

Waarnemingen.be – Plant occurrences in Flanders and the Brussels Capital Region, Belgium

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Abstract

Waarnemingen.be - Plant occurrences in Flanders and the Brussels Capital Region, Belgium is a species occurrence dataset published by Natuurpunt. The dataset contains almost 1.2 million plant occurrences of 1,222 native vascular plant species, mostly recorded by volunteers (citizen scientists), mainly since 2008. The occurrences are derived from the database <http://www.waarnemingen.be>, hosted by Stichting

Natuurinformatie and managed by the nature conservation NGO Natuurpunt. Together with the datasets Florabank1 (Van Landuyt and Brosens 2017) and the Belgian IFBL (Instituut voor Floristiek van België en Luxemburg) Flora Checklists (Van Landuyt and Noé 2015), the dataset represents the most complete overview of indigenous plants in Flanders and the Brussels Capital Region.

Keywords

native, distribution, observation, citizen science, waarnemingen.be

General description

Purpose: Plants have a long history of being recorded by both amateur and professional botanists. Volunteer data from amateur botanists were always an important source of distribution data of plants. The atlas of Flanders and the Brussels Capital region (Van Landuyt et al. 2006) was based on the teamwork of many volunteer botanists, NGOs, scientific institutes and governmental organisations. Since Natuurpunt, the largest nature conservation NGO in Flanders, Belgium, launched the web portal www.waarnemingen.be in 2008, the number of plant observations in Flanders and the Brussels Capital Region has risen sharply. Beside IFBL-mapping and project-related observations, this database is easily used for occasional observations and can be used for monitoring (wildlife) areas. Old notebooks and reports were screened and stored in the database (Steeman et al. 2012). The team of specialized validators motivates the inexperienced observers and validates observations. Here we publish these records on a IFBL (Instituut voor Floristiek van België en Luxemburg) grid cell resolution of 4×4 km².

Data published through

Source publication: <http://dataset.inbo.be/planten-natuurpunt-occurrences> This paper describes version 1.4 of this resource.

Dataset on GBIF: <http://www.gbif.org/dataset/bfc6fe18-77c7-4ede-a555-9207d60d1d86>, DOI: <https://doi.org/10.15468/fyuklz>

Taxonomic coverage: the taxonomic reference for the dataset is Heukels' Flora of the Netherlands by Van der Meijden (2005) which follows the classification as suggested by the Angiosperm Phylogeny Group (APG II 2003).

General taxonomic coverage description: The datasets contains 1,222 native vascular plant (Plantae) species (as well as an additional number of subspecies, varieties, forms, hybrids and multispecies) recorded in Flanders and the Brussels Capital Region. This includes angiosperms (flowering plants), gymnosperms, ferns and allies, but not algae, mosses and lichens. If the observer remarked that the specific individual of this native plant was introduced by man, then this is recorded in the field *establishmentMeans*.

Taxonomic ranks

Kingdom: Plantae

Families: *Adoxaceae, Alismataceae, Amaranthaceae, Amaryllidaceae, Apiaceae, Apocynaceae, Aquifoliaceae, Araceae, Araliaceae, Asparagaceae, Aspleniaceae, Asteraceae, Athyriaceae, Balsaminaceae, Berberidaceae, Betulaceae, Blechnaceae, Boraginaceae, Brassicaceae, Butomaceae, Buxaceae, Campanulaceae, Cannabaceae, Caprifoliaceae, Caryophyllaceae, Celastraceae, Ceratophyllaceae, Cistaceae, Colchicaceae, Convolvulaceae, Cornaceae, Crassulaceae, Cucurbitaceae, Cupressaceae, Cyperaceae, Cystopteridaceae, Dennstaedtiaceae, Dioscoreaceae, Droseraceae, Dryopteridaceae, Elaeagnaceae, Elatinaceae, Equisetaceae, Ericaceae, Euphorbiaceae, Fabaceae, Fagaceae, Gentianaceae, Geraniaceae, Grossulariaceae, Haloragaceae, Hydrocharitaceae, Hypericaceae, Iridaceae, Juncaceae, Juncaginaceae, Lamiaceae, Lentibulariaceae, Liliaceae, Linaceae, Lycopodiaceae, Lythraceae, Malvaceae, Marsileaceae, Melanthiaceae, Menyanthaceae, Molluginaceae, Montiaceae, Myricaceae, Nartheciaceae, Nymphaeaceae, Oleaceae, Onagraceae, Onocleaceae, Ophioglossaceae, Orchidaceae, Orobanchaceae, Osmundaceae, Oxalidaceae, Papaveraceae, Plantaginaceae, Plumbaginaceae, Poaceae, Polygalaceae, Polygonaceae, Polypodiaceae, Potamogetonaceae, Primulaceae, Ranunculaceae, Resedaceae, Rhamnaceae, Rosaceae, Rubiaceae, Ruppiaceae, Salicaceae, Santalaceae, Sapindaceae, Saxifragaceae, Scrophulariaceae, Solanaceae, Taxaceae, Thelypteridaceae, Typhaceae, Ulmaceae, Urticaceae, Verbenaceae, Violaceae, Zosteraceae*

The number of records (observations) per plant species is shown in Fig. 1 and the top 10 most frequently recorded species are shown in Table 1.

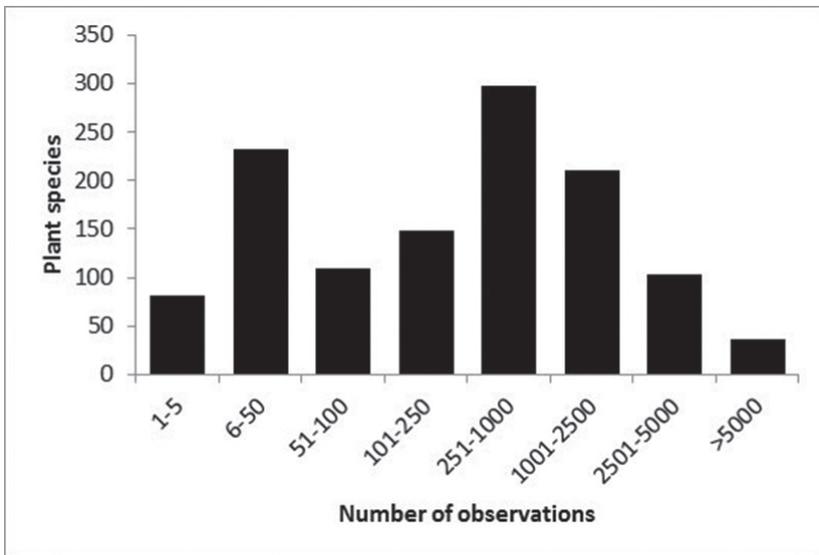


Figure 1. The number of observations per plant species (excluding subspecies, varieties, forms, hybrids and multispecies).

Table 1. Top 10 of the most frequently recorded plant species in www.waarnemingen.be.

Scientific name	Number of observations
<i>Urtica dioica</i>	8687
<i>Cardamine pratensis</i>	8446
<i>Glechoma hederacea</i>	7741
<i>Quercus robur</i>	7695
<i>Plantago lanceolata</i>	7438
<i>Filipendula ulmaria</i>	7024
<i>Cirsium arvense</i>	7010
<i>Anemone nemorosa</i>	6902
<i>Ranunculus repens</i>	6863
<i>Achillea millefolium</i>	6830

Spatial coverage

General spatial coverage: Flanders and the Brussels Capital Region (Fig. 2). These regions are situated in the north of Belgium and cover an area of 13,522 km² and 162 km² respectively (13,684 km² in total or 45% of the Belgian territory).

Flanders is largely covered by agricultural land (51%), urban areas (30%) and woodland (10%) while the Brussels Capital Region mainly consists of urban areas (73%), woodland (12%) and other green areas (10%) (Vriens et al. 2011). All occurrence data are generalized to IFBL grid cells of 4 × 4 km² (Fig. 3), with the grid codes indicated in the field *verbatimCoordinates*. The WGS84 centroids of these grid cells are calculated in *decimalLatitude/Longitude* with a *coordinateUncertaintyInMeters* of 2,828 meters (using Wiczorek et al. 2004).

Coordinates: 50°40'48"N and 51°30'36"N Latitude; 2°32'24"E and 5°55'12"E Longitude.

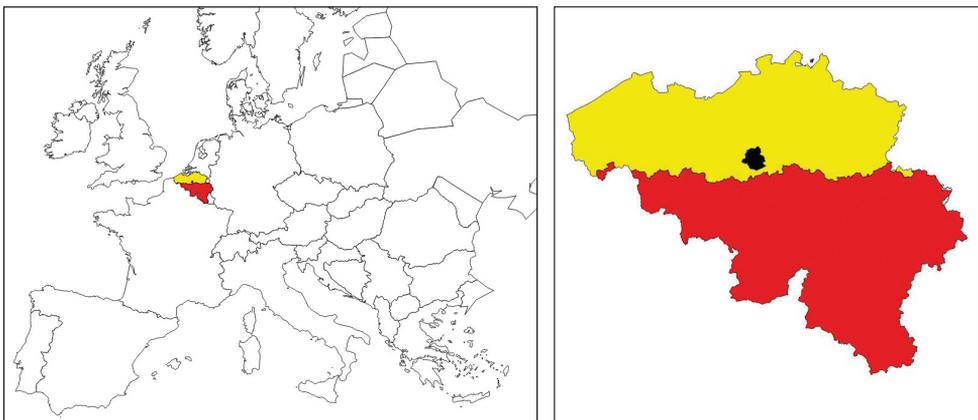


Figure 2. Location of Belgium within Europe (left) and the three administrative regions in Belgium (yellow = Flanders, black = Brussels Capital Region, red = Wallonia)

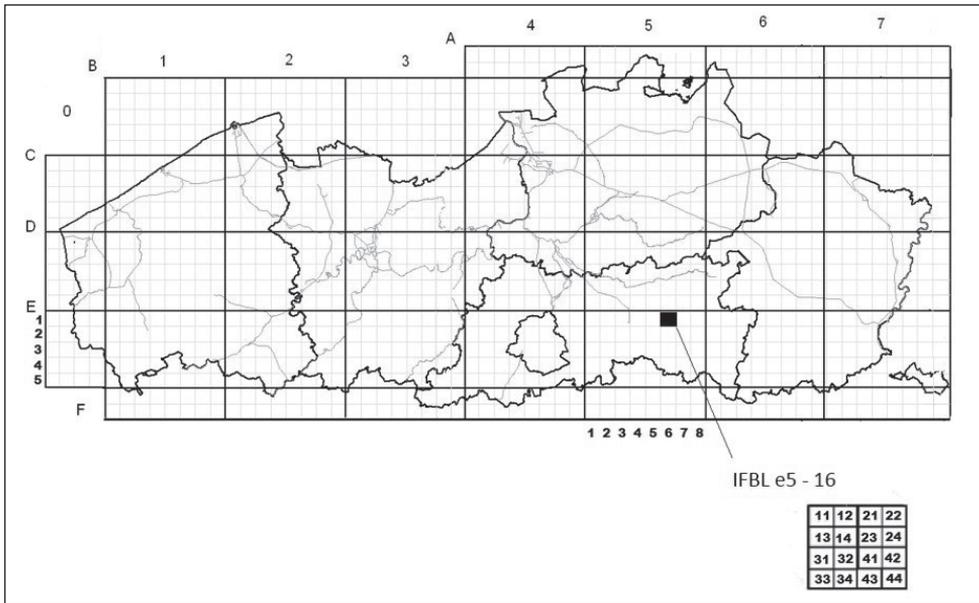


Figure 3. 4 × 4 km² IFBL grid cells in Flanders and the Brussels capital region.

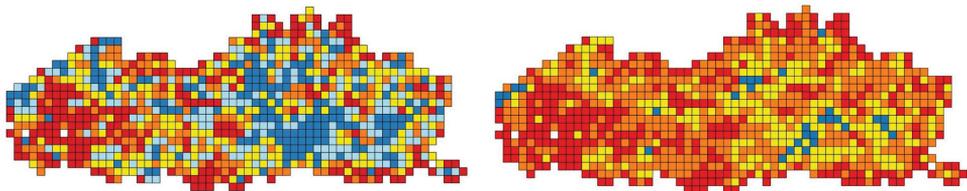


Figure 4. Left: the number of plant observations per IFBL grid cell. Red (1–200), orange (201–500), yellow (501–1000), light blue (1001–2000) and dark blue (2001–14000). Right: the number of plant species (subspecies, varieties, forms, hybrids and multispecies not included) per IFBL grid cell. Red (1–150), orange (151–300), yellow (301–450) and blue (451–600). The two white IFBL grid cells in the west of Flanders are locations without plant observations.

We show the number of plant observations and the number of plant species per IFBL grid cell (Fig. 4). Figure 5 shows the frequency distribution of plant species per number of IFBL grid cells. The top 10 of the most widespread recorded plant species is shown in Table 2.

Temporal coverage: June 30, 1855 - December 31, 2016

The majority of records was collected since the launch of www.waarnemingen.be in 2008 (Fig. 6).

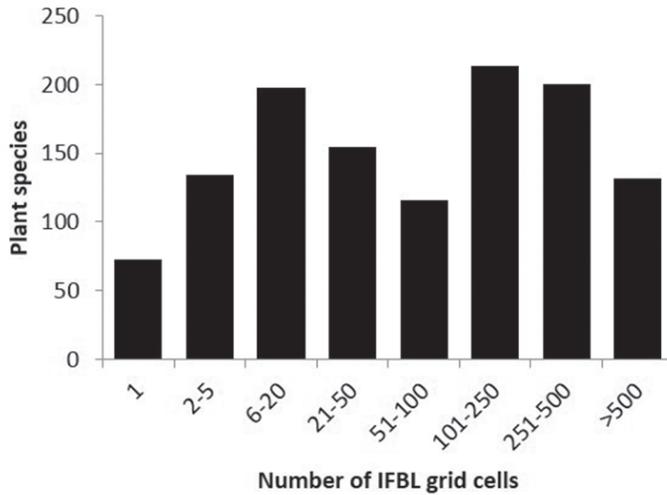


Figure 5. Known distribution based on the data from www.waarnemingen.be of true plant species (sub-species, varieties, forms, hybrids and multispecies not included) based on the number of IFBL grid cells with observation of this species.

Table 2. Top 10 of plant species registered in the most IFBL grid cells.

Scientific name	Number of IFBL grid cells
<i>Urtica dioica</i>	790
<i>Achillea millefolium</i>	777
<i>Plantago lanceolata</i>	772
<i>Glechoma hederacea</i>	765
<i>Ranunculus repens</i>	765
<i>Cardamine pratensis</i>	762
<i>Cirsium arvense</i>	743
<i>Sambucus nigra</i>	740
<i>Tanacetum vulgare</i>	739
<i>Rumex obtusifolius</i>	736

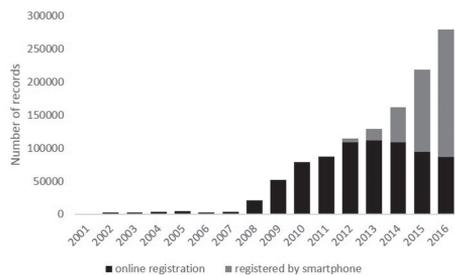
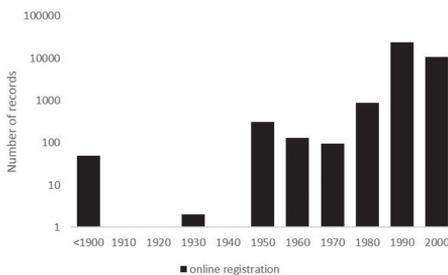


Figure 6. Number of collected records between 1855 and 2000 (left) and between 2001 and 2016 (right). Each number on the left x-axis is a period of 10 year (e.g., 1910 = 1901–1910, etc.). Note the difference between the scales on the y-axis between the left and right figures and the strong increase in smartphone registration of records since the launch of an app (ObsMapp for Android) in 2012.

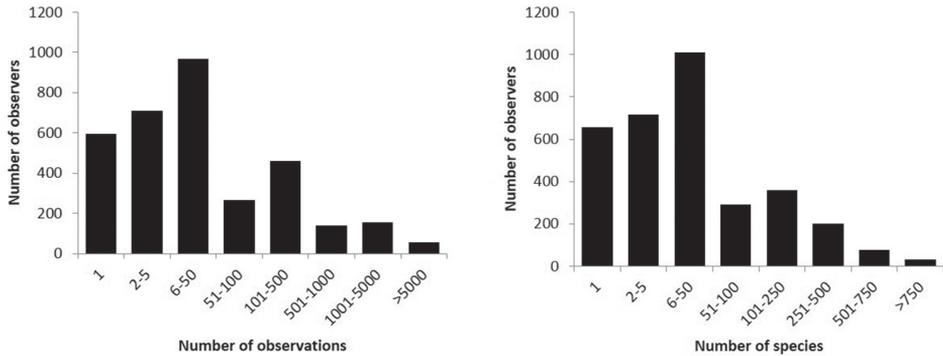


Figure 7. Frequency distribution of observers per number of observations (left) or species (right). Note the difference between the x-axis in the left and right y-axis.

Methods

Sampling description: Most observations (species, date, location, observer) were recorded by volunteers (citizen scientists). The dataset also includes historical records and datasets imported in waarnemingen.be. The large majority of records (95%) is a casual observation (presence only record). 5% of observations were registered as part of a species checklist. This is also recorded in the field *samplingProtocol*. The frequency distribution of number of observers per number of records or species is shown in Fig. 7.

Quality control description: Recorded data are verified by a group of botanical experts (including professional botanists), based on collected specimens, the observer's species knowledge, added photographs and known species list of locations. The validation procedure from www.waarnemingen.be consists of an interactive procedure in which observers can be asked for additional information by a team of validators, after which the validator manually adds a validation status. Manual validation focuses on rare species, species that are reported outside their known range and observations accompanied by pictures. Records that are not manually validated are additionally checked by an automated validation procedure that takes into account the number of manually validated observations of a species within a specified date and distance range. 12% of the plant records in this dataset are supported by photographs in www.waarnemingen.be. The validation status is indicated in the field *identificationVerificationStatus*, the link to the original record in *references*.

Datasets

Dataset description

The Plant occurrences in Flanders and the Brussels Capital Region, is an export from www.waarnemingen.be. The data were standardized to Darwin Core using a SQL query. The included terms are:

occurrenceID, type, language, license rightsHolder, accessRights, references, datasetID, institutionCode, datasetName, basisOfRecord, informationWithheld, dataGeneralizations, individualCount, sex, reproductiveCondition, establishmentMeans, samplingProtocol, eventDate, continent, countryCode, stateProvince, municipality, verbatimCoordinates, verbatimCoordinateSystem, verbatimSRS, decimalLatitude, decimalLongitude, geodeticDatum, coordinateUncertaintyInMeters, georeferenceRemarks, identificationVerificationStatus, taxonID, scientificName, kingdom, taxonRank, scientificNameAuthorship, vernacularName, nomenclaturalCode.

Generalized and/or withheld information: location information is generalized to 4×4 km² IFBL grid cells. Observer name, exact XY-coordinates, toponyms, and photographs are not included in the published dataset, but are stored in the source database. The dataset will be updated on GBIF on a regular basis (currently planned every two year).

Object name: Waarnemingen.be - Plant occurrences in Flanders and the Brussels Capital Region, Belgium

Format name: Darwin Core Archive format

Format version: 1.0

Character encoding: UTF-8

Language: English

License: <http://creativecommons.org/publicdomain/zero/1.0/>

Usage norms: <http://www.natuurpunt.be/normen-voor-datagebruik>

First publication date: 2016-12-23

Distribution: <http://dataset.inbo.be/planten-natuurpunt-occurrences>

DOI: <https://doi.org/10.15468/fyuklz>

Discussion

Since 2010, the number of plant observations registered annually is larger than all the records available in www.waarnemingen.be before 2008. Observations are currently mainly presence only records (95%). Presence is certain, absence of data can have multiple reasons: an IFBL grid cell was not visited, the species was not present/seen, the species was present but not registered in the database. For this reason, since the end of 2016, www.waarnemingen.be focusses more on lists and transect registration. During field work, the route can be tracked via the mobile app ObsMapp. At the end of the excursion, observers can indicate different types of lists, depending on whether: (1) the records are opportunistically collected presence only data (some records of some of the species encountered), (2) all individuals of selected species were registered, (3) all species were recorded or (4) all individuals of all species (more useful for animals than plants). This additional information allows to account for a better observation effort than currently is the case.

The most frequently and widespread observed plant in www.waarnemingen.be is *Urtica dioica*. This species was in Van Landuyt et al. (2006) also the most widespread plant. The other plants on the top 10 of most frequently recorded plants shows there is bias in the data collected by the plant observers of [waarnemingen.be](http://www.waarnemingen.be). Species like *Poa annua* or *Sagina procumbens* should be seen much more than striking species like *Cardamine pratensis*, *Filipendula ulmaria* and *Anemone nemorosa*. This might be explained by the observers' lack of interest in very common species (Mair and Ruete 2016). Furthermore, spatial biases are expected since the data is collected opportunistically without mandatory sampling protocol (Geldmann et al. 2016). Sampling bias related to variation in recorder activity has been grouped in four main categories by Isaac et al. (2014): 1) uneven recording intensity over time, 2) uneven spatial coverage, 3) uneven sampling effort per visit and 4) uneven detectability. We aim to understand these biases better by stimulating the use of species lists rather than the collection of presence only data.

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Typifications for *Galactia purshii* and *G. volubilis* (Fabaceae)

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Abstract

The pervasive difficulties encountered with studying *Galactia* in the eastern USA necessitate additional typifications to stabilize the taxonomy. *Galactia purshii* is lectotypified here as the earliest available but overlooked name for a fairly common species of the Atlantic Coast and peninsular Florida. *Galactia volubilis* is epitypified here since the characterization of the species has been limited by its lectotype being an illustration. A lectotype is designated for *Galactia pilosa* var. *angustifolia*, a form with narrow leaves here considered synonymous with *G. volubilis*.

Keywords

Galactia brachypoda, *Galactia glabella*, *Galactia michauxii*, *Galactia regularis*, *Galactia volubilis*

Introduction

Galactia P.Browne (1756: 298) comprises about 100 species, of which only a few are found in the Old World (Rogers 1949, Nesom 2015). Both the genus and its species can be difficult to define. Some characters of the genus include a four-lobed calyx, papilionaceous corolla, and dehiscent fruits (Fawcett and Rendle 1920, Burkart 1971, Nesom 2015). In the USA, *Galactia* is most diverse in Texas and Florida (Nesom 2015).

The 10–15 species of *Galactia* in the eastern USA (including Florida) have had a turbulent taxonomic history, with the application of many names being excessively multifarious. Studies of type specimens and taxonomic history in *Galactia* require meticulous scrutiny. Typifications are still needed to further stabilize taxonomy in *Galactia*. A lectotype is designated for *G. purshii* Desv. and its application is discussed. An epitype is designated for *G. volubilis* (L.) Britton and a lectotype is designated for one of its synonyms, *G. pilosa* Nutt. var. *angustifolia* Torr. & A.Gray.

Typification

Galactia purshii Desv., *Ann. Sci. Nat. (Paris)* 9: 413. 1826

Figs 1, 2

Galactia purshii Desv., *Ann. Sci. Nat. (Paris)* 9: 413. 1826. *Galactia glabella* DC., *Prodr.* 2: 238, 1825 *nom. illeg.* (Art. 53.1) non *G. glabella* Michx. *Fl. Bor.-Amer.* (Michaux) 2: 62. 1803 *nom. illeg.* (Art. 52). **Lectotype** (designated here): Carol. [Carolina] mer. [meridionale], *Fraser s.n.* (G [G00726366]).

=*Galactia floridana* Torr. & A.Gray var. *longeracemosa* Vail, *Bull. Torrey Bot. Club* 22: 505. 1895. **Lectotype** (designated by Nesom 2015): USA, Florida, 1889, *Simpson s.n.* (US; isolectotypes, MU, US). **syn. nov.**

=*Galactia michauxii* A.R.Franck, *Phytologia* 99: 148–149. 2017. **Type:** USA, Florida, Palm Beach Co., W side of US 1, Juno Beach area, 21 Apr 1962, *Lakela 24958* (holotype, USF; isotype, FSU). **syn. nov.**

Remarks. One species of *Galactia* found along the Atlantic Coast and Florida peninsula, USA, that still lacks stable nomenclature is characterized by its strigose stems that are prostrate to occasionally twining or climbing, petioles usually shorter than the terminal leaflet, leaflets often drying to a darkened or brownish color with conspicuous reticulate venation adaxially and prominent secondary venation abaxially, flower buds usually acuminate at the apex, and non-villous flowers 10–18 mm long not drying reddish that are often congested together near the apex of the inflorescence. The earliest applicable name for this species is *G. purshii*, a name chiefly ignored, and the recently introduced *G. michauxii* A.R.Franck is a synonym. This species had previously gone under several misapplied names, including *G. glabella* Michx., *nom. illeg.* (Pursh 1814, Nuttall 1818, Elliott 1824, Candolle 1825, Torrey and Gray 1838–1840, Chapman 1860, Britton 1881, Duncan 1979), *G. regularis* (L.) Britton et al. (Britton et al. 1888, Vail 1895, Small 1903, Small 1933, Rogers 1949, Long and Lakela 1971, Wunderlin 1982, Gleason and Cronquist 1991, Isely 1998), *G. volubilis* (Ward and Hall 2004, Wunderlin and Hansen 2011), and *G. brachypoda* Torr. & A.Gray (Nesom 2015, 2017). Due to the scarcity of specimen citations, it is often difficult to know if the species concepts of these authors were wholly equivalent to *G. purshii* or had conflated *G. purshii* with other species.

The first description of the taxon here referred to as *G. purshii* may be attributable to Michaux (1803), who supplied a brief and somewhat insufficient description. He introduced the name *G. glabella*, probably partly based on one of his own specimens (P [P00680461], Nesom 2015: fig. 6, Franck 2017a: fig. 15), and gave its distribution as Carolina and Georgia. This sterile specimen has narrowly ovate and brownish leaflets with conspicuous reticulate venation, leafy curvaceous stems, and one leafless twining stem. The twining stem is a disconnected fragment twining around the leafy stems. Assuming all stems are of the same plant, the Michaux specimen is consistent with *G. purshii* (Duncan 1979 [as *G. glabella*], Franck 2017a [as *G. michauxii*]). The Michaux specimen is similar to other specimens of *G. purshii* that have some moderately twining stems such as *Daoud 49* (USF) from North Carolina, *Kral 11078* (USF) from Virginia, and *Seymour 91 7 20* (USF) from Virginia, each of which had been previously annotated with three different names: *G. glabella*, *G. regularis*, and *G. volubilis*. The Michaux specimen had also been identified as *G. volubilis* partly because of the twining found on the specimen (Nesom 2015). However, *G. volubilis* usually has profusely twining stems and leaflets that dry to a light green and have obscure, inconspicuous reticulate and secondary venation unlike the Michaux specimen. The leaflet shape and stem vestiture also do not seem consistent with *G. mollis* Michx. or *G. regularis*, which also occur in the Carolinas and Georgia.

Nevertheless, *G. glabella* is an illegitimate name because Michaux cited the earlier name *Ervum volubile* Walter in synonymy, thereby adopting the type of *E. volubile* (McNeill et al. 2012: Art. 52, Franck 2017a). *Ervum volubile* (= *G. glabella*) so far remains untypified. Within *Galactia* its precise application may be relatively inconsequential since its specific epithet is blocked by *G. volubilis* (L.) Britton. Additionally, the species of *Galactia* in the eastern USA are likely to remain in *Galactia* as they appear to be closely related to the type species of *Galactia*, *G. pendula* Pers., and part of a monophyletic clade based on a recent DNA phylogeny (Queiroz et al. 2015).

Pursh (1814: 487) adopted the name *G. glabella* and expanded Michaux's description by adding the Latin terms "prostrata, subvolubilis, foliis ternatis utrinque glabris, racemis axillaribus simplicibus abbreviatis paucifloris" [prostrate, partly twining, leaflets three both sides glabrous, raceme axillary singular short few-flowered], and "leguminibus villosis" [legume villous]. With the annotation "v.v." he noted he had made field observations of this species. Pursh stated that the flowers were "extremely pretty, purple, red and white mixed." His description of purple flowers matches *G. purshii* but the red flower color and villous legume seem to pertain more to *G. mollis* (Radford et al. 1968: 644), possibly indicating Pursh had included more than one species in his description. Pursh gave the distribution as New Jersey to Carolina and cited *E. volubile* of Walter and *Dolichos regularis* of Willdenow (1803) in synonymy. Willdenow (1803: 1049) had simply repeated the description of *D. regularis* from Linnaeus.

Nuttall (1818: 117) continued the use of *G. glabella*, with his description closely matching that of Pursh (1814). Nuttall added that the leaves were subcoriaceous and lucid, racemes pedunculate and a little shorter than the leaves, flowers pedicellate, and legumes smooth. Under *G. mollis*, Nuttall stated that "In Herb. Muhl. [*G. mollis* was]

confounded with *G. glabella*,” supporting the notion that Pursh may have also conflated *G. mollis* with his concept of *G. glabella*. *Galactia glabella* was also recognized by Elliott (1824: 239).

Candolle’s (1825: 238) Latin description of *G. glabella* was nearly verbatim of Pursh (1814), but added that the flowers were pedicellate as Nuttall (1818) had also described. Candolle mentioned that the legume was villous based on Michaux and Pursh but was glabrous based on Nuttall and his own observations. Anent this discrepancy he stated “An duae spec. confusae?” Since Michaux never described the fruits in the protologue, perhaps Candolle observed a Michaux specimen labeled *G. glabella* with villous fruits, a character which would be more like *G. mollis*. In synonymy Candolle listed *E. volubile* Walter and *D. regularis* L.

In Desvau’s (1826) account of *Galactia*, he included descriptions for five species. For his first species he introduced the name *G. purshii*, validated solely by the description of *G. glabella* given by Candolle (1825: 238). I could find no explanation for its etymology, but it presumably honors Frederick Pursh. Desvau considered *G. glabella* and its listed synonyms (Candolle 1825: 238) to be misapplied to the newly coined *G. purshii*. Desvau excluded the synonyms listed by Candolle (*E. volubile* and *D. regularis*) with the abbreviation “excl. syn.” By excluding *E. volubile*, Desvau excluded *G. glabella* since it is a superfluous name homotypic with *E. volubile*. Furthermore, for his second species, Desvau (1826) listed and provided a separate description for *G. glabella* of Michaux, and included *G. pilosa* as its synonym. *Galactia pilosa* is currently considered a synonym of *G. mollis* and the ambiguously described *E. volubile* (= *G. glabella*) might also be conspecific with *G. mollis* (Franck 2017a). Desvau’s description of *G. glabella* could fit the current concept of *G. mollis* or *G. volubilis*. Desvau errantly cited page 64 instead of page 62 for the protologue of *G. glabella* Michx.

After Desvau’s (1826) treatment, *G. purshii* was abandoned from usage, treated as a synonym, or considered illegitimate. The name *G. glabella* continued to be utilized (Torrey and Gray 1838–1840: 287, Chapman 1860: 109, Britton 1881: 27), although it is difficult to ascertain if its taxonomic concept was completely equal to the concept of *G. purshii* here. *Galactia glabella* was then considered a synonym of *G. regularis* without mention of *G. purshii* (Britton et al. 1888: 14, Jackson 1893: 987, Small 1903: 650, Small 1933: 719, Long and Lakela 1971: 493, Gleason and Cronquist 1991: 305, Isely 1998: 569). Vail (1895) listed both *G. glabella* and *G. purshii* as synonyms of *G. regularis*. Duncan (1979) resurrected the use of *G. glabella*, including *G. purshii* in synonymy and separating it from *G. regularis*, and some specimens at USF were annotated by Nesom as *G. glabella*. Ward and Hall (2004) included *G. glabella* as a synonym of *G. volubilis*.

Galactia purshii is a legitimate name since its protologue unequivocally excluded *D. regularis*, *E. volubile*, and *G. glabella*. Since *G. purshii* is validated by Candolle’s description (1825: 238), any specimens seen by Candolle for his treatment should be considered original material (McNeill et al. 2012: Arts. 7.7 and 9.3, note 3). Candolle’s (1825) annotation “(v.s.)” indicated he had seen specimens. There are two specimens in the Candolle herbarium together on one sheet, labeled in Candolle’s handwriting (Burdet 2017) as “*Galactia glabella* Nutt. Michx.” (Fig. 1). The specimen on the right (G00726367) is



Figure 1. Sheet at G labeled *Galactia glabella* by Candolle. The specimen on the left is the lectotype of *G. purshii* (G00726366). The specimen on the right is *G. volubilis* (G00726367). Conservatoire et Jardin botaniques de la Ville de Genève.

G. volubilis, twining and with ovate lightly glaucous leaflets drying pale greenish with inconspicuous secondary and reticulate venation. The John Fraser specimen on the left (G00726366, Fig. 2) is consistent with *G. glabella* sensu Candolle (1825); it has leaflets drying to a dark brown adaxially with conspicuous abaxial secondary and reticulate venation, and flowers ca. 13 mm long. The indumentum of the stem is retrorsely strigose and of the calyx abaxially antrorse but scant (L. Gautier, pers. comm.). A phrase written on the label “An *Ervum* Walter” indicated an association with the modern sense of *Galactia*. This Fraser specimen must have come from L’Héritier’s herbarium, which was purchased by Candolle in 1805 (Gray 1889, Stafleu 1966, Brummitt 1972), and can be considered part of the original material. The Fraser specimen (Figs 1–2) is designated here as the lectotype of *G. purshii*. The specimens cited for *G. michauxii* by Franck (2017a: Appendix 1) are here identified as *G. purshii*, with *G. michauxii* being a later synonym.

Recent descriptions for *G. fasciculata* Vail, such as having strigose stems (Nesom 2015, 2017), may apply to specimens here considered to be *G. purshii*. However, the indumentum of the type specimens of *G. fasciculata* appears more similar to the villous stems of *G. floridana* (Isely 1998, Franck 2017a). *Galactia fasciculata* was described as prostrate or climbing high by Vail (1895), whereas Nesom (2015, 2017) described it as high-climbing with coiling stems. The holotype label stated “climbing on small shrubs.” Additional study is needed to determine if a high-climbing habit is a reliable and distinctive character since it can only be confidently ascertained from living plants and field observations. Ward and Hall (2004) considered *G. fasciculata* very rare while Nesom (2015, 2017) considered it an endemic of central peninsular Florida.

