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

Daniel B. Montesinos Tubée

1 Nature Conservation & Plant Ecology Group, Wageningen University, Netherlands. Droevendaalsesteeg 3a, 6708PB Wageningen, The Netherlands 2 Naturalis Biodiversity Centre, Botany Section, National Herbarium of The Netherlands, Herbarium Vadense. Darwinweg 2, 2333 CR Leiden, The Netherlands 3 Instituto Científico Michael Owen Dillon, Av. Jorge Chávez 610, Cercado, Arequipa, Perú

Corresponding author: Daniel B. Montesinos Tubée (dbmtperu@gmail.com; daniel.montesinos@wur.nl)

Academic editor: A. Sennikov

Received 8 April 2014 | Accepted 3 June 2014 | Published 19 June 2014

Citation: Montesinos Tubée DB (2014) Three new caespitose species of Senecio (Asteraceae, Senecioneae) from South Peru. PhytoKeys 39: 1–17. doi: 10.3897/phytokeys.39.7668

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 pucapampaensis 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 pucapampaensis Beltrán, Senecio sykorae Montesinos, sp. nov. (En Peligro Crítico) el cual se asemeja más Senecio gamolepis Cabrera, y Senecio tassaensis Montesinos, sp. nov. (En Peligro Crítico) el cual se asemeja más a Senecio moqueguensis Montesinos.

Copyright Daniel B. Montesinos Tubée. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
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 subser. 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, involucres 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. scorzonerifolius 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, Pelser 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 (Pelser 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
Three new caespitose species of Senecio (Asteraceae, Senecioneae) from South Peru

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 involucral 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 40×-1000× 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, *Montesinos 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 subpinnaatifid; 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; carpodopium 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, *Montesinos 4022* (USM, HUSA). Moquegua Region, General Sánchez Cerro Province, Ubinas District, NW of Tassa, terrestrial on bare clayey soils in the verges of
Three new caespitose species of *Senecio* (Asteraceae, Senecioneae) from South Peru

Figure 1. *Senecio moqueguensis* Montesinos. A Leaf (upper side) B Leaf (underside) C Phyllary trichomes D Leaf trichomes E Capitulum F Calycural 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 Cochapa, elevation 4687 m, 16°08'56"S, 70°43'0.30"W, 9 December 2013, Montesinos 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 km² (ca. 50 km²) (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* Montesinos, 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, Montesinos & 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.
Three new caespitose species of Senecio (Asteraceae, Senecioneae) from South Peru

Figure 2. *Senecio sykorae* 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 Papilllose stigma L Achene
|                      | *S. moqueguensis* | *S. sykorae* | *S. tassaensis* | *S. pucapampaensis* | *S. gamolepis* | *S. algens* |
|---------------------|------------------|--------------|-----------------|---------------------|----------------|-------------|
| **Distribution**    | PE (Moquegua)    | PE (Moquegua) | PE (Moquegua)   | PE (Junin)          | PE, CH, AR, BO | PE, BO, AR  |
| **Altitude**        | 4500–4800 m      | 4550–4800 m  | 4650–4700 m     | 4500–4600 m         | 4000–4800 m    | 4500–5000 m |
| **Habit**           | dense caespitose mat | tuft mat    | tuft            | postrate, decumbent | dense caespitose mat | caespitose subshrub |
| **Plant dimensions**| 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 |
| **Indumentum**      | glandular, multicellular, 0.1–0.3 mm | absent | glandular, multicellular, 0.3–1.2 mm | finely puberulous, <0.1 mm | absent | absent |
| **Leaf shape**      | oblong-spathulate, subpin-natifid | obovate-spathulate | obovate-spathulate, incised or acuminate | cuneiform-subpinatifid, incised | linear-lanceolate | spathulate, obtuse |
| **Leaf (length, width)** | 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 |
| **Leaf pubescence** | sparsely covered by thin trichomes | glabrous | densely covered by trichomes | ciliate margins | glabrous | glabrous |
| **Involucre (shape; length; width)** | 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 |
| **Calycular bracts (shape; margin; size)** | linear-oblong; sparse trichomes; 5–8 × 0.7–1.2 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 mm | linear; glabrous; 6–9 × 0.8–1.1 mm |
| **Phyllaries (shape; size)** | 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 |
| **Phyllaries (number)** | 9–12 | 12–14 | 12–16 | 12–14 | 7–9 | 10–15 |
| **Phyllaries (margins)** | densely covered with trichomes | glabrous | densely covered with trichomes | scarious, ciliate | glabrous | glabrous |
| **Corolla (color)** | bright yellow | white | purple-pink to pale white | white | yellow | yellow |
| **Achene (shape, texture)** | cylindrical, with trichomes | cylindrical, with trichomes | ovate, striate, with trichomes | cylindrical, glabrous | cylindrical, glabrous | cylindrical, glabrous |
| **Pappus (length)** | 5–6 mm | 4–6 mm | 3.5–5 mm | 5–6 mm | 6–9 mm | 6–8 mm |
| Table 1. | \( S. \) evacoides | \( S. \) humillimus | \( S. \) expansus | \( S. \) trifurcifolius | \( S. \) repens |
| --- | --- | --- | --- | --- | --- |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
| **Distribution** | PE, BO, AR | BO, South Peru | AR, BO, PE | PE, BO, CH | BO, EC, PE |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | suffrutiouse or shrubby | dense caespitose mat | ground rosette herb | suffrutiouse | ground rosette herb |
| **Plant dimensions** | | | | | |
| **Habit** | | | | | |
| **Altitude** | 4000–4800 m | 3500–4500 m | 3900–4800 m | 4000–4500 m | 3000–4600 m |
| **Habit** | | | | | |
| **Plant dimensions** | | | | | |
homogamous, discoid and pedicled (5–10 mm long). Involucres at first narrowly cylindrical becoming cylindrical-campanulate with age (7–9 mm long × 3–5 mm wide). Calycular bracts linear-oblong (6–8 mm × 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 × 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 × 0.5–0.8 mm wide; anthers linear-lanceolate, 1.5–2 mm long × 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 × 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, Montesinos 4023 (USM).

