of combined chloroplast and nuclear data (redrawn from Appelhans et al. 2014a). The clade marked with an asterisk (\*) was not supported so that the placement of *Acronychia* J.R. Forst. & G. Forst. within or apart from *Melicope* is not certain.

This new species of *Melicope* differs from other species in that genus by the combination of alternate to sub-opposite leaves and oblanceolate leaves with a cordate base.

**Description.** *Shrub* 50 to 150 cm of height; plants possibly dioecious; trichomes simple, greyish-white; branches brown-red and glabrous, 2–3 mm wide at third internode. *Leaves* with glandular dots, alternate to sub-opposite, unifoliolate, glossy dark green above with yellow or green-white midrib, 4.5–9 × 2.3–3.8 cm, petiole 0–1 mm long, terete, glabrous; blades sub-coriaceous, glabrous on both sides, obovate to oblanceolate, margin entire, apex rounded or obtuse, base cordate; venation brochidodromous, midrib prominulous or plane on both surfaces, secondary veins and veinlet reticulation prominulous, 10–17 secondary veins per side. *Inflorescences*



**Figure 2.** Distribution of *Melicope* section *Melicope*. **A** *Melicope* section *Melicope* sensu Appelhans et al. (2014a), consisting of six species including the newly circumscribed *Melicope balgooyi* from Rapa **B** *Melicope* section *Melicope* sensu Hartley (2001) consisting of 38 species.

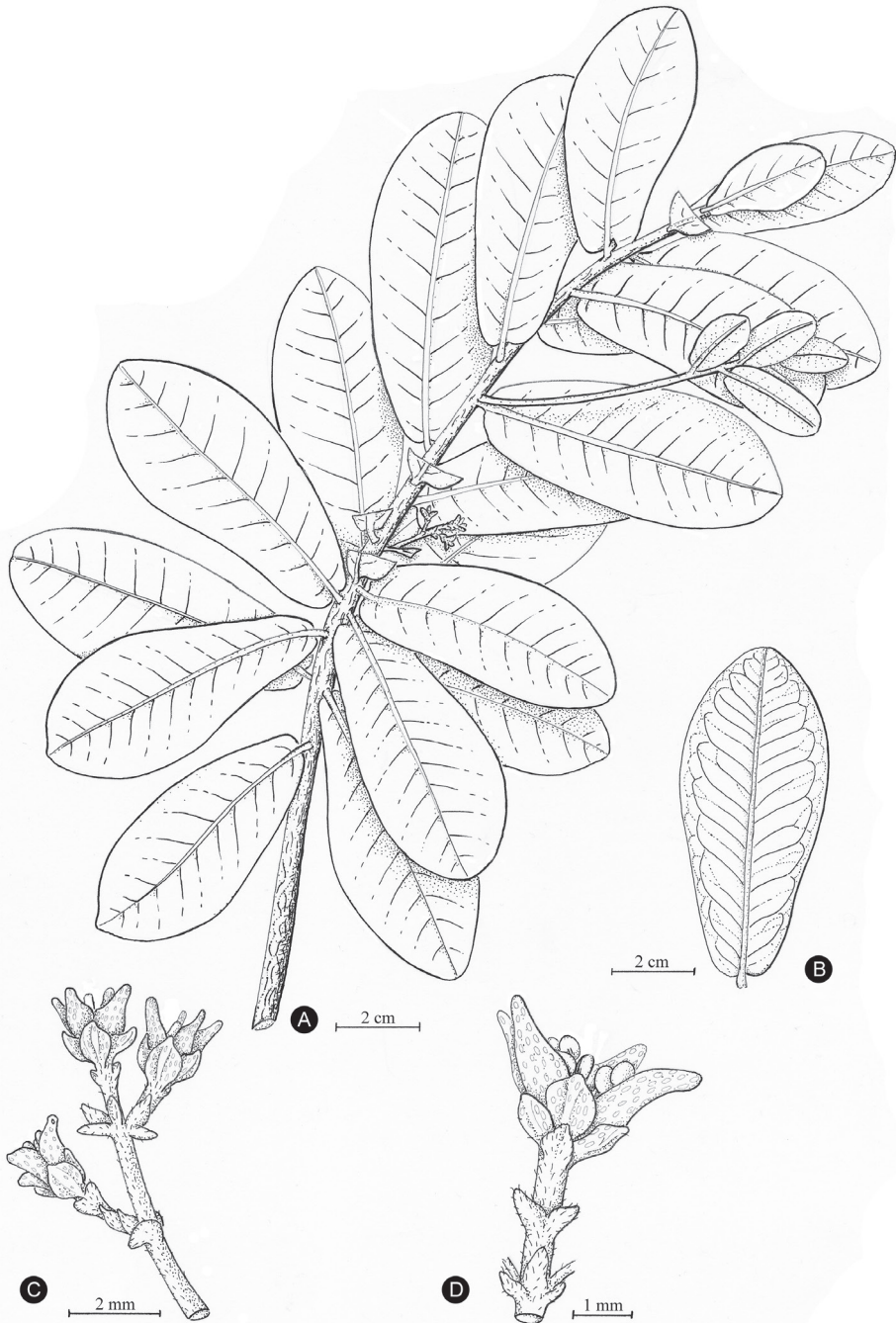
unisexual, axillary, bracteate, several-flowered, up to 1.8 cm long, axes and bracts puberulent. *Flowers* unisexual, tetramerous; pedicel 1.3 to 2.2 mm long; sepals ovate to rounded, pellucid-dotted, glabrous or slightly ciliate, 1.2 to 1.5 mm long, same size in staminate and pistillate flowers; petals ovate to elliptic, cream-green, pellucid-dotted, glabrous, 2.5 to 2.8 mm long, same size in staminate and pistillate flowers; stamens 8, glabrous; gynoecium 4-carpellate, glabrous, pellucid-dotted, 2 mm long, stigma peltate, young stigma white. *Fruiting* carpels and seeds not known.