The stem indumentum of the holotype of *G. floridana* Torr. & A.Gray var. *longeracemosa* Vail does not appear to be villous like *G. floridana*, but appears more like *G. purshii*. *Galactia floridana* var. *longeracemosa* is considered here to be a synonym of *G. purshii*. The holotype of *G. floridana* var. *longeracemosa* was probably collected by Joseph H. Simpson relatively near to Bradenton, Manatee Co., Florida where he had lived (Small 1919; Harper 1948).

The name *G. brachypoda* was apparently misapplied (Nesom 2015, 2017) to specimens here considered to be *G. purshii*. *Galactia brachypoda* was first described by Torrey and Gray (1838–1840), who indicated the habit as not twining with a two foot long flexuous stem, the calyx villous, and the flowers half as large as *G. glabella* (*G. glabella* sensu Torrey & Gray probably being misapplied to *G. purshii*). Chapman (1860), who collected the two type specimens of *G. brachypoda* (NY), described it as erect, 1–1.5 feet high and with a woolly calyx, noting his descriptions were “all my own, copying no one, when I knew the plant” (Chapman 1839–1890: 4 Apr 1959). On the label of the presumed holotype Chapman wrote “seems to come between *G. mollis* & *G. sessiliflora* [= *G. erecta* (Walt.) Vail]” which was later crossed out by a different pen, possibly by Torrey who also added what appears to be “*brevipedunculata* n. sp.” to the same label. Vail (1895) described its calyx as “clothed with spreading” hairs, the lower calyx lobes acutish, corolla 8–10 mm long, and the “vexillum” 7–8 mm long, which Small (1903) mostly repeated. All of these observations are consistent with the type specimens of *G. brachypoda*, none of which match the concept of *G. purshii*.

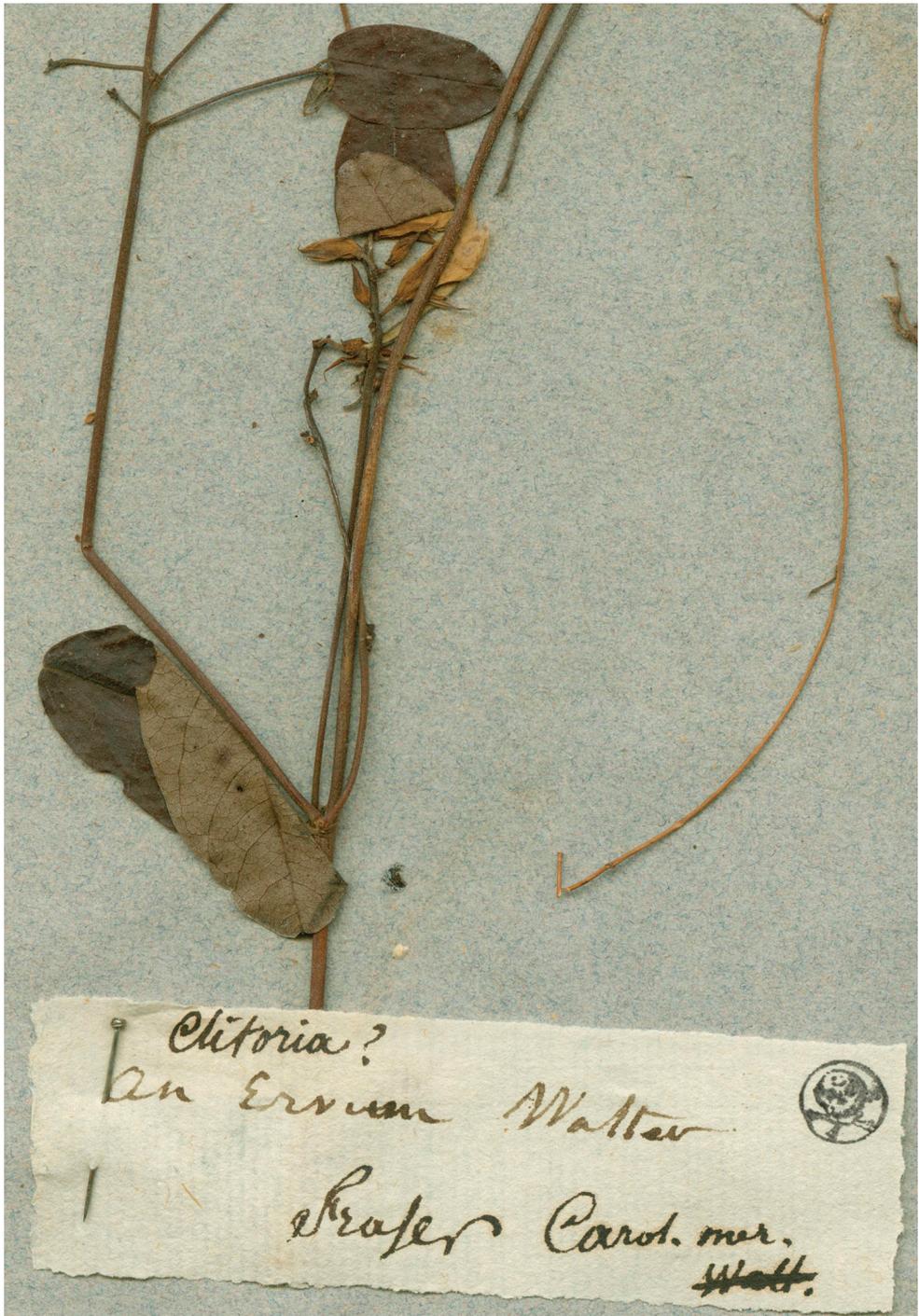


Figure 2. Close-up of the lectotype of *G. purshii* (G00726366). The stem fragment on the right appears to be from the specimen of *G. volubilis*. Conservatoire et Jardin botaniques de la Ville de Genève.

The habit of *G. brachypoda* has sometimes been described as similar to *G. purshii*. However, the descriptions of a decumbent (Vail 1895, Small 1903, Small 1933), ascending or sprawling (Isely 1986), procumbent (Nesom 2015), or prostrate habit (Nesom 2017) for *G. brachypoda* appear to be based on speculation from specimens and not field observations. While it was conjectured that it was impossible for *G. brachypoda* to be erect because its type specimens had stems to 37 cm long (Nesom 2017), another collection identified as *G. brachypoda* (Anderson 15642 [FSU, GA]) with stems well over 40 cm long described on its label “robust, erect plants with limited twining” and was noted to be very similar to the type specimens of *G. brachypoda* (Franck 2017a, Nesom 2017). Furthermore, stems of some specimens of the erect *G. erecta* can reach 32–36 cm long (e.g. *Biltmore 3956a* [NY], *Horn 1032* [DUKE], *Orzell & Bridges 14271* [USF], *Rugel 150* [NY]). It does not appear to be impossible for *G. brachypoda* to be erect and have stems to 37 cm long. The characterization of *G. brachypoda* as erect by Chapman (1860) and Anderson 15642 is considered here to be accurate.

Numerous authors noted a semblance of *G. brachypoda* with *G. erecta* (Rogers 1949, Ward and Craighead 1990, Isely 1998, Ward and Hall 2004, Franck 2017a), while others also noted a similarity to *G. mollis* (Chapman’s notes on the holotype of *G. brachypoda*, label notes of Anderson 15642, Franck 2017a). The acutely-tipped flower buds and relatively small reddish-drying flowers of the type specimens of *G. brachypoda* are features shared with *G. erecta* and *G. mollis*. The erect habit and elliptic leaflets with relatively long petioles of the type specimens of *G. brachypoda* are more similar to *G. erecta*. If the inflorescences of the type specimens of *G. brachypoda* are interpreted as immature (Nesom 2017), the sizes of the flower buds and corolla (including the individually mounted petals of the holotype) are still rather small compared to *G. purshii*. The long stems, pedunculate inflorescences, and villous calyces of the type specimens of *G. brachypoda* are more similar to *G. mollis*. However, inflorescences of *G. erecta* can occasionally be pedunculate, with a peduncle to 14 mm long in *Harper s.n.* (NY [02569186]). Nesom (2017) characterized the calyx of *G. brachypoda* as “very sparse,” dissimilar to other observations of the calyx as villous (Torrey and Gray 1838–1840), woolly (Chapman 1860), or “clothed with spreading” hairs (Vail 1895). Another rather odd specimen (*Duncan 17113* [GA]) seems to mix features of *G. erecta* and *G. mollis* in that it has sessile inflorescences and long petioles like *G. erecta* and long, partly twining stems like *G. mollis*. Lastly, the left-most plant of a Chapman collection at MO (793008) appears erect like *G. erecta* but has shortly pedunculate inflorescences and indumentum more like *G. mollis*.

There are two known type specimens of *G. brachypoda* at NY (00008088 and 00008090), although there is a third specimen (NY [00008089]) that was labeled as *G. brachypoda* in Chapman’s handwriting. This third specimen is clearly *G. erecta*. It had been proposed that other authors were attempting to make two species out of *G. erecta* with the use of the name *G. brachypoda* through the study of this *G. erecta* specimen labeled as *G. brachypoda* (Nesom 2015, 2017). This specimen consists of plants ca. 13 cm tall with sessile inflorescences. Among authors who recognized both *G. brachypoda*

and *G. erecta*, this specimen matches their concepts of *G. erecta*, and is clearly incongruent with their concepts of *G. brachypoda* (Torrey and Gray 1838–1840, as *G. sessiliflora* Chapm., Chapman 1860, Vail 1895, Small 1903). The discordance of this specimen with Chapman's (1860) concept of *G. brachypoda* suggests the possibility of a labeling error. Vail annotated the holotype of *G. brachypoda*, but not this *G. erecta* specimen. This *G. erecta* specimen was otherwise annotated only by Anita F. Cholewa in 1986, erroneously as a probable isotype of *G. brachypoda*. When Isely (1986) mentioned that *G. brachypoda* could be a "freak form" of *G. erecta*, he also stated that there were "two Chapman sheets [of *G. brachypoda*] at NY" and that *G. brachypoda* had pedunculate inflorescences, unlike this *G. erecta* specimen. Ward and Craighead (1990) speculated *G. brachypoda* was "probably an aberrant form" of *G. erecta*, and later Ward and Hall (2004) also stated that *G. brachypoda* was "based upon two A.W. Chapman specimens (NY)." The evidence does not support the idea that this specimen (NY [00008089]) nor any other of *G. erecta* was used to formulate concepts of *G. brachypoda*. I concur with previous botanists that *G. brachypoda* is closely related to *G. erecta* and *G. mollis*, and numerous features associated with the type specimens of *G. brachypoda* (i.e., its erect habit, elliptic leaflets on a long petiole, acutely-tipped flower buds, villous calyx, and relatively small reddish-drying flowers) are inconsistent with *G. purshii*.

***Galactia volubilis* (L.) Britton, Mem. Torrey Bot. Club 5: 208. 1894**

Figs 3, 4

Galactia volubilis (L.) Britton, Mem. Torrey Bot. Club 5: 208. 1894. *Hedysarum volubile* L., Sp. Pl. 2: 750. 1753. **Lectotype** (designated by Reveal & Jarvis 2009: 979): Dillenius, Hort. Eltham. t. 143., f. 170. 1732. **Epitype** (designated here): USA, Florida, Lafayette Co., NFMYC [North Florida Methodist Youth Camp, Mayo], 13 Jun 1964, Caudle *et al.* 5744 (epitype, USF; probable isoeotypes, Caudle *et al.* 5292A, FLAS, Caudle *et al.* 5292B, FTG).

=*Galactia macreei* M.A.Curtis, Boston J. Nat. Hist. 1: 120. 1835. *Galactia pilosa* Nutt. var. *macreei* (M.A.Curtis) Torr. & A.Gray, Fl. N. Amer. 1: 287. 1838. **Type**: USA, North Carolina, Curtis *s.n.* (probable holotype, GH [00002425], photograph in Rogers 1949: 88, pl. 22).

=*Galactia pilosa* Nutt. var. *angustifolia* Torr. & A.Gray, Fl. N. Amer. 1: 287. 1838. *Galactia volubilis* (L.) Britton var. *intermedia* Vail, Bull. Torrey Bot. Club 22: 508. 1895 *nom. illeg.* (Art. 52). **Lectotype** (designated here): USA, Florida, *Lt. Alden s.n.* (lectotype, NY [02569414]).

Remarks. Precise measurements of flower size and plant indumentum can be essential towards the application of names in *Galactia* as demonstrated by Duncan (1979) for *G. regularis*. Since *G. volubilis* is lectotypified by an illustration, an epitype would be useful to help secure the application of *G. volubilis* and further allay any possible confusion with other taxa. No information is known for the provenance of the *G. volubilis*

plant in Sherard's garden, which was used for the Dillenius lectotype illustration. An epitype was sought here that closely matches the morphology supplied by Dillenius.

Caudle et al. 5744 (USF) (Fig. 3) is chosen here as the epitype of *G. volubilis* because it is very consistent with the Dillenius lectotype and the description given by Dillenius (1732). The stems of both the lectotype and epitype are moderately sinuous with retrorsely hirsute indumentum. A close-up image of the stem indumentum of *Caudle et al. 5744* is given in Franck (2017a: fig. 40). The leaflets are lanceolate-ovate in both the lectotype and epitype. The leaflets of the epitype are glaucescent abaxially consistent with the Dillenius (1732) description "prona pallidiora & glaucescentia." The adaxial secondary venation of the leaflets is discernible while reticulate venation is obscured in both the lectotype and epitype. The flower length is ca. 70% of the maximum leaflet width in the lectotype and ca. 75% in the epitype. The flower fascicles of both are relatively distant along the inflorescence.

Two other specimens, *Caudle et al. 5292A* and *5292B*, are very likely isoeotypes. In all features, they are markedly identical in morphology to the epitype, including the development of inflorescences with only immature fruits. The collection numbers of the labels are different but they do not appear to be traditional collection numbers. The specimens were gathered by several undergraduate students as part of a few National Science Foundation (NSF) grants awarded to Margaret L. Gilbert, the curator of the Florida Southern College herbarium (FSCL, now incorporated into USF). It appears this sequence of collection numbers was given to any specimen under the purview of these NSF grants, and were simply sequentially added as the specimens were processed back at the herbarium. It seems likely that these *G. volubilis* specimens were gathered by one group of students but later processed separately resulting in their sequential separation. Although several students and the curator were all involved with the field work, Carol F. Caudle (now Carol Baskin) related that she herself was the main person responsible for the herbarium specimens (Franck 2017b). No collectors were named on the original label but Caudle has been credited as the probable main collector.

The concept of *G. pilosa* sensu Torrey and Gray (1838–1840) matches the sense of *G. volubilis* here (Franck 2017a). One variety introduced by Torrey and Gray was " γ . *angustifolia*" and its range was given as " δ . Middle Florida, *Croom!* East Florida, *Lieut. Alden!*" The mismatched greek symbols, γ for the name and δ for the range, must have been an error. There is a sheet at NY with both syntypes mounted on it that was annotated by Rogers as *G. macreei* in 1947 and *G. volubilis* in 1948 (Fig. 4). On the right is the Croom specimen (NY [02569415]), which likely came from near Croom's properties in the Florida panhandle (Troyer 2002). On the left is the Alden specimen (NY [02569414]), which is labeled as *Galactia pilosa* var. *angustifolia*. Alden was stationed at Fort Brooke (Tampa, Florida) in 1832 and Fort King (Ocala, Florida) from 1832–1833 (Cullum 1891: 488; Harper 1948), and his specimen likely came from near these areas. The leaflet shapes of both specimens are narrowly oblong-ovate, being 3–6 times as long as wide and usually being widest near the base of the leaflet. The Alden specimen is selected here as the lectotype since it exemplifies the exerted long inflorescence and distantly spaced flower fascicles of *G. volubilis*.

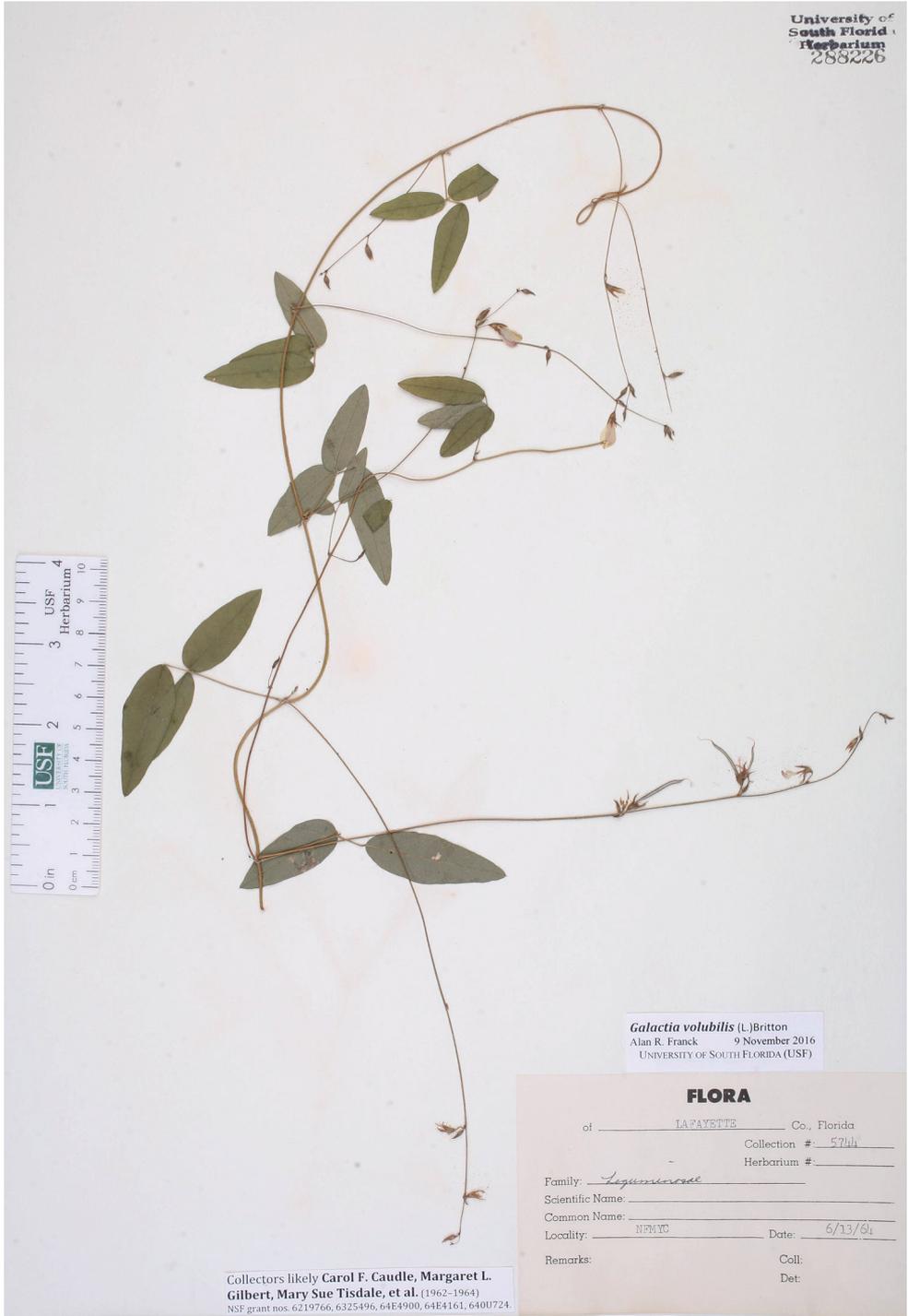


Figure 3. Epitype of *G. volubilis* at USF.



Figure 4. The Alden specimen on the left is selected as the lectotype of *G. pilosa* var. *angustifolia*; the specimen on the right was collected by Croom. This image belongs to The C. V. Starr Virtual Herbarium (<http://sweetgum.nybg.org/science/vh/>).

The leaflet shape of *G. pilosa* var. *angustifolia* approaches *G. austrofloridensis* A.R.Franck, but fits within the variation of *G. volubilis*, matching other specimens with narrow leaflets such as *Correll 51775* (USF), *Hansen 5972* (USF), *Hansen 9896* (USF), and *Popenoe 2080* (USF). The linear-oblong leaflets (> 4 times as long as wide) of *G. austrofloridensis* only subtly distinguish it from *G. volubilis*. One collection from the West Indies, *Correll & Correll 47675* (FTG, NY) from the Bahamas, appears identifiable as *G. austrofloridensis*. *Galactia grisebachii* Urb., possibly endemic to Cuba (e.g. *León 7461* [NY]), has similarly linear-oblong leaflets (Nesom 2017) but seems to differ by its consistently short inflorescences (Franck 2017a). The poorly characterized *Galactia parvifolia* A.Rich., of the Greater Antilles and Bahamas, is similar to *G. grisebachii* but may differ by its lateral leaflets often being ca. ½ as long as the terminal leaflet (Urban 1900, Franck 2017a).

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A new combination and taxonomic notes in *Pseudobombax* Dugand (Malvaceae)

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Abstract

Taxonomic notes in the Neotropical genus *Pseudobombax* (Malvaceae) are presented. One new combination and two new heterotypic synonyms for taxa originally described from Brazil and Ecuador are proposed based on both morphological and previously published molecular evidence. The taxonomic changes will be adopted in a treatment of *Pseudobombax* for the upcoming Brazilian Flora 2020 and in a forthcoming revision of the genus throughout its range.

Keywords

Bombacoideae, *Bombax*, Brazilian Flora 2020, nomenclature, synonymy

Introduction

Field and herbarium studies of the Neotropical genus *Pseudobombax* Dugand (Malvaceae) along with previously published molecular phylogenetic studies (Carvalho-Sobrinho et al. 2016) revealed that taxonomic changes are needed in the genus. Nomenclatural changes are proposed herein for taxa that will be included in a monograph of *Pseudobombax* for Brazil (Carvalho-Sobrinho in prep.), which is being prepared for the upcoming Brazilian Flora 2020 (<http://floradobrasil.jbrj.gov.br/>). The changes also will be incorporated in a taxonomic revision of the genus throughout its range.

Methods

Taxonomic literature related to *Pseudobombax* was evaluated in order to check typifications and synonymies of taxa. Information about type specimens was derived from protologues and checked against major online nomenclatural indices (Tropicos – <http://www.tropicos.org/>; JSTOR Global Plants – <https://plants.jstor.org>). Herbarium abbreviations follow *Index Herbariorum* (Thiers 2017). Type specimens that have been examined in person by the first author are followed by exclamation marks. When digital images were discovered online, a barcode number is given for the specimen followed by its source.

Nomenclatural changes

Pseudobombax majus (A. Robyns) Carv.-Sobr., comb. & stat. nov.

urn:lsid:ipni.org:names:60474975-2

Basionym. *Pseudobombax grandiflorum* var. *majus* A. Robyns, Bull. Jard. Bot. État Bruxelles 33(1): 56. 1963. — Type: Brazil. Minas Gerais: Viçosa, Chacha Valley, near Chacha House, 17 May 1930, *Y. Mexia* 4711 (holotype: F! [F neg. 57390, F0052177F, JSTOR image]; isotypes: BM [BM000645666, JSTOR image], G!, K! [K000913925, JSTOR image], MO! [MO-357466, JSTOR image], NY! [NY133608, JSTOR image], P! [P06622849, JSTOR image], S! [S10-38043], U [U0000789, JSTOR image], US! [US00101966, JSTOR image], VIC!, WIS!).

Notes. Robyns (1963) proposed *Pseudobombax grandiflorum* var. *majus* based on specimens with longer pedicels and staminal tubes as well as wider calyces and petals than are found in the nominate variety. Analysis of the protologue and type material of this variety and the nominate one, along with a comprehensive examination of herbarium specimens, reveals that *P. grandiflorum* var. *majus* is also morphologically distinct from the nominate variety in having mostly 9–11 (vs. mostly 5) leaflets (7 leaflets rarely occur in both taxa), often 3–7-flowered cymes (vs. flowers solitary, rarely 2–3-flowered cymes), and 5-angulate (vs. 5-costate) fruits in cross-section. Moreover, *P. grandiflorum* var. *majus* has calyces that are urceolate (vs. cupuliform) and often lobed (vs. truncate).

In addition to these morphological differences, the two taxa can be distinguished by their distribution in Eastern Brazil. *Pseudobombax grandiflorum* var. *majus* inhabits semi-deciduous forests and occasionally granitic outcrops in wet forests whereas the nominate variety inhabits mainly coastal restinga vegetation. Thus, morphological evidence along with the parapatric distribution are sufficient to recognize *Pseudobombax grandiflorum* var. *majus* at species rank.

Pseudobombax majus can be distinguished from its sister species *P. longiflorum* (Mart.) A. Robyns (Carvalho-Sobrinho et al. 2016: fig. 2), a widespread species in South American savannas, by its cuneate (vs. truncate) leaflets, shorter (c. 10 vs. 16–50 mm long) petiolules, and its 5-angulate (vs. circular) fruits in cross-section.

***Pseudobombax millei* (Standl.) A. Robyns, Bull. Jard. Bot. État Bruxelles 33: 69. 1963.**

Basionym. *Bombax millei* Standl., Trop. Woods 45: 16. 1936. — Type: Ecuador. Sept 1929, *L. Mille* 868 (holotype: F! [F0052111F, F0052112F, JSTOR image]).

= *Pseudobombax guayasense* A. Robyns, Bull. Jard. Bot. État Bruxelles 33(1): 68. 1963. — Type: Ecuador. Guayas: vicinity of Guayaquil, Cerro Azul, 10 Sept 1955, *E. Asplund* 17588 (holotype: S! [S10-39074, S10-39076, S-R-11308, JSTOR image]!; isotypes: BR [BR0000006961367, JSTOR image], NY! [NY00133609, JSTOR image]), **syn. nov.**

Notes. The characters (leaflet shape, calyx dimensions, and pubescence of staminal tubes) used by Robyns (1963) to segregate *Pseudobombax guayasense* are not sufficient to distinguish it from *P. millei* based on a more comprehensive sampling of herbarium collections. Previously, phylogenetic analyses of DNA sequences were interpreted as supporting the accessions examined of these two taxa as sister groups (Carvalho-Sobrinho et al. 2016: fig. 2), but we now consider *P. guayasense* to be a synonym of *P. millei* on the basis of combined morphological and molecular evidence.

***Pseudobombax munguba* (Mart.) Dugand, Mutisia 9: 4. 1952.**

Basionym. *Bombax munguba* Mart., Nov. Gen. Sp. Pl. 1: 93, t. 99. 1826. — Type: Brazil. Amazonas: Rio Negro, *Martius s.n.* (lectotype, designated by Robyns (1963): M! [M0211657, JSTOR image]).

= *Pseudobombax amapaense* A. Robyns, Mem. New York Bot. Gard. 17(1): 195. 1967. — Type: Brazil. Amapá: Rio Jari, near Cachoeira Miriti, 0°41'N, 53°6'W, 180 m, 25 Aug 1961, *W. A. Egler & H. S. Irwin* 46673 (NY! [NY00133605, NY00133606, NY00133607, JSTOR image]), **syn. nov.**

Notes. The characters (tree height and pubescence of staminal tubes) used by Robyns (1967) to segregate *P. amapaense* do not permit it to be distinguished from *P. munguba* based on a more comprehensive sampling in the field and in herbarium collections. Previously, phylogenetic analyses of DNA sequences were interpreted as supporting the accessions examined of these two taxa as sister groups (Carvalho-Sobrinho et al. 2016: fig. 2), but we now consider *P. amapaense* to be a synonym of *P. munguba* on the basis of combined morphological and molecular evidence.

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A new species of *Saracha* (Solanaceae) from the Central Andes of Peru

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Abstract

Saracha andina Rob. Fernandez, I. Revilla & E. Pariente, **sp. nov.** (Solanaceae), a new species endemic to the central Andes of Peru, is described here. The new species differs from other species of *Saracha* Ruiz & Pav. by the combination of small and coriaceous leaves and clearly tubular flowers. A summary of the taxonomic history of the genus *Saracha*, an identification key for its species and a phylogenetic analysis of this genus and related genera are provided.

Resumen

Saracha andina Rob. Fernandez, I. Revilla & E. Pariente, **sp. nov.** (Solanaceae), una nueva especie endémica de los Andes centrales del Perú se describe aquí. La nueva especie se distingue de las demás especies de *Saracha* Ruiz & Pav. por poseer hojas coriáceas pequeñas y flores claramente tubulares. Se proporciona un resumen de la historia taxonómica del género *Saracha*, una clave de identificación revisada para sus especies y un análisis filogenético del género y géneros afines.

Keywords

Saracha, Solanaceae, Peru, Andes, relict forests

Palabras clave

Saracha, Solanaceae, Perú, Andes, bosques relictos

Introduction

The genus *Saracha* Ruiz & Pav. (Solanaceae) comprises two species of sometimes armed shrubs and small trees, with subcoriaceous to coriaceous leaves, pendant campanulate to tubular flowers, and fruits that blacken when mature. The species are distributed from Venezuela to Bolivia from 2200 to 4500 m.a.s.l. (Alvarez 1996, Smith and Baum 2006). Some authors have postulated that the flowers of *Saracha* are entomophilous (Cocucci 1999, Knapp 2010), but field observations indicate that at least one species, *S. quitensis* (Hook.) Miers, is pollinated by hummingbirds (Alvarez 1996, Tinoco et al. 2009).

Despite its small size, *Saracha* presents a complex taxonomic history. In 1794, Ruiz and Pavón established the genus *Saracha* in their *Florae Peruvianae et Chilensis Prodrromus*, without describing any species or designating any type specimen. They presented only the generic description and an illustration. However, both match *Saracha punctata* Ruiz & Pav., which was described in the second volume of the *Flora Peruviana et Chilensis* (Ruiz and Pavón 1799). Therefore, according to Art. 40.3 of the International Code of Nomenclature (McNeill et al. 2012), *Saracha punctata* should be considered as the type species of the genus, as previously indicated by other authors (Gentry 1974, Miers 1853, Morton 1938). In the second volume, Ruiz and Pavón (1799) also described four new species, *Saracha biflora* Ruiz & Pav., *Saracha contorta* Ruiz & Pav., *Saracha dentata* Ruiz & Pav. and *Saracha procumbens* (Cav.) Ruiz & Pav., the latter four are now unanimously considered within the genus *Jaltomata* Schldtl. (Benítez 1976, D'Arcy et al. 1993, Gentry 1973, Mione and Yacher 2005, Mione et al. 2001, Mione et al. 2016).

Years later, Miers (1848) identified two groups within *Saracha*, one comprising shrub and tree species with campanulate flowers and the other comprising herbaceous species with rotate flowers. In 1848, he created a new genus (*Poecilochroma* Miers) for the first group, using *Saracha punctata* as the type. He described five new species of *Poecilochroma*, and transferred *Lycium quitense* Hook. to *Poecilochroma quitensis* (Hook.) Miers. For the second group, Miers (1849) created an amended description of *Saracha*, together with the description of ten new species and a list of previously published species.

Due to the type chosen for *Poecilochroma*, Miers had created a superfluous genus which therefore had to be rejected (Art. 52.1 of the International Code of Nomenclature; McNeill et al. 2012). In subsequent work, Miers (1853) identified his error and transferred of all recognized species in *Poecilochroma* to *Saracha*. Nevertheless, the problematic circumscriptions of the genera *Saracha* and *Poecilochroma* sensu Miers (1848, 1849) were widely used in subsequent studies (Dunal 1852, Benítez 1974, Macbride 1962, Miers 1849–1857, Walpers 1852–1853, Wettstein 1895), although these circumscriptions were disputed by some authors (Macbride 1930, 1962, Morton 1938).

The nomenclatural confusion was clarified by Gentry (1973), who restored the genus *Jaltomata*, corresponding to *Saracha* sensu Miers (1849). Further, Gentry (1974) discussed the typification of *Saracha* and reduced *Poecilochroma* to a synonym. These new re-circumscriptions of the genera *Saracha* and *Jaltomata* have been accepted and continue to be used in treatments of Solanaceae (Alvarez 1996, D'Arcy 1979, Hun-

ziker 2001, Mione et al. 1993). Currently, the names registered in *Saracha*, most of which were published by Miers (1849, 1853) and Bitter (1913, 1921, 1922, 1924a, 1924b), have become synonyms of the two accepted species of *Saracha* or transferred to *Jaltomata* (Alvarez 1996, Mione et al. 1993). The most recent treatment of *Saracha* (Alvarez 1996) recognized only two species, *S. punctata* and *S. quitensis*, although the former is divided among three subspecies.

Recent phylogenetic studies have clarified the evolutionary history of *Saracha*. The genus falls within the fleshy-fruited subfamily Solanoideae, but is distantly related to *Jaltomata* (Olmstead et al. 1999, 2008). Indeed, the closest relatives to *Saracha* belong to the genera *Acnistus* Schott, *Dunalia* Kunth, *Eriolarynx* (Hunz.) Hunz., *Iochroma* Benth. and *Vassobia* Rusby. Together, these six genera comprise the subtribe Iochrominae (Miers) Hunz., which along with the subtribes Physalinae (Miers) Hunz. and Withaninae Bohs & Olmstead form the tribe Physaleae sensu Olmstead et al. (1999, 2008). *Saracha* species do not form a monophyletic group due to the nested placement of *Dunalia solanacea* Kunth, a species which differs dramatically in form from *Saracha* (Smith and Baum 2006, Cueva et al. 2015). Nonetheless, like *Saracha*, *D. solanacea* is restricted to the Andes and produces black fruits (unlike the remaining species of Iochrominae).

During botanical collections carried out in the Department of Ayacucho as part of the “Inventario Nacional Forestal-Ecozona Sierra” in 2015, individuals were collected with clear affinities to the genus *Saracha*. After molecular phylogenetic analysis and the review of additional material across Peru, these individuals have been recognized as a distinct undescribed species. In this article, we provide a complete description of this new species, along with ecological information and a revised identification key for the genus.

Methods

The description was made through examination of herbarium specimens deposited in COLO, F, HSP, MO, MOL and USM (acronyms according to the Index Herbariorum, <http://sweetgum.nybg.org/science/ih/>), and notes taken during the study of individuals in the field. Conservation status was assigned using IUCN criteria (2012), combining field information, bibliographic data on habitat and geographic distribution based on herbarium specimens.