**Discussion.** Senecio sykorae appears to be closely related to S. gamolepis which grows at higher elevations but approaches the known range of S. sykorae 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. sykorae is a smaller plant, of about 4–6 cm wide and has shorter corolla, less than 9 mm long. Senecio sykorae 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. sykorae are distinctive in that they are obovate-spathulate vs. linear-lanceolate. Also, the achenes in S. sykorae are larger (1.5–2 mm long) vs. 1–1.3 mm long in S. gamolepis. Senecio sykorae also differs from S. algens by the leaf and capitula length (shorter in S. sykorae), 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. evacoides, and from which S. sykorae 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 km² (ca. 5 km²) (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. sykorae* 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. Involucres 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 ecalarcate; 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.
Three new caespitose species of *Senecio* (Asteraceae, Senecioneae) from South Peru

**Figure 4.** Habit photographs of: A *Senecio moqueguensis* B *Senecio sykorae* C *Senecio tassaensis*.

**Figure 5.** Distribution map showing collection and recorded sites for *Senecio moqueguensis* (red circles), *S. sykorae* (yellow squares) and *S. tassaensis* (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; carpododium 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. evacoides*, *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 km² (ca. 5 km²) (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; involucres longer than 11 mm .................................2
1b Plants caespitose; involucres shorter than 11 mm long ....................5
2a Achenes densely pubescent; leaves 1–2 cm long, deeply dentate or lobulate... .............................................................. *S. adenophyllus*
2b Achenes glabrous; leaves 1–3.5 cm long, entire ................................3
3a Leaves 3–5 mm wide; involucre bracts oblong ....................... *S. rufescens*
3b Leaves 0.7–2 mm wide; involucre bracts linear ..........................4
4a Leaves 25–80 mm long; phyllaries 13–18 ....................... *S. scorzonerifolius*
4b Leaves 15–25 mm long; phyllaries 15–20 .............................. *S. danai*
Three new caespitose species of Senecio (Asteraceae, Senecioneae) from South Peru

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.........................S. humillimus
6b Leaves entire or dentate, glabrous or lanuginose; phyllaries 13......S. vegetus
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 spathulate, 10–20 mm long; involucre 7–8 mm tall; phyllaries
13–20.................................................................................................S. evacoides
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.........................S. expansus
10b Involucre 6–7 mm long; phyllaries 13–20.................................S. repens
11a Leaves cuneiform, lamina glabrous except puberulous margins........S. pucapampaensis
11b Leaves oblong, lamina with trichomes on surfaces and margins......12
12a Leaves 8–12 mm long, lamina oblong-spathulate; involucre 7–10 mm; phyl-
laries 9–12 ......................................................................................S. moqueguensis
12b Leaves 6–9 mm long, lamina obovate-spathulate; involucre 6–8 mm; phyllaries
12–16 ...............................................................................................S. tassaensis
13a Leaves dentate, linear-cuneiform..................................................S. trifurcifolius
13b Leaves entire..................................................................................14
14a Leaves 10–35 mm long.................................................................S. algens
14b Leaves less than 14 mm long.........................................................15
15a Leaves 8–12 mm, linear-lanceolate; involucre 8–11 mm; phyllaries 6–8......
........................................................................................................S. gamolepis
15b Leaves 9–14 mm, obovate-spathulate; involucre 7–9 mm; phyllaries 12–14....
........................................................................................................S. sykorae

Acknowledgements

I acknowledge Edwin Banegas and Cristian Tejada for field work support; Fabio Calisaya and Esteban Mamani for their hospitality; Hamilton Beltrán and Arturo Granda for their taxonomic comments; John Birks, Blanca León, Pieter Pelser and Jan Wieringa for their valuable observations on the manuscript; two anonymous reviewers for their constructive comments, which helped to improve the manuscript; Delsy Trujillo for the illustrations; Theo Damen, John Pruski, Lauren Peters and Karen Ventura for facilitating the barcodes of the collections at WAG, MO, and HUPCH; Benjamin DeVries for map image support; The Dirección General Forestal y de Fauna Silvestre (DGFFS) for permits to collect outside protected areas; the herbaria B, BR, CUZ, F, HSP, HUPCH, HUSA, L, LPB, MO, MOL, P, USM, and WAG for providing access
to their material; Cuzzi y Cía., S.A. for facilitating the scanning of images; and Ruben Sierra for assisting with the literature. This work was done as part of the phytosociological studies sponsored by Alberta Mennega Stichting and Hugo de Vries Fonds, the Netherlands. The language editor was Joy Burrough.

References

Arakaki M, Cano A (2003) Composición florística de la cuenca del río Ilo–Moquegua y lomas de Ilo, Moquegua, Perú. Revista Peruana de Biología 10(1): 5–19.

Beltrán H (2009) Dos especies nuevas de Senecio (Asteraceae: Senecioneae) del Perú. Arnaldoa 15(2): 211–215.

Beltrán H, Granda A, León B, Sagástegui A, Sánchez I, Zapata M (2007) Asteráceas endémicas del Perú. In: León B, Roque J, Ulloa C, Pitman N, Jorgensen PM, Cano A (Eds) El Libro Rojo de las Plantas endémicas del Perú. Revista Peruana de Biología. Número Especial 13(2): 64–164.

Brako L, Zarucchi J (1993) Catálogo de las Angiospermas y Gimnospermas del Perú. Monographs in Systematic Botany from the Missouri Botanical Garden 45: 1–1286.

Bremer K (1994) Asteraceae: Cladistics and Classification. Timber Press, Portland, 1–752.

Cabrera A (1949) El género Senecio en Chile. Lilloa 15: 27–501.

Cabrera A (1955) Notas sobre los Senecio sudamericanos, VIII. Notas Museo de la La Plata, Botánica 18(89): 191–240.

Cabrera A (1985) El Género Senecio (Compositae) en Bolivia. Darwiniana 26: 79–217.

Cabrera A, Freire SE, Ariza Espinar L (1999) Tribu VIII. Senecioneae. In: Hunziker AT, Flora Fanerogámica Argentina 62. Museo Botánico de Córdoba, Córdoba, 3–164, 171–179.

IUCN (2001) IUCN Red List Categories and Criteria: Version 3.1. Second Edition. Gland, Switzerland and Cambridge, UK.

JSTOR (2013) JSTOR Plant Science http://plants.jstor.org/ [accessed 15.12.2013]

Montesinos D (2011) Diversidad Florística de la cuenca alta del río Tambo–Ichuña, Moquegua, Peru. Revista Peruana de Biología 18(1): 119–132.

Montesinos D (2012) Lista anotada de nuevas adiciones para la flora andina de Moquegua, Perú. Revista Peruana de Biología 19(3): 303–312.

Neotropical Herbarium Specimens (2013) The Field Museum http://fm1.fieldmuseum.org/vrrc/ [accessed 15.12.2013]

Nordenstam B (1977) Senecioneae and Liabeae—systematic review. In: Heywood VH, Harborne JB, Turner BL (Eds) The biology and Chemistry of the Compositae, vol. 2. Academic Press, London, 799–830.

Nordenstam B, Pelser PB, Kadereit JW, Watson LE (2009) Senecioneae. In: Funk VA, Susanna A, Stuessy TF, Bayer RJ (Eds) Systematics, Evolution and Biogeography of Compositae. International Association for Plant Taxonomy, Institute of Botany, University of Vienna, 503–521.
Pelser PB, Nordenstam B, Kadereit JW, Watson LE (2007) An ITS phylogeny of tribe Senecioneae (Asteraceae) and a new delimitation of Senecio L. Taxon 56(4): 1077–1104. doi: 10.2307/25065905

Roque N, Keil DJ, Susanna A (2009) Illustrated glossary of Compositae. In: Funk VA, Susanna A, Stuessy TF, Bayer RJ (Eds) Systematics, Evolution and Biogeography of Compositae. International Association for Plant Taxonomy, Institute of Botany, University of Vienna, 781–805.