**Additional specimens (paratypes). Austral Islands. Rapa:** Pokumaru summit region, upper windswept slopes of Maii, 21 Apr 2002, K.R. Wood 9698 (PTBG!, NY!).

**Distribution and ecology.** Austral Islands (French Polynesia), only known from the type locality on slopes near the summit of Mount Pokumaru on Rapa; 550–580 m.

*Melicope balgooyi* was discovered around the tall spire-like peak of Pokumaru (Fig. 4b) between 550 and 580 m. The habitat is characterized by a windswept shrubland and forest that runs along and below an east to west ridgeline. The plant communities around Pokumaru are unique with small relictual patches of tropical montane cloud forest (TMCF) along with adjacent wet cliffs and steep slopes dominated by *Freycinetia arborea* Gaudich. Tree species in the TMCF zone which are associated with *M. balgooyi* include *Fitchia rapense* F. Br., *Meryta choristantha* Harms, *Oparanthus coriaceus* (F. Br.) Sherff, *Carokia collenettei* Riley, *Metrosideros collina* (J.R. Forst. & G. Forst.) A. Gray, *Geniostoma rapense* F. Br., and *Weinmannia rapensis* F. Br. Shrubs, vines, and herbs include *Dianella intermedia* Endl. var. *punctata* F. Br., *Astelia rapensis* Skottsbo., *Plantago rupicola* Pilg., *Alyxia stellata* (J.R. Forst. & G. Forst.) Roem. & Schult., *Freycinetia arborea*, and *Hebe rapensis* (F. Br.) Garnock-Jones. Dominant ferns include *Sphaeropteris medullaris* (G. Forst.) Bernh., *Alsophila stokesii* (E.D. Br.) R.M. Tryon, *Blechnum attenuatum* (Sw.) Mett., *Blechnum orientale* L., *Blechnum venosum* Copel., *Blechnum vulcanicum* (Blume) Kuhn var. *rapense* E.D. Br., *Polystichum rapense* E.D. Br., *Dicranopteris linearis* (Burm. f.) Underw., *Belvisia dura* (Copel.) Copel., *Doodia media* R. Br., *Elaphoglossum savaiense* (Baker) Diels, and *Davallia solida* (G. Forst.) Sw. Less than 20 individuals of *M. balgooyi* are estimated to occur around this only known site.