For molecular phylogenetic analysis, genomic DNA was extracted from silica-dried plant material (*S. Smith & R. Fernandez 594*) using the CTAB method (Doyle and Doyle 1987). We amplified and sequenced three gene regions: *LEAFY* intron II, exons 2 through 9 of the granule-bound starch synthase gene (*waxy*), and the internal transcribed spacer (ITS), following protocols described in Smith and Baum (2006). The sequences were edited and aligned to Iochrominae sequences from previous studies (e.g., Cueva et al. 2015) using MacClade 4.0 (Maddison and Maddison 2000). The Genbank numbers for *Saracha andina* sequences are KY172040 (*LFY*), KY172039 (*waxy*) and KY172041 (ITS). The phylogenetic placement of *S. andina* was inferred

using maximum-likelihood analysis of the combined dataset in raxML 7.0.4 (Stamatakis 2006). We carried out model selection with likelihood ratio test in PAUP 4.0b10 (Swofford 2002) and compared the following models: JC, K2P, HKY, GTR and GTR+ Γ . We conducted a partitioned likelihood search in raxML using the best model (GTR+ Γ) and completed 100 bootstrap replicates to estimate support.

Taxonomic treatment

Saracha andina Rob.Fernandez, I.Revilla & E.Pariante, sp. nov.

urn:lsid:ipni.org:names:60474974-2

Figures 1–2

Saracha andina affine *S. punctata* Ruiz & Pav., sed foliis coriaceus parvus, corolla tubularis et bacca ovoideus differt.

Type. PERÚ. **Ayacucho:** Prov. Lucanas, Dist. Ocaña, Centro Poblado San José de Tomate [CP Pachaca] – Sector Palca, 14°18'12.9"S, 74°45'33.11"W, 3700 m, 26 Jun 2015 (fl, fr), E. Pariante, R. Fernandez & L. Ríos 110 (holotype MOL; isotypes MOL, USM, HSP).

Description. Shrub to 2.5 m tall, widely branched from the base; younger stems, petioles and flowers pubescent with unbranched trichomes; older stems cylindrical, to 5 cm in diameter, finely striated, ash-colored; younger stems circular in cross section, 3–4.5 mm in diameter, dark, densely pubescent; internode 3–8 mm long; spines 0.9–1.5 cm long, 0.5–ca. 1 mm in diameter at the base. Leaves simple, alternate and spirally arranged, rarely geminate; petiole 2–3 (–5) mm long, planoconvex and slightly grooved, light green, moderately pubescent, but more densely so in the basal part; leaf blades (1.2–) 1.6–2.3 (–2.7) cm long, 0.6–1.4 cm wide, coriaceous, shiny, oblong to broadly elliptic, sometimes oblong-obovate, the apex obtuse, the base acute-attenuate, the margin entire and slightly revolute when dry, the adaxial surface dark green and glabrous, the abaxial surface light green with dispersed unbranched trichomes on the midrib, leaf blades concolorous when dry, the venation brochidodromous, inconspicuous, with (4–) 5–6 secondary veins. Inflorescences terminal or axillary, fascicled, with 1–2 flowers; buds ellipsoid, green with purple spots, densely pubescent. Flowers pendulous, hermaphroditic, actinomorphic; pedicels moderately pubescent, 23–27 mm long, 1–1.5 mm in diameter, green to dark purple; calyx narrowly campanulate, green to dark purple, 8.5–9.5 mm long, 4–5 mm wide, the outer surface moderately pubescent, the inner surface glabrous to minutely puberulent, the lobes 5, acute, 2–2.5 mm long, 3–3.5 mm wide, tomentose at the apex; corolla tubular, yellow at anthesis, sometimes tinged blue or purple, 25–35 mm long, 8–10 mm in diameter, the base slightly narrowed, 4–6 mm in diameter, the inner surface pubescent at the base, the outer surface densely pubescent with uniformly dispersed unbranched trichomes, the lobes 5, acute, 2–2.4 mm long, 4–6 mm wide; stamens 5, equal, filaments, white, flat-

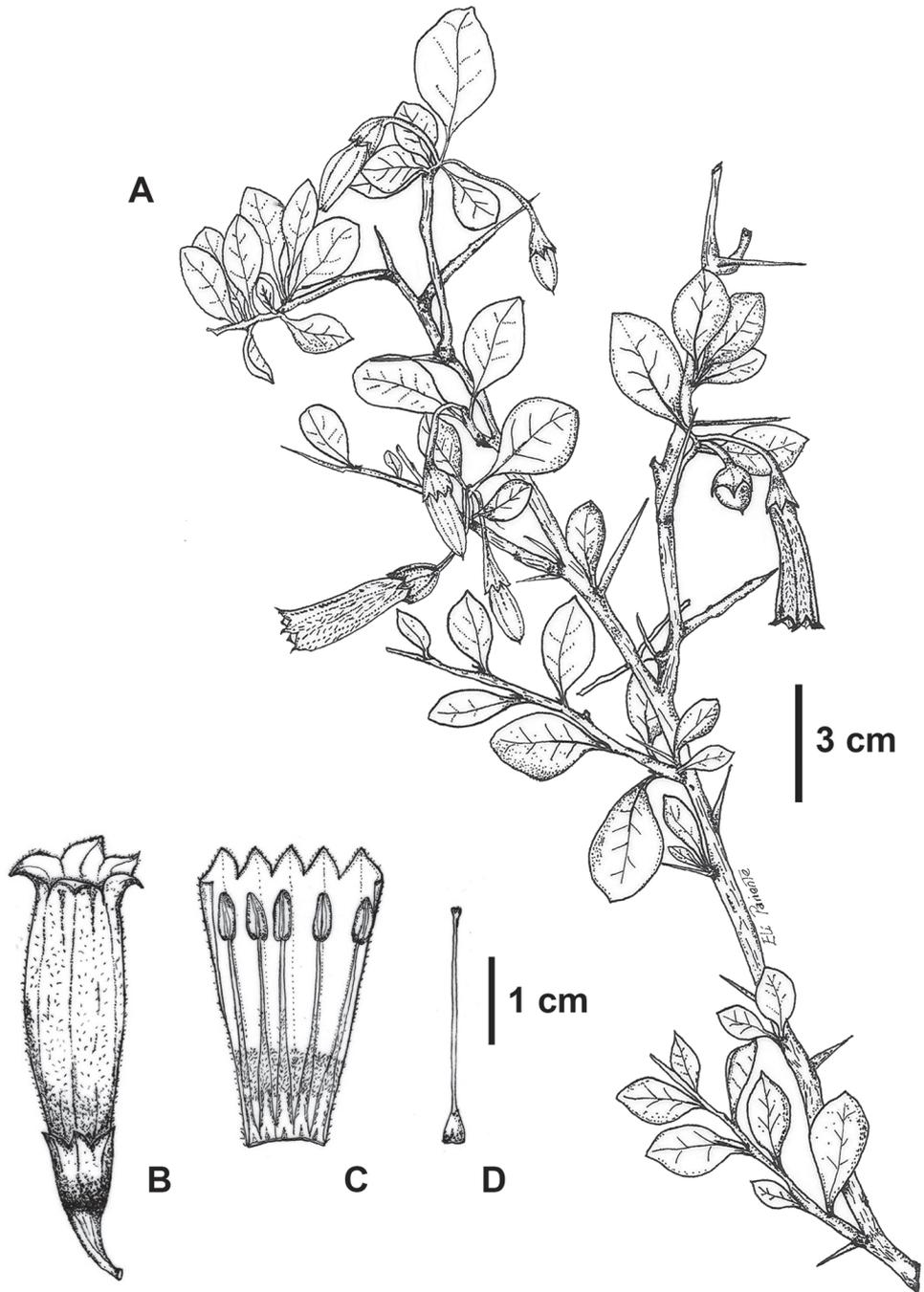


Figure 1. *Saracha andina*. **A** Flowering branch **B** Flower in anthesis **C** Open corolla with the stamens **D** Gynoecium. From E. Pariente et al. 110 (MOL). Drawing by Eli Pariente.

tened, adnate to the base of the corolla, 25–28 mm long, densely pubescent at the base, becoming glabrous at the apex; anthers oblong, 4.5–5.5 mm long, 2–3 mm wide, basifixed, with longitudinal dehiscence, the connective 4–4.5 mm long; ovary conical and glabrous, 3–3.5 mm long, 2–2.5 mm in diameter at the base; style glabrous, 17.5–18 mm long, ca. 0.5 mm wide; stigma clavate, 0.5 mm long, ca. 0.7 mm wide. Fruit a berry, ovoid and apiculate, black at maturity, 10–13 mm long, 7–8 mm in diameter, the tip 1–1.5 mm long; fruiting calyx slightly accrescent, 5–7 mm long; fruiting pedicels puberulent to moderately pubescent. Seeds not seen.

Distribution and habitat. *Saracha andina* is a shrub endemic to the scrub and relict forests in the central Andes of Peru (Depts. Ayacucho, Huancavelica and Lima) at over 3500 to 4000 m in elevation (Fig. 2). *Saracha andina* grows in stony areas, on slight to moderate slopes, and near creeks. Populations of this species in the Ayacucho region have been recorded to occur in relict forest with a maximum height from 4 to 5 meters dominated by *Polylepis microphylla* (Wedd.) Bitter and accompanied by *Escallonia myrtilloides* L.f., sharing the understory with *Berberis lutea* Ruiz & Pav. and *Hesperomeles obtusifolia* (Pers.) Lindl.

Ecology. Flowering and fruiting from June to September. Characteristics of the flower suggest pollination by hummingbirds (Faegri and van der Pijil 1979). In the forest where *S. andina* was collected, we observed hummingbirds such as *Metallura phoebe* and *Oreotrochilus estella*, common species in relict forests of “Queñuales” (Servat et al. 2002). These birds may be pollinators of this new species.

Common name and uses. In Pachaca (Dept. Ayacucho) it is commonly known as “checc-ches” in where the native people mention that strong and straight branches had been used for yarnning wool (pers. comm.).

Conservation status. According to the IUCN Red List Categories (IUCN 2012), *S. andina* is classified as Endangered [EN (B1biii)]. The extent of occupancy is estimated to be less than 1,000 sqkm. Furthermore, no population of *S. andina* currently grows in any protected area and the relict forests where it lives have been reduced as result of increasing anthropogenic pressure. In this context, *S. andina* populations are highly susceptible to processes of fragmentation and degradation in short term.

Additional specimens examined. PERÚ. **Ayacucho, Prov. Lucanas, Dist. Ocaña:** Centro Poblado de Pachaca, Sector Palca, 14°18'12.9"S, 74°45'33.11"W, 3700 m, 26 Jun 2015 (fl, fr), *R. Fernandez et al.* 973 (HSP, MOL); Carretera Palpa-Laramate-Pachaca, ca. 3 km past Pachaca toward el puno, 14°18'12.06"S, 74°45'33.08"W, 3750 m, 09 Jul 2016 (fl), *S. Smith & R. Fernandez* 594 (COLO, F, MO, USM); **Huancavelica, Prov. Huaytará, Dist. Huaytará:** Ruinas de Incahuasi, 13°34'25.77"S, 75°15'14.33"W, 3798 m, 15 Aug 2014 (fl, fr), *P. Gonzáles et al.* 3385 (USM); Carretera Los Libertadores, km. 130, pasando el puente Yuraccasa, 13°34'53.07"S, 75°16'42.96"W, 3800–3850 m, 26 Jun 2001 (fl), *J. Roque & C. Arana* 3309 (USM); Puente Mollepallana on road Pisco-Ayacucho, 3900–4000 m, 29 Sep 1997 (fl), *M. Weigend & H. Forther* 97/604 (USM); **Lima, Prov. Canta:** Acacay, cerca a Huacoy, 29 Jul 1960 (fl), *C. Acleto* 207 (USM); Ruta Canta-Obrajillo-Huacos, catarata Ongongoy, ca. 2 km NE de Huacos, 11°23'57.41"S, 76°36'11.70"W, 3900 m, 11 Jul 2016 (fl),

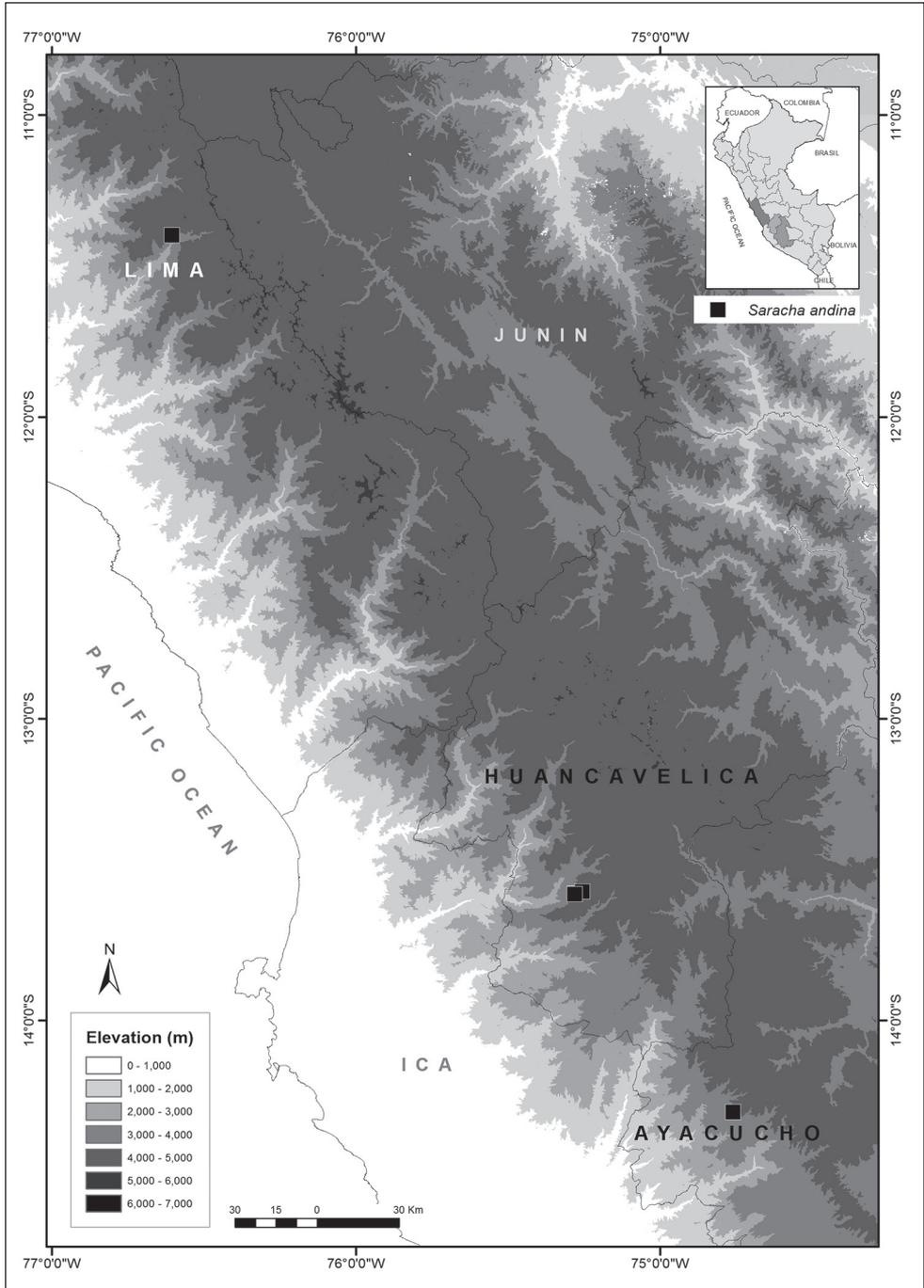


Figure 2. Distribution map of *Saracha andina*.

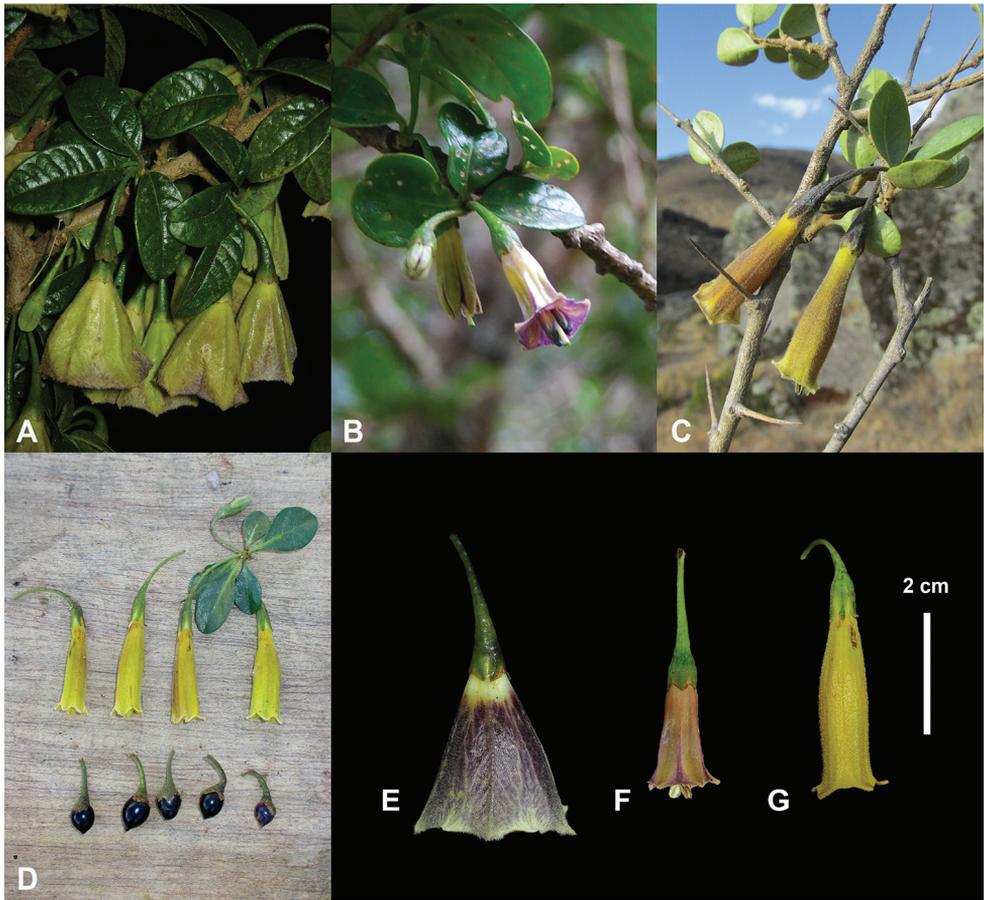


Figure 3. *Saracha* species. **A** *Saracha punctata* (R. Fernandez et al. 260; MOL) **B** *Saracha quitensis* (S. Smith 257; MO) **C** *Saracha andina* (P. Gonzáles et al. 3385; USM) **D** *Saracha andina* (R. Fernandez et al. 973; MOL) **E** *Saracha punctata* (R. Fernandez 998; MOL) **F** *Saracha quitensis* (S. Smith 257; MO) **G** *Saracha andina* (R. Fernandez et al. 973; MOL). Photos by: **A, D, E, G** Robin Fernandez; **B, F** Stacey Smith; **C** Paul Gonzáles.

S. Smith 596 (COLO, MO, MOL, USM); Lachaqui, cuesta de Yacahuana, 3800 m, 27 Mar 1973 (fl), *G. Vilcapoma* 188 (MOL, USM); Lachaqui, camino a Quinana, 3900 m, 02 Feb 1979 (fl), *G. Vilcapoma* 302 (MOL, USM); Huacos, catarata de Ongogoy, 3500 m, 09 Sep 2001 (fl), *G. Vilcapoma* 5564 (MOL, USM).

Discussion. *Saracha andina* differs from other species of the genus in its small oblong to broadly elliptic leaves 12–27 × 6–14 mm with inconspicuous nerves and tubular flowers 33.5–35 mm long. In contrast, *S. punctata* has elliptic leaves 20–150 × 8–60 mm and widely campanulate flowers, and *S. quitensis* has shorter tubular to infundibuliform flowers 12–26 mm long (Figure 3). Among other members of the subtribe Iochrominae sensu Olmstead et al. (1999, 2008), *S. andina* is perhaps most easily confused with species of *Dunalia*, many of which have tubular flowers of similar

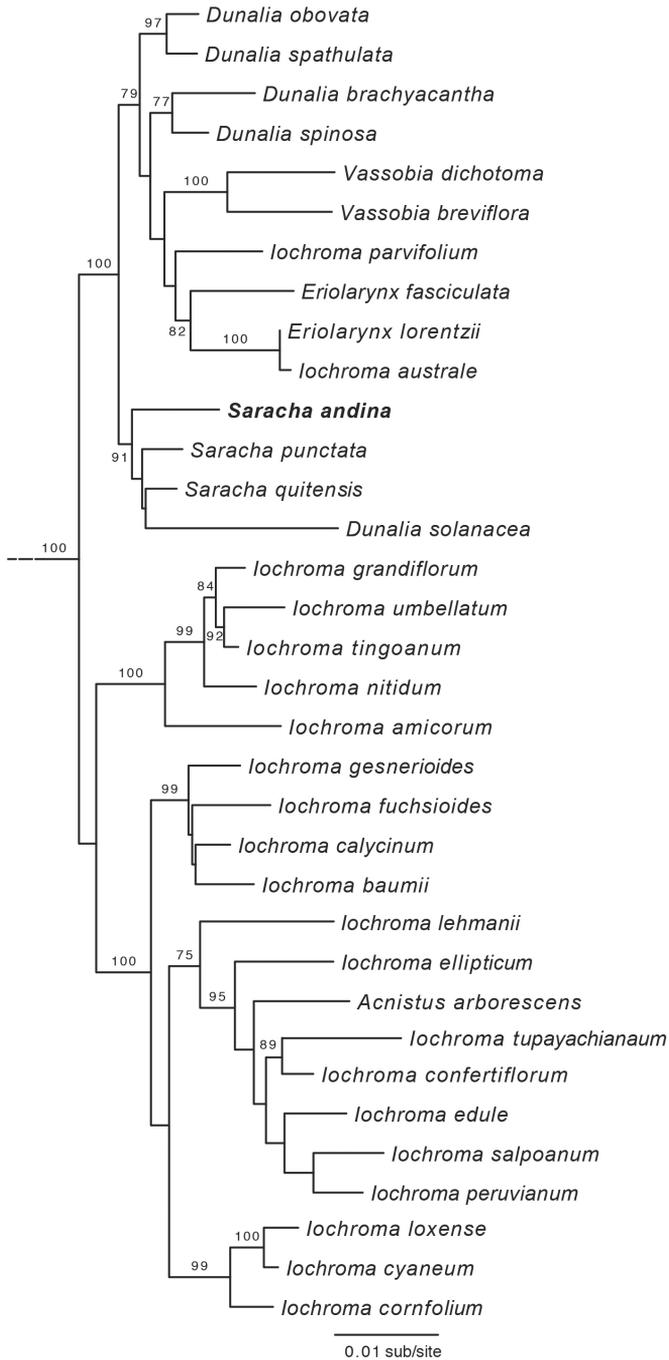


Figure 4. Maximum likelihood phylogeny of Ichromiinae (sensu Smith & Baum, 2006) showing placement of *Saracha andina*. The outgroups (*Physalis peruviana*, *Leucophysalis grandiflora*, *Witheringia solanacea*, *Tubocapsicum anomalum*, *Cuatresia colombiana*, and *Larnax sachapapa*) have been pruned from the tree. Bootstrap support (>70%) is indicated.

length and the plants are spiny (see discussion in D’Arcy and Smith 1987). Nonetheless, species of *Dunalia* have a diagnostic pair of appendages on either side of the filament base (“stapet”) (Hunziker 1960, 2001), and sometimes the leaves clustered on short shoots but they lack the conspicuous coriaceous leaves of *Saracha*.

Key to the species of *Saracha*, expanded from Alvarez (1996)

- 1 Corolla broadly campanulate, mainly yellow or yellow green, usually purple or brown spotted; leaves subcoriaceous, 20–150 mm long ***S. punctata***
- Corolla tubular to tubular-infundibuliform, purple or yellow, sometimes with purple spots or tinges; leaves coriaceous, 10–90 mm long **2**
- 2 Inflorescences with 4–10 flowers; corolla tubular-infundibuliform, 12–26 mm long; leaves 10–90 mm long; fruits globose with glabrous pedicels ***S. quitensis***
- Inflorescences with 1–2 flowers; corolla tubular, 25–35 mm long; leaves 12–27 mm long; fruits ovoid with puberulent to pubescent pedicels .. ***S. andina***

The maximum likelihood phylogenetic analysis places *S. andina* together with the other members of *Saracha* with high bootstrap support (91%, Figure 4). As in previous analyses (Smith and Baum 2006, Cueva et al. 2015), *Saracha* is allied with *Dunalia*, *Eriolaryx* and *Vassobia*, all of which are distributed principally in the Andes of South America. *Dunalia solanacea* remains nested within *Saracha*, a placement supported by its black fruits, which are present in *Saracha* but absent in other *Dunalia* species (Smith and Baum 2006). Overall, these molecular results are consistent with the placement of *S. andina* in the genus *Saracha*.

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Eithea lagopaivae, a new critically endangered species in the previously monotypic genus *Eithea* Ravenna (Amaryllidaceae)

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Abstract

Eithea lagopaivae Campos-Rocha & Dutilh, **sp. nov.** is described as the second species of the formerly monotypic genus *Eithea*. It is characterized by a one flowered inflorescence, completely hollow scape, white or lightly magenta-striated flower that is enclosed by spathe bracts fused for more than the lower fifth of its length. Comments on its range, habitat, phenology, as well as photographs and illustrations are provided. In addition, a distribution map and an identification key for the two species of the genus are presented and anatomical and ecological differences compared. Known by only two small populations exposed to several types of threats and without any guarantee of protection, *E. lagopaivae* is considered a Critically Endangered (CR) species.

Resumo

Eithea lagopaivae Campos-Rocha & Dutilh, **sp. nov.** é descrita como a segunda espécie do gênero previamente monotípico *Eithea*. Caracteriza-se por apresentar a inflorescência uniflora, escapo totalmente oco, flor alva ou com leves estrias magenta, protegida por brácteas espatáceas fundidas na base por mais de um quinto do seu comprimento. Comentários sobre a sua área de ocorrência, hábitat, dados de fenologia, fotografias e ilustrações são fornecidos. Adicionalmente, um mapa de distribuição e uma chave de identi-

cação para as duas espécies do gênero são apresentados e suas diferenças anatômicas e ecológicas comparadas. Conhecida de apenas duas pequenas populações sujeitas a diversos tipos de ameaça e sem qualquer garantia de proteção, *E. lagopaivae* é considerada uma espécie Criticamente em Perigo (CR) de extinção.

Keywords

Anatomy, Asparagales, Endemism, Hippeastreae, São Paulo

Palavras-chave

Anatomia, Asparagales, Endemismo, Hippeastreae, São Paulo

Introduction

Eithea Ravenna (2002) was proposed as a monotypic genus with the transfer of *Griffinia blumenavia* K.Koch & C.D.Bouché ex Carrière, historically a species of somewhat uncertain classification. It was described from material collected in Santa Catarina state, Brazil, cultivated at the Berlin Botanical Garden and originally placed in the genus *Griffinia* Ker Gawl. (Carrière 1867) presumably because of the pseudopetiolate, evergreen leaves. Combinations for both *Hippeastrum* Herb. (Sealy 1937) and *Amaryllis* L. (Traub 1938) were subsequently proposed. Transfer to *Hippeastrum* was indicated due to perceived similarities with the flowers and seeds of *H. reticulatum* Herb. (Sealy 1937) while Traub (1938) proposed the transfer to *Amaryllis*, in line with his belief that the type specimen of *Amaryllis belladonna* L. was an American plant (see Goldblatt 1984, for full details of this controversy). Satô (1938) published a chromosome number of $2n = 77$ for the species, which would be consistent with $x = 11$ chromosomes as a basic chromosome number for *Hippeastrum* (Naranjo and Andrada 1975, Flory 1977). Almost fifty years later, Traub (1983) proposed the restoration of the species in *Griffinia* based on the work of Arroyo (1982), who reported $2n = 20$ chromosomes for the species.

A phylogenetic analysis of nrDNA ITS sequences resolved *G. blumenavia* as having a closer relationship to the genus *Rhodophiala* Presl, than with either *Griffinia* or *Hippeastrum* (Meerow et al. 2000). This work also reported a chromosome number of $2n = 18$ for *G. blumenavia*, the number found in most *Rhodophiala* species (Satô 1942, Ficker 1951, Naranjo 1969, Flory 1977). Meerow et al. (2000) considered that these findings would justify the separation of *G. blumenavia* from *Griffinia* and *Hippeastrum* with recognition as a distinct monotypic genus. The authors of the current paper analyzed different individuals of the species and found the main somatic chromosome number of $2n = 18$. However, a few cells from some individuals exhibited 19 to 20 chromosomes, perhaps explaining Arroyo (1982) report of $2n = 20$. These additional smaller or supernumerary chromosomes are considered B-chromosomes (Jones and Rees 1982, Dutilh 1989, Ising 1990, Ising and Wide-Andersson 1991) due to their erratic behavior. Ravenna (2002) described the species as *Eithea blumenavia* (K.Koch & C.D.Bouché ex Carrière) Ravenna based on some morphological considerations, not on phylogeny nor chromosome number.

Currently, *Eithea* is positioned in tribe Hippeastreae, which includes *Hippeastrum* and *Rhodophiala* (Meerow et al. 2000, Oliveira 2012, García et al. 2014, 2017). In the same studies, *Griffinia*, sister of monotypic *Worsleya*, is included in the tribe Griffinieae Ravenna, a strongly supported clade. *Eithea* has some unusual morphological attributes for Hippeastreae, such as pseudopetiolate oblanceolate leaves with attenuate base, as well as globose seeds with elaiosome, features also found in *Griffinia*. However, testa of *Eithea* seeds contains phytomelanin, a typical trait of Hippeastreae, not found in *Griffinia*.

At the end of the 1990s, the researcher Celso do Lago Paiva discovered the new species in Piracicaba, São Paulo state, Brazil. Morphological, ecological and anatomical analyses conducted on material of the species over the past ten years have confirmed that it is an undescribed species of *Eithea*.

Material and methods

The following national and international herbaria with the most important collections of Brazilian Amaryllidaceae, particularly those from the state of São Paulo, were visited: BR, C, ESA, HRCB, IAC, K, MBM, MO, NY, RB, SP, SPF, SPSF, UEC, and US (acronyms according to Thiers 2017). The terminology used for the morphological description follows Radford et al. (1974), Meerow and Snijman (1998), and Stearn (2004), with minor modifications. In addition, comments on the conservation status of the taxon are provided as recommended by IUCN (2016). GeoCAT (Bachman et al. 2011) was used to calculate Area of Occurrence (AOO) and Extent of Occurrence (EOO). Climatic data was obtained from Banco de Dados Climáticos do Brasil (EMBRAPA 2003) for the municipalities of Indaial (Santa Catarina) and Piracicaba (São Paulo). These two localities present collections of *E. blumenavia* and *E. lagopaivae* respectively. The map was drawn with ArcGIS 10.5 (ESRI).

For the morphological analysis, measurements were made on at least 15 individuals of each species, fresh plants and exsiccates. For the anatomical analysis, slides were prepared with fresh mature leaves of *E. blumenavia* and *E. lagopaivae*. At least five fully expanded and mature leaves of each species were fixed in Karnovsky (Karnovsky 1965) for 24 h, dehydrated in ethanol series (10%, 30%, 50% - 1 h each) and stored in 70% ethanol. Samples of leaves from both species were selected, encompassing the middle region of the pseudopetiole and the lamina, which was subdivided into midrib region and area between the midrib and margin. Infiltration was performed in plastic resin (Leica Histo-resin[®]) according to manufacturer's instructions. Transverse and longitudinal sections of 7 µm thickness were obtained with manual rotary microtome (Leica[®]) and stained with 0.05% toluidine blue (Sakai 1973) in citrate buffer. Slides were mounted in synthetic resin "Entellan[®]" (Merck[®]) and images were obtained with an Olympus DP71 digital camera attached to an Olympus BX51 microscope.

Vouchers of the species and populations were deposited at UEC.

Results and discussion

Eithea lagopaivae Campos-Rocha & Dutilh, sp. nov.

urn:lsid:ipni.org:names:77165357-1

Figures 1, 2

Diagnosis. *Eithea lagopaivae* differs from *E. blumenavia* (Figure 3) by its smaller size, one flowered inflorescence (vs. 2–6, very rarely 1), a fully hollow scape (vs. solid in the lower fifth), terminated by spathe bracts fused for more than the lower fifth of their length (vs. free or fused up to the lower fifth), absence of bracteoles (vs. presence), white or only very lightly striated flowers (vs. strongly striated) and lateral and lower petals of similar width (vs. lateral petals up to twice the width of the lower).

Type. BRAZIL. São Paulo: Piracicaba, sub-bosque de uma plantação comercial de *Eucalyptus* abandonada, 07 Dec 2016, *A. Campos-Rocha 1654* (holotype: UEC!; isotypes: NA!, RB!).