Tropicos.org (2013) Missouri Botanical Garden http://tropicos.org [accessed 15.12.2013]

Vision TJ, Dillon MO (1996) Sinopsis de Senecio L. (Senecioneae, Asteraceae) para el Perú. Arnaldoa 4(1): 23–46.
Hieracium sinoaestivum (Asteraceae), a new species from North China

Alexander N. Sennikov

1 Botanical Museum, Finnish Museum of Natural History, P.O. Box 7, 00014 University of Helsinki, Finland
2 Herbarium, Komarov Botanical Institute of Russian Academy of Sciences, Prof. Popov str. 2, 197376 St. Petersburg, Russia

Corresponding author: Alexander N. Sennikov (alexander.sennikov@helsinki.fi)

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. Prenanthes × 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 Lülian 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.
**Hieracium sinoaestivum** (Asteraceae), a new species from North China

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

![Figure 2. Pubescence on the phyllaries of *Hieracium sinoaestivum* Sennikov (Harry Smith 7219, S). Scale bar: 1 mm.](image-url)
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.
Hieracium sinoaestivum (Asteraceae), a new species from North China

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.

**Acknowledgements**

A loan of the type collections from the Swedish Museum of Natural History (S) is gratefully acknowledged. Mats Hjertson (Uppsala) kindly sent information about the collection of Harry Smith at UPS. Ari Taponen (Helsinki) scanned the holotype specimen. Sampsa Lommi (Helsinki) produced the map. Alexander Ebel (Tomsk) provided photographs of type specimens of the Siberian *Hieracium* species kept in TK. The friendly criticism of Walter Lack (Berlin) and an anonymous reviewer is accepted with pleasure. Teuvo Ahti (Helsinki) kindly commented upon the final text.

**References**

Abdulina SA (1999) Checklist of vascular plants of Kazakhstan. Institute of Botany and Plant Introduction, Almaty, 1–187.

Chrtek J, Mráz P, Zahradníček J, Marco G, Szélag Z (2007) Chromosome numbers and DNA ploidy levels of selected species of *Hieracium* s. str. (Asteraceae). Folia Geobotanica 42: 411–430. doi: 10.1007/BF02861703

Kotukhov YA (1971) Supplement to the Flora of Kazakhstan, II. Botanicheskie Materialy Gerbariya Institutu Botaniki Akademii Nauk Kazakhskoi SSR 7: 10–14. [in Russian]
McNeill J, Barrie FR, Buck WR, Demoulin V, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Marhold K, Prado J, Prud’homme van Reine WF, Smith GF, Wiersema JH, Turland NJ (Eds) (2012) International Code of Nomenclature for algae, fungi, and plants (Melbourne Code) adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011. Regnum Vegetabile 154: I–XXX + 1–208.

R Development Core Team (2013) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. www.R-project.org

Schljakov RN (1989) **Hieracium** L. In: Tzvelev NN (Ed) Flora of the European part of the USSR, vol. 8. Science Publishers, Leningrad, 140–300, 378–379. [in Russian]

Sell P, Murrell G (2006) Flora of Great Britain and Ireland, vol. 4. Cambridge University Press, Cambridge, I–XXVIII, 1–624.

Sennikov AN (1999) The genus *Hieracium* s. str. (Asteraceae) in the flora of the European part of Russia. Sections *Foliosa, Robusta, Accipitrina, Prenanthoidea, Prenanthella, Aestiva, Alpestria*. Botanicheskii Zhurnal [St. Petersburg] 84(12): 124–133. [in Russian]

Sennikov AN (2002) The taxonomy of *Hieracium* L. and *Pilosella* Hill (Asteraceae) in northwestern Russia. PhD Thesis, Komarov Botanical Institute, Russia. [in Russian]

Sennikov AN (2008) *Hieracium* L. In: Grubov VI (Ed) Plants of Central Asia, vol. 14b. KMK Scientific Press, Moscow, 19–28. [in Russian]

Sennikov AN (2012) Critical notes on the genera *Hieracium* and *Pilosella* (Asteraceae, Cichorioideae) in the Himalayas. Willdenowia 42(1): 85–88. doi: 10.3372/wi.42.42110

Shih C (1997) *Hieracium* L. In: Ling Y, Shih C (Eds) Flora of China, vol. 80(1). Science Press, Beijing, 1–302. [in Chinese]

Shih C, Gottschlich G (2011) *Hieracium* L. In: Wu ZY, Raven PH, Hong DY (Eds) Flora of China, vol. 20–21. Science Press, Beijing & Missouri Botanical Garden Press, St. Louis, 350–352.

Stepanov NV (1998) A new species of the genus *Hieracium* L. (Asteraceae) from the black taiga of the West Sayan. Turczaninowia 1(1): 5–6. [in Russian]

Sun H (2013) Phytogeographical regions of China. In: Hong DY, Blackmore S (Eds) Plants of China. Science Press, Beijing, 176–204.

Tupitzina NN (2004) The hawkweeds of Siberia. Science Publishers, Novosibirsk, 1–208. [in Russian]

Vaniot E (1903) *Hieracium* L. (Asteraceae) in the flora of China. Bulletin de l’Académie Internationale de Géographie Botanique 12: 489–503.

Wang HS (1997) Floristic geography of North China. Wanhai Books, Beijing, 1–229. [in Chinese]

Zahn KH (1921–1922) *Hieracium*. Sect. I–XXXIX. In: Engler A (Ed) Das Pflanzenreich, vols 75–77, 79. W. Engelmann, Leipzig, 1–1146.
A new species of spiny Solanum (Solanaceae) from Peru

Stephen R. Stern

1 Department of Biological Sciences, Colorado Mesa University, 1260 Kennedy Ave, Grand Junction, CO 81501

Corresponding author: Stephen R. Stern (sstern@coloradomesa.edu)

Academic editor: S. Knapp | Received 14 March 2014 | Accepted 26 May 2014 | Published 20 June 2014

Citation: Stern SR (2014) A new species of spiny Solanum (Solanaceae) from Peru. PhytoKeys 39: 27–34. doi: 10.3897/phytokeys.39.7513

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. subinerme and S. poinsettiifolium. Solanum subinerme has larger flowers, longer cauline prickles, and often has long straight prickles on the adaxial leaf surface that are lacking in S. junctum. Solanum poinsettiifolium 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. Oxpampa, 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
A new species of spiny Solanum (Solanaceae) from Peru

Inflorescences and lacks the white tomentum on the adaxial leaf surface and the more abundant interpetalar tissue of S. poinsettiifolium.

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 2–4 × 0.5–1 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 8–12 × 4–7 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 2–3 × 1–2 mm, triangular. Corolla 2–3 cm in diameter, chartaceous, light violet to purple, lobed nearly to the base, the lobes 8–12 × 2–3.5 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 8–12 × 1–1.5 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 1–2 × ca. 0.5 mm, style in hermaphroditic flowers 12–14 × 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, 3–4 × 2–3 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.
A new species of spiny *Solanum* (Solanaceae) from Peru

**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 km²) 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; Särkkinen 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. poinsettiifolium, a species ranging from Dept. Beni, Bolivia along the eastern slope of the Andes to central Peru. Solanum poinsettiifolium 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 poinsettiifolium 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. poinsettiifolium has more abundant interpetal 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 Marañón, 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:
A new species of spiny Solanum (Solanaceae) from Peru

A new species of spiny Solanum (Solanaceae) from Peru

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).