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**Figure 3.** The newly described *Melicope balgooyi* Appelhans, W.L. Wagner & K.R. Wood. **A** Flowering branch **B** Leaf with detailed venation **C** Pistillate inflorescence [peduncle not shown in full length] **D** Single staminate flower. Based on K.R. Wood 9727 (PTBG, A–C) and K.R. Wood 9698 (PTBG, D).



**Figure 4.** **A** Habit of *Melicope balgooyi* Appelhans, W.L. Wagner & K.R. Wood in situ **B** Habitat of *M. balgooyi* around the steep precipitous slopes of Pokumaru, Rapa, Austral Islands.

**Etymology.** The species is named in honor of Dr. Max M.J. van Balgooy, a specialist of the SE Asian flora. Dr. van Balgooy has annotated the herbarium sheets of this new species stating that it is an “unusual Rutaceae near *Platydesma*”. Phylogenetic studies (Harbaugh et al. 2009; Appelhans et al. 2014a, 2014b) have shown that *Platydesma* is included within *Melicope*, proving Dr. van Balgooy’s assumptions to be true. In addition to *M. maxii* T.G. Hartley, which is endemic to Sulawesi (Indonesia), *M. balgooyi* is the second species of *Melicope* named after Dr. van Balgooy.

## Discussion

### Characteristics of the new species and its sectional placement in *Melicope*

The new species from Rapa differs from most *Melicope* species by its alternate to sub-opposite phyllotaxis. While most *Melicope* species are typically opposite-leaved, some species from all sections except *Vitiflorae* can have whorled leaves. This character state is most common on the Hawaiian Islands, where eight of the 52 species (incl. four species of *Platydesma*; Wagner et al. 1990) can have whorled leaves with mainly three to four leaves per node (up to eight leaves per node in *M. clusiifolia* (A.Gray) T.G.Hartley & B.C.Stone). Only two *Melicope* species are reported to have

sub-opposite or alternate leaves. The New Caledonian *M. lasioneura* (Baill.) Baill. ex Guillaumin usually has opposite leaves, but can have leaves in whorls of three or an alternate phyllotaxis. *Melicope rubra* (Lauterb. & K. Schum.) T.G. Hartley from New Guinea and northeastern Australia has opposite or rarely sub-opposite leaves. The alternate to sub-opposite leaves of the new taxon from Rapa therefore represent a rare condition in *Melicope*.

The placement of the new taxon in *Melicope* is assured by molecular phylogenetic data (Appelhans et al., 2014a), which places it close to the type *M. ternata* in *Melicope* section *Melicope* (Fig. 1).

Two other species of *Melicope* [*M. bracteata* (Nadeaud) S.L. Welsh and *M. margaretae* (F. Br.) T.G. Hartley] have been described previously from the Austral Islands, but they are both members of *Melicope* section *Vitiflorae* (Fig. 1). Among other features, the new species differs most distinctly from *M. bracteata* and *M. margaretae* in stamen number (8) and oblanceolate leaves with a cordate base. *Melicope bracteata* and *M. margaretae* each have 4 stamens and usually elliptic leaves with a rounded or acute base.

The new taxon is connected to its closest relatives within *Melicope* section *Melicope* by its 8 stamens. Morphologically, and also phylogenetically, the new taxon mostly resembles the Tahitian *M. lucida* and *M. tahitiensis*. The often auriculate leaf base of many specimens of *M. lucida* and *M. tahitiensis* is similar to the cordate leaf base of the new taxon. The leaf shape among the three taxa is also similar; however, *M. lucida* and *M. tahitiensis* have acuminate to acute apices as opposed to a rounded or slightly obtuse apex in the new taxon. Leaves of *M. lucida* and *M. tahitiensis* are petiolate, while those of the new taxon are sessile or subsessile. The new species further shares unisexual flowers and peltate stigmas with *M. lucida* and *M. tahitiensis*. The holotype specimen has pistillate flowers, while the paratype has staminate flowers, indicating the species may be dioecious like its closest relatives *M. lucida* and *M. tahitiensis*. However, it is important to note that the description of the new taxon is based on only two collections with a very low number of flowers, so that a definite statement about the sexual system of the species is not possible with the data at hand.