Description. Geophytic herb 12–25 cm tall. Bulb subterranean, globose to ovoid or obovoid, tunicate, whitish or with a thin grey-brownish outer tunic, 1.3–3.5 cm long and 1.2–3 cm diameter; neck formed by sheathing leaf bases up to 4.5 cm long and 3–8 mm diameter (occasionally very short to absent). Leaves 1–3(–4), suberect, dark green adaxially, pale green abaxially, frequently pseudopetiolate; pseudopetiole flattened adaxially, rounded abaxially, greenish, with reddish pigmentation near the base or throughout its length, up to 9.5 cm long, 2–5.5 mm wide; lamina linear, narrowly elliptic or oblanceolate to slightly falcate, apex acute, frequently asymmetric, base attenuate, margin flat, venation transverse reticulate (with short transverse veins between the longitudinal ones), midrib inconspicuous adaxially, prominent abaxially, 8–20.8 × 1.1–2.6 cm. Inflorescence one flowered; scape erect, cylindrical, slightly laterally compressed, hollow and fragile, greenish, sometimes with reddish pigmentation near the base, 7.8–30 cm long and 2.4–6 mm diameter, elongating and becoming decumbent with fructification; spathe bracts 2, tubular, fused in the basal 0.4–2.4 cm, apex acute, whitish, generally light rose colored at the tip before opening, turning papery, 1.7–3.8 cm long. Pedicels greenish, (0.3–)1.3–5.5 cm long, often elongating with fructification to 6.5 cm long. Perigone campanulate to infundibular, white (in bud white with a rose colored tip), usually with faint thin magenta striations on the sepals and petals, especially on the upper sepal, with greenish pigmentation near the base, mostly close to the midrib, 3–5.8 cm long; hypanthium greenish, 2–4.5 mm long, paraperigone of fimbriae 0.5–2 mm long at the throat. Sepals much wider than the petals, oblanceolate to obovate, the upper one wider and longer, apex acute, apicule subapical; upper 2.7–5.6 × 1–2.4 cm, apicule 0.8–2 mm long; lateral 2.5–5.4 × 0.6–2 cm, apicule 0.6–1.4 mm long. Petals oblanceolate, apicule inconspicuous or absent; lateral 2.5–5.5 × 0.6–1.4 cm; lower slightly narrower, 2.5–5.5 × 0.4–1.2 cm. Filaments 6, in four different lengths, inserted at the mouth of the hypanthium tube, shorter than limb segments, declinate-ascending, free portion white; upper episepal 1.1–2.5 cm long; lateral episepal 1–2.2 cm long; lateral epipetal 1.7–4 cm long; lower

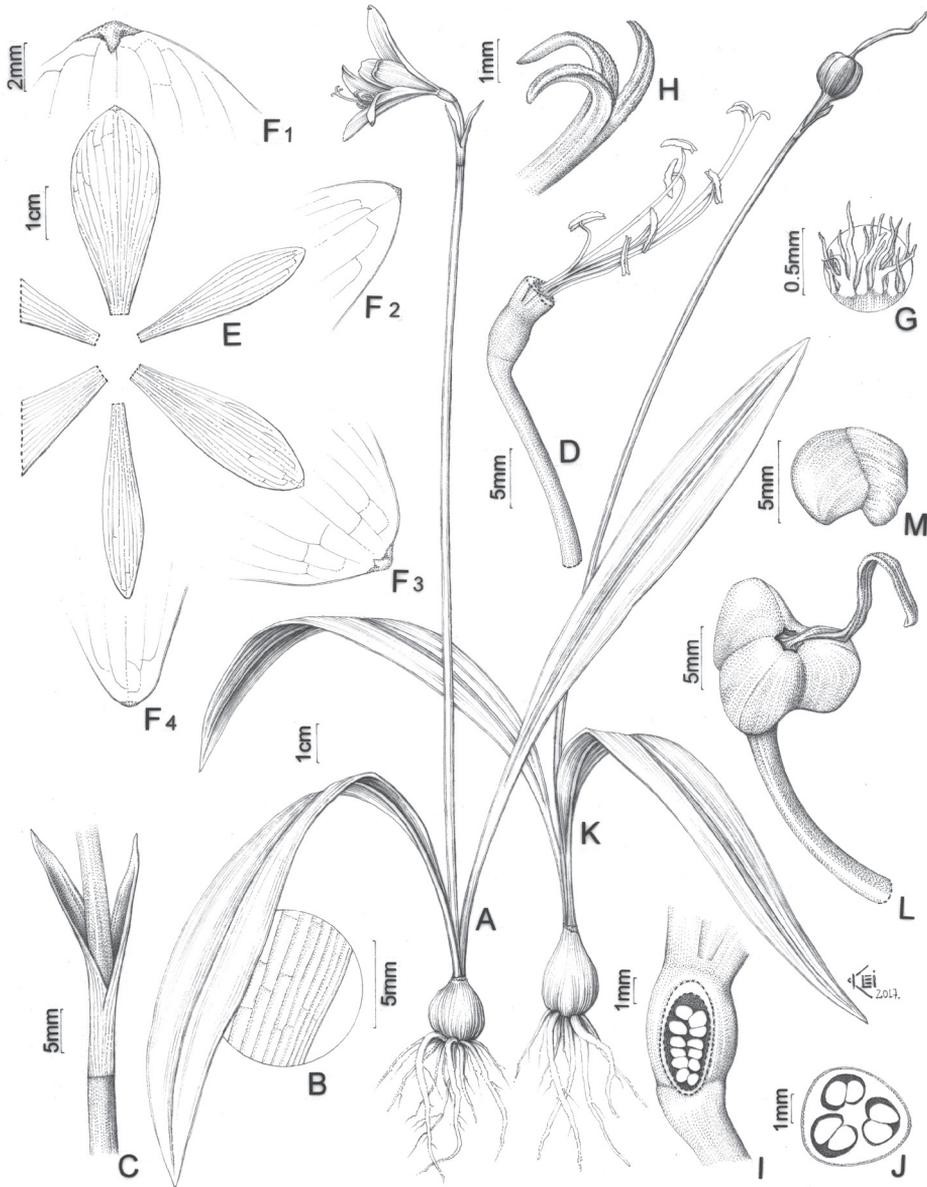


Figure 1. *Eithea lagopaivae* **A** Habit in flower **B** Detail of leaf venation **C** Spathe bracts **D** Flower with perigone removed, showing stamens and style **E** Sepals and petals **F** Tips of sepals and petals **F1** Upper sepal **F2** Lateral petal **F3** Lateral sepal **F4** Lower petal **G** Detail of fimbriae of the paraperigone **H** Stigma **I** Longitudinal section of the ovary **J** Cross section of the ovary **K** Habit in fruit **L** Fruit **M** Seed.

epipetal 1.6–3.8 cm long. Anthers oblong to oblong-reniform, dorsifixed, versatile, dehiscent longitudinally, 2.5–5 mm long before anthesis; pollen pale yellow. Ovary trilobular, obtuse trigonal, obovoid, greenish, 3.5–9 mm long and 3–8 mm diameter;

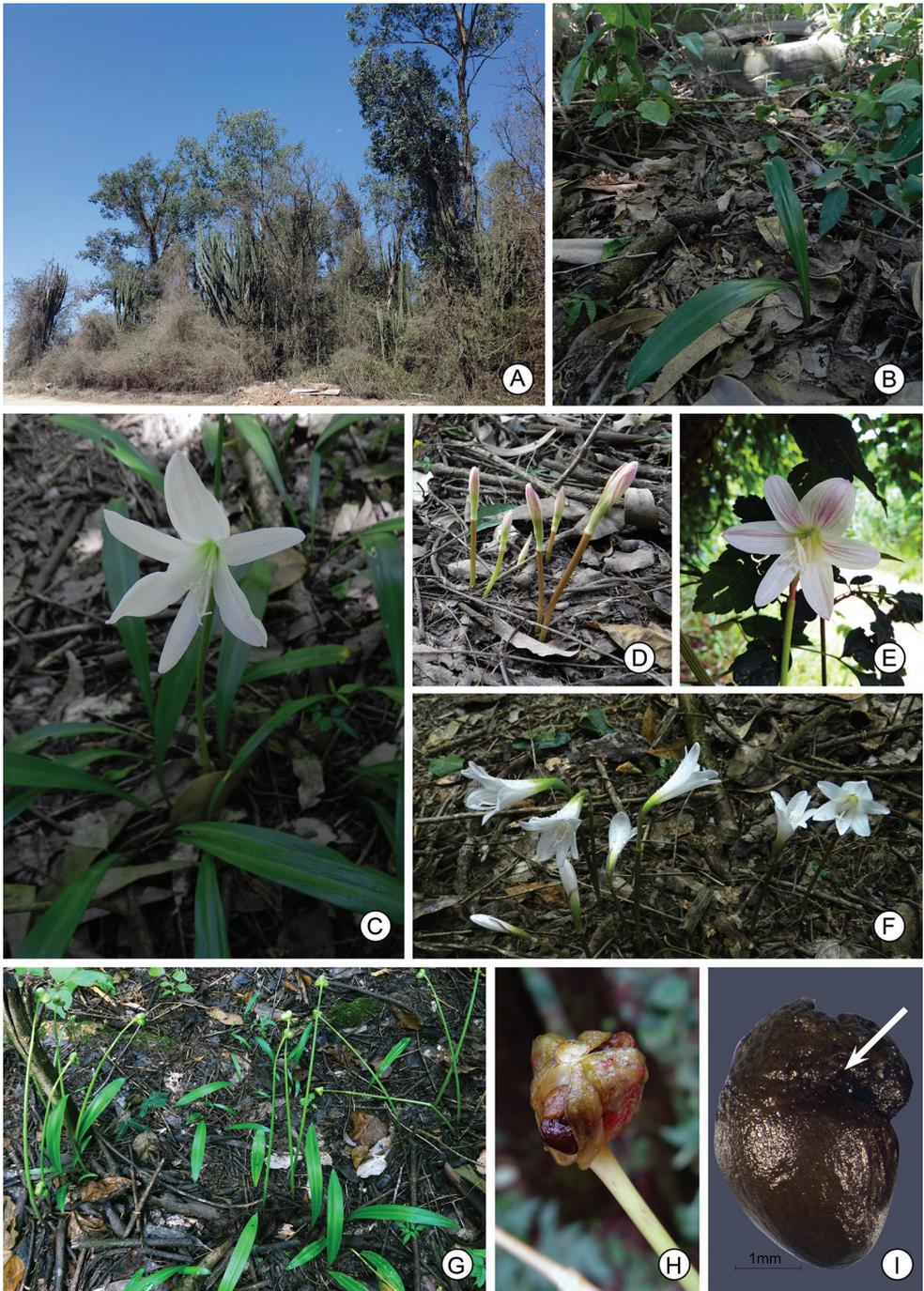


Figure 2. *Eitheia lagopaivae* **A** Typical habitat (October 2016) **B** Individual plant flowering amid trash dumped at type locality **C** Flowering plant (*Campos-Rocha* 1647) **D** Flower buds **E** Flower, frontal view (*Bernacci* 4483) **F** Flower buds and flowers (*Campos-Rocha* 1654) **G** Plants in fruit **H** Mature capsule exposing the seeds **I** Seed (elaiosome indicated by the arrow).



Figure 3. *Eithea blumenavia* **A** Flowering plants in habitat **B** Lateral view of inflorescence **C** Detail of spathe bracts **D** Bracteoles (white arrow) **E** Sepals and petals (adaxial view) separated from stamens and style. **B–E** of Campos-Rocha 1624, UEC.

8–14 ovules per locule; ovules 0.6–1 mm long. Style declinate-ascending, white, occasionally with greenish pigmentation near the base, 2.6–5 cm long; stigma trifid, white, lobes already expanded when the flower opens, occasionally of different lengths, 1.5–4.5 mm long. Fruit capsule loculicidal, globose to globose-compressed trilobed, greenish when ripe, occasionally with reddish pigmentation, cream colored inner side, 1–2.5 cm long and 1.2–2.6 cm diameter. Seeds irregular, angular, with grey brownish to black testa containing phytomelanin, 3.5–6 mm long and 3–5.5 mm diameter, with wrinkled elaiosome up to 4.5 mm long.

Distribution, habitat and ecology. *Eithea lagopaivae* is known from only two small populations separated about 50 km, each composed of less than 50 individuals. The type population (Piracicaba) occurs in the understory of an abandoned *Eucalyptus* plan-

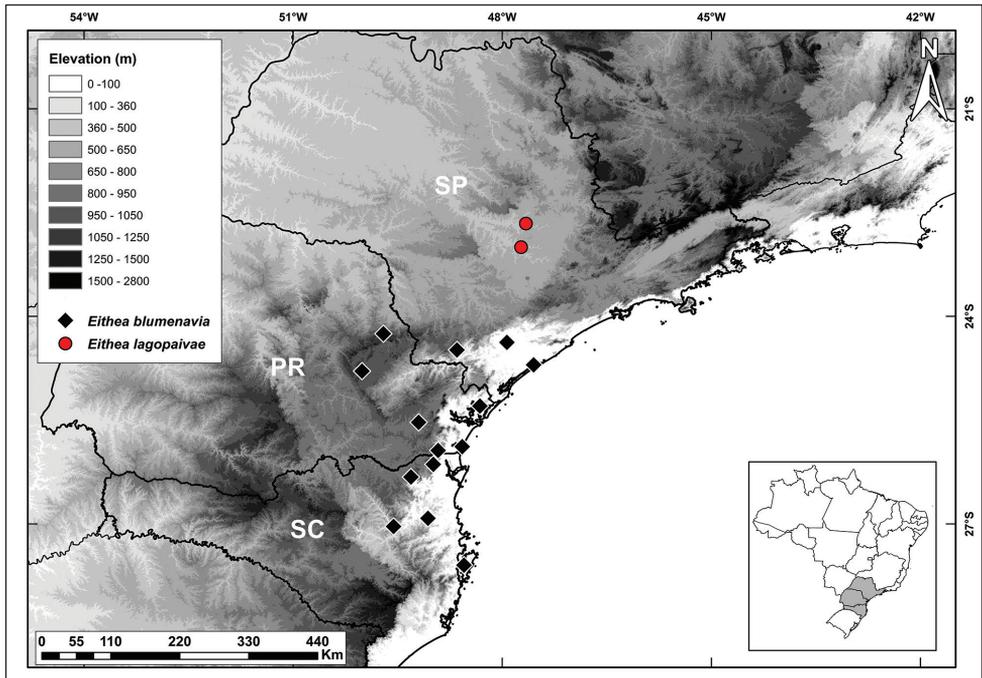


Figure 4. Distribution map showing collections of *Eithea lagopaivae* (red circles) and *E. blumenavia* (black diamonds). PR = Paraná. SC = Santa Catarina. SP = São Paulo.

tation, next to fragments of deciduous and semideciduous forest, where the Corumbataí river meets the Piracicaba river. The second is located in a small fragment of semideciduous forest, near the junction of the basins of the Piracicaba and Tietê rivers in the municipality of Tietê (Figure 4). Both fragments are located on gravelly soils of litholic limestone origin (Oliveira and Prado 1989). The region presents a well-defined seasonality, with total annual rainfall of 1230 mm and precipitation of 50 mm or less, for six months, during autumn and winter. During spring and summer, rainfall exceeds 100 mm for six months, reaching close to 250 mm in January (EMBRAPA 2003). Ants were observed removing elaiosomes from the seeds of *E. lagopaivae* in their natural habitat, indicating that these animals might be dispersal agents, as is known for *Griffinia*.

Phenology. *Eithea lagopaivae* has been collected in bloom between October and January, and occasional blooming occurs until early March. Fruits have been observed from November.

Conservation status. With estimated AOO of 8 km² and EOO of 13.7 km², *Eithea lagopaivae* can be considered as Critically Endangered [CR, B1ab(iii) + B2ab(iii)], due to the low number of known locations (≤ 5) and decline in quality of habitat (IUCN 2016). In the municipality of Piracicaba, at the end of the year 2016, when the species was again visited, two small scattered groups were encountered ca. 500 meters apart. The smaller of the two groups was in a trash dump on the side of the wooded area, and the second in an area of higher humidity, near a small stream. This fragment,

on the edge of the urban sprawl of Piracicaba, is highly disturbed and subject to regular episodes of fire. The population of the Tietê municipality is in a slightly larger fragment of semideciduous forest with an impoverished understory, intense edge effects, with many lianas and invasive exotics. The area is located within a livestock breeding facility.

Etymology. The epithet is a tribute to Celso do Lago Paiva, environmental analyst at ICMBio, who has collected the plant for the first time and has dedicated his life to the study and conservation of the flora of Brazil.

Additional specimens examined. BRAZIL. São Paulo: Piracicaba, 18 Mar 1999, *J. Dutilh* s.n. (UEC-170468!); 17 Nov 1999, *J. Dutilh* s.n. (UEC-174104!); 29 Nov 1999, *J. Dutilh* s.n. (UEC-174105!); em cultivo no Jardim Botânico Plantarum, Nova Odessa-SP, 10 Oct 2012, *A. Campos-Rocha* 810 (NA!, RB!, UEC!); em cultivo em Campinas-SP, 10 Oct 2013, *A. Campos-Rocha* & *J. Dutilh* 1165 (NA!, UEC!); plantação abandonada de *Eucalyptus*, 09 Oct 2016, *A. Campos-Rocha* & *R.M. Goffi* 1626 (UEC!); plantação de *Eucalyptus* abandonada, 20 Nov 2016, *A. Campos-Rocha* 1647 (NA!, UEC!). Tietê, 20 Nov 2001, *J. Dutilh* & *L.C. Bernacci* s.n. (UEC-170469!); *L.C. Bernacci et al.* 4483, fragmento de floresta semidecídua, 03 Mar 2017 (IAC!, UEC!).

Notes. *Eithea lagopaivae* and *E. blumenavia* form a clade with maximal support in all phylogenetic analyses performed by García et al. (2017). *Eithea lagopaivae* can be distinguished from *E. blumenavia* by a number of characteristics (Table 1). It is a smaller plant (ca. 12–25 cm), usually with 2–3 leaves, rarely 4, which are deciduous before the onset of winter. *Eithea blumenavia* however is evergreen, with 2–8 leaves, and up to 50 cm in height, although specimens of extremely reduced size are known, also with several flowers.

Eithea lagopaivae is known from an area originally of deciduous and semideciduous forests with a well-defined dry season. In turn, *E. blumenavia* is found in wetlands of the Atlantic rainforest, from the south of the state of São Paulo to eastern Santa Catarina (Dutilh 2010, Dutilh and Oliveira 2015) (Figure 4), especially in the coastal mountains. The region has some of the highest average annual rainfall (1650 mm) of any area of extra-Amazonian Brazil, distributed throughout the year, but more intensely during the summer, although with an average under 200 mm/month. From April to July, monthly averages are close to 100 mm (EMBRAPA 2003).

Eithea blumenavia is considered an Endangered (EN) species (MMA 2014).

Anatomy. The three most obvious anatomical characteristics differentiating the two species of *Eithea* are: 1. Margins and cortex of the pseudopetiole (Figure 5A–B); 2. Ornamentation and shape of the epidermal cells on the adaxial side of the leaf blades (Figure 5C–D); 3. Presence or absence of protrusions on the upper side of the blades in the region of the midrib (Figure 5I–J).

Cross section of pseudopetiole margins of *E. lagopaivae* are flatter, more laminar (Figure 5A, arrow) than those of *E. blumenavia*, which are angular (Figure 5B, arrow). The pseudopetiole is composed by chlorenchyma, aerenchyma and vascular bundles. In *E. lagopaivae*, 1–3 aerenchyma lacunae were found below the vascular bundles (Figure 5A), while in *E. blumenavia* several lacunae above and below the bundles could be observed (Figure 5B).

Table 1. Ecological, morphological and anatomic character states that distinguish *Eithea lagopaivae* from *E. blumenavia*. CS = cross section.

Character state	<i>Eithea lagopaivae</i>	<i>Eithea blumenavia</i>
Habitat	Semideciduous and deciduous forest	Rain forest
Foliage	Deciduous	Perennial, rarely deciduous
Scape	Fully hollow	Solid in lower fifth
Spathe bracts	Fused more than 1/5 th basally	Free to fused for up to 1/5 th basally
Bracteoles	Absent	Present
No. flowers per inflorescence	1	2–6, rarely 1
Perigone color	White, sometimes with a few magenta striations	White with many conspicuous, magenta striations
Width ratio of lateral to lower petals	4:4 to 4:3	4:3 to 4:2
Pseudopetiole margins	Laminar	Angular
Adaxial epiderm cells (leaf blade) in CS	Elongated rectangular	Polyhedral
Ornamentation of external periclinal epidermal cell wall (leaf blade)	Absent	Present
Adaxial surface in the midrib region (leaf blade) in CS	Flat	2 protrusions

In the cross section of leaf lamina, epidermal cells were more elongated in *E. lagopaivae* and polyhedral in *E. blumenavia* (Figure 5C–D, respectively). We found periclinal thickening on the outer wall of the epidermal cells of both species as occurs in *Hippeastrum puniceum* (Lam.) Kuntze (Alves-Araújo et al. 2012). Ornamentation of the external periclinal epidermal cell wall of *E. blumenavia* (Figure 5D, arrow) was not found in *E. lagopaivae* (Figure 5C). Mesophyll of *E. lagopaivae* and *E. blumenavia* is composed of about 6–8 layers of chlorenchyma with arm-palisade cells (also called arm-cells, H-palisade or H-cells) (Figure 5E–F), which showed their typical morphology in paradermic sections (Figure 5G–H). Arm-cells were first described by Haberlandt (1880) as a morphological modification of palisade cells and seem to be more common in plants of forest understory, probably increasing photosynthetic capacity (Chatelet et al. 2013). In the midrib region, the lacunae of the aerenchyma were larger and wider in *E. lagopaivae* than in *E. blumenavia* (Figure 5I–J).

A protrusion on the abaxial leaf surface opposite the central vascular bundle was evidenced in both species (Figure 5I–J, arrows) and the parenchyma cells in this region were regular and rounded. However, adaxial surface of the leaf in *E. lagopaivae* was flat (Figure 5I), while in *E. blumenavia* it was possible to observe two protrusions opposite to the vascular bundles adjacent to the midrib (Figure 5J, arrowheads). The alternation of aerenchyma with vascular bundles found in *Eithea* species was described for other species of the family (Arroyo and Cutler 1984, Meerow 1989, Raymúndez et al. 2000,

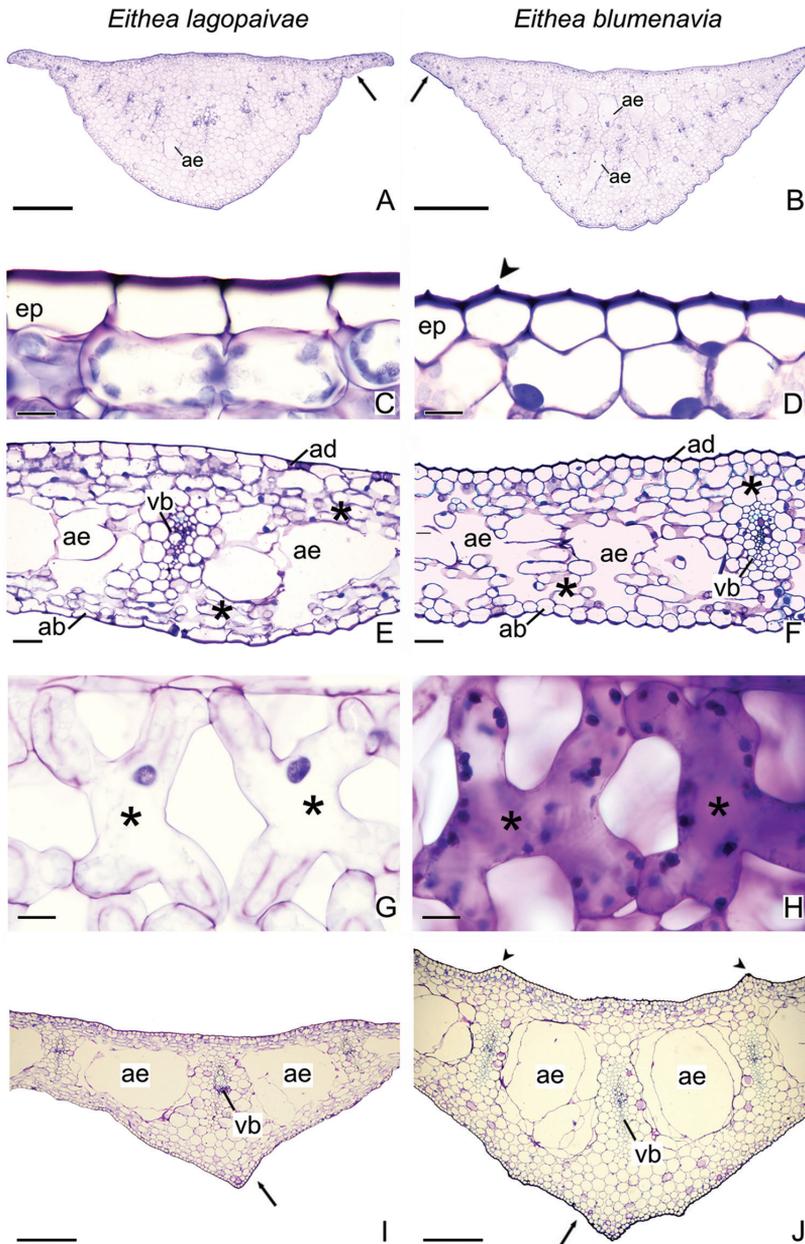


Figure 5. Comparative leaf anatomy of *Eithea lagopaivae* and *E. blumenavia*. **A** Cross section of the pseudopetiole of *E. lagopaivae* and **B** *E. blumenavia* **C** Cross section detail of the adaxial epidermis of *E. lagopaivae* and **D** *E. blumenavia* **E** Cross section of the leaf blade of *E. lagopaivae* and **F** *E. blumenavia* **G** Longitudinal paradermic section detail of the leaf blade, showing the arm-cells of the chlorenchyma in *E. lagopaivae* and **H** *E. blumenavia* (slide of stained fresh material) **I** Cross section of the leaf blade in the midrib region of *E. lagopaivae* and **J** *E. blumenavia*. * = arm-cell; ab = abaxial epidermis; ad = adaxial epidermis; ae = aerenchyma; ep = epidermis; vb = vascular bundle. Scales bars: 500 μm (**A, B**); 10 μm (**C, D**), 50 μm (**E, F**), 20 μm (**G, H**); 200 μm (**I, J**).

Alves-Araújo et al. 2012). In *Eithea*, lacunae of aerenchyma in the pseudopetiole and leaf blade may have been originated by lysis, as suggested for *Griffinia*, *Habranthus*, *Hippeastrum* and *Nothoscordum* Kunth (Alves-Araújo et al. 2012); however leaf development studies are needed to confirm this hypotheses.

Key to the species of *Eithea*

- 1 Inflorescence one flowered; bracts fused for more than the lower 1/5th; scape completely hollow; flowers white or only with a few narrow magenta striations; ratio between the width of the lateral and lower petals 4:3 to 4:4; plants from deciduous and semideciduous forest..... *E. lagopaivae*
- Inflorescence with 2–6 flowers, very rarely 1; bracts free or fused up to the lower 1/5th; scape solid towards the base; flowers with many conspicuous magenta striations; ratio between the width of the lateral and lower petals 4:2 to 4:3; plants from rainforest *E. blumenavia*

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Gelidocalamus xunwuensis (Poaceae, Bambusoideae), a new species from southeastern Jiangxi, China

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Abstract

Gelidocalamus xunwuensis W.G.Zhang & G.Y.Yang, a new species collected from Xunwu County of Jiangxi Province in China, is described and illustrated. The new species is similar to *G. stellatus* in the habit, but differs by internodes sparsely hairy with granuliferous warts, culm sheath stiffly hairy, culm sheath blade broadly lanceolate to narrowly triangular, each node with a ring of appressed trichomes below, foliage leaves broadly lanceolate to narrowly oblong, and new shoots occurring in late October.

Keywords

Arundinarieae, Bambusoideae, bamboo, leaf epidermis, SEM, taxonomy

Introduction

The genus *Gelidocalamus* Wen (1982: 21) includes ca. 9–13 species in the tribe Arundinarieae (Poaceae: Bambusoideae) and is endemic to China. This genus is characterized by leptomorph rhizomes, several branches per node, leaves usually solitary on each ultimate branch, semelauctant inflorescence, three stamens, and with new shoots occurring in the autumn to winter seasons (Wen 1982, Geng and Wang 1996, Li et al. 2006, Yi et al. 2008, Soreng et al. 2015, Liu et al. 2017).

Most species of *Gelidocalamus* are restricted to southern China in Hunan, Jiangxi, Zhejiang, Fujian, Taiwan, Guangdong, Guangxi, Yunnan, and Guizhou Provinces, and

distributed at elevations of 200–1200 m, along ravines and under evergreen broad-leaved forests (Li et al. 2016). However, within the past 30 years, most newly discovered species, e.g. *Gelidocalamus annulatus* T. H. Wen, *G. longinternodus* T. H. Wen & S. C. Chen, *G. multifolius* B. M. Yang and *G. dongdingensis* C. F. Huang & C. D. Dai, are known only from their type locations suggesting that the diversity and distribution of *Gelidocalamus* species is in need of further study.

During a botanical expedition in central and southern China in 2014, a distinctive “*Gelidocalamus*-like” collection with many branches per node and leaf solitary on each ultimate branch was found from Xunwu County. Xunwu County (24°30'40"–25°12'10"N, 115°21'22"–115°54'25"E) is a hot and humid region in the southeastern corner of Jiangxi Province, located at the junction of Wuyi Mountain and Jiulian Mountain, and has a subtropical climate with abundant monsoon rainfall. It is also a minor centre of plant endemism in China and especially exhibits high richness in palaeo-endemic species (Jordi et al. 2011). Twenty-six endemic species and 11 new species have been discovered in this region in recent years (Ji 2007, Ji et al. 2010).

To investigate this collection, we made a complete morphological characterization, including description, illustrations, taxonomic comments, and scanning electron microscope (SEM) images of the abaxial leaf epidermis. This collection has the typical characteristics of *Gelidocalamus* with leptomorph rhizomes, several branches per node and leaves usually solitary on each ultimate branch. It can be readily distinguished from other *Gelidocalamus* species by its internodes being sparsely hairy with granuliferous warts, culm sheath stiffly hairy, and foliage leaves broadly lanceolate to narrowly oblong. By all the evidence obtained, we believe that this collection is a new species and herein described and illustrated.

Materials and methods

From Jul. 2014 to Nov. 2016, mature leaves were collected from individuals of the type localities (the Xunwu population – the Guizhumao of Xunwu in Jiangxi, *Gelidocalamus stellatus* T. H. Wen – the Xiazhuang of Jinggang Mountain in Jiangxi, *G. tessellatus* T. H. Wen & C. C. Chang – the Maolan of Libo in Guizhou, *G. dongdingensis* C. F. Huang & C. D. Dai – the Dongding Mountain of Longyan in Fujian, respectively) and immediately fixed in FAA solution. Leaves were cleaned by ultrasonic wave with ultrapure water, dried at room temperature, and mounted on stubs. After gold sputtering, the samples were photographed using the scanning electron microscope Hitachi S-4800. Terminology for the epidermis appendages follows Ellis (1979), Wu et al. (2014), and Zhang et al. (2014). Voucher specimens were deposited in the herbarium of the College of Forestry, Jiangxi Agricultural University, China (JXAU). Morphological traits, including habit and new shoot, culm and culm sheath, branch and leaf, were described with both fresh and exsiccated specimens.

Results

The Xunwu population plants are most similar to *G. stellatus* in the habit and branching pattern. However, they differ from the latter by the following characters: culms sparsely hairy (vs. glabrous) with granuliferous warts (vs. smooth), culm leaf sheath densely hispidulous (vs. hairless), each node with a ring of fulvous appressed trichomes below (vs. white appressed trichomes), foliage leaves oblong (vs. lanceolate) and new shoot in late Oct. (vs. early Sep.) (Table 1 and Fig. 1).

Leaf epidermis characters of the Xunwu population plants are almost identical to that of *Gelidocalamus stellatus* Wen (1982: 22) and *G. tessellatus* T. H. Wen & C. C. Chang (1982: 24) (Fig. 2A–C). Each stomatal apparatus (usually 3 rows between the veins) is surrounded by 8–10 short papillae, but covered with dense wax. The saddle-shaped silica bodies on the veins can be clearly identified, but the long cells and short cells cannot be distinguished. Microhairs are gracile, composed of two cells with the apical cell withered, and mostly occur on the intercostal regions of the abaxial leaf epidermis.

On the contrary, *Gelidocalamus dongdingensis*, a species collected from the adjacent area of Xunwu County, Longyan of Fujian (about 200 km), has obviously different characters of leaf epidermis (Fig. 2D). Each stomatal apparatus (usually 8–10 rows between the veins) is nearly invisible, overarched by 14–20 long papillae. The saddle-shaped silica bodies on the veins can be also clearly identified. However, there are three types of trichomes (i.e. macrohairs, microhairs and prickles) on the abaxial leaf epidermis. Except microhairs, macrohairs can be visualized with the naked eye and can be used to discriminate from the Xunwu population plants, while prickles are short and relatively stiff with sharp apices, located at the intercostal regions.

Table 1. Comparison of morphological traits of the Xunwu population plants with those of *Gelidocalamus stellatus*.

Characters	Xunwu Plants	<i>Gelidocalamus stellatus</i>
Culm	internodes rough with granuliferous warts, strigose; each node with a ring of fulvous appressed trichomes below	internodes glabrous; each node with a ring of white appressed trichomes below
Branch	branching intravaginal from 4 th node up, usually 4–9 on mid-culm	branching intravaginal from 7 th node up, usually 6–12 on mid-culm
Culm leaf	culm leaf sheath carmine, densely pubescent with stiffly dark-brown hairs; oral setae 3–5-paired, ca. 2–5 mm; blade deciduous, narrowly triangular or linear-lanceolate, ca. 1/3–1/2 as wide as sheath apex	culm sheath purple-red, glabrous; oral setae absent or weak; blade deciduous, linear or linear-lanceolate, ca. 1/5–1/4 as wide as sheath apex
Foliage leaf	leaf blade broadly lanceolate to narrowly oblong, usually 15–20×2.3–3.0 cm, pubescent near base, basally slightly revolute and symmetrical	leaf blade lanceolate to narrowly lanceolate, usually 14–19×2.1–2.7 cm, basally cuneate and asymmetrical
New shoot	late October	early September

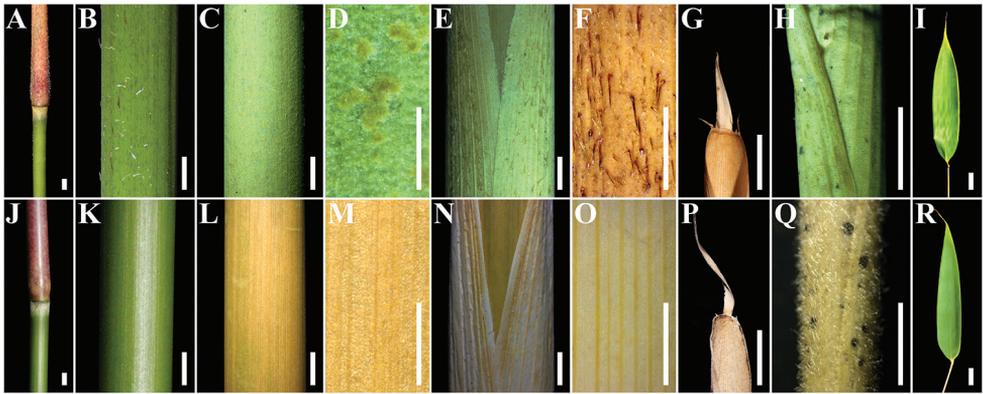


Figure 1. Comparison of morphological characters between plants from Xunwu (A–I) and *Gelidocalamus stellatus* (J–R). A–D, J–M culm and node E–G, N–P culm leaf sheath H, Q branch sheath I, R foliar leaf. Scale bars: 3 mm (A–C, E, J–L, N), 1 mm (D, F–H, M, O–Q), 2 cm (I, R).