Acknowledgements

We thank herbaria for their loans, particularly BRIT, LL, TAES, TAMU, TEX, UTEP, and US; Eric Tepe for assistance in the field; Mariah Weinke for lab assistance; Lynn Bohs and Sandra Knapp for discussions about spiny solanums; Loren Eakins for the drawing; and two reviewers for their helpful suggestions to improve this manuscript. This work was supported by NSF grant DEB-0316614 (PBI Solanum: A Worldwide Treatment).

References

Bachman S, Moat J, Hill AW, de la Torre J, Scott B (2011) Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. In: Smith V, Penev L (Eds) e-Infrastructures for data publishing in biodiversity science. ZooKeys 150: 117–126. doi: 10.3897/zookeys.150.2109

Bohs L (2005) Major clades in Solanum based on ndhF sequence data. In: Keating RC, Hollowell VC, Croat TB (Eds) A festschrift for William G. D’Arcy: the legacy of a taxonomist. Monographs in Systematic Botany from the Missouri Botanical Garden Vol. 104. Missouri Botanical Press, St. Louis, Missouri, 27–49.

IUCN Standards and Petitions Subcommittee (2010) Guidelines for Using the IUCN Red List Categories and Criteria. Version 8.0. Prepared by the Standards and Petitions Subcommittee in March 2010. http://jr.iucnredlist.org/documents/redlist_cats_crit_en.pdf [accessed 10 October 2013]

Farruggia FT, Bohs L (2010) Two new South American species of Solanum section Crinitum (Solanaceae). Phytokeys 1: 67–77. doi: 10.3897/phytokeys.1.661
Knapp S (2010) New species of Solanum (Solanaceae) from Peru and Ecuador. Phytokeys 1: 33–52. doi: 10.3897/phytokeys.1.659
Levin RA, Myers NR, Bohs L (2006) Phylogenetic relationships among the spiny solanums” (Solanum subgenus Leptostemonum, Solanaceae). American Journal of Botany. 93: 157–169. doi: 10.3732/ajb.93.1.157
Macbride JF (1962) Flora of Peru: Volume 13. Chicago Mueseum of Natural History, Chicago. 1–267.
Nee M (1999) Synopsis of Solanum in the New World. In: Nee M, Symon DE, Lester RN, Jessops JP (Eds) Solanaceae IV: Advances in biology and utilization. Kew: Royal Botanic Gardens, 285–333.
Nee M, Bohs L, Knapp S (2006) New species of Solanum and Capsicum (Solanaceae) from Bolivia, with clarification of nomenclature in some Bolivian Solanum. Brittonia 58(4): 322–356. doi: 10.1663/0007-196X(2006)58[322:NSOSAC]2.0.CO;2
Sarkinen T, Gonzáles P, Knapp S (2013) Distribution models and species discovery: the story of a new Solanum species from the Peruvian Andes. Phytokeys 31: 1–20. doi: 10.3897/phytokeys.31.6312
Stern S, Bohs L (2010) Two new species of Solanum (Solanaceae) from the Amotape-Huanca-bamba Zone of southern Ecuador and northern Peru. Phytokeys 1: 53–65. doi: 10.3897/phytokeys.1.660
Stern SR, Weese T, Bohs L (2010) Phylogenetic relationships in Solanum section Androceras (Solanaceae). Systematic Botany 34: 885–893. doi: 10.1600/036364410X539934
Stern SR, Agra MF, Bohs L (2011) Molecular delimitation of clades within New World species of the ‘spiny solanums’ (Solanum subg. Leptostemonum). Taxon 60: 1429–1441.
Tepe EJ, Ridley G, Bohs L (2012) A new species of Solanum named for Jeanne Baret, an overlooked contributor to the history of botany. Phytokeys 8: 37–47. doi: 10.3897/phytokeys.8.2101
Weese TL, Bohs L (2007) A three-gene phylogeny of the genus Solanum (Solanaceae). Systematic Botany 32: 445–463. doi: 10.1600/036364407781179671
Whalen MD (1984) Conspectus of species groups in Solanum subgenus Leptostemonum. Gentes Herbarium 12: 179–282.
Viola kauaensis var. hosakae (Violaceae),
a new variety of endemic Hawaiian violet

J. Christopher Havran¹, Susan Ching Harbin², Talia Portner²

¹ Department of Biological Sciences, 205 Day Dorm Rd, Campbell University, Buies Creek, NC 27506, USA
² O’ahu Plant Extinction Prevention Program, 2551 Waimano Home Rd, Rm 202, Pearl City, HI 96782, USA

Corresponding author: J. Christopher Havran (havran@campbell.edu)

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 Koʻolau 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 Oʻahu) 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 Koʻolau 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. Waiʻaleʻale”. In November 2012, the summit of Mt. Waiʻaleʻale 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 Oʻahu 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 Oʻahu 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 lamia 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 |
|-------|-------------------|---------|-------------------------|-----------|
| V. k. var. hosakae | 3 | O`ahu | E.Y. Hosaka 2504 | BISH |
| V. k. var. hosakae | 1 | O`ahu | E.Y. Hosaka 1927 | BISH |
| V. k. var. hosakae | 1 | O`ahu | F.R. Fosberg 13973 | BISH |
| V. k. var. hosakae | 1 | O`ahu | F.R. Fosberg 14229 | BISH |
| V. k. var. hosakae | 1 | O`ahu | J.C. Havran 2013.4 | BISH |
| V. k. var. hosakae | 1 | O`ahu | J.C. Havran 2013.5 | BISH |
| V. k. var. hosakae | 1 | O`ahu | S. Perlman 14704 | PTBG |
| V. k. var. kauaensis | 3 | Kaua`i | C.N. Forbes 1135K | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | C.J.F. Skottsberg 939 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | J.C.F. Rock 2124 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | J.C.F. Rock 2130 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | C.N. Forbes 906 K | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | D.R. Herbst 2388 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | P. van Royen 11708 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | O. Degener 21747 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | O. Degener 21477 | BISH |
| V. k. var. kauaensis | 3 | Kaua`i | H. St. John 10753 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | C.N. Forbes 406 K | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | J.F.C. Rock 2131 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | O. Degener 21477 | BISH |
| V. k. var. kauaensis | 2 | Kaua`i | H. St. John 23038 | BISH |
| V. k. var. kauaensis | 2 | Kaua`i | W.N. Takeda Alakai_130a | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | P.K. Higashino PKH 9633 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | T.G. Lammers 5382 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | H.F.J. Huber 20 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | W.L. Wagner 5049 | BISH |
| V. k. var. kauaensis | 1 | Kaua`i | K. Kajimoto 1 | CAU |
| V. k. var. kauaensis | 1 | Kaua`i | K. Kajimoto 2 | CAU |
| V. k. var. kauaensis | 1 | Kaua`i | K. Kajimoto 3 | CAU |
| V. k. var. kauaensis | 1 | Kaua`i | K. Kajimoto 4 | CAU |
| V. k. var. kauaensis | 1 | Kaua`i | K. Kajimoto 5 | CAU |
| V. k. var. kauaensis | 1 | Kaua`i | H. St. John 1347 | DUKE |
| V. k. var. wahiawaensis | 1 | Kaua`i | H. St. John 10845 | BISH |
| V. k. var. wahiawaensis | 1 | Kaua`i | H.U. Stauffer 5911 | BISH |
| V. k. var. wahiawaensis | 1 | Kaua`i | D.R. Herbst 2415 | BISH |
| V. k. var. wahiawaensis | 1 | Kaua`i | B.C. Stone 1650 | BISH |
| V. k. var. wahiawaensis | 1 | Kaua`i | L.H. MacDaniels 606 | BISH |
| V. k. var. wahiawaensis | 2 | Kaua`i | C.N. Forbes 166.K (Holotype) | BISH |
| V. k. var. wahiawaensis | 1 | Kaua`i | C.N. Forbes 166.K (Isotype) | BISH |
| V. vanroyenii | 3 | Kaua`i | P. van Royen 11733 (Holotype) | 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          | *V. k. var. kauaensis* (Kaua`i) | *V. k. var. wahiawaensis* | *V. kauaensis* (O`ahu) | *V. vanroyenii* |
|----------------|-------------------------------|---------------------------|------------------------|-----------------|
|                | 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.
Figure 2. PCA Biplot of PC1 and PC2. Symbols: closed squares = Viola kauaensis var. hosakae; closed triangles = Viola vanroyenii; open circles = Viola kauaensis var. kauaensis; open squares = Viola kauaensis var. wahiawaensis.