In order to differentiate between *Melicope* and several of its closely related genera on a morphological basis, fruit and seed characters are needed (Hartley 2001, Kubitzki et al. 2011). With fruits lacking on the only known specimens of the new taxon, its position is not absolutely confirmed from a morphological point of view. Consistent with the phylogenetic evidence, further support for the placement of the new taxon in *Melicope* is supported by its distribution. Out of the genera that resemble the flowering and vegetative characters of *Melicope*, most taxa are distributed in Australasia and Malesia (Kubitzki et al. 2011). Only the distribution of *Euodia* J.R. Forst. & G. Forst. reaches deep into the Pacific so that one could expect to find *Euodia* on the Austral Islands. However, the New Caledonian endemic *E. tietaensis* (Guillaumin) T.G. Hartley is the only *Euodia* species with eight stamens (like the new species) and all species that occur further eastward in the Pacific have four stamens (Hartley 2001).

## Geology and biogeography

The Austral Islands are part of French Polynesia and are situated in the Southern Pacific. The Archipelago lies south of the Society Islands and consists of seven main islands of volcanic origin. Rapa is the second largest of these islands (i.e. 40 km<sup>2</sup>) and is about 5 million years old. The island is very rugged and is characterized by its steep central ridges, mist shrouded spires, and towering black basalt sea-cliffs. The highest peak is Mont Perau at about 650 m (Gates Clarke 1971, Clouard and Bonneville 2005, Meyer 2010).

The affinities of Rapa's flora are closely allied to New Zealand and Australia, yet with numerous exceptions. The high levels of endemic biological diversity in both the flora and fauna still puzzle many scientists because of the islands relatively small square area (Wood 2002). Concerning Rapa's floristic relationships, van Balgooy (1971) stated "I think it best to place Rapa in the SE Polynesian Province, as an anomalous district". More than 75 plant taxa are single island endemics to Rapa, including three endemic plant genera, namely *Apostates* N. S. Lander (Asteraceae) *Pacifigeron* Nesom (Asteraceae) and *Metatrophis* F. Br. (Urticaceae) (Wood 2002, 2010).

Three species of *Melicope* occur on the Austral Islands, which are the result of two independent colonization events. The newly described species is part of section *Melicope* and its closest relatives stem from Tahiti, the Kermadec Islands, and New Zealand. The two other species, *M. bracteata* and *M. margaretae*, are part of section *Vitiflorae* with an origin probably in the area of New Caledonia, Vanuatu, and Fiji based on the distributions of their closest relatives (Hartley 2001, Appelhans et al. 2014a). The new species described here is a new record within section *Melicope* for the Austral Islands and an updated distribution map for the newly revised section is provided in Fig. 2.

## Conservation status

*IUCN Red List Category.* When evaluated using the World Conservation Union (IUCN) criteria for endangerment (IUCN, 2001), *Melicope balgooyi* falls into the Critically Endangered (CR) category, which designates this species as facing the highest risk of extinction in the wild. Our evaluation can be summarized by the following IUCN hierarchical alphanumeric numbering system of criteria and subcriteria: B1ab(v); B2a, B2b(i–iii); D. These criteria are defined as: B1, extent of occurrence less than 100 km<sup>2</sup>; B1a, known to exist at only a single location; B1b(v) continuing decline inferred in number of mature individuals; B2, total area of occupancy less than 10 km<sup>2</sup>; B2a, one population known; B2b(i–iii), habitat continuing decline inferred; D, population estimated to number fewer than 50 individuals. Threats to *M. balgooyi* include habitat degradation and destruction by feral goats (*Capra hircus* L.), competition with non-native plant taxa especially *Psidium cattleianum* Sabine, possible landslides and fire, and the potential for inbreeding depression from small population.

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