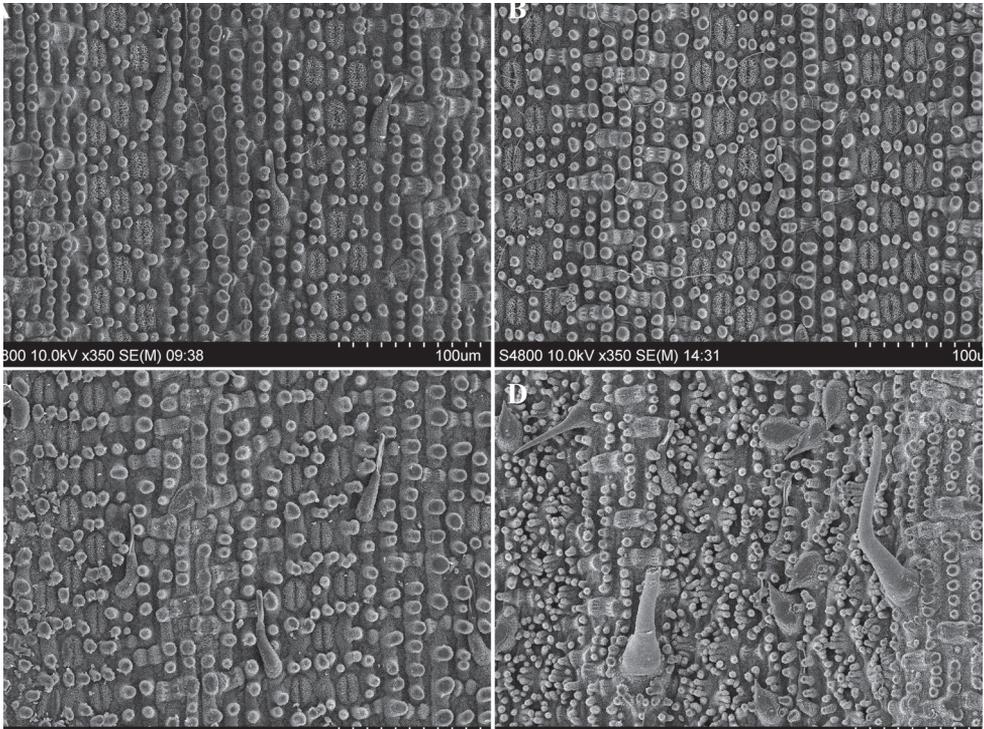


Figure 2. SEM images of the abaxial leaf epidermis. A Xunwu plants (Xunwu, Jiangxi, China) B *Gelidocalamus stellatus* (Jinggang Mountain, Jiangxi, China). C *Gelidocalamus tessellatus* (Libo, Guizhou, China) D *Gelidocalamus dongdingensis* (Longyan, Fujian, China).

Discussion

Recently, phylogenetic studies have indicated that *Gelidocalamus* is polyphyletic (Zeng et al. 2010, Zhang et al. 2012). Four species (*G. tessellatus*, *G. rutilans* T. H. Wen and two unnamed species) were examined by Zeng et al. (2010) and were found to be widely divergent. However, few species have been examined molecularly and more extensive sampling within *Gelidocalamus* is necessary. Similarly, studies of leaf micromorphology show that there are various patterns of the papillae surrounding the stomata among species of *Gelidocalamus* (Wu et al. 2014, Zhang et al. 2014, Liu et al. 2017).

In contrast, previous studies have also shown that leaf epidermis characters are almost identical among the main taxa of *Gelidocalamus*, e.g. *G. stellatus*, *G. tessellatus*, *G. annulatus*, *G. multifolius*, *G. latifolius* T. H. Wen (1985: 53) (Wu et al. 2014, Zhang et al. 2014, Long et al. 2015). The stomatal apparatuses are embossed outwards and usually surrounded by ca. 6–10 short papillae, obviously distinguished from those of other taxa, such as *G. subsolidus* W. T. Lin & Z. J. Feng (1990 : 18), *G. solidus* C. D. Chu & C. S. Chao (1984:75), *G. rutilans*, *G. monophyllus* (Yi & B. M. Yang) B. M. Yang (1989: 338), *G. kunishii* (Hayata) P. C. Keng & T. H. Wen (1983: 20) and *G. dongdingensis* (Fig. 2D) (Wu et al. 2014, Zhang et al. 2014, Liu et al. 2017), indicating that the genus *Gelidocalamus* may be good after eliminating several taxa.

In the present study, the Xunwu population has the typical characteristics of *Gelidocalamus*, and can be readily distinguished from other *Gelidocalamus* species as observed above. Based on the unique morphological characters, and possibly the disjunct distribution of the new species, we believe that the Xunwu population represents a new species, and is herein described and illustrated.

Taxonomic treatment

Gelidocalamus xunwuensis W.G.Zhang & G.Y.Yang, sp. nov.

urn:lsid:ipni.org:names:77165358-1

Figs 3–4

Diagnosis. Similar to *G. stellatus* Wen (1982: 22) in the habit and branch, but differs by culms sparsely hairy (early period) with granuliferous warts (adult or later period), each node with a ring of fulvous appressed trichomes below, culm leaf sheath densely hispidulous with a blade broadly lanceolate and 3–5–paired oral setae, branch sheath glabrous, foliage leaves broadly lanceolate to narrowly oblong, and new shoots late October.

Type. CHINA. Jiangxi Province: Xunwu County, 24°54'1.59"N, 115°28'2.78"E, elev. ca. 540 m, 7 Nov. 2015, *W.G. Zhang et al. 1107* (holotype: JXAU!) (Fig. 3A).



Figure 3. *Gelidocalamus xunwuensis* and *Gelidocalamus stellatus*. **A** *G. xunwuensis*, China, Jiangxi, Xunwu County, Guizhumao, W.G. Zhang et al. 1107 (holotype, JXAU!), with culm leaf sheath stiffly hairy and foliage leaf broadly lanceolate to narrowly oblong **B** *G. stellatus*, China, Jiangxi, Jinggangshan, Xiazhuang, W.G. Zhang & W.J. Li 1606 (JXAU!), with culm leaf sheath glabrous and foliage leaf lanceolate to narrowly lanceolate.

Description. Rhizomes leptomorph. Culms up to 2.5 m tall, ca. 2.0–5.6 mm in diam., erect, apically slightly nodding; internodes rough strigose with granuliferous warts, 12–20 cm long, wall 0.5–1.5 mm thick; each node with a ring of fulvous appressed hairs below and above sheath scar; nodal line upheaving markedly above 3–5 unequal buds, supranodal ridge present and prominent. Branching intravaginal from 4th node up, ca. 4–9 branches each node; branches equal or subequal, ca. 8–32 cm long, 1–2 mm in diam. Culm leaf sheaths tardily deciduous, 7–10 cm, abaxially carmine and densely hispidulous when young, then grey-white when old, ribbed-striate, pubescent with stiffly dark-brown hairs, apex slightly oblique and truncate; auricles absent or weak; oral setae curved, ca. 2–5 mm, 3–5-paired; ligule truncate, ca. 1 mm, scabrous, very shortly finely fimbriate; blade deciduous, narrowly triangular or linear-lanceolate, 10–15×0.9–1.2 mm, erect or recurved, apex acuminate, base blunt or truncate, ca. 1/3–1/2 as wide as sheath apex, margins scabrous. Ultimate branches usually with 1 foliage leaf; branch sheath glabrous; ligule truncate, ca. 1 mm, scabrous; auricles absent or weak; oral setae erect or curved; leaf blade narrowly oblong, ca. 15–20×2.3–3.0 cm, abaxially pubescent near base, apically acuminate, basally cuneate and symmetrical, margins serrulate and slightly revolute near base.

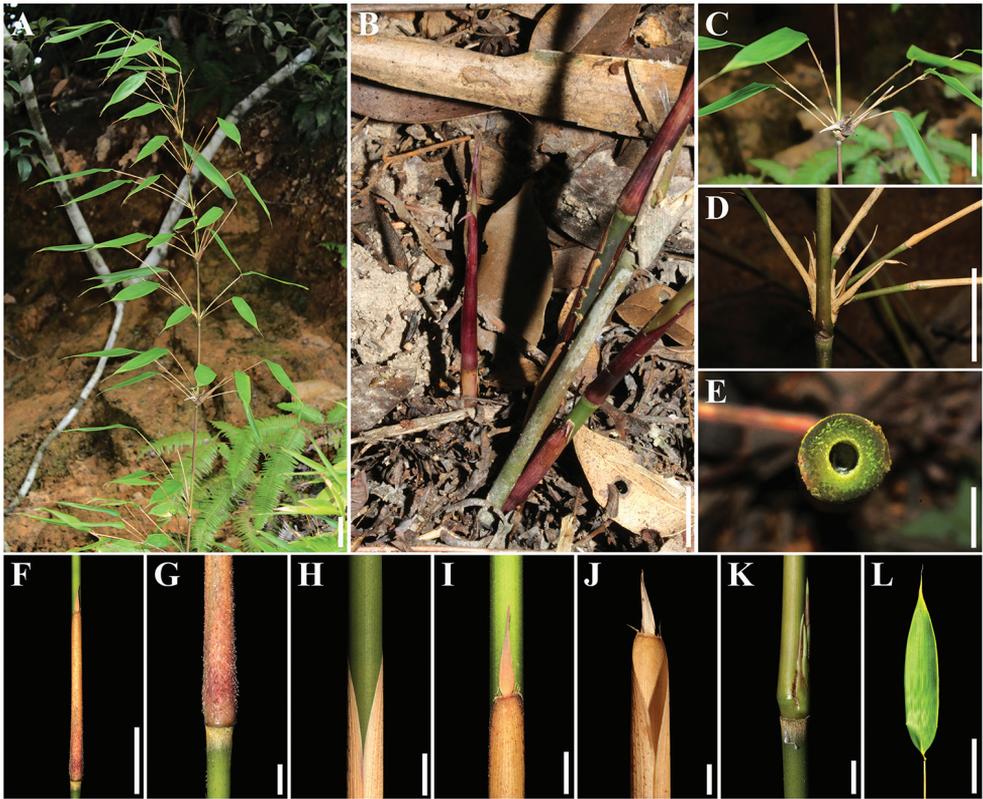


Figure 4. *Gelidocalamus xunwuensis*. **A** habitat plants **B** new shoot **C–L** detailed characters, show branch and branch sheath (**C–D**), transection of culm and pith-cavity (**E**), culm and its leaf sheath (**F–J**), buds (**K**) and foliage leaf (**L**). Scale bar: 5 cm (**A–D, F, L**), 5 mm (**E, G–K**).

Etymology. The species epithet *xunwuensis* refers to the locality of the type specimen: Xunwu County, Jiangxi, China.

Phenology. New shoots late October; flowering unknown.

Distribution and habitat. *Gelidocalamus xunwuensis* occurs under evergreen broad-leaved forests, along ravine, and roadsides at elev. ca. 400–600 m. It grows together with *Castanopsis kawakamii* Hay., *Dicranopteris pedata* (Houtt.) Nakaike, *Gnetum parvifolium* (Warb.) C. Y. Cheng & Chun, *Eurya chinensis* R. Br., *Semiliquidambar cathayensis* H. T. Chang, and *Ormosia semicastrata* Hance. *Gelidocalamus xunwuensis* is currently known from only one small populations (less than 100 culms) in the southern China.

Leaf micromorphology. Stomatal apparatuses, ca. 22 (20–24) × 12 (10–14) μm, are embossed outwards and covered by platelet-like wax. Short papillae occur on the abaxial leaf epidermis and appear randomly around the stomata (ca. 6–10 short papillae). Microhairs are composed of two cells with the apical cell withered, mostly distributed on the intercostal regions of abaxial epidermis. Silica bodies are saddle-shaped on the veins and can be clearly identified (Fig. 2A).

Conservation status. As a running bamboo, the new species is difficult to count each individual. Using the World Conservation Union Red List Categories and Criteria (IUCN 2012), *G. xunwuensis* should be treated as a data deficient species with less than 100 culms in the type locality.

Acknowledgments

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Incadendron: a new genus of Euphorbiaceae tribe Hippomaneae from the sub-Andean cordilleras of Ecuador and Peru

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Abstract

Incadendron esseri K.Wurdack & Farfan, **gen. & sp. nov.**, from the wet sub-Andean cordilleras of Ecuador (Cordillera del Cóndor) and Peru (Cusco, Oxapampa) is described and illustrated. This recently discovered large canopy tree with a narrow elevational range presents an unusual combination of rare morphological characters in Hippomaneae including mucilage-secreting sheathing stipules, conduplicate ptyxis, and large, woody fruits. The broader significance of these characters in Hippomaneae is discussed. The morphology and anatomy of *Incadendron* were investigated, highlighting its fruit similarities with Guiana Shield endemic *Senefelderopsis*, and the systematics value of ptyxis variation, which remains poorly studied for the family.

Keywords

Anatomy, ecology, Euphorbiaceae, Hippomaneae, *Incadendron*, ptyxis, taxonomy

Introduction

Euphorbiaceae contains about 330 genera and 6300 species, and new genera continue to be added both through taxonomic adjustments to non-monophyletic groups discovered during molecular phylogenetic studies (e.g., *Karima*, Cheek et al. 2016),

and more rarely through their discovery as recently collected novelties (e.g., *Gradyana*, Athiê-Souza et al. 2015; *Tsaiodendron*, Zhou et al. 2017). One such novelty, described herein, has been relatively well collected over the past 15 years due to intensive floristic and ecological studies in several sub-Andean cordilleras of Ecuador and Peru. These wet, mid-elevation mountains between the main Andean chain to their west and Amazonian lowlands to their east are rich in plant and animal endemism, especially in the Cordillera del Cóndor (Neill 2005, Ulloa Ulloa and Neill 2006), which contains the northern part of the known range of this plant and has floristic ties to the Guiana Shield. However, this region is relatively sparse in Euphorbiaceae endemism and a new genus is noteworthy. Based on morphological features, the Andean plant was quickly determined to be an undescribed member of Euphorbiaceae subfamily Euphorbioideae, and affiliated with tribe Hippomaneae. The shared diagnostic features include exudate of white latex, indument lacking, staminate bracts glandular at their base, perianth small in both pistillate and staminate flowers, petals absent, and staminate flowers inclinate in bud.

Euphorbioideae contains 40–45 genera (Esser 2001, Radcliffe-Smith 2001, Webster 2014; plus newly described *Gradyana*, Athiê-Souza et al. 2015) grouped in 3–5 tribes, and includes about 30 genera with New World species. Most of those 30 genera belong to tribe Hippomaneae and are wholly restricted to the neotropics, although a few have North American and/or Old World species. The taxonomy of the subfamily is difficult in regard to tribal and some generic circumscriptions, and a reclassification is needed within a phylogenetic framework (Wurdack et al. 2005). Most of the taxonomic problems relate to Hippomaneae, and distinctions among its many small-flowered, constituent genera are especially challenging. Such difficulties were found to be the case when considering the taxonomy of the Andean plant. Molecular phylogenetic placement within a well-sampled 4-gene phylogeny of subfamily Euphorbioideae (Wurdack, unpublished) establishes it as a member of subclade H1 of the hippomanoids (i.e., the clade of three tribes comprising paraphyletic Hippomaneae with embedded Hureae and Pachystromateae; Wurdack et al. 2005), although its divergence is deep and resolution is poor as to its closest relatives. The lack of assignment to an existing genus using morphological and molecular evidence indicates it deserves recognition as the novelty described below.

Taxonomic treatment

Incadendron K.Wurdack & Farfan, gen. nov.

urn:lsid:ipni.org:names:77165359-1

Diagnosis. Differs from other members of Euphorbiaceae by its combination of exudate of white latex, indument lacking; leaves coriaceous, with marginal glands, ptyxis conduplicate; stipules, large, sheathing, mucilage-secreting, deciduous; inflorescences leaf-opposed, spicate, with solitary pistillate flowers and numerous 3-flowered, glan-

dular staminate cymules; flowers apetalous with 3 sepals, staminate flowers with 3 stamens; fruits large, woody, dehiscent; and seeds dry, ecarunculate.

Type species. *Incadendron esseri* K. Wurdack & Farfan.

Description. Monoecious, glabrous trees. Latex white. Leaves alternate, petiolate, stipulate, simple, entire, glandular along margin near base, base minutely auriculate, penninerved, coriaceous, ptyxis conduplicate; stipules large and sheathing, entire, mucilage-secreting, eglandular, deciduous; petioles eglandular. Inflorescences terminal, solitary, appearing leaf-opposed, subtended by stipuliform bracts; pistillate flower 0–1, basal, bracteate; staminate flowers distal in numerous 3-flowered cymules subtended by verruculose bract and glands, bracteoles absent. Staminate flowers inclinate in bud and later erect, pedicellate; sepals 3, shortly connate; stamens 3, filaments short, free, anthers basifixed, extrorse, 2-thecate, longitudinally dehiscent; petals, pistillodes, staminodes, and disc absent. Pollen subprolate in equatorial view, 3-lobate in polar view, 3-colporate, margo present, tectum perforate. Pistillate flowers pedicellate; calyx 3-lobed, eglandular; ovary smooth, 3-locular, ovules 1 per locule, styles long; stigmas 3, undivided, eglandular; petals, staminodes, and disc absent. Fruit long-pedicellate, subglobose, smooth, dehiscing septicidally into 3 mericarps; pericarp dry, woody, thick; septa of mericarps with single or bifurcated vascular strand; columella alate, persistent. Seeds 3 per fruit, ellipsoid, smooth, ecarunculate.

***Incadendron esseri* K. Wurdack & Farfan, sp. nov.**

urn:lsid:ipni.org:names:77165360-1

Figure 1

Type. PERU. Cusco: La Convención, Distrito Quellouno, Abra de Yavero, 12°28'43"S 072°29'00"W, 2301 m, 24 Sep 2007 (fl, fr green fide label), *G. Calatayud*, *I. Huaman-tupa*, *E. Suclli*, & *R. Ayerbe* 4711 (holotype: USM; isotypes: AMAZ, CUZ, HUT, MO-6669029, MOL, US-3679263).

Description. *Trees* 6–26 m tall, to at least 56.7 cm dbh, trunk bark thin, monoecious; flowering and fruiting branchlets with leaves present, branching in pairs, leafy stems 1.5–2 mm dia., internodes 1–1.5 cm apart, branchlet bark smooth with scattered leaf and stipule scars, pith soft. *Exudate* present, white latex, watery. *Indument* absent. *Leaves* alternate, petiolate, stipulate, simple. *Stipules* free, paired, overlapping to sheath terminal bud, lanceolate, 10–13 × 3–4 mm, tip acute; base cordate, slightly asymmetric, with rounded free lobes extending to 1 mm below central point of attachment; eglandular, margins hyaline, deciduous before new leaf has fully expanded (abscised before leaf is 1/3 of mature size), after abscission leaving elliptic to reniform scars 1.3–1.7 × 0.4–0.5 mm. *Petioles* 9–20 × 1–1.8 mm (dia. mid-length), slightly flared at base, adaxially canaliculate, groove shallow and wide at petiole base (proximal) then narrowed mid-length and finally deep and wide at distal apex where shoulders of grove support minutely auriculate leaf base, petiolar glands absent. *Leaf blades*: laminar size class microphyll to notophyll, blade 6.7–13 × 2.9–3.8 cm, length:width ratio 1.97–



Figure 1. Illustration of *Incadendron esseri*. **A** Habit **B** Shoot tip **C** Leaf base (adaxial) **D** Leaf base and marginal glands (abaxial). **E** Staminate subinflorescence **F** Staminate cymule (distal view) **G** Staminate cymule (proximal view, without lateral buds) **H** Staminate flower **I** Pistillate flower **J** Fruit **K** Mericarp valve **L** Columella **M** Seed (ventral face). (Source: **A–G** Calatayud *et al.* 4711, MO; **H–I** Monteagudo *et al.* 4458, US; **J** Vásquez & Valenzuela 37638, MO; **K–M** Monteagudo & Ortiz 4605, US).

2.89:1 (mean = 2.49, SD = 0.212, n = 40, 2–3 mature leaves each from 14 collections), symmetrical, elliptic to slightly obovate, apex acute to rounded, often minutely retuse, base acute and minutely auriculate at point of attachment; margin with distinct smooth edge ca 0.1 mm wide, slightly revolute with more pronounced inward rolling at leaf base; marginal glands up to 12 per side with 2–4 larger ones consistently near base then sparse and progressively smaller distally, glands embedded in leaf margin (those at base hidden or appearing abaxial due to rolling of margin) and often appear perpendicular to blade, 0.2–1 × 0.1–0.5 mm, narrowly elliptic, surface slightly sunken, smooth; apex of midvein (where terminating at margin zone) minutely apiculate or thickened with globular mass 0.2 mm dia.; lamina coriaceous, adaxial surface of new leaves glossy, abaxially appearing smooth; ptyxis conduplicate, halves of young blade folded tightly together along adaxial surface; embedded laminar glands absent. *Venation* pinnate, brochidodromous; secondaries (10)13–17(19) pairs, spacing uniform, vein angle uniform to decreasing proximally, (10)20–30(40)°, decurrent attachment to midvein; intersecondaries frequent, parallel to secondaries; intercostal tertiaries reticulate; primary to tertiary venation prominulous on both surfaces. *Inflorescence* bisexual or staminate, solitary, terminal but appearing leaf-opposed, spicate thyrse, 5–12 cm long including 0.9–1.8 cm peduncle and distal rachis; in young bud protected by adjacent sheathing leaf stipules and bracts; bracts 2, free to shortly connate, stipuliform, inserted at start of fertile part (i.e., just below pistillate flower), 7 × 3.5 mm, rarely with 1–2 glands at base, cauducous. *Flowers* unisexual, lacking petals, disc, staminodes, or pistillodes. *Staminate partial inflorescence* a lax spiral of numerous cymules, each cymule on a tissue pad bearing a bract and subtended by glands; cymule bracts ca 0.5 (free portion) × 1 mm, widely acute to rounded, verruculose, persistent, when young forming protective scale-like sheath around staminate subinflorescence and inclinate buds; glands 4–5(6) in row or cluster per side of bract, 0.5–0.6 × 0.3–0.4 mm, disc-shaped or prismoidal when tightly abutting each other, face concave, yellow-orange in life; flowers 3 per cymule, central flower precocious and senescent well before laterals; bracteoles absent. *Staminate flowers* erect at anthesis; pedicels 3 × 0.3 mm for central flower (laterals seen only in bud), articulated at base; sepals 3, connate to 0.2 mm, widely rounded, 0.5 × 0.7 mm; stamens 3, free; filaments distinct, shorter than anthers, to 0.3 mm long; anthers 0.6 × 0.6 mm, 2-thecate, basifixed, exerted slightly through sinus between sepal lobes, dehiscent through longitudinal slits to 0.3 mm long, slit margins slightly recurved at anthesis; connective tip acute, barely protruding beyond thecae, not elaborated; yellow in life. *Pollen* polar:equatorial ratio (1.13)1.16–1.25:1 (based on SEM), tectum perforations smaller near apertures. *Pistillate flower*: (0)1, basal, pedicellate; pedicel 3.5–4.5 × 0.8–1 mm; pistillate bracts (1)2, at base of pedicel (shortly distal to stipuliform inflorescence bracts), 1–4 × 0.6–1 mm, elliptic to lanceolate, cauducous, leaving scars 0.3 × 0.2 mm; glands absent; flower 6–9 mm long; sepals 3, connate to 1 mm, broadly acute, 1.7–3.5 × 1.8–1.9 mm, margins hyaline; ovary 3-locular, ca 2 × 2 mm, top tapering and barely distinguished from start of styles; placentation apical pendulous with single ovule per locule; styles connate into column ca 5 × 0.9–1 mm; stigmas 3, free, undivided, eglandular, ca 3 mm long, erect in bud, recurved to loosely coiled at anthesis, surface

minutely papillose. *Infructescence* axis 23–40 mm long, consisting of peduncle 11–20 × 1.3–1.5 mm (dia. mid-length) and pistillate flower pedicel 10–20 × 1–1.3 mm (dia. mid-length and distinctly thinner than peduncle), prominent scars where staminate partial inflorescence and bracts abscised. *Fruit* subglobose, trigonous, 20 × 20 mm; ventral (septal) sutures sulcate; dorsal (loculicidal) sutures smooth when fresh, becoming ridged when dry; apex with woody beak ca 3 mm tall, sepals and stigmas deciduous; mericarps equal, 2-valved, splitting septically then loculicidally to release seeds. *Pericarp* 3–4 mm thick (equatorial at dorsal suture); dried exocarp thin, 0.2 mm mid-mericarp to 1 mm at ventral septal sutures and 2 mm at base, loosely adherent (can be easily peeled off dry specimens) to woody mesocarp on dehiscence, prominulous (likely drying artifact) veined with one primary vein descending from apex per valve, lower vein orders reticulate, major venation tracking embossed ridges on woody mesocarp; mericarp valves (cocci) barely twisted when dehisced, remaining attached together via basal triangle 3–5 × 6–7 mm (width at base); septa of mericarps woody, nearly continuous except for small semi-circular gap 2 (wide) × 1 mm (deep) where traversed by funicle; abscission layer between septa with well-developed spongy layer except absent at beak, vascular strand single or bifurcate; columella (carpophore) 18–20 mm long, proximally (where traversing pericarp at fruit base) rounded, distally (where confluent with septa) trigonous, distal part alate with jagged wing extending to 2 mm from central axis; funicle erect, slender, 2 × 0.3 mm. *Seeds* ellipsoid, apically (hilar end) rounded, basally flattened to slightly depressed, 8.8–9.7 (long) × 6.6–7.5 (wide; lateral-lateral) × 6.6–7 mm (deep; raphe-antiraphe), ventral face longitudinally traversed by narrow raised raphe 0.2 mm wide; seed coat ca 0.1 mm thick, testa thin, dry, uniformly dark brown; exotegmen mechanical, uniseriate palisade layer of elongate thick-walled cells, cells 3–4× shorter at apex versus bottom and sides, cell orientation vertical, inclined, or curved depending on location; caruncle absent; seed contents separated from mechanical coat by thin spongy layer except at base where solidly attached; endosperm yellowish, fleshy, slightly oily, forming layer up to 1 mm thick around central flattened ellipsoidal pocket containing embryo with cotyledons adhering to side of pocket; embryo type spatulate fully developed, embryo straight, extending most of seed length; cotyledons flat, elliptic, 4.5 × 3 mm, thin (ca 0.1 mm), apex broadly rounded, base subcordate, prominulous central vein that is distally branched; hypocotyl-radicle (stalk sensu Martin 1946) 2 × 1 mm, laterally slightly flattened.

Etymology. The genus is combined from “*Inca*” (as *Inka*, Quechua for “ruler” or “lord”) referring to the indigenous Inca people and pre-Columbian empire that was centered in Cusco and encompassed much of the range of this taxon, and “*dendron*” (Greek) referring to tree, which is the habit of the plant. Some localities occur near the Trocha Unión, an ancient Inca path. The specific epithet is from “*Esser*”, the surname of Hans-Joachim Esser (Botanische Staatssammlung München, Germany) and honors this expert on Hippomaneae who has contributed much to our understanding of the tribe and Euphorbiaceae in general.

Distribution, life history, and ecology. *Incadendron* is known from three well-separated clusters of localities (hereafter referred to as Cónдор, Manu, and Oxapampa

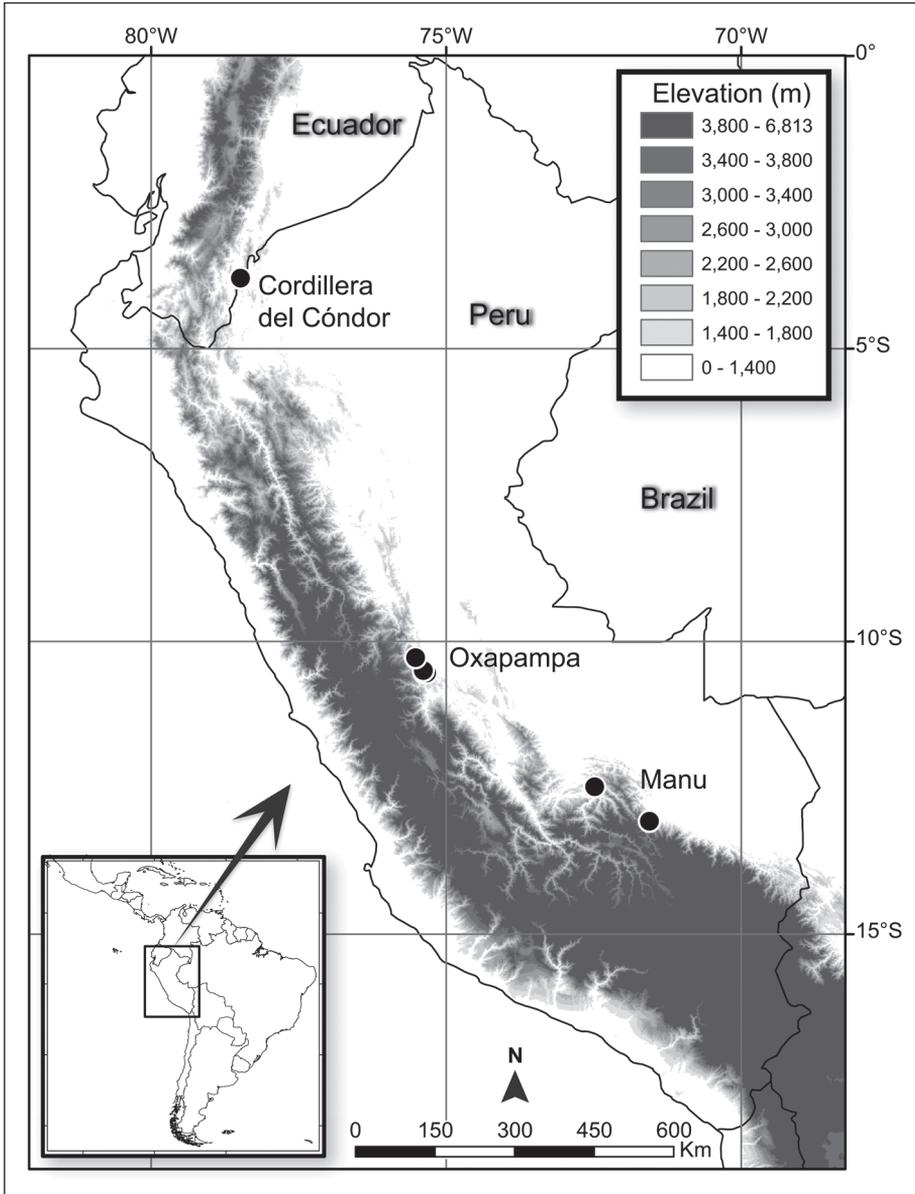


Figure 2. Distribution map of *Incadendron esseri*.

populations) on the eastern slopes of the main Andean mountain range in Peru and Ecuador, where it occurs in wet montane forests at 1800–2400 m elevation (Fig. 2). The extent of discontinuity in its range is presently unclear due to the floristically poorly known nature of the intervening areas, and it should be looked for in similar habitats between the three populations. There are minor vegetative differences including leaf apex variation with most tips distinctly acute versus more rarely rounded (i.e.,

Neill & Kajekai 16620, Monteagudo et al. 16929), and a larger-leaved collection (i.e., *Monteagudo et al. 4458*). The differences exist within the populations and presently do not suggest differentiation worthy of taxonomic recognition.

Detailed field observations were made in the tropical montane cloud forests of the Kosñipata Valley in Manu National Park (Parque Nacional del Manu), which contains the southernmost part of the known range of *Incadendron*. The general site characteristics are well documented (see Girardin et al. 2010, Farfan Rios 2011, Feeley et al. 2011, Rapp et al. 2012) as part of intensive forest monitoring using permanent forests plots established by the Andes Biodiversity and Ecosystem Research Group (ABERG, <http://www.andesconservation.org/>) along an elevational gradient (i.e., Kosñipata transect) from the Andes to the Amazon. *Incadendron* has been found (i.e., *Farfan et al. 1049, 1090, 1131*) in the cloud immersion zone between 1800–2250 m at the study site. The substrate where the tree was collected is granite between 1800–2000 m, and shale at 2250 m. The soils below the thick organic surface layer are relatively poor in nutrients. At the elevations where found, *Incadendron* is among the taller components of the forest and its habit is a canopy tree with a spreading crown. The maximum height observed was 21.2 m, and maximum tree diameter at breast height (dbh) was 56.7 cm. When cut, the thin trunk bark has a cream-yellowish color with abundant white latex. Mean tree growth (diameter increment) at the study site was $4.02 \text{ mm yr}^{-1} \pm 0.90$ (95% CI). Mean wood density is $0.55 \text{ g/cm}^3 \pm 1.18$ (95% CI), based in field sampling. The highest population density in the network of one hectare plots was found at 2000 m of elevation, with 30 adult individuals/ha ($\geq 10 \text{ cm dbh}$), making it the ninth most abundant tree in that plot (Parcela VII). The main associated species include *Alzatea verticillata* Ruiz & Pav. (Alzateaceae), *Cyathea lechleri* Mett. (Cyatheaceae), and *Ilex villosula* Loes. (Aquifoliaceae). The Euphorbiaceae diversity for the tropical montane forests of this region includes nine genera, of which there is notable species-richness in *Alchornea* Sw. (Farfan-Rios et al. 2015). The closet relatives of *Incadendron* (i.e., other members of Euphorbioideae) among these nine genera include *Sapium* spp. and *Pseudosenefeldera inclinata* (Müll. Arg.) Esser, with the latter occurring at lower elevations. The basal marginal leaf glands of *Neill & Kajekai 16620* from the Cordillera del Cóndor are overgrown by unusual clusters of tiny, 0.1 mm diameter black globules that are fruiting bodies of a likely ascomycete fungus. While epiphyllous fungal growth such as mold growing on glandular secretions is to be expected, these unusual fruiting structures are very different and deserve further study.