Floral morphology

Removal of sepals from the preserved flower (V. kauaensis 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. kauaensis 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. kauaensis. 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. kauaensis. 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 20th 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) Kuhlm 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 m². 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 Jarbücher für Systematik, 111(2), 173, 1989.

**Type.** Hawai`i, O`ahu Island, Ko`olau Range, divide between head of Kawainui and Kaipaupau 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 1.5 mm long, ovate, acute; ventral stamen 3.6 mm long, filament 0.5 mm long and wide, anther 2.3 mm long oblancoeloid, 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
Viola kauaensis var. hosakae (Violaceae), a new variety of endemic Hawaiian violet

**Figure 3.** Type of *Viola kauaensis* 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 km², 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. wabiawaensis**
– 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.

References

Ballard HE, Sytsma KJ (2000) Evolution and biogeography of the woody Hawaiian violets (Viola, Violaceae): Arctic origins, herbaceous ancestry and bird dispersal. Evolution 54(5): 1521–1532. doi: 10.1111/j.0014-3820.2000.tb00698.x

Ellis B, Douglas CD, Hickey LJ, Mitchell JD, KR Johnson KR, Wilf P, Wing SL (2009) Manual of Leaf Architecture. Comstock Publishing Associates, 1–200.

Flora of the Hawaiian Islands: Violaceae; Viola; Viola hosakae. http://botany.si.edu/pacificislandbiodiversity/hawaiianflora/synresult.cfm?genus=Viola&epithet=hosakae&rank1=&epithet1= [accessed 26.09.2013]

Forbes CN (1920) New Hawaiian Plants – VII. Occasional Papers of the Bernice Pauahi Bishop Museum 7(3): 33–39.

Fosberg FR, Hosaka EY (1939) An open bog on O`ahu. Occasional papers of the Bernice Pauahi Bishop Museum 16(1): 1–6.

Havran JC, Sytsma KJ, Ballard HE (2009) Evolutionary relationships, interisland biogeography, and molecular evolution in the Hawaiian violets (Viola: Violaceae). American Journal of Botany 96(11): 2087–2099. doi: 10.3732/ajb.0900021

Loope LL, Giambelluca TW (1988) Vulnerability of island tropical montane cloud forests to climate change, with special reference to East Maui, Hawai`i. Climatic Change 39(2–3): 503–517.

Rasband W (2012) ImageJ. National Institutes of Health, Bethesda, Maryland. http://imagej.nih.gov/ij/

R Core Team (2012) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, http://www.R-project.org/

Skottsberg C (1940) Observations on Hawaiian violets. Meddelanden Fran Goteborgs Botaniska Tradgard 13: 451–528.

St. John H (1989) Hawaiian plant studies 135: Revision of the Hawaiian species of Viola (Violaceae). Botanische Jarbücher für Systematik 111(2): 165–204.

Wagner WL, Herbst DR, Sohmer SH (1999) Manual of the flowering plants of Hawai`i, revised ed. University of Hawai`i Press and Bishop Museum Press, Honolulu, 1–1919.

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); Kaholualaniu, 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); Kaholumanu, 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); Kaholumanu Lehua Makanoe, E of Waialae, Sep 1909, Forbes 406K (BISH); Below Mt. Wai‘ale‘ale, Mar 1932, Rogers 1 (BISH); Kaholumanu, 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); Koloa 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 (Kanea 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 (Kanea 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)

Harold Robinson¹, Sterling C. Keeley², John J. Skvarla³,†, Raymund Chan¹

¹ Department of Botany, MRC 166, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, Washington, DC., 20013-7012, USA ² Department of Botany, University of Hawaii, Manoa, 3190 Maile aWay, #101, Honolulu, Hawaii, 96822-2279, USA ³ Department of Botany and Microbiology, and Oklahoma Biological Survey, University of Oklahoma, Norman, Oklahoma, 73018-6131, USA, deceased 2 March 2014

Corresponding author: Harold Robinson (robinsoh@si.edu)

Academic editor: A. Sennikov  |  Received 1 April 2014  |  Accepted 8 July 2014  |  Published 18 July 2014

Citation: Robinson H, Keeley SC, Skvarla JJ, Chan R (2014) Two new genera, *Hoffmannanthus* and *Jeffreycia*, mostly from East Africa (Erlangeinae, Vernonieae, Asteraceae). PhytoKeys 39: 49–64. doi: 10.3897/phytokeys.39.7624

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 involucres, 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 Vernonieae, 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 Vernonieae 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 involucral bracts, 5-angled achenes, and ovate to cordate, non-panduriform leaves. Vernonia brachycalyx was not treated in the first effort to resolve paleotropical Vernonieae 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 Vernonieae, 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 Jeffreycia zanzibarensis (E form with panduriform leaves F, G typical form) H J. hildebrandti 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).
Two new genera, *Hoffmannanthus* and *Jeffreycia*, mostly from East Africa...

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, *Jeffreycia*, includes three of the species mistakenly placed in *Gymnanthemum* in the subtribe Gymnanthemiae by Robinson (1999a), a genus from which the present group is now seen to be subtribally distinct. Among the
most obvious differences are the presence in *Gymnanthemum* of a broad abaxial shield in the involucral bracts and the tendency for the inner involucral bracts to be deciduous in *Gymnanthemum*, instead of persistent as in *Jeffreycia*.