Phenology. The trees are evergreen, with an observed flowering season during July–September and fruiting during August–November. Herbarium collections also indicate a spring reproductive period of January–April for the Manu and Oxapampa populations. Fruits can be abundant, they turn brown when mature (Fig. 3G–H), and due to their large, heavy nature become pendulous on the relatively long infructescence axes. They are subject to predispersal seed predation by Lepidoptera, based on caterpillar remains recovered from inside fragmented fruits of *Monteagudo & Ortiz 4605*. In developing fruits these moths (likely members of Phycitinae, Pyralidae: Pyraloidea; A. Solis, personal communication) hollow out the seeds, which have well-developed endosperm, and leave holes (1.75 mm dia.) in the mericarp septa and seed coats (Fig. 3I–J). Plant

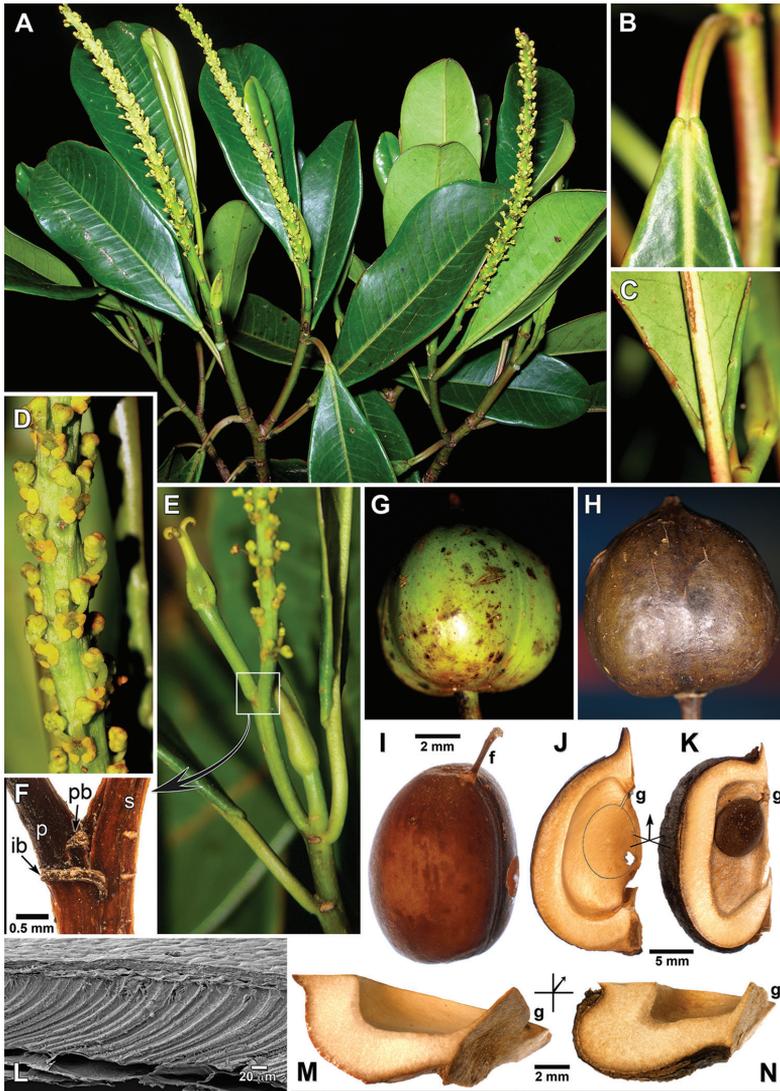


Figure 3. Morphology of *Incadendron* (A–J, L–M) and *Senefelderopsis* (K, N). **A** Habit, with paired branching and staminate inflorescences; note latex at damaged nodes **B** Leaf base (adaxial) with basal lobes **C** Leaf base (abaxial) with curled glandular margin **D** Staminate inflorescence with cymules subtended by glands; central flowers abscised leaving two lateral buds per cymule **E** Branch tip showing leaf-opposed inflorescence and stipule-enclosed renewal shoot **F** Summit of peduncle showing bract scars **G** Nearly mature green fruit **H** Mature brown fruit **I** Seed with funicle; holes in I & J come from insect predation **J** Mericarp valve with outline of seed position **K** Mericarp valve with a seed; funicle obscures gap **L** Seed coat, transverse view (SEM) **M** Pericarp profile and top half of valve (exocarp removed) **N** Pericarp profile and top half of valve. (Abbreviations: f = funicle, g = gap, ib = inflorescence bract scar, p = pistillate, pb = pistillate bract scar, s = staminate. Orientation of **M–N** relative to **J–K** shown by diagrams where x-y = plane of cross section, z = apically pointing arrow. (Source: *Incadendron*, **A–E, G–H** Farfan et al. 1049, 1131; **F** Farfan et al. 706, MO; **I–J, M** Monteagudo & Ortiz 4605, US; **L** Monteagudo et al. 4484, US. *Senefelderopsis croizatii*, **K, N** Radosavljevic 296, US).

defenses to deter herbivory would appear to be high in *Incadendron* due to latex, and the thick, lignified pericarp. Seed predation by specialist moths is well known for other Hippomaneae including in *Mabea* Aubl., where oviposition occurs early in fruit development when the pericarp is thin and soft (De Steven 1981). One young *Incadendron* fruit (4 mm dia.) on *Monteagudo & Ortiz 4605* (US) has what appears to be an oviposition hole at the top of the ovary that is likely a weak spot into the interior.

Conservation status. Following the criteria and categories of IUCN (2012), *Incadendron esseri* is given a preliminary status of Vulnerable (VU) under geographic range criteria B2 area of occupancy <2000 km² (B2a, known to exist at no more than 10 locations; B2b, continuing decline projected). Threats to this taxon in the Cordillera del Cóndor include mining for the underlying silica sand. Parts of its Peruvian range are protected within the Parque Nacional Yanachaga Chemillén and Parque Nacional del Manu.

Additional collections. ECUADOR. Zamora-Chinchipe: Yantzaza Cantón. Cordillera del Cóndor region. Río Machinaza watershed, east of Los Encuentros, in and near a 0.25-ha forest inventory plot, tree #1477 in Aurelian Plot #6, La Zarza mining concession of Kinross Aurelian Corp., about 1.7 km southeast of and 500 m above Las Peñas camp, 03°47'50"S 78°29'05"W, 1840 m, 30 Jun 2009 (fl), *D. Neill & C. Kajekai 16620* (MO, US); [same locality], tree #1362 in Aurelian Plot #6, 1840 m, 30 Jun 2009 (fl), *D. Neill & C. Kajekai 16622* (MO, US); [same locality], tree #1477 in Aurelian Plot #6, 1840 m, 30 Jun 2009 (fl), *D. Neill & C. Kajekai 16646* (MO, US). **PERU. Cusco:** Prov. Paucartambo, Kosñipata, Trocha Unión, km 13, Parcela VIII, subparcela 16, árbol 706, 19L 0222887, UTM 8553630, 1835 m, 19 Aug 2003 (fl, fr), *W. Farfan et al. 1049* (CUZ, F, HUT, MO, USM, DAV; cited as *Garcia et al. 1049* in Farfan-Rios et al. 2015); Trocha Unión, km 10, parcela VI, subparcela 2, árbol 74, 19L 0221737, UTM 8552556, 2295 m, 4 Sep 2003 (sterile), *W. Farfan et al. 1090* (CUZ, MO, USM, WFU); Trocha Unión, km 11, parcela VII, subparcela 3, árbol 105, 19L 0222622, UTM 8553538, 2000 m, 9 Sep 2003 (fl, fr), *W. Farfan et al. 1131* (CUZ, MO, USM, WFU); Prov. Paucartambo, Callanga, 19L 196221, UTM 8578219, 2245 m, 13 Sep 2007 (sterile), *W. Farfan et al. 3635* (USM, WFU); Callanga, 19L 196364, UTM 8579065, 2110 m, 14 Sep 2007 (sterile), *W. Farfan et al. 3696* (USM, WFU). **Pasco:** Oxapampa, Distrito Oxapampa, Parque Nacional Yanachaga Chemillén, cercanías del Refugio el Cedro, 10°32'S, 75°21'W, 2240 m, 27 Nov 2002 (fl), *A. Monteagudo et al. 4458* (MO, US); Parque Nacional Yanachaga Chemillén, cercanías del Refugio el Cedro, 10°32'S, 75°22'W, 2200–2400 m, 6 Feb 2003 (fl, fr), *A. Monteagudo et al. 4484* (MO, US); Parque Nacional Yanachaga Chemillén, camino del Refugio al Abra La Esperanza, 10°31'S, 75°20'W, 2400 m, 8 Mar 2003 (fr), *A. Monteagudo & G. Ortiz 4605* (MO, US); Parque Nacional Yanachaga Chemillén, Refugio Abra Esperanza y sus alrededores, 10°31'55"S 75°20'59"W, 2786 m, 23 Apr 2009 (fr), *M. Cueva 592* (MO, US); Parque Nacional Yanachaga Chemillén, Estación Biológica San Alberto, Refugio El Cedro, 10°32'20"S 75°20'14"W, 2731 m, 11 Feb 2012 (fr), *R. Vásquez & L. Valenzuela 37638* (MO, US); Localidad Grapanazú, 10°29'34"S 75°23'28"W, 2288 m, 22 Nov 2012 (young fr), *R. Vásquez 38201* (MO);

Distrito Huancabamba, zona de amortiguamiento del Parque Nacional Yanachaga Chemillén, al borde de las chacras y pastizales cercanías de la casa del Señor Orlando Quispe, 10°16'38"S 75°31'06"W, 1894 m, 24 Jul 2008 (young infl), A. Monteagudo *et al.* 16929 (MO, US).

Discussion. Specimens of *Incadendron* mostly were tentatively identified by collectors either as *Sapium* Jacq., due to similarities in coriaceous leaves and glandular, spicate inflorescences (Fig. 3A, D), or as *Micrandra* Benth. (e.g., Farfan-Rios *et al.* 2015), due to their shared unusually large fruits and white latex. *Sapium* notably differs in its bistaminate flowers and red-arillate seeds, and *Micrandra* is florally very different as a member of subfamily Crotonoideae. Within the context of the generic key to South American Hippomaneae in Athiê-Souza *et al.* (2015), *Incadendron* would group with *Sebastiania* Spreng. A comparison of select genera and distinguishing characters is given in Table 1. These genera are the most morphologically and geographically similar to *Incadendron* but are not necessarily its closest relatives, which are presently unclear. *Senefelderopsis* Steyerem., however, may have a closer relationship as suggested by similar fruit structure (see below), biogeographic ties between the Andean cordilleras and Guiana Shield (Berry and Riina 2005), and isolated phylogenetic placement in the same diverse subclade H1 of Hippomaneae (Wurdack *et al.* 2005).

Incadendron presents a unique combination of rare characters (discussed below) within Hippomaneae including sheathing stipules, conduplicate ptyxis, leaf margins entire and with unusual glands, and large, woody fruits. None of these characters appears phylogenetically very informative because they are autapomorphic or clearly homoplasious when considered in the context of molecular phylogenies (i.e., Wurdack *et al.* 2005, Wurdack, unpublished). Thus, while the rare character combination serves well to distinguish *Incadendron* and indicates a degree of morphological disparity deserving of generic recognition, it does not inform on relationships nor provide much insight into how such characters evolved. Major floral features that are variable in Hippomaneae have broadly distributed, likely plesiomorphic, states in *Incadendron*, including terminal and unbranched inflorescences, single pistillate flower per bisexual inflorescence, staminate cymules that are multiflowered and glandular, and 3-merous pedicellate staminate flowers with free stamens.

Pollen morphology and ultrastructure are remarkably diverse across Euphorbiaceae, but are less variable in Euphorbioideae, and Hippomaneae in particular (Punt 1962, Park and Lee 2013). The pollen of *Incadendron* resembles that of other hippomanoids in being tricolporate with a perforate exine (Fig. 4C–D). The seed structure of *Incadendron* is also similar to that of other Hippomaneae (Martin 1946, Tokuoka and Tobe 2002). Its seed coat (Fig. 3L) with a thin testa of collapsed cells and palisade-like mechanical exotegmen of elongate, pitted, thick-walled cells resembles that of exotegmic genera across the entire family. Depending on exact location, the pallisadal cells vary in length (3–4× shorter at apex versus bottom and sides) and orientation (vertical, inclined, or curved). Embryos generally deserve more careful description and study given their diversity in Euphorbiaceae, although most are variants of the spatulate fully developed type (Martin 1946). The embryo of *Incadendron*

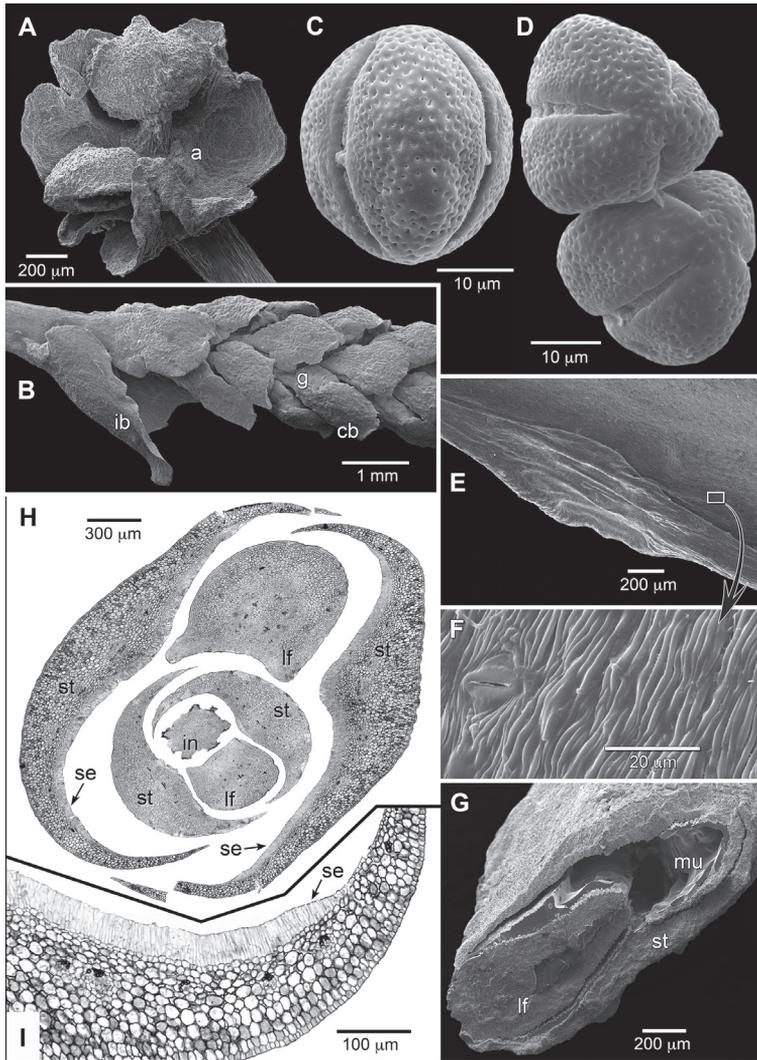


Figure 4. Micromorphological and anatomical features of *Incadendron*. **A** Staminate flower with one anther removed, showing short filaments and basally connate sepals **B** Young inflorescence, showing inflorescence bract and staminate cymules subtended by glands and bracts **C** Pollen; mesocolpium-centered equatorial view of whole grain **D** Pollen; slightly oblique polar view of whole grains **E** Abaxial laminar surface with marginal gland **F** Abaxial laminar surface closeup, showing striate micro-sculpturing and stomata **G** Fractured shoot tip, showing stipule surrounding young leaf with conduplicate ptyxis **H** Anatomical cross section of shoot apex, showing central terminal inflorescence surrounded by nested series of two developing leaves with subtending sheathing stipules (composite tiled image) **I** Closer view of anatomical cross section of stipule, showing mucilage-secreting cell layer. (Abbreviations: a = site of attachment of missing anther, cb = cymule bract, g = glands, ib = inflorescence bract, in = inflorescence, lf = leaf, mu = dried mucilage, se = secreting cells, st = stipule. **A–G** imaged with a Zeiss EVO MA15 SEM at 10–12 kV after sputter coating with 25 nm of Au/Pd; SEM samples untreated and directly mounted from dried herbarium specimens; pollen from dehiscent anthers. **H–I** from paraffin-embedded, rehydrated herbarium specimens; 7 µm sections stained with iron-mordanted safranin O and celestine blue B; imaged with a Zeiss Universal. Source: **A, C–D** *Monteagudo et al.* 4458, US; **B** *Neill & Kajekai* 16622, US; **E–I** *Neill & Kajekai* 16646, US).

Table 1. Comparison of *Incadendron* with the morphologically most-similar neotropical genera. Based on primary observations with supplements from Kruijt (1996) and Esser (1995, 2001). The circumscription of *Sebastiania* is controversial leading to some uncertainty in the breadth of character states.

Character	<i>Incadendron</i>	<i>Senefelderopsis</i>	<i>Sapium</i>	<i>Sebastiania</i>
Stipules	Lanceolate, sheathing, 10–13 × 3–4 mm, deciduous leaving elliptic scar	Lanceolate, 2.5–5 × 0.5–0.8 mm, deciduous leaving trigonous scar	Triangular, usually <2 × 2 mm but up to 8 mm long, persistent (rarely tardily deciduous)	Lanceolate, small, persistent
Indument	Absent	Present; multicellular, uniseriate	Absent	Usually absent; multicellular, uniseriate in some potential segregates (e.g., <i>Sebastiania vestita</i> Müll. Arg.)
Leaf features	Coriaceous; glands along margin; margin entire; ptyxis conduplicate	Coriaceous; large glands at base and rimmed laminar glands; margin entire; ptyxis supervolute-curved	Usually coriaceous; petiolar glands 2 (0 or 4), laminar glands absent; margin entire, glandular or toothed; ptyxis involute	Membranous to subcoriaceous; glands absent or rimmed glands near base; margins usually minutely toothed; ptyxis involute
Inflorescence structure	Terminal, simple thyrses; 0–1 pistillate proximal, staminate distal in numerous 3-flowered cymules; cymule bract glands 4–5 per side, discoid; bracteoles absent	Terminal, compound thyrses; 0–2 pistillate proximal per branch, staminate distal in numerous 5–10 flowered cymules; cymule bract glands 1 per side, fleshy and elongate; bracteoles present	Terminal or axillary, simple thyrses; 0–15 pistillate proximal, staminate distal in numerous 2–16 flowered cymules; cymule bract glands 1 per side, elliptic, flattened; bracteoles present	Terminal or axillary, simple thyrses; 0–5 pistillate proximal, staminate distal in numerous 1–3(7)-flowered cymules; cymule bract with 1 discoid gland to large segmented glandular mass per side; bracteoles usually absent
Staminate flowers	Stamens 3; sepals 3, connate at base	Stamens 3–5; sepals 3, connate at base	Stamens 2; sepals 2, connate at base to 2/3 of length	Stamens 3; sepals 3, connate at base
Fruits	Large; pericarp thick, woody	Large; pericarp thick, woody	Small to large; pericarp woody to leathery, usually thin	Small to large; pericarp thin

agrees with this generalization (see Description for details, based on one intact seed) and in particular resembles that of other Hippomaneae including *Senefelderopsis croizatii* Steyerl. (examined here, *Maas et al.* 5828, US), which has a slightly longer hypocotyl-radicle axis at 3 × 1 mm (versus 2 × 1 mm) and thicker cotyledons at 0.5 mm (versus 0.1 mm).

Unusual morphological features of *Incadendron*. The entire hippomanoid clade (sensu Wurdack et al. 2005) is considered here for the purposes of broad discussion rather than restricted to paraphyletic Hippomaneae. This broad grouping is reflected in the nomenclaturally problematic (see Esser 2012) Hippomaneae s.l. of Webster (2014). Stipules in the hippomanoids are typically small, scale-like (Fig. 5D) or absent. Conspicuous, sheathing stipules are relatively rare and in addition to *Incadendron* (Fig. 1B) also characterize *Conosapium* Müll. Arg., *Homalanthus* A. Juss. (Fig. 5A),

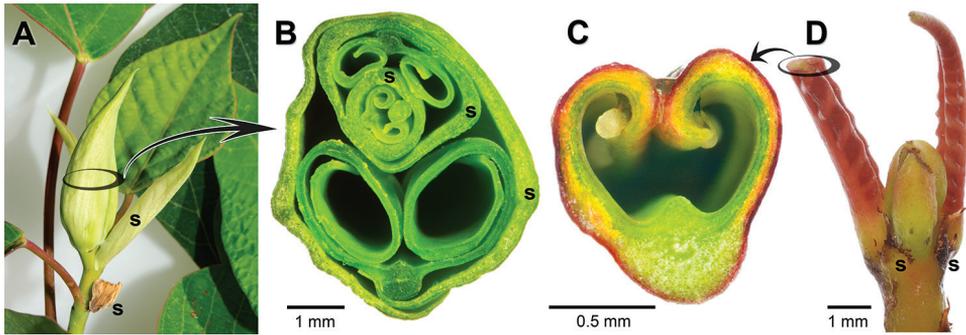


Figure 5. Hippomaneae shoot tips showing stipule and ptyxis variation. **A** *Homalanthus nutans* (G. Forst.) Guill. with large, deciduous, sheathing stipules protecting shoot tip **B** Transverse view of *H. nutans* shoot tip, showing nested series of three developing leaves with scroll-like lamina (ptyxis involute), each surrounded by a pair of sheathing stipules **C** Transverse view of *Excoecaria cochinchinensis* Lour. young leaf showing slightly inrolled lamina (ptyxis conduplicate-involute) **D** *E. cochinchinensis* shoot tip with small persistent stipules. (Abbreviation: s = stipule. Source: Freehand sections of fresh tissues grown in Department of Botany greenhouses).

Hura L., *Neoshirakia* Esser, and *Pachystroma* Müll. Arg. While functionally these large stipules are similar in conferring additional protection to the shoot apex, they differ in morphological details and likely are convergent size increases. The stipules in *Incandendron* are large, sheath the terminal bud, unusually stout in keeping with the coriaceous leaves, deciduous, and centrally attached such that an elliptic scar remains after abscission (Fig. 3E). The buds are internally mucilaginous. Serial sections of a single bud show a distinct palisade-like cell layer on the inner surfaces of the stipules that is the likely source of this secretion (Fig. 4H–I). This layer appears to differentiate late in development as it is present in the outer stipules but not on the enclosed next younger pair of the bud (Fig. 4H). The inflorescence bracts resemble a smaller version of the stipules (rarely with a few subtending glands of the type found with the staminate cy-mules) and are also deciduous, leaving large scars (Figs 3F, 4B). Conspicuous sheathing stipules in other taxa are mostly thinner except in *Pachystroma*, and may be centrally attached, leaving elliptic scars (*Homalanthus*, *Hura*, *Neoshirakia*) or broadly attached along their entire base, leaving semi-circumferential scars (*Conosapium*, *Pachystroma*).

Leaf folding (ptyxis) is variable but poorly studied for Euphorbiaceae in general (Cullen 1978). Based on recent surveys (K. Wurdack, personal observations) *Incandendron* appears unique in the hippomanoids in having conduplicate ptyxis (Fig. 4G). In bud and early expansion after stipule abscission, the halves of the blade are folded tightly together along their adaxial surface and the leaf in transverse section shows no curling at the edges. After the blade halves spread open, the margins recurve before hardening and finally at maturity the halves assume a flattened aspect with a slightly revolute margin (Fig. 3A, C). The terminal buds are flattened (Fig. 3E, 4G), which likely reflects the conduplicate nature of the enclosed developing leaf blades, although this point needs further study with fresh material. Other hippomanoids have varying

degrees of developing leaf blade curvature including tightly rolled scrolls, rolled edges, or gently curved loops that span involute (e.g., *Homalanthus*, Fig. 5B) to supervolute-curved ptyxis (e.g., *Senefeldersopsis*). Cullen (1978) indicated the hippomanoid *Excoecaria cochinchinensis* Lour. (as *E. bicolor* [Hassk.] Zoll. ex Hassk.) was conduplicate. Our observations on living (Fig. 5C) and herbarium material indicate its glandular-toothed margin is inwardly curled and the ptyxis is more accurately described as a conduplicate-involute intermediate. The hippomanoids contain a wide diversity of petiolar and leaf gland form and position. *Incadendron* has no acropetiolar or embedded laminar glands but it has glands along the leaf margin, which are best developed (i.e., consistent in presence and largest in size) near the leaf base. Curling of the leaf edge with age shields these basal glands (Fig. 3C), although the scattered more distal glands remain exposed. The marginal glands (Fig. 4E) are not associated with teeth or setae and are similar in morphology to those found on *Gymnanthes schottiana* Müll. Arg. Hippomanoid leaf margins typically have regular teeth or marginal setae, and are more rarely similar to *Incadendron* or entire without any associated glands. The abaxial leaf surface of *Incadendron* is finely striate, but the stomata are not shielded or sunken (Fig. 4F). Some high elevation hippomanoids have micro-papillose surfaces and concealed stomata (e.g., *Dendrothrix* Esser, *Senefeldersopsis*).

Inflorescences in the hippomanoids are axillary and/or terminal. In *Incadendron* the inflorescence is terminal but appears distinctly leaf-opposed due to near simultaneous development of both the inflorescence and adjacent leaf, coupled with the start of renewal shoot growth from the axillary bud before flowering is finished (Fig. 3E). Axial growth and orientation in *Incadendron* branches is not deflected by inflorescence development and gives little hint of being sympodial by substitution. Specimens of *Incadendron* show twinned branching (Fig. 1A, 3A), due to the occasional growth of additional leaf-axil accessory buds close to the growing branch tips. Most accessory buds, even in older parts of the shoot system, remain as barely visible meristems.

Large fruits, ≥ 2 cm in diameter are relatively rare among the hippomanoids (i.e., *Incadendron esseri*, *Duvigneaudia inopinata* [Prain] J. Léonard, *Hippomane mancinella* L., *Pachystroma longifolium* [Nees] I.M. Johnst., *Sebastiania obtusifolia* Pax & K. Hoffm., and a few species each of *Algermonia* Baill., *Excoecaria* L., *Hura* L., *Mabea* Aubl., *Ophthalmoblapton* Allemão, *Sapium*, *Senfeldera* Mart., *Senefeldersopsis*, and *Shirakiopsis* Esser), which otherwise typically have fruits less than half that size. Among the likely correlates of increased fruit size are larger seeds (see size variation in Tokuoka and Tobe 2002), thickened pericarps, indehiscence, and being borne singly (rarely two). Especially noteworthy is the combination of a dehiscent fruit with a thick pericarp (≥ 3 mm), which is rare among the big-fruited species. These generalizations do have exceptions such as thin walls in inflated fruits (i.e., *Excoecaria bussei* [Pax] Pax), or multiple fruits in large-fruited taxa with robust or compound inflorescences (e.g., *Mabea Senfeldera*, *Senefeldersopsis*). *Incadendron* exhibits some of these large-fruit trends including seed size, pericarp thickness, and being borne singly.

The fruits of *Incadendron* most closely resemble those of *Senefeldersopsis*. In addition to large size, they share many structural features including a thick pericarp with an ex-

ceptionally thick woody mesocarp (≥ 3 mm), sharp woody apex, well-developed septa, mericarp valves connected with a basal triangle, and a thin funicle. These features individually (or in various combinations) occur in other genera, but the thick mesocarp is exceptional among the large-fruited, dehiscent species. The mesocarp of *Incadendron* has a prominent dorsal-suture lip, has non-vascularized raised ridges that follow underneath major exocarp venation, and is stratified with a darker layer of different structure lining the locule (Fig. 3M); these features are to varying degrees shared with *Senefelderopsis* (Fig. 3N). In both *Incadendron* and *Senefelderopsis* the robust septa dividing the locules are lignified and nearly complete except for a small apical gap (Fig. 3J–K, M–N) to accommodate the funicle and its attachment to the placenta. Many other hippomanoids differ in having thin, poorly lignified septa that become destroyed during dehiscence, and/or septa that are incomplete leaving a large gap descriptively called a “C-shaped cut” (Athiê-Souza et al. 2015). Fruit vascular variation, especially septal strand number, has been considered potentially informative at the generic level in Hippomaneae (Esser et al. 1997, Esser 2001), but can be difficult to observe and its functional significance is not well understood. The septal vascular strand numbers are very similar between *Incadendron* (single or bifurcating) and *Senefelderopsis* (single or rarely bifurcating). The seemingly delicate, suspended nature of the relatively large seeds in the locules of both genera is unusual. Their thin, nearly erect funicles differ in length, which allow the seeds of *Incadendron* to be further displaced downward in the locule from the point of attachment to the columella as compared with *Senefelderopsis* (Fig. 3I–K). Many other hippomanoid taxa have better support for their seeds either through greater filling of the locule cavity by the seed that leaves little free space around it, and/or through more robust attachment to the columella via a short and thickened funicle or fusion along the raphe. The fruit and locule shape differ slightly between the genera in being subglobose in *Incadendron* versus elongate and more trigonous in *Senefelderopsis* (Fig. 3J–K, M–N). In addition, the exocarps (not examined anatomically and topographically defined here as the more or less removable outer layer) differ in gross structure with prominent vasculature at the interface between the loosely attached exocarp and woody mesocarp in *Incadendron*, likely supporting greater fleshiness when fresh. In *Senefelderopsis* there is little exocarp vascularization and tight adherence via a stiff, porous layer of apparently sclerified cells that is best developed in *S. chiribiquetensis* (R.E. Schult. & Croizat) Steyererm. Although there are considerable morphological differences between *Incadendron* and *Senefelderopsis* (see Table 1), the striking fruit similarities may have special significance for indicating a closer relationship between the genera.

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A valid name for the Xishuangbanna gourd, a cucumber with carotene-rich fruits

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Abstract

Herbarium specimens deposited in publicly accessible collections are the basis for all scientific names because only permanent specimens can be re-studied by independent researchers, the very essence of science. Re-investigations may be done with morphological, chemical, genomic, computer-tomographic, or other methods. Based on new herbarium material, I here provide a name for the Xishuangbanna gourd, a plant long cultivated in Yunnan because of its large non-bitter fruits, rich in β -carotene. Genome re-sequencing of numerous accessions has shown that this cucumber mutant is closer to *Cucumis sativus* var. *sativus* than is the wild bitter-fruited progenitor *C. sativus* var. *hardwickii*, and two dozen studies have further clarified the genetics of key traits, including pulp color, fruit shape, and flowering times. Morphological and molecular diagnoses of the new variety are provided and museum-quality specimens have been distributed to the World's major herbaria.

Keywords

China, Yunnan, cucumber, *Cucumis sativus*, plant breeding, genomics, valid name

Introduction

Southern Yunnan has a rich flora, with elements of both Indian and Chinese tropical biota, and local farmers from different ethnic backgrounds have long exerted diversifying selection on plants domesticated in this region of Southeast Asia. One such crop is the cucumber, *Cucumis sativus* L., of which bitter-fruited progenitor populations (*C. sativus* var. *hardwickii* (Royle) Alef.) occur in the Himalayan foothills in India, Myanmar (Burma), North and West Thailand, and Southwest China (Royle 1839: plate 47 shows *C. hardwickii*; Naudin, 1859: p. 30 discusses *C. hardwickii*; Sebastian et al. 2010). Genome re-sequencing of 115 cucumber lines sampled from 3,342 accessions worldwide has revealed four deeply separated genetic clusters consisting of Eurasian, East Asian, Indian, and Xishuangbanna cucumbers (Qi et al. 2013; Fig. 1). The Xishuangbanna gourd or cucumber (both English names are used) has large cylindrical or sub-globose smooth fruits and a pulp that at maturity resembles honey melon, *Cucumis melo* L., in color (Fig. 2). A single fruit can weigh 2–3 kg, and the seed number can exceed 1000 (Qi et al. 1983; Yang et al. 1991; Chen et al. 1994). No other variety of *C. sativus* has these traits.

The Xishuangbanna cucumber was brought to horticulturists' attention by 1979–1980 investigations of crop cultivars of the Yunnan province (Yang et al. 1991), and Qi Chunzhang, Yuan Zhenzhen, and Li Yuxian in 1983 were the first to argue that this local form deserves a formal name so that insights about its traits can be shared widely. They provided three arguments for naming it as a variety of *C. sativus*: (i) It has $2n = 14$ chromosomes, just like *C. sativus*, but unlike the remaining species of *Cucumis* so far counted (Kirkbride 1993; Chen et al. 1999; Yang et al. 2012, 2013). (ii) Crosses between typical *C. sativus* and the Xishuangbanna plants are fertile. (iii) Peroxidase zymograms of Xishuangbanna gourd and *C. melo* are quite different from each other.

Unfortunately, Qi and colleagues failed to make a type collection and to provide a Latin diagnosis or description, which in 1983 was still required for validly naming a plant taxon. No herbarium material is mentioned in their paper, but their text, geographic information, and B/W photos leave no doubt about which plant they are referring to. A search in the Chinese virtual herbarium (<http://www.cvh.ac.cn/news/8>) and correspondence with curators at KUN, IBSC, PE, and XTBG showed that no specimens have been deposited in these largest Chinese herbaria. The USDA's National Plant Germplasm System (NPGS) has only germplasm PI 618931 of the Xishuangbanna gourd, but it is not available for distribution because it has proven difficult to regenerate (K. R. Reitsma, Curator of Vegetable Crops, North Central Regional Plant Introduction Station, Iowa State University, Ames, Iowa; personal communication on 9 June 2017). The Beijing Crop Germplasm Resources information system supported by the Vegetable Research Center (BVRC) maintains 1915 accessions labeled as '*Cucumis sativus*' but provides no further taxonomic information; the database (icgr.caas.net.cn) supported by the Chinese Academy of Agricultural Sciences (CAAS) contains 1447 records for cucumber, again without further taxonomic data (Guo Shaogui, personal communication, 12 June 2017).

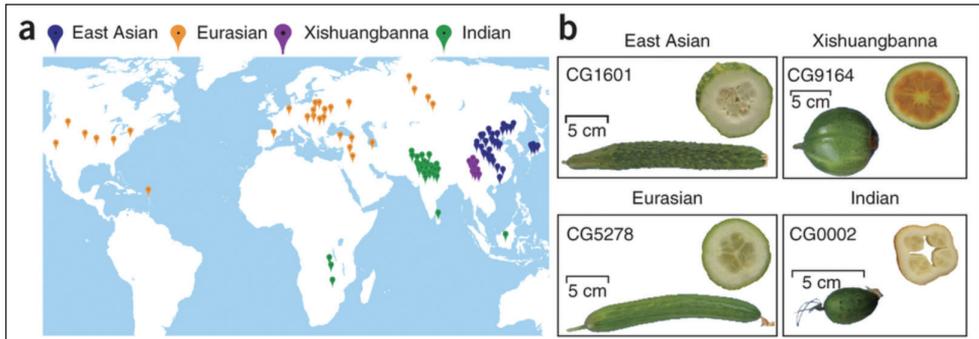


Figure 1. Cucumber populations. **a** The core collection of 115 lines re-sequenced by Qi et al. (2013). Colour codes indicate geographic groups **b** Fruit morphology of the four groups. The cucumber line CG1601 (East Asian) bears fruits with dense, white spines and an elongated stalk. Fruits of cucumber line CG5278 (Eurasian) lack spines and have a short fruit stalk. Cucumber line CG9164 (Xishuangbanna) bears melon-like fruits with a low fruit shape index (length/width) and a unique orange endocarp. Cucumber line CG0002 (Indian) bears small, oval fruits with sparse, black spines. Note that the images differ in scale. Reproduced from Qi et al. including Renner (2013).

Based on newly prepared herbarium specimens from Xishuangbanna, I here provide a valid name for the Xishuangbanna cucumber and briefly discuss research results on its main traits.

Methods

Plants were collected on fields in the Xishuangbanna region and nine duplicates dried between newspaper.

Results

Morphological diagnosis

Cucumis sativus L. var. *xishuangbannanensis* Qi & Yuan ex S.S.Renner, var. nov.
 urn:lsid:ipni.org:names:77165361-1

Notes. Differs from all other forms of *C. sativus* in producing thick-cylindric fruits that have ≥ 5 carpels and at maturity a non-bitter orange pulp (Fig. 2), while var. *hardwickii* and var. *sativus* both have 3 carpels and green pulp, which in var. *hardwickii* is bitter, in var. *sativus* non-bitter.

Molecular diagnosis. Verifiable DNA differences (characters): On chromosome 3, within the physical interval that spans the *ore* gene, Xishuangbanna cucumbers carry asparagine, whereas all other *C. sativus* (37 from East Asia, 29 from Eurasia,

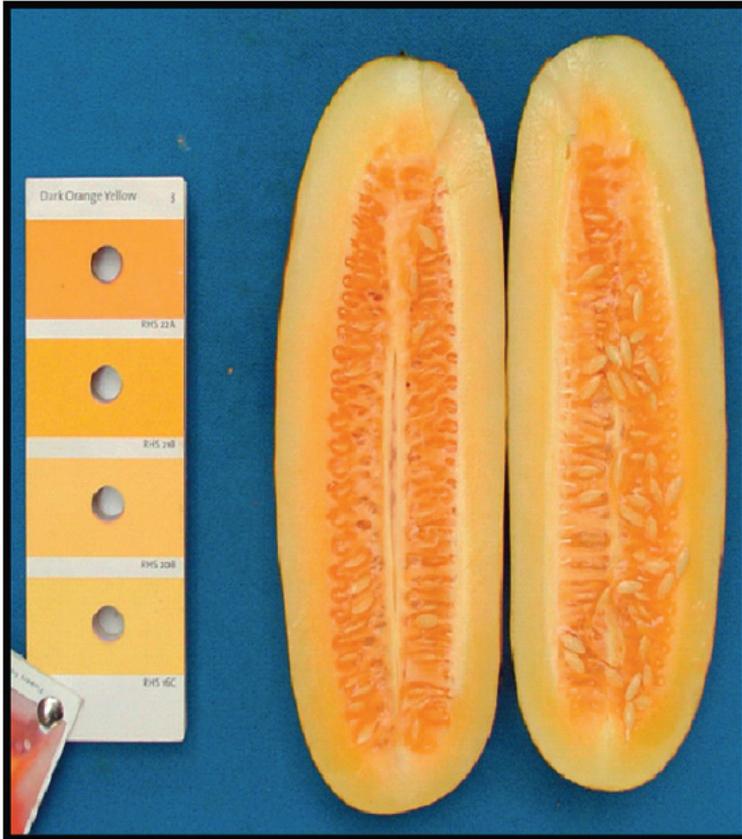


Figure 2. Section of a mature fruit of *Cucumis sativus* var. *xishuangbannanensis*. Reproduced from Staub et al. (2011).

30 from India) and homologous proteins from ten other species of flowering plants carry alanine at this site. This amino acid change at residue 257 (p.Ala257Asp) in *Csa3G183920*, affects a gene encoding a putative β -carotene hydroxylase, designated *CsaBCH1* by Qi et al. (2013; Fig. 3).

Type. CHINA, Yunnan Province, Xishuangbanna region, Menglun, Mengla county. Farmland of the Jinuo people at 1200 m, collected in flower on 18 July 2017; young fruits photographed on 20 July 2017 to show the pulp just beginning to turn orange; Chang Yanfen 1141 (holotype: PE; isotypes: IBSC, K, KUN, L, M, MO, US, XTBG).

Distribution. China (Yunnan), Laos, Vietnam, probably also Myanmar/Burma.

Flowering in July, mature fruits from the end of August onward (personal observation by Chang Yanfen).

Habitat, cultivation, and use. Growing in a tropical warm, humid climate above 1000 m alt. This form of cucumber has long been cultivated by the Jinuo, Hani, and Aini ethnic groups of China, Laos, and Vietnam, who call it ‘shihuo’ (Chen et al. 1994; Chang Yanfen, personal communication, July 2017) or ‘da huang gua’ (big cucumber) and ‘shan huang gua’ (mountain cucumber; Yang et al. 1991). Local farmers intercrop

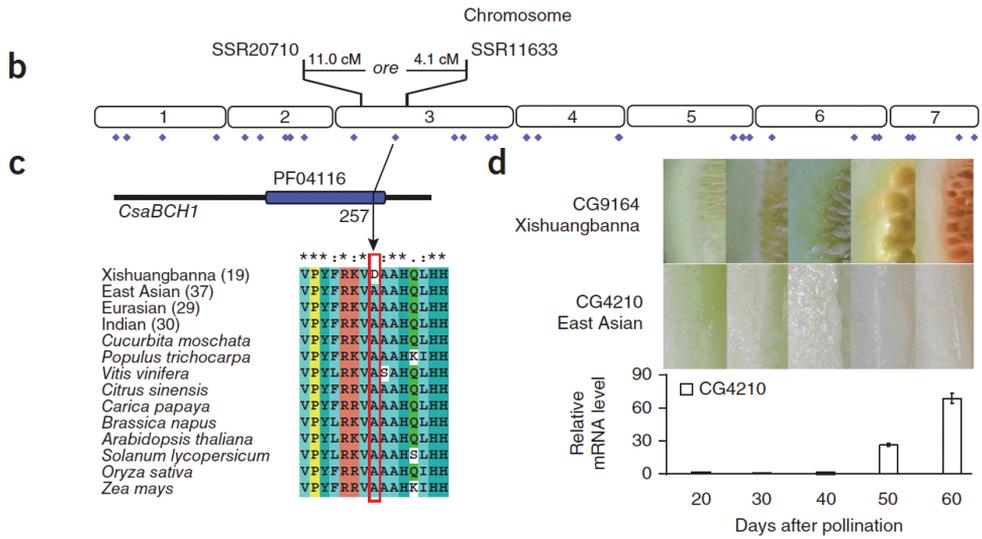


Figure 3. Physical position of the *ore* gene on *Cucumis sativus* chromosome 3. Blue diamonds below the seven chromosomes indicate the positions of 43 SNPs **c** Mutation at residue 257 changing the conserved amino acid of a putative β -carotene hydroxylase (*CsaBCH1*). Xishuangbanna group cucumbers carry asparagine, whereas all other cucumbers and homologous proteins from ten other species carry alanine **d** *CsaBCH1* mRNA levels in Xishuangbanna cucumbers that accumulate β -carotene. Reproduced from Qi et al. (2013).

gourd plants with dry rice, and cultivate three regional types, called Cattle shihuo, Ivory shihuo, and Round shihuo (Chen et al. 1994). They sow the seeds in April and harvest fruits from August to October/November. The Xishuangbanna gourd has primary stems 6–7 meters long and 20–40 lateral branches; plants are monoecious, and nodes often bear one female and one male flower (Chen et al. 1994). A single plant can bear about 10 mature fruits with a yield of 10–20 kilograms per plant (Chen et al. 1994). Like other cucumbers in China, the fruits are eaten raw or boiled, sliced, and spiced (Yang et al. 1991; Chen et al. 1994).

Etymology. The epithet was proposed by Qi et al. (1983) and refers to the geographic occurrence.

Specimens examined. The monograph of *Cucumis* by Kirkbride (1993) mentions Qi et al.’s (1983) paper on the Xishuangbanna cucumber in the discussion following *C. sativus* (with the erroneous spelling ‘*xishuangbannanensis*’ of the original paper), but does not formally treat the name because Kirkbride, of course, knew that the name was not valid for lack of a type and a Latin diagnosis or description. KUN has three specimens from Yunnan of which Kirkbride in 1991 annotated one as ‘*C. sativus*’, while the other two are annotated by Chinese taxonomists as var. *hardwickii*. Without mature fruits (whose carpel number could be determined) or DNA sequencing, it cannot be decided whether any of these specimen might represent the orange cucumber. I have not found any herbarium specimens annotated as ‘var. *xishuangbannanensis*’ despite numerous emails (cf. Acknowledgements).

Discussion

Cucumis sativus var. *xishuangbannanensis* has an orange endocarp high in carotenoids (Qi et al. 1983; Navazio 1994, Simon and Navazio 1997, Navazio and Simon 2001; Staub et al. 1999; McCreight et al. 2013). Efforts to incorporate genetic variation found in the Chinese material into U.S. cucumber germplasm to improve human health (Staub et al. 2011) have met with limited success. The orange fruit pulp is due to the accumulation of β -carotene (i.e., provitamin A), and the inheritance of this trait is by now well understood (Navazio 1994; Navazio and Simon 2001; Cuevas et al. 2010; Shen et al. 2011; Bo et al. 2012; Qi et al. 2013; Lu et al. 2015): Two recessive genes control the β -carotene content in the mesocarp, while one recessive gene controls β -carotene content in the endocarp (Cuevas et al. 2010). In the most extensive study so far, Qi et al. (2013) re-sequenced 115 *C. sativus* accessions from central and western Asia, Europe, the United States, and the Xishuangbanna region and found that a single SNP, resulting in an amino acid change at residue 257 (pAla257Asp) in *Csa3G183920*, modifies a gene encoding a putative β -carotene hydroxylase, designated *CsaBCHI* (Fig. 3), which is upregulated during the maturation of Xishuangbanna cucumbers so that 40–60 days after pollination, fruits rapidly accumulate β -carotene (Qi et al. 2013; Fig. 3).

Flowering time and fruit size variation in the Xishuangbanna cucumber have also been studied, and a QTL analysis implicated 11 QTLs on two chromosomes in determining photoperiod-dependent flowering time and the round fruit shape (Qu et al. 2014; Pan et al. 2017). The short hypocotyl is controlled by a recessive allele (Bo et al. 2016), and the carpel number of usually 5, not three carpels as in var. *hardwickii* and var. *sativus*, is controlled by a single gene for which a candidate locus has been identified (Li et al. 2016).

Concerning the time of domestication of the Xishuangbanna cucumber, synteny analyses among *C. sativus* var. *sativus*, var. *hardwickii*, and var. *xishuangbannanensis* have revealed that the Xishuangbanna cucumber shares major chromosomal rearrangements in chromosomes 4, 5, and 7 with var. *sativus* but not var. *hardwickii*, suggesting that it originated through diversifying selection after cucumber domestication (Bo et al. 2015). Comparison of fluorescence *in situ* hybridization (FISH) patterns in the three varieties also supports these relationships (Zhao et al. 2011: this study misspells the varietal name *xishuangbannanensis*). The sister species of *C. sativus* is *C. hystrix*, which has 12 (not seven like *C. sativus*), chromosomes (Chen et al. 1999), and both these species belong to an Asian/Australian clade of the genus *Cucumis* (Renner et al. 2007). A bottleneck that could have occurred during the initial domestication of the Xishuangbanna cucumber mutant has been dated to 3450 years ago (Qi et al. 2013: table 1).

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Pteris latipinna sp. nov. (Pteridaceae), a new species segregated from *Pteris fauriei*

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Abstract

Pteris fauriei is widely distributed in Eastern Asia and has high morphological variation. Some morphologically similar plants related to this species are difficult to distinguish. We showed that the new *Pteris* species from Taiwan, previously identified as *P. fauriei*, can be morphologically distinguished by its wide pinnae, larger terminal pinnae than the lateral pinnae in sterile fronds, and triangular basal segments of the lateral pinnae. It was confirmed that this species is phylogenetically separated from the other East Asian *Pteris* species, except for a morphologically distinct species *P. arisanensis*, by means of chloroplast genes, *rbcL* and *matK*. The new species is named as *Pteris latipinna* **sp. nov.**, referring to its wide pinnae. Here, we provide a key to facilitate the identification of the morphologically similar *Pteris* species in Asia. The morphological descriptions, images, ecology, and distribution are also presented.

Keywords

Pteris, *Pteris fauriei*, *Pteris latipinna*, Taiwan, taxonomy

Introduction

Pteris fauriei Hieron. is widely distributed in Eastern Asia. Two varieties of *P. fauriei* have been confirmed, and both varieties have different cryptic characteristics and prefer different niches. *Pteris fauriei* Hieron. var. *fauriei*, apomictic and triploid

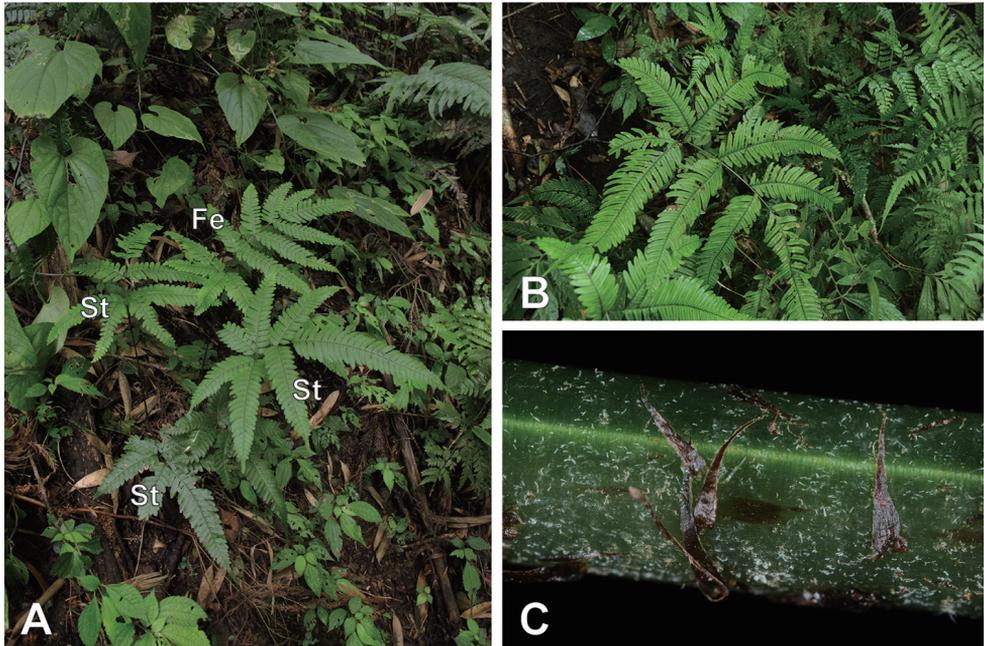


Figure 1. Photographs of *Pteris latipinna* Y.S.Chao & W.L.Chiou, sp. nov. in Hsinchu, Taiwan. **A** Habitat. Terminal pinna of sterile frond is larger than the lateral pinna. St, sterile fronds; Fe, fertile fronds **B** A frond **C** Concolorous scales a stipe.

($2n = 87$), usually has herbaceous laminae and prefers cooler sites; *P. fauriei* var. *minor* Hieron., sexual and diploid ($2n = 58$), usually has coriaceous laminae and is found in warmer sites (Huang et al. 2006; Huang et al. 2007). In Taiwan, some undescribed *Pteris* plants (Fig. 1), usually regarded as *P. fauriei* var. *fauriei*, with herbaceous laminae were found in understory of evergreen forests. However, those plants have wider laminae and pinnae than other bipinnatifid *Pteris* species recorded in Taiwan. Outside Taiwan, *P. natiensis* Tagawa, a Japanese endemic fern (Iwatsuki 1995), apomictic and diploid (Nakato and Ebihara 2016), is the most morphologically similar species in East Asia.

Pteris fauriei and morphologically similar *Pteris* species are phylogenetically close. Chao et al. (2014) revealed that the clade (A1, including those species with bipinnatifid laminae mostly) arose more recently than most of other clades in *Pteris*. Because of similar morphology, the characteristics to delimitate species need to be examined and compared in detail, such as venation, scale color, shapes of pinnae and segments, and pinnae stalked or sessile (Chao et al. 2013).

In this study, we clarified the morphological and phylogenetic characteristics of the undescribed *Pteris* plants, in comparison with *P. fauriei*, *P. natiensis*, and related bipinnatifid *Pteris* species from East Asia, including *P. wulaiensis* C.M. Kuo endemic to Taiwan; *P. arisanensis* Tagawa, *P. biaurita* L., *P. kawabatae* Sa. Kurata, *P. kiuschiuensis* Hieron., and *P. oshimensis* Hieron. distributed in China and Japan; and *P. boninensis*

H. Ohba, *P. laurisilvicola* Sa. Kurata, *P. satsumana* Sa. Kurata, and *P. yakuinsularis* Sa. Kurata endemic to Japan (Iwatsuki 1995; Liao et al. 2013). On the basis of morphological and molecular data, the taxonomic treatments were applied.

Materials and methods

Morphology

We examined type materials of morphologically similar taxa, including *P. fauriei* var. *fauriei* (in herbaria B, BM, KYO, MO, P), *P. fauriei* var. *minor* (in herbaria B, BM, KYO, P), and *P. natiensis* (in herbaria KYO, P). Several morphologically similar species in neighboring areas were also compared, including *P. arisanensis*, *P. biaurita*, *P. boninensis*, *P. kawabatae*, *P. kiuschiuensis*, *P. laurisilvicola*, *P. oshimensis*, *P. satsumana*, *P. wulaiensis*, and *P. yakuinsularis*.

Phylogenetic analyses

To clarify the phylogenetic relationships of the undescribed plants, 34 other *Pteris* taxa with bipinnatifid laminae were sampled. Three *Pteris* species, *P. grevilleana*, *P. longipinna*, and *P. venusta*, were used as outgroups. These bipinnatifid and outgroup species belong to clades A1 and A2, respectively, according to the phylogenetic tree of *Pteris* (Chao et al. 2014). Vouchers and GenBank accession numbers are listed in Appendix 1. Total genomic DNA was extracted from young fronds, following a modified cetyltrimethylammonium bromide (CTAB) method (Doyle and Doyle 1990). Two chloroplast genes, *rbcL* and *matK*, were amplified using the PCR primers for *rbcL* and *matK* as per Chao et al. (2014). Alignment was performed with ClustalW (Thompson et al. 1994) and manually edited using BioEdit 7.1.3 (Hall 1999). Gaps were treated as missing data.

Maximum likelihood (ML) analyses were performed using GARLI v.2.0.1019 (Zwickl 2006). Ten independent runs were conducted using automatic termination following 10,000 generations without a significant (lnL increase of 0.01) change in topology. To calculate ML bootstrap support for each node, 1,000 bootstrap replicates were performed with automatic termination at 10,000 generations, under one run.

Results

Morphology

The distinct morphologies that distinguished the undescribed species from other bipinnatifid *Pteris* species are its wide pinnae, up to 7 cm wide, and fewer pairs of lateral

Table 1. Morphological comparisons among *Pteris latipinna* Y.S.Chao & W.L.Chiou, sp. nov., *P. fauriei* var. *fauriei*, *P. fauriei* var. *minor*, and *P. natiensis*.

Species/ Characteristics	<i>P. latipinna</i>	<i>P. fauriei</i> var. <i>fauriei</i>	<i>P. fauriei</i> var. <i>minor</i>	<i>P. natiensis</i>
Lamina size	15–45 cm long, 15–40 cm wide; length/width ratio about 1	15–40 cm long, 10–35 cm wide; length/width ratio 1.2–1.5	10–30 cm long, 10–25 cm wide; length/width ratio about 1	15–40 cm long, 10–35 cm wide; length/width ratio about 1.1–1.2
Number of lateral pinnae of sterile fronds	2–3(4) pairs	2–7 pairs	2–5 pairs	2–5 pairs
Lateral pinnae of sterile fronds	Slightly incurved	Straight	Straight	Incurved
Petiolule	Sessile or short-petiolate. Most basal pinna-segments free to the rachis, sometimes adnate	Sessile or short-petiolate. Basal pinna-segments free to the rachis	Sessile or short-petiolate. Basal pinna-segments free to the rachis	Sessile. Basal pinna-segments adnate to the rachis; except basal pinnae
Basal segment of lateral pinnae	Triangular	Falcate	Falcate	Falcate
Terminal pinna size of sterile fronds	Distinctly wider than lateral pinnae except basal ones	Smaller than lateral pinnae	Smaller than lateral pinnae	Almost the same size as lateral pinnae
Pinna shape	Ovate-lanceolate, distinctly narrowed at base	Lanceolate, not narrowed at base	Lanceolate, not narrowed at base	Ovate to lanceolate, more and less narrowed at base
Width of lateral pinna	3–7 cm	2–3.5 cm	1–3 cm	3–5 cm

pinnae, only 2–5 pairs (Fig. 1). Furthermore, its terminal pinnae of sterile fronds are larger than the lateral pinnae (Table 1). In Taiwan, these characteristics can separate the undescribed species from *P. fauriei* var. *fauriei* and *P. fauriei* var. *minor* (these two taxa were illustrated by one of their type materials, Figs. S1 and S2, respectively).

An endemic species in Japan, *Pteris natiensis* (illustrated by holotype, KYO, Fig. S3), also has sterile fronds with slightly larger terminal pinnae than the lateral pinnae. Its pinnae are slightly narrower than those of the undescribed species (3–5 cm vs. 3–7 cm), and the basal pinna-segments are adnate to the rachis whereas they are not adnate to the rachis in the undescribed species (Table 1). Another specific trait of the undescribed species is the triangular (vs. falcate) basal segments of the lateral pinnae, which could be used to identify the new species from other similar species, including *P. fauriei* and *P. natiensis* (Table 1). The triangular and falcate basal segments are resulted by the longer costa adnate with the segments of the undescribed species and shorter costa adnate with the segments of the other species, respectively.

Phylogeny and chloroplast DNA differences

Genetic data and the accession numbers of the sequences are listed in Appendix 1. The chloroplast DNA (cpDNA) alignment matrix of *rbcL* (1,278 bp) and *matK* (900 bp) contained a total of 2,178 characters with 121 parsimony-informative sites. The log-likelihood score for the most likely ML tree was -5304.42470.

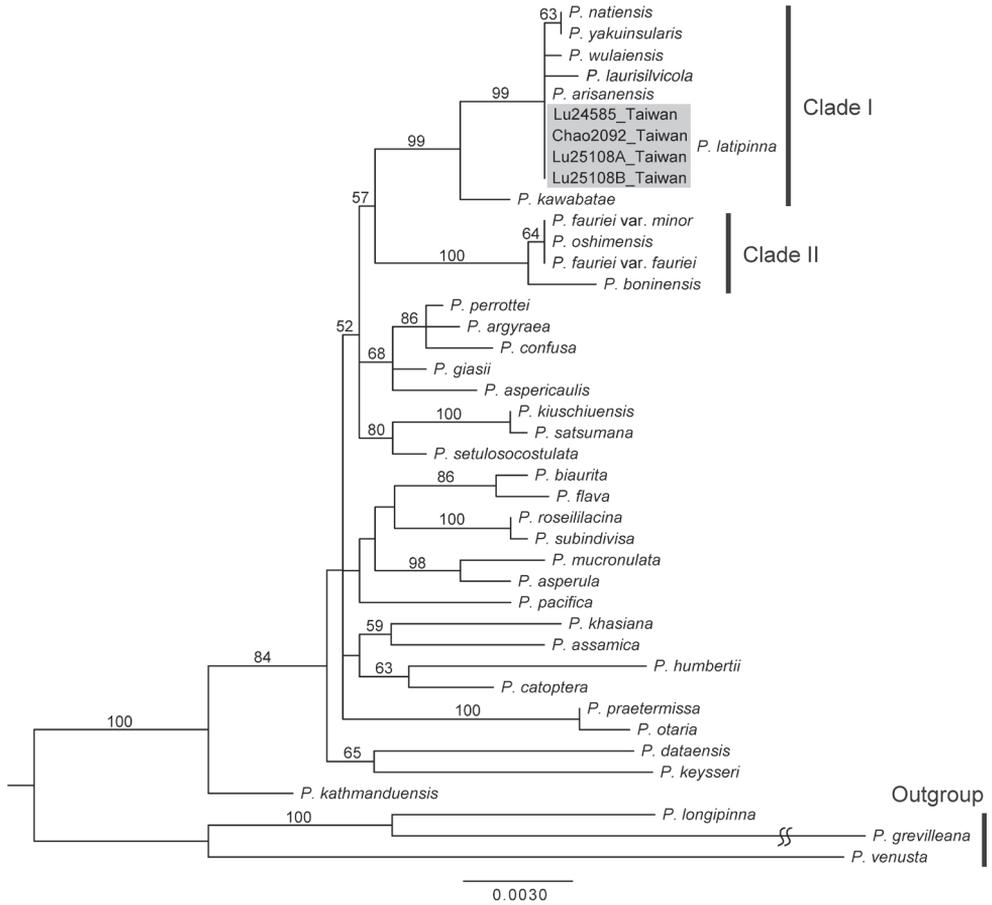


Figure 2. Chloroplast DNA phylogeny of the *Pteris latipinna* Y.S.Chao & W.L.Chiou, sp. nov. and related taxa. ML bootstrap support values are indicated on each branch.

The phylogenetic tree (Fig. 2) infers that the *Pteris* species with bipinnatifid laminae formed one monophyletic group (the clade of ingroup taxa), as revealed in the previous *Pteris* phylogeny (Chao et al. 2014). The undescribed taxon and *P. fauriei* were divided into two different clades, Clade I and II. In Clade I, the undescribed taxon shared identical cpDNA sequences with *P. arisanensis*, although they can be separated by their morphologies, such as venation and lamina shape (Fig. S4). The undescribed taxon cpDNA differed from *P. natiensis*, *P. wulaiensis* (Fig. S5), and *P. yakuinsularis* cpDNA by one nucleotide substitution, and from *P. laurissilvicola* cpDNA by two nucleotide substitutions. In Clade II, *P. fauriei* var. *fauriei*, *P. fauriei* var. *minor*, and *P. oshimensis* shared identical cpDNA sequences.

Both morphological and DNA characteristics support that this taxon is a new species, rather than a variety of *P. fauriei*. Here, we describe the new species and delimitate *P. fauriei* var. *fauriei* and *P. fauriei* var. *minor*. The morphology of the new species is presented in Fig. 3 and described below.

Taxonomic treatment

Pteris latipinna Y.S.Chao & W.L.Chiou, sp. nov.

urn:lsid:ipni.org:names:77165362-1

Figs 1, 3

Type. TAIWAN. Hsinchu County: Zhudong Town, Wuchihshan, 3 March 2013, Y.-S. Chao 2092 (holotype TAIF!, isotype TAIF!, TNS!).

Description. Rhizomes short, ascending, apex scaly; scales linear lanceolate, 1–4 mm long, 0.2–0.5 mm wide, concolorous, dark brown, entire, apex long-acuminate. Fronds clustered, 30–100 cm long, nearly monomorphic. Sterile fronds 30–70 cm long; stipes green, 2–4 mm thick, 10–30 cm long, base with persistent and scattered scales; grooved on the adaxial side; laminae widely ovate, 15–45 cm long, 15–40 cm wide, bipinnatifid; 2–3(4) pairs lateral pinnae, pinna angle against rachis 60–70°, straight, basal pinnae with one pair of exaggerated basiscopic pinnules, terminal pinnae distinctly longer and wider than the lateral except basal ones; pinnae ovate-lanceolate, distinctly narrowed at base, pectinate, 8–21 cm long, 3–7 cm wide, sessile or short-petiolate, apex caudate, 1–4 cm long. Basal segments of the lateral pinnae triangular, the other segments of pinnae falcate, 4–9 mm wide, apex obtuse, margins entire; veins forked, free. Fertile fronds 50–105 cm long; stipes 25–55 cm long; laminae ovate to widely ovate, 20–50 cm long, 20–35 cm wide, bipinnatifid; 3–5 pairs lateral pinnae, slightly incurved or straight; terminal pinna usually wider than the lateral; pinnae 8–20 cm long, 2–6 cm wide, 1–4 cm long; segments of pinnae 4–6 mm wide, apex acute or obtuse. Sori along pinna margins, protected by pseudoindusia; spore number 32; spores tetrahedral, tan.

Other specimens examined. TAIWAN. Hsinchu County: Guanxi, Chike Mt., *P.-F. Lu* 24585, 24586 (TAIF); Jianshi, *P.-F. Lu* 25108 (TAIF); Pawushan, *P.-F. Lu* 26666, 26673 (TAIF); Shuitien Logging Trail, *L.-Y. Kuo* 01 (TAIF). Miaoli County: Sintikusyu, komokwan, *Yaiti Simada* 5175A (HAST).

Distribution. Taiwan (Fig. 4).

Ecology. In shaded places, understory of evergreen broad leaf forests, below 1,000 m in elevation.

Etymology. The specific epithet ‘latipinna’ refers to its wide pinnae.

Preliminary conservation assessment. We investigated the distribution of *P. latipinna* Y.S.Chao & W.L.Chiou, sp. nov. in Taiwan. To date, only a few small populations are recorded. However, the available information is inadequate to support the assessment of its extinction risk. According to the IUCN (2012) criteria, the category of Data Deficient (DD) is appropriate.

Discussion

A new species, *P. latipinna* Y.S.Chao & W.L.Chiou, sp. nov., growing understory of forests in Taiwan was found and identified in this study. *Pteris latipinna* is the largest

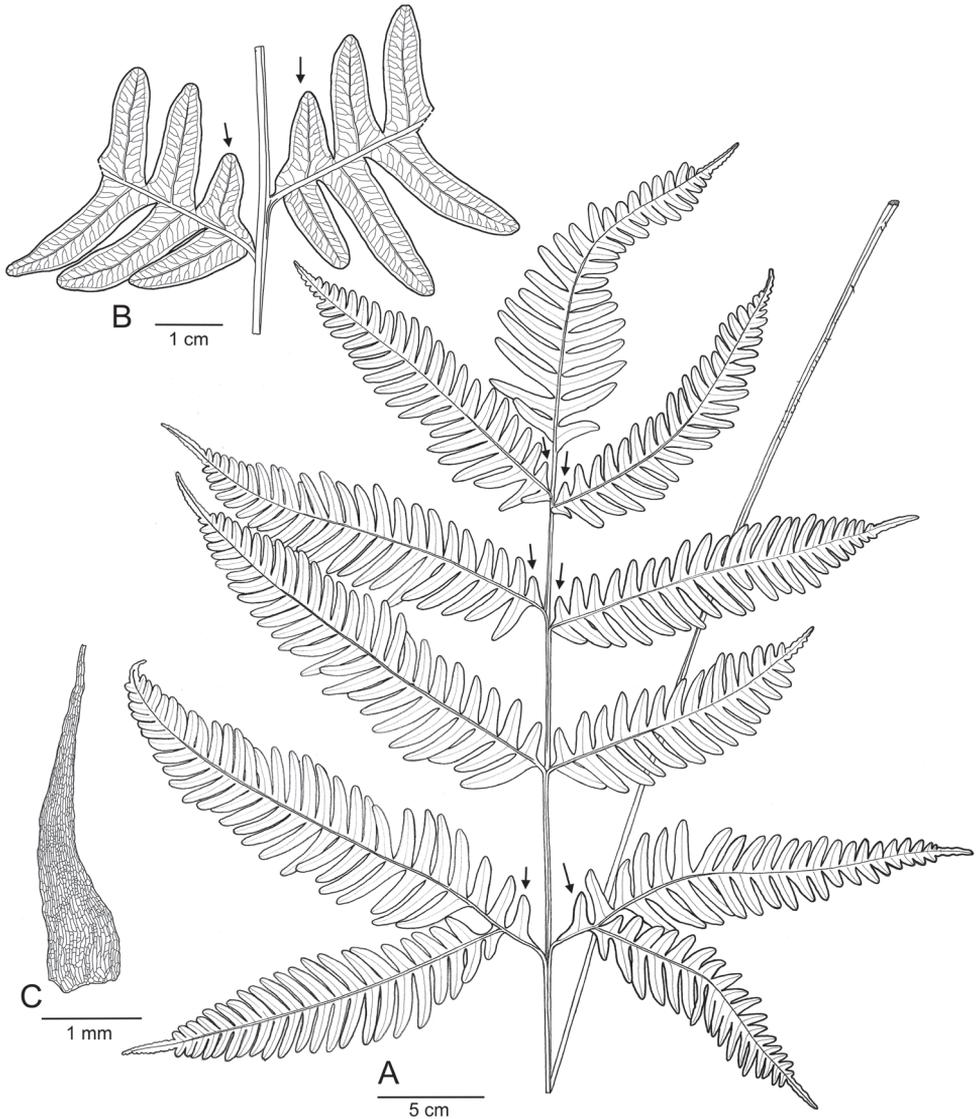


Figure 3. Illustration of *Pteris latipinna* Y.S.Chao & W.L.Chiou, sp. nov., based on holotype. **A** A fertile frond **B** Venation **C** Linear, concolorous scale. Basal segments of lateral pinnae are triangular (indicated by arrows).

species among the bipinnatifid *Pteris* species with single-axis in Taiwan. There were 29 *Pteris* species recorded in the Flora of Taiwan (Shieh 1994), and several new species and new records have been recently found (Chao et al. 2013; Chao et al. 2015; Ebihara et al. 2014; Knapp 2011; Knapp and Hsu 2017). In this study, we describe one more new species, and thus in total, 36 *Pteris* species, including infraspecies, have been documented in Taiwan.