**Figure 3.** Scanning electron micrographs of *Jeffreycia zanzibarensis* pollen (Tanzania, Faulkner 3866, US). **A** polar view **B** equatorial view **C** oblique lateral view **D** lateral view **E** view of fractured grain.
Two new genera, *Hoffmannanthus* and *Jeffreycia*, mostly from East Africa...

A genus that is possibly closely related to *Jeffreycia* is the recently described *Uniyala* H. Rob. & Skvarla of India and Sri Lanka (Robinson and Skvarla 2009) with which *Jeffreycia* 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 *Jeffreycia* 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 4.** Scanning electron micrographs of *Jeffreycia zeylanica* pollen (Ceylon, K. Wirawan 695, US). **A** polar view **B** equatorial view **C** lateral view **D** fractured grain.
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

**Figure 5.** Scanning electron micrographs of *Jeffreycia* 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.
Two new genera, *Hoffmannanthus* and *Jeffreycia*, mostly from East Africa...

3 Perennial herbs with root crown with densely pilose apex; often flowering before leaves appear ................................................................. *Vernonella* Sond.

4 Annual or perennial herbs with rootstock not densely pilose at apex; flowers usually appearing after leaves ..............................................

5 Mostly small herbs with pollen either sublophate, triporate or pantoporate ................................................................. (most Erlangeinae and Centrapalinae) *Cabo-banthus* 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 .................................................................

6 Weak herbs with involucral bracts bearing smooth broad shields abaxially, not marginally toothed or apically appended .......... *Anathura* H. Rob. & Skvarla

- Coarse herbs to subshrubs; involucral bracts marginally toothed or apically appended ................................................................. (Linziinae) 6

7 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.

8 Involucral bracts broad, smooth abaxially with broad median shield; inner bracts often deciduous ................................................................. *Gymnanthemum*

- Involucral bracts oblong-lanceolate to linear-lanceolate, without broad smooth shield abaxially; inner bracts persistent .................................................................

9 Pollen lophate, with little or no perforated tectum ........... *Ambassa* Steetz

- Pollen sublophate, with continuous perforated tectum in intercolpi ............

10 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 ................................................................. *Jeffreycia*

**Taxonomic treatment**

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

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

**Type.** *Vernonia brachycaulx* 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 dentate 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; involucral 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, epilose. Florets ca. 15 in a head, homogamous, bisexual; corollas violet to purple, narrowly funnelform, 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, Kili-mandjaro, 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, isotype BM, K).

_Vernonia meiocalyx_ S. Moore, J. Bot. 38: 155. 1900. Type: Kenya, Delamere s.n. (synotypes 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
Two new genera, *Hoffmannanthus* and *Jeffreycia*, mostly from East Africa...

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 involucral bracts. The inner involucral 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).

*Jeffreycia* 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; involucral 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, epaneate, 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; endothecial cells with-
Two new genera, *Hoffmannanthus* and *Jeffreycia*, mostly from East Africa...

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; carpododium 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, *Jeffreycia*, honors the author of the study of the Vernonieae 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 *Jeffreycia*, distinguished from the others by the appendages on the tips of their involucral 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 *Jeffreycia* recognized here, and any close relationship to *Jeffreycia* 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.

*Jeffreycia 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.
Jeffreycia 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.

Jeffreycia 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.

Jeffreycia 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.

Jeffreycia 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.
Two new genera, *Hoffmannanthus* and *Jeffreycia*, mostly from East Africa...

---

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

1. Heads with 5–10 florets; with only rather short involucral bracts at base; corollas 5–6 mm long; leaf blades with crenate margins
   - Heads with 20–40 florets; with elongate filiform bracts at base; corollas 7–11 mm long; leaf blades with serrate margins
   2. Undersurfaces of leaves and branches of inflorescence with short hispidulous pubescence; heads with ca. 10 florets
      - Undersurfaces of leaves and branches of inflorescence with long hairs forming tomentum; heads with ca. 5 florets
      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
         - 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. Peduncles with appressed stiff hairs; leaf blades shortly pubescent below; inner involucral bracts to ca. 8 mm long
         - Peduncles with mostly spreading, crisped hairs; leaf blades crispate pubescent below, somewhat obscurely pubescent on lamina surface; inner involucral bracts ca. 6 mm long

---

**Acknowledgements**

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 *Jeffreycia*. We also thank Ingrid Pol-yin Lin of the Department of Botany for the scan of the isolecotype 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.

**References**

Anderson LE (1954) Hoyer’s solution as a rapid permanent mounting medium for Bryophytes. *The Bryologist* 57: 242–244. doi: 10.1639/0007-2745(1954)57[242:HSAARP]2.0.CO;2

Chissoe WF, Skvarla JJ (1996) Combining sputter coating with OTOTO treatment to eliminate charging artifacts in pollen preparations. Proceedings of the Oklahoma Academy of Science 76: 83–85.

Chissoe WF, Vezey EL, Skvarla JJ (1995) The use of osmium-thiocarbohydrazide for structural stabilization and enhancement of secondary electron images in scanning electron microscopy of pollen. *Grana* 34: 317–324. doi: 10.1080/00173139509429065
Erdtman G (1960) The acetolysis method. A revised description. Svensk Botanisk Tidskrift 54: 561–564.
Grierson AJC (1980) Compositae. In: Dassanayake MD, Fosberg FR (Eds) A revised handbook to the Flora of Ceylon, vol. 1. Amerind Publishing Co., Dew Delhi, 111–278.
Herz W (1996) A review of the terpenoid chemistry of the Vernonieae. In: Hind DJN, Beentje HJ (Eds) Compositae: Systematics. Proceedings of the International Compositae Conference, Kew, 1994, vol. 1. Royal Botanic Gardens, Kew, 229–251.
Hoffmann O (1894) Compositae africanae. II. Botanische Jahrbücher für Systematik, Pflanzenengeschichte und Pflanzengeographie 20: 219–237.
Hoffmann O (1895) Compositae. In: Engler A (Ed) Die Pflanzenwelt Ost-Afrikas und der Nachbargebiete, vol. C. D. Reimer, Berlin, 402–422.
Hoffmann O (1898) Compositae africanae. III. Botanische Jahrbücher für Systematik, Pflanzenengeschichte und Pflanzengeographie 24: 462–475.
Jeffrey C (1988) The Vernonieae in East Tropical Africa (Notes on Compositae V). Kew Bulletin 43(2): 195–277. doi: 10.2307/4113734
Jones SB (1981) Synoptic classification and pollen morphology of Vernonia (Compositae: Vernonieae) in the Old World. Rhodora 83: 59–75.
Jones SB (1982) IOPB Chromosome Numbers Reports LXXIV. Taxon 31: 126–127.
Keeley S, Jones S (1977) Taxonomic implications of external pollen morphology to Vernonia (Compositae) in the West Indies. American Journal of Botany 64: 576–584. doi: 10.2307/2442006
Keeley S, Jones S (1979) Distribution of pollen types in Vernonia (Vernonieae-Compositae). Systematic Botany 4: 195–202. doi: 10.2307/2418418
Keeley S, Robinson H (2009) Chapter 28, Vernonieae. In: Funk VA, Susanna A, Stuessy TF, Bayer RJ (Eds) Systematics, Evolution, and Biogeography of Compositae. IAPT, Vienna, 439–469. doi: 10.2988/08-21.1
Keeley S, Forsman ZH, Chan R (2007) A phylogeny of the “evil tribe” (Vernonieae: Compositae) reveals Old/New World long distance dispersal: Support from separate and combined congruent datasets (trnL1, ndhF, ITS). Molecular Phylogenetics and Evolution 44(1): 89–103. doi: 10.1016/j.ympev.2006.12.024
Lessing CF (1831) De synanthereis dissertatio quarta. Linnaea 6: 624–721.
Robinson H (1999a) Revisions in paleotropical Vernonieae (Asteraceae). Proceedings of the Biological Society of Washington 112(1): 220–247.
Robinson H (1999b) Generic and subtribal classification of American Vernonieae. Smithsonian Contributions to Botany 89: i–iv, 1–116.
Robinson H (2009) Additions to the genus Orbivestrus H. Rob. (Asteraceae: Vernonieae) and neotypification of Vernonia teitensis O. Hoffm. Phytologia 91(3): 483–493.
Robinson H, Skvarla JJ (2009) A new genus, Uniyala, from Peninsular India and Sri Lanka (Vernonieae: Asteraceae). Proceedings of the Biological Society of Washington 122(2): 150–154.
Skvarla JJ, DeVore ML, Chissoe WF (2005) Lophate sculpturing of Vernonieae (Compositae) pollen. Review of Palaeobotany and Palynology 133: 51–68. doi: 10.1016/j.revpalbo.2004.09.001
A new species of *Hibiscadelphus* Rock (Malvaceae, Hibisceae) from Maui, Hawaiian Islands