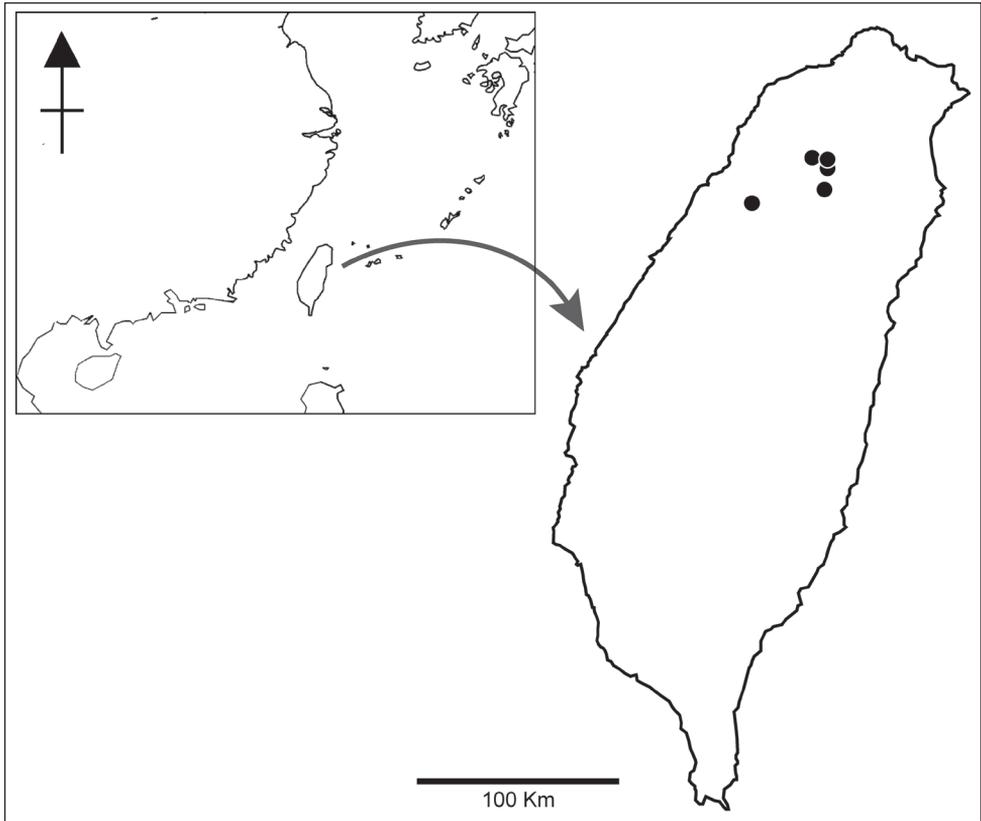


Figure 4. Distribution of *Pteris latipinna* Y.S.Chao & W.L.Chiou, sp. nov. (black circles) in Taiwan.

Although the ploidy of *P. latipinna* is not known, with the similar morphology and apomitic reproductive mode, it is inferred that those species possibly evolved through a complex reticulate hybridization-polyploidization speciation. Those apomictic *Pteris* species have also been suggested with possible hybrid origins (Chao et al. 2012a; Chao et al. 2012b; Walker 1979). *Pteris latipinna* has 32 spores per sporangium, which is thought as apomictic (Chao et al. 2010; Huang et al., 2006; Nakato 1975; Walker 1979). For those species in the same clade (Clade I) of *P. latipinna*, it is reported that *P. laurisilvicola* is diploid and triploid and apomictic (Nakato 1996; Nakato and Ebihara 2016); *P. natiensis* and *P. wulaiensis* are diploid (Huang et al. 2011; Kurita 1962; Nakato and Ebihara 2016); *P. yakuinsularis* are triploid (Nakato and Ebihara 2016); *P. arisanensis* is tetrapolyploid (Tsai and Shieh 1984). Remarkably, *P. latipinna* and *P. arisanensis* have the same cpDNA characteristics although their morphologies are clearly different. They have different lamina shapes (wide ovate for *P. latipinna* vs. ovate for *P. arisanensis*) and venation (free veins in *P. latipinna* vs. costal areolae in *P. arisanensis*) (Fig. S4). Similarly, in Clade II, *P. oshimensis* does not morphologically resemble *P. fauriei* but share

identical cpDNA sequences. More cpDNA and nuclear DNA markers are needed to clarify the relationships among these species in *P. fauriei* complex.

In this study, taxa in Clade I and Clade II compose *Pteris fauriei* complex because they are morphologically similar and phylogenetically close with *Pteris fauriei*. All of them are distributed in Asia, mostly in Japan and Taiwan. Interestingly, distributions of most of those species are limited: *Pteris latipinna* and *P. wulaiensis* are endemic in Taiwan; *P. boninensis*, *P. natiensis*, and *P. yakuinsularis* are endemic in Japan (Iwatsuki 1995; Shieh 1994). This pattern of distribution implies those species arose in a small area within a short time recently (Chao et al. 2014).

The traits useful for separating *P. latipinna* from the similar species are used in a key for identification of this species as shown below.

Key for *Pteris latipinna* and related bipinnatifid *Pteris* species

- 1 Stipes <2 mm thick 2
- 2 Pairs of lateral pinnae 4–6; basal pinnae shorter or equal to the second basal ones; pinnae narrowest at base *P. wulaiensis*
- 2' Pairs of lateral pinnae 6–11; basal pinnae longer than the second basal ones; pinnae widest at base *P. oshimensis*
- 1' Stipes 2.5–4 mm thick 3
- 3 Laminae widely lanceolate; ratio of length to width approximately 3:2 4
- 4 Laminae bipinnatifid; the segments extending to 2/3–4/5 of the way toward the costae; venation free or with costal areolae 5
- 5 Costal areolae arched, few triangular, connective veins with free veinlets *P. biaurita*
- 5' Costal areolae triangular or absent; if present, connected by a pair of furcated veinlets *P. arisanensis*
- 4' Laminae bipinnatisect; the segments extending almost to the costae; venation completely free, no costal areolae 6
- 6 Pinnae caudate with long tail 2–4 cm. *P. boninensis*
- 6' Pinnae acute or caudate with short tail 0.5–2 cm 7
- 7 Scales at stipe base caducous; pinnae sessile *P. laurisilvicola*
- 7' Scales at stipe base persistent; pinnae often stalked *P. yakuinsularis*
- 3' Laminae widely ovate, ratio of length to width approximately 5:4 8
- 8 Pinnae sessile except basal ones, with basal pinna-segments adnate to the rachis, pinna angle against rachis nearly 90°, incurved 9
- 9 Pinnae sometimes suddenly wider at base; segments oblong with rounded apex *P. kawabatae*
- 9' Pinnae not wider at base; segments falcate with obtuse apex 10
- 10 Pinnae nearly oblong, equally wide, 2–3 cm wide *P. kiuschiuensis*
- 10' Pinnae ovate-lanceolate to lanceolate, widest at middle, 3–6 cm wide 11

- 11 Lateral pinnae 5–6 pairs, pinnae 3–4 cm wide, terminal pinna-segments long, >1 cm *P. satsumana*
- 11' Lateral pinnae 2–5 pairs, pinnae 3–6 cm wide, terminal pinna-segments short, <0.5 cm *P. natiensis*
- 8' Pinnae stalked to sessile, without basal pinna-segments adnate to the rachis, pinna angle against rachis 60–70°, straight 12
- 12 Basal segments of lateral pinnae triangular *P. latipinna*
- 12' Basal segments of lateral pinnae falcate (*P. fauriei*) 13
- 13 64 spores per sporangium; laminae coriaceous *P. fauriei* var. *minor*
- 13' 32 spores per sporangium; laminae herbaceous *P. fauriei* var. *fauriei*

Acknowledgments

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Appendix I

Specimen information and GenBank accession numbers.

Taxon	Specimen collection number	Collection locality	GenBank accession numbers for <i>rbcL</i>	<i>matK</i>	Herbarium for voucher specimen
<i>P. setulosocostulata</i>	Y.-S. Chao 1146	Taiwan	KF289634	KF289501	TAIF
<i>P. keyseri</i>	Y.-S. Chao 1403	Philippines	KF289640	KF289510	TAIF
<i>P. mucronulata</i>	Y.-S. Chao 1410	Philippines	KF289641	KF289511	TAIF
<i>P. pacifica</i>	P.I. Forster 27643	Australia	KF289647	KF289517	MEL
<i>P. kawabatae</i>	Y.-S. Chao 1637	Vietnam	KF289655	KF289525	TAIF
<i>P. giasii</i>	C. R. Fraser-Jenkins 30176	Bangladesh	KF289660	KF289530	TAIF
<i>P. kathmanduensis</i>	C. R. Fraser-Jenkins FN35	Nepal	KF289663	KF289533	TAIF
<i>P. otaria</i>	C. R. Fraser-Jenkins FN26	India	KF289666	KF289536	TAIF
<i>P. roseililacina</i>	C. R. Fraser-Jenkins FN31911	Nepal	KF289669	KF289539	TAIF
<i>P. biaurita</i>	P.-F. Lu 17285	Taiwan	KF289676	KF289546	TAIF
<i>P. argyraea</i>	C. R. Fraser-Jenkins FN145	India	KF289684	KF289554	TAIF
<i>P. aspericaulis</i>	C. R. Fraser-Jenkins FN36	India	KF289685	KF289555	TAIF
<i>P. assamica</i>	C. R. Fraser-Jenkins FN5	Nepal	KF289686	KF289556	TAIF
<i>P. khasiana</i>	C. R. Fraser-Jenkins FN129	India	KF289688	KF289558	TAIF
<i>P. praetermissa</i>	C. R. Fraser-Jenkins FN64	India	KF289692	KF289562	TAIF
<i>P. subindivisa</i>	C. R. Fraser-Jenkins FN266	Bhutan	KF289700	KF289570	TAIF
<i>P. asperula</i>	Y.-C. Liu 9870	Philippines	KF289702	KF289572	TAIF
<i>P. dataensis</i>	Y.-C. Liu 9973	Philippines	KF289703	KF289573	TAIF
<i>P. catoptera</i>	G. Rouhan 301	Madagascar	KF289714	KF289584	P
<i>P. humbertii</i>	F. Rakotondrainibe 5965	Madagascar	KF289718	KF289588	P
<i>P. confusa</i>	Y.-M. Huang 20061128-A	India	KF289726	KF289596	TAIF
<i>P. flava</i>	M. Kurutok 23	Sabah	KF289731	KF289601	KEP
<i>P. perrottei</i>	C. R. Fraser-Jenkins FN215	Nepal	KF289736	KF289606	TAIF
<i>P. grevilleana</i>	Y.-S. Chao 770 (diploid)	Taiwan	HM582644	KF289484	TAIF
<i>P. venusta</i>	Y.-S. Chao 873	Taiwan	HM582650	KF289486	TAIF
<i>P. longipinna</i>	P.-F. Lu 11383	Taiwan	HM582603	KF289495	TAIF
<i>P. laurisilvicola</i>	Y.-S. Chao 1848	Japan	KF289738	KF289608	TAIF
<i>P. kiuschiuensis</i>	Y.-S. Chao 1852	Japan	KF289739	KF289609	TAIF
<i>P. satsumana</i>	Y.-S. Chao 1853	Japan	KF289740	KF289610	TAIF
<i>P. oshimensis</i>	Y.-S. Chao 1881	Japan	KF289741	KF289611	TAIF
<i>P. yakuinsularis</i>	Y.-S. Chao 1906	Japan	KF289742	KF289612	TAIF
<i>P. boninensis</i>	Y.-S. Chao 1941	Japan	KF289743	KF289613	TAIF
<i>P. natiensis</i>	Y.-S. Chao 1835	Japan	KF289744	KF289614	TAIF
<i>P. arisanensis</i>	Y.-S. Chao 1621	Vietnam	KF289677	KF289547	TAIF
<i>P. latipinna</i>	P.-F. Lu 24585	Taiwan	MF416317	MF416323	TAIF
<i>P. latipinna</i>	P.-F. Lu 25108A	Taiwan	MF416318	MF416324	TAIF
<i>P. latipinna</i>	P.-F. Lu 25108B	Taiwan	MF416319	MF416325	TAIF
<i>P. wulaiensis</i>	P.-F. Lu 26667-1	Taiwan	MF537503	MF537504	TAIF
<i>P. fauriei</i> var. <i>minor</i>	Y.-S. Chao 2078	Taiwan	MF416320	MF416327	TAIF
<i>P. fauriei</i> var. <i>fauriei</i>	Y.-S. Chao 2083	Taiwan	MF416321	MF416328	TAIF
<i>P. latipinna</i>	Y.-S. Chao 2092	Taiwan	MF416322	MF416326	TAIF

Supplementary material 1

Figure S1.

Authors: Yi-Shan Chao, Atsushi Ebihara, Wen-Liang Chiou, Yao-Moan Huang

Data type: JPEG image file

Explanation note: Type material of *Pteris fauriei* Hieron. var. *fauriei* in B (B20012819).

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Link: <https://doi.org/10.3897/phytokeys.85.14884.suppl1>

Supplementary material 2

Figure S2.

Authors: Yi-Shan Chao, Atsushi Ebihara, Wen-Liang Chiou, Yao-Moan Huang

Data type: JPEG image file

Explanation note: Type material of *Pteris fauriei* var. *minor* Hieron. in B (*U. Fauriei* 685, B200128109).

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Link: <https://doi.org/10.3897/phytokeys.85.14884.suppl2>

Supplementary material 3

Figure S3.

Authors: Yi-Shan Chao, Atsushi Ebihara, Wen-Liang Chiou, Yao-Moan Huang

Data type: JPEG image file

Explanation note: Holotype of *Pteris natiensis* Tagawa in KYO (*G. Koidzumi s.n.* Aug. 3, 1922).

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Link: <https://doi.org/10.3897/phytokeys.85.14884.suppl3>

Supplementary material 4

Figure S4.

Authors: Yi-Shan Chao, Atsushi Ebihara, Wen-Liang Chiou, Yao-Moan Huang

Data type: JPEG image file

Explanation note: Holotype of *Pteris arisanensis* Tagawa in KYO (*U. Fauriei* 603).

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Link: <https://doi.org/10.3897/phytokeys.85.14884.suppl4>

Supplementary material 5

Figure S5.

Authors: Yi-Shan Chao, Atsushi Ebihara, Wen-Liang Chiou, Yao-Moan Huang

Data type: JPEG image file

Explanation note: Holotype of *Pteris wulaiensis* C.M. Kuo in TAI (*S.-J. Moore*4383, TAI283138).

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Link: <https://doi.org/10.3897/phytokeys.85.14884.suppl5>

Bituminaria antiatlantica (Psoraleeae, Fabaceae), a new species from Morocco

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Abstract

A new species of *Bituminaria* is described and illustrated: *Bituminaria antiatlantica* Brullo, C. Brullo, Cambria, Cristaudo & Giusso, **sp. nov.**, which is endemic to Anti-Atlas Mountains (Morocco). It is a true chasmophyte, characterized by a suffruticose habit, several woody branches, leaflets coriaceous, rounded to ovate, small, few-flowered inflorescences and corolla pale coloured.

Keywords

Fabaceae, Leguminosae, New species, Endemic, Morocco, *Bituminaria*, Psoraleeae, Taxonomy, Pollen grain, Seed testa

Introduction

The genus *Bituminaria* Heist. ex Fabricius (Psoraleeae, Fabaceae), is widespread across the Mediterranean region and Macaronesian Islands, where, according to Egan and Crandall (2008), it is estimated to have diverged from other Psoraleoid genera approximately 6.78 million years ago. The first significant diversification of populations in the Psoraleeae occurred about 6.3 mya after the transcontinental split between North America and the Old World (Lavin et al. 2005). Molecular studies have revealed that

after this event it radiated rapidly and diversified into many taxa at generic and specific level (Egan and Crandall 2008, Egan and Reveal 2009, Dlodlu et al. 2013). Several monophyletic genera have been recognized within the Psoraleae ((Rydberg 1928, Stirton 1981, 1989, 2005, Grimes 1990, 1997, Egan and Crandall 2008, Egan and Reveal 2009, Dlodlu et al. 2013), some of them occurring in the New World (e.g. *Hoita* Rydb., *Orbexilum* Rafin., *Pediomelum* Rydb., *Psoralidium* Rydb., *Rupertia* J. W. Grimes, *Otholobium* C.H. Stirt., *Ladeania* A.N. Egan & Reveal) and other ones in the Old World and Australia (i.e. *Bituminaria*, Cullen Medik., *Psoralea* L. and *Otholobium*). Previous taxonomic and phytogeographic investigations have emphasized that several of these genera exhibit an outstanding species richness, which can be explained by evolutionary and ecological processes.

The causes of diversification of the Psoraleae can be attributed mainly to range fragmentation, geographical isolation, reproductive biology, ecological adaptations, competitive factors, climatic changes and habitat modifications. These speciation processes have been active in the genus *Bituminaria* which is represented by eight distinct species (Stirton 1981, Greuter et al. 1989, Minissale et al. 2013, Giusso et al. 2015, Brullo et al. 2016; Bogdanović et al. 2016): *B. bituminosa* (L.) C.H. Stirt., *B. morisiana* (Pignatti & Metlesics) Greuter, *B. flaccida* (Nábělek) Greuter, *B. basaltica* Miniss., C. Brullo, Brullo, Giusso & Sciandr., *B. kyreniae* Giusso, C. Brullo, Brullo, Cambria & Miniss. (2015: 278), *B. palaestina* (Bassi) Brullo, C. Brullo, Miniss., Salmeri & Giusso and *B. plumosa* (Rchb.) Bogdanović, C. Brullo, Brullo, Ljubičić & Giusso, all belonging to subgenus *Bituminaria*, and finally *B. acaulis* (Steven ex M. Bieb.) C.H. Stirt. included in the subgenus *Christevenia* Barneby ex C.H. Stirt.

Bituminaria usually colonizes ecologically well-differentiated habitats: *B. morisiana* and *B. kyreniae* are true chasmophytes linked to the Mediterranean climate and both grow on cliffs; *B. flaccida* is exclusively found on sandstone outcrops of desertic areas; *B. palaestina* occurs on moist soils along streams and marshes; *B. basaltica*, *B. bituminosa* and *B. plumosa* grow in steppic grasslands and synanthropic habitats; and finally *B. acaulis* is a mountain species linked to mesophilous open environments within Colchic forests.

Morphologically, the genus *Bituminaria* subgenus *Bituminaria* is differentiated by several apomorphic characters, such as determinate capitate inflorescences, as well as pods which are represented by a corpus with a coriaceous pericarp strongly fused with the seed and entirely covered by rigid long white hairs, usually with mixed to black or ivory prickles, very unequal, compact and rigid, while the long beak, inserted in the corpus through a callus, is flat, compact, rigid, provided with very short white and black hairs, forming a dense or scattered indumentum. Other characters shared by all the other species of this subgenus include: trifoliolate petiolate leaves; unequal, entire leaflets, discontinuous, floral vasculature, bracts each subtending 2-3 flowers; calyx gibbose with unequal teeth; corolla anthocyanic; vexillary stamen partially fused with the other filaments; and ovary inserted on a long stalk. Recent taxonomic investigations carried out on *Bituminaria* (Muñoz et al. 2000, Minissale et al. 2013, Bacchetta et al. 2014, Giusso et al. 2015, Toksoy et al. 2015, Brullo et al. 2016; Bogdanović

et al. 2016) highlighted that more studies were needed to discriminate clearly the taxa belonging to the *B. bituminosa* complex, which is widely distributed in the Mediterranean territories. As part of these investigations we examined an isolated population of plants occurring in Morocco, which had been described by Maire (1936) as *Psoralea bituminosa* var. *rotundata*. To clarify the taxonomic position of this plant, we visited the Anti Atlas Mountains (southern Morocco), during which it was possible to collect specimens used as exsiccata and pods for its cultivation.

Plants referable to *Psoralea bituminosa* var. *rotundata* (previously recorded by Maire (1936) and Benabid and Cuzin (1997)) were found in two locations of the subdesertic area. They are represented by Mount Tachilla (*locus classicus*) and Djebel Imzi respectively, where the plant grows in the crevices of cliffs and steep rocky north-facing surfaces. In-depth taxonomic investigations of herbarium specimens and living plants cultivated from wild pods allowed us to observe significant morphological differences between these Moroccan populations and those of other *Bituminaria* species, occurring in various Mediterranean territories. These Moroccan plants (*Psoralea bituminosa* var. *rotundata*) are recognised as a distinct species and raised to specific rank as *B. antiatlantica*. The plants are characterized by: a suffruticose habit and very branched, woody stems; coriaceous semi-round to ovate leaves; small, few-flowered inflorescences and pale coloured corollas. It is a rare chasmophyte linked to very dry climatic conditions, and grows together with several other relic endemic species.

Species treatment

***Bituminaria antiatlantica* Brullo, C. Brullo, Cambria, Cristaudo & Giusso, sp. nov.**

urn:lsid:ipni.org:names:77165363-1

Figs 1, 2

Bituminaria bituminosa (L.) C.H. Stirt. *affinis, sed habitu suffruticoso, ramis lignosis, foliolis glabris vel sparsim pilosis, subrotundatis vel ovatis, max. 35 mm longis, petiolis usque ad 6 cm longis, inflorescentia laxa, saepe subspicata, 1,5-2 cm longa, 3-10-flora, calice 12-13.5 mm longo, corolla pallida.*

Synonym. *Psoralea bituminosa* L. var. *rotundata* Maire, Bull. Soc. Hist. Nat. Afr. N. 27(8): 222, 1936.

Type. Morocco: In rupibus arenaceis Mountis Tachilla ad radices septentr. Anti-Atlantis, 400 m, 10 April 1935, R. Maire & E. Wilczek s.n. (holotype MPU!; isotype RAB!), sub *Psoralea bituminosa* L. var. *latifolia* Moris f. *rotundata*).

Description. Perennial, suffruticose, dark green, erect to ascending, up to 60 cm tall. *Stems* dark green-brown, sparsely hairy, with hairs short and appressed, very branched; branches woody, leafy along entire length. *Stipules* 5–6 mm long, rigid, linear-triangular, adnate to the petiole. *Leaves* pinnately 3-foliolate, green, with petiole 1.8–6(7) cm long, sparsely hairy; *leaflets* semi-round to ovate, subglabrous

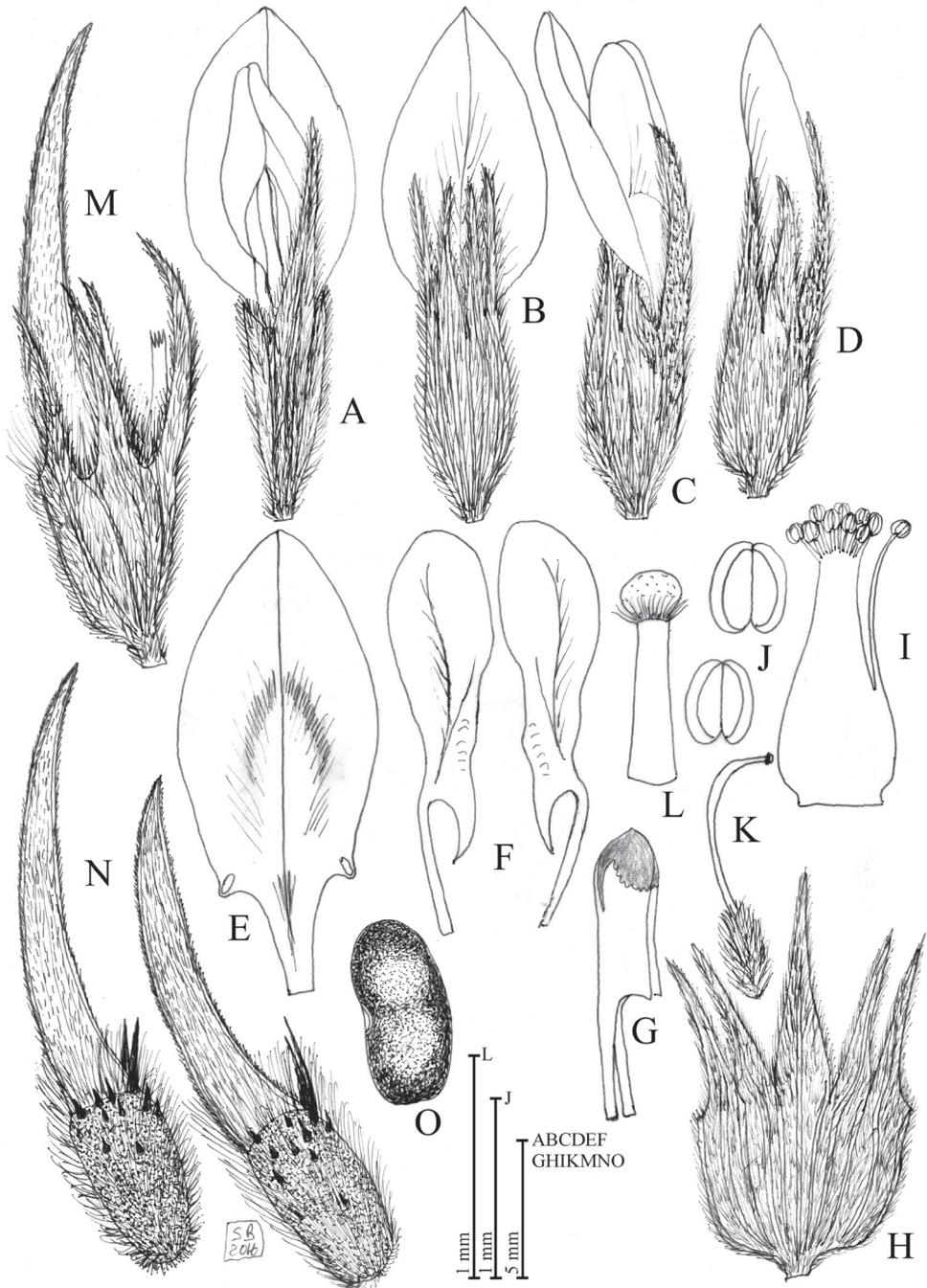


Figure 1. Diagnostic features regarding the reproductive structures of *Bituminaria antiatlantica*. **A** Flower (ventral view) **B** Flower (dorsal view) **C** Flower (lateral view) **D** Bud **E** Standard **F** Wings **G** Keel (lateral view) **H** Calyx (open) **I** Staminal tube **J** Anthers **K** Pistil **L** Stigma **M** Fruiting calyx and pod **N** Pods **O** Seed. Illustration by S. Brullo based on living material coming from Mount Tachilla and Djebel Imzi in Morocco (CAT).

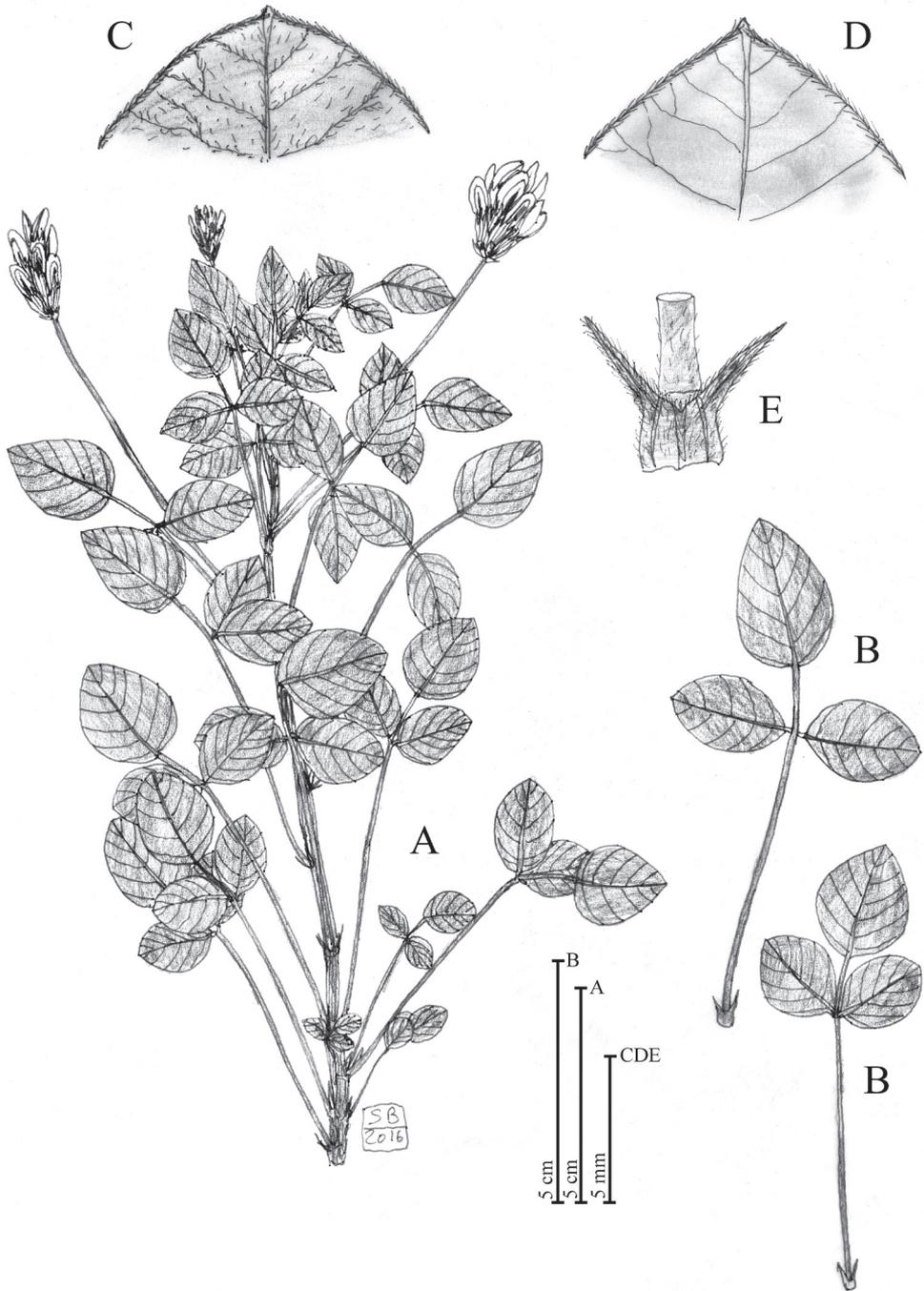


Figure 2. Diagnostic features regarding the vegetative structures of *Bituminaria antiatlantica*. **A** Habit **B** Leaves **C** Leaf apex (abaxial side) **D** Leaf apex (adaxial side) **E** Stipules. Illustration by S. Brullo based on living material coming from Mount Tachilla and Djebel Imzi in Morocco (CAT).

above and sparsely hairy below, 10–35 × 8–21 mm, with apex obtuse to acute, ending in a straight mucro 0.3–0.5 mm long. *Inflorescence* definite, subspicate, lax, 1.5–2 cm long, with 3–10 flowers. *Peduncle* 3.5–14 cm long, overtopping the leaves. *Bracts* 1–3 toothed, 5–8 mm long, subtending 2 or more flowers. *Flowers* 16–17 mm long. *Calyx* 12–13.5 mm long, green, densely hairy, with hairs white mixed to short black hairs; lower teeth 7–8 mm long, laterals shorter, 5.5–7 mm long. *Corolla* whitish-pink to whitish lilac; standard 16–16.5 × 7–7.5 mm, elliptic, striate with lilac in the middle, apex obtuse; wings 14–15 × 3–4 mm; keel 10.5–11 × 2–2.3 mm, having a macula dark violet in the upper part. *Staminal tube* 11–11.5 mm long, with anthers yellow, 0.7–0.8 × 0.3–0.35 mm; vexillary w with filament fused below with the other ones. Pistil 10–10.5 long, ovary hairy, style curved towards the apex, thickened at point of flexure, stigma capitate, penicillate and ovary hairy. Pod 11–23 mm long (beak included), with beak pubescent, 14–16 mm long. Seed reniform, 6–7 × 3.4–4 mm.

Distribution and ecology. *Bituminaria antiatlantica* is a rare and localized species, currently known only from Mount Tachilla and Djebel Imzi in the Anti-Atlas Mountains in southern Morocco, (Fig. 3). It grows between 300 and 1500 m of altitude, on steep, north-facing slopes, chiefly constituted of Precambrian quartzite. From the bioclimatic viewpoint, this area falls within the infra- and the thermo-mediterranean type, with semiarid to subhumid ombrotypes (Benabid and Cuzin, 1997). This species is an element of a chasmophytic vegetation type characterized by *Celsia longirostris* Murb. var. *antiatlantica* Emb., *Salvia taraxacifolia* Coss. & Balansa, *Chiladenus hesperius* (Maire & Wilczek) Brullo, *Teucrium wernerii* Emb., *Aeonium arboreum* (L.) Webb & Berthel, *Dianthus lusitanus* Brot., *Micromeria hochreutineri* (Briq.) Maire, *Caralluma hesperidum* Maire, *Teline segonnei* (Maire) Raynaud, *Davallia canariensis* (L.) Sm., *Asplenium aethiopicum* (Burm. fil.) Becherer (Fig. 4C). Besides, several phanaerophytes occur in these rupestrian habitats such as *Dracaena draco* L. subsp. *ajgal* Benabid & Cuzin, *Laurus azorica* (Seub.) Franco, *Argania spinosa* L., *Kleinia anteuophorbium* (L.) Haw., *Rhus tripartita* (Ucria) Grande, *Euphorbia echinus* Hook.f. & Coss., *Warionia saharae* Benth. et Coss. Many of these species are rare and endemic to the southern part of Morocco, thus highlighting the relic character of this plant community. In particular, Benabid and Cuzin (1997) consider