Hank L. Oppenheimer¹, Keahi M. Bustamente¹, Steven P. Perlman²

¹ Plant Extinction Prevention Program, Pacific Cooperative Studies Unit, University of Hawai‘i Manoa, Dept. of Botany, P.O. Box 909, Makawao, HI 96768, USA ² National Tropical Botanical Garden, 3530 Papalina Rd., Kalaheo, HI 96741, USA

Corresponding author: Hank L. Oppenheimer (HenryO@Hawaii.edu)

Academic editor: L.J. Dorr  |  Received 25 February 2014  |  Accepted 25 June 2014  |  Published 25 July 2014

Citation: Oppenheimer HL, Bustamente KM, Perlman SP (2014) A new species of *Hibiscadelphus* Rock (Malvaceae, Hibisceae) from Maui, Hawaiian Islands. PhytoKeys 39: 65–75. doi: 10.3897/phytokeys.39.7371

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 Kaua‘ula 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 involucral 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*.

| Species            | Extinct | Cultivation only | Extant in wild | USFWS status         | IUCN status |
|--------------------|---------|------------------|----------------|-----------------------|-------------|
| *H. bombycinus*    | X       |                  |                | Species of Concern    | EX          |
| *H. crucibracteatus* | X       |                  |                | Species of Concern    | EX          |
| *H. distans*       | X       |                  |                | Endangered            | CR          |
| *H. giffardianus*  | X       |                  |                | Endangered            | CR          |
| *H. hualalaiensis* | X       |                  |                | Endangered            | CR          |
| *H. stellatus*     | X       |                  |                |                       | EN          |
| *H. wilderianus*   | X       |                  |                | Species of Concern    | EX          |
| *H. woodii*        | 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, involucral bracts, and corolla; linear-subulate to lanceolate involucral 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 suborbicular 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, involucral 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-spathulate, apex obtuse, tips and outer margins slightly reflexing with age, outer exposed portion purple, purple-green or purple-yellow, inner
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 exserted 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,
A new species of *Hibiscadelphus* Rock (Malvaceae, Hibisceae)...

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. & Schltdl.) 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 multifloris* Gaudich. ex Hook. & Arn., *Osteomeles anthyllidifolia* (Sm.) Lindl., *Pipturus albidus* (Hook. & Arn.) A. Gray, *Pleomele auwahiensis* H. St. John, *Remya mauiensis* Hillebr., *Urena 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 nepelophilum* Gaudich., *Triquetra 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 involucral 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.
A new species of *Hibiscadelphus* Rock (Malvaceae, Hibisceae)...  

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 Puaulu 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 wooodii* 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 hirca*) and/or pigs (*Sus scrofa*). Small populations of feral goats and pigs are encroaching in surrounding areas, although the West Maui Moun-
contains 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., *Buddlea 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 500km² (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

![Figure 3. Distribution map showing known locations of *Hibiscadelphus stellatus* on West Maui.](image)
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; involucral 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 Involutral bracts connate ca. ½ of their length; mesocarp weakly developed and usually adnate to the exocarp; endocarp segments 5 ............... *H. distans*

1b Involutral bracts free or slightly connate at base; reticulate mesocarp strongly developed; endocarp segments 10 .................................................. 2

2a Involutral bracts filiform or obsolete; up to 1.1 mm wide toward base....... 3

2b Involutral bracts linear-subulate to spathulate, 1–7 mm wide toward base .... 4

3a Involutral 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 Involutral bracts 18–35 mm long; corolla grayish green externally, dark magenta internally, (5–)6–7 cm long; Mauna Loa, Hawai`i...... *H. giffardianus*

4a Involutral bracts mostly 4(–5), (20–)23–27(–30) mm long

.......................................................... *H. crucibracteatus*

4b Involutral 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 sparingly 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; capsule ovoid; Auwahi, East Maui .......... *H. wilderianus*

7b Plants mostly densely pubescent; bracts linear-subulate to lanceolate, apex acute to acuminate, capsule globose-cuboid to ovoid; Kaua`ula, West Maui ...................................................... *H. stellatus*

**Acknowledgements**

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.

**References**

Baker JK, Allen MS (1978) Roof rat depredations on *Hibiscadelphus* (Malvaceae) trees. In: Smith CW (Ed) Proceedings of the Second Conference in Natural Sciences Hawaii Volcanoes National Park; 1978 June 1–3; Honolulu. University of Hawai`i at Manoa, Department of Botany, Honolulu (HI), 2–5.

Bishop LE, Herbst D (1973) A new *Hibiscadelphus* (Malvaceae) from Kaua`i. Brittonia 25(3): 290–293. doi: 10.2307/2805589
Forbes CN (1920) New Hawaiian Plants-VII. Bishop Museum Occas. Pap. Vol. 7 No. 3. Honolulu.
Giffard WM (1920) Miscellaneous notes and exhibits of insects collected at Puu Waawaa, North Kona, and Kilauea, Hawai`i. Proceedings of the Hawaiian Entomological Society for the year 1919, vol. 4 No. 2, Honolulu.
Hobdy RW (1984) A re-evaluation of the genus Hibiscadelphus (Malvaceae) and the description of a new species. Occas. Pap. of the B.P. Bishop Museum, Vol. 25, No. 11. Bishop Museum Press, Honolulu.
IUCN (2013) Guidelines for using the IUCN red list categories and criteria. Version 10. Gland, Switzerland and Cambridge, UK.
Lorence DH, Wagner WL (1995) Another new, nearly extinct species of Hibiscadelphus (Malvaceae) from the Hawaiian Islands. Novon 5(2): 183–187. doi: 10.2307/3392243
Pukui MK, Elbert SH (1986) Hawaiian Dictionary. Revised and enlarged edition. University of Hawai`i Press, Honolulu, 1–572.
Radlkoffer L, Rock JF (1911) New and noteworthy Hawaiian plants. Hawaiian Board of Agriculture and Forestry Botanical Bull 1: 1–15.
Rock JF (1913) The Indigenous trees of the Hawaiian Islands. Privately published. Honolulu, Hawai`i, 548 pp.
Wagner WL, Herbst DR, Sohmer SH (1999) Manual of the flowering plants of Hawai`i. revised edition, 2 vol. Bishop Museum Press and Univ. of Hawai`i Press, Honolulu, Hawai`i, 1853 pp.
Wood KR (2012) Possible extinctions, rediscoveries, and new plant records within the Hawaiian Islands. Bishop Museum Occasional Papers 113: 91–102.
Melicope balgooyi Appelhans, W.L. Wagner & K.R. Wood, a new species and new record in Melicope section Melicope (Rutaceae) for the Austral Islands

Marc S. Appelhans¹, Warren L. Wagner², Kenneth R. Wood³

¹ Department of Systematic Botany, Albrecht-von-Haller Institute of Plant Sciences, University of Göttingen, Untere Karspüle 2, 37073 Göttingen, Germany ² Department of Botany, Smithsonian Institution, PO Box 37012, Washington, DC 20013-7012, USA ³ National Tropical Botanical Garden, 3530 Papalina Road, Kalaheo, HI 96741, USA

Corresponding author: Marc S. Appelhans (Marc.Appelhans@biologie.uni-goettingen.de)

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

Copyright Marc S. Appelhans et al. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
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., Playdesma 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. mantelli 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.
urn:lsid:ipni.org:names:77140886-1
Figs 3, 4a

**Type.** AUSTRAL ISLANDS: Rapa Iti, Maii, below rim near Pokumaru, 29 Apr 2002, K.R. Wood 9727 (holotype: PTBG-041326!, isotype: NY!).
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*
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 ciliolate, 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, Metrostideros 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 Skottsb., Plantagion rupestris 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 savatense (Baker) Diels, and Davallia solida (G. Forst.) Sw. Less than 20 individuals of M. balgooyi are estimated to occur around this only known site.
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* 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 apexes 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 km²) 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 km²; 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 km²; 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.
Acknowledgements

We would like to thank Timothy Flynn (PTBG) for providing leaf material for molecular work and a loan of specimens to GOET. Jean-Yves Meyer and Priscille Frogier of the Délégation à la Recherche, Polynésie Française, for their continued logistical support of research in French Polynesia. Timothy J. Motley (NYBG), organizer of the 2002 Rapa Expedition, and the National Geographic Society for partial funding. Steve Perlman (NTBG), Jean-Francois Butaud (Service du Développement Rural, Tahiti), Cerdan Faraire (Rapa), and Jean-Yves Meyer for field assistance. The first author would like to thank Anita Walsmit Sachs-Jansen (L) and Alice Tangerini (US) for sharing knowledge on scientific illustration. We thank María Elena Reiner-Drehwald (GOET) for scanning the line drawing. We appreciate careful editorial review by Nancy Khan (US) and we thank H.-J. Esser (M) for the helpful and constructive review of the manuscript.

References

Appelhans MS, Wen J, Wagner WL (2014a) A molecular phylogeny of Acronychia, Euodia, Melicope and relatives (Rutaceae) reveals polyphyletic genera and key innovations for species richness. Molecular Phylogenetics and Evolution 79: 54–68. doi: 10.1016/j.ympev.2014.06.014

Appelhans MS, Wen J, Wood KR, Allan GJ, Zimmer EA, Wagner WL (2014b) Molecular phylogenetic analysis of Hawaiian Rutaceae (Melicope, Platydesma and Zanthoxylum) and their different colonisation patterns. Botanical Journal of the Linnean Society 174: 425–448. doi: 10.1111/boj.12123

Clouard V, Bonneville A (2005) Ages of seamounts, islands and plateaus on the Pacific Plate. In: Foulger GR, Natland JH, Presnall DC, Anderson DL (Eds) Plates, plumes, and paradigms. Geological Society of America, Special Paper 388: 71–90. doi: 10.1130/0-8137-2388-4.71

Gates Clarke JF (1971) The Lepidoptera of Rapa Island. Smithsonian Contributions to Zoology 56: 1–282. doi: 10.5479/si.00810282.56

Harbaugh DT, Wagner WL, Allan GJ, Zimmer EA (2009) The Hawaiian Archipelago is a stepping stone for dispersal in the Pacific: an example from the plant genus Melicope (Rutaceae). Journal of Biogeography 36(2): 230–241. doi: 10.1111/j.1365-2699.2008.02008.x

Hartley TG (1981) A revision of the genus Tetradium (Rutaceae). Garden’s Bulletin, Singapore 34(1): 91–131.

Hartley TG, Stone BC (1989) Reduction of Pelea with new combinations in Melicope (Rutaceae). Taxon 38(1): 119–123. doi: 10.2307/1220910

Hartley TG (2001) On the taxonomy and biogeography of Euodia and Melicope (Rutaceae). Allertonia 8(1): 1–328.

IUCN (2001) IUCN Red List Categories and Criteria Version 3.1. Prepared by the IUCN Criteria Review Working Group. IUCN, Cambridge.
Kubitzki K, Kallunki JA, Duretto M, Wilson PG (2011) Rutaceae. In: Kubitzki K (Ed.) The families and genera of vascular plants, vol. 10. Springer Verlag, Berlin, 276–356.
Meyer J-Y (2010) Montane cloud forests in remote islands of Oceania: the example of French Polynesia (South Pacific Ocean). In: Bruijnzeel LA, Scatena FN, Hamilton LS (Eds) Tropical Montane Cloud Forests: Science for Conservation and Management. Cambridge University Press, Cambridge, 121–129.
van Balgooy MMJ (1971) Plant-geographical analysis of the pacific. Blumea Supplement 6: 1–122.
Wagner WL, Herbst DR, Sohmer SH (1990) Manual of the flowering plants of Hawai`i. University of Hawai`i Press, Bishop Museum Press, Honolulu, 1853 pp.
Wood KR (2002) Further Notes on Rapa, Austral Islands, French Polynesia. Garden Chronicles, National Tropical Botanical Garden, Kalaheo, Hawai`i, 3(2): 13–15.
Wood KR (2010) Tales from the Field: Following an inner voice in search of Rapa’s rare Apostates. The Bulletin, National Tropical Botanical Garden, Kalaheo, Hawai`i, 27(2): 11–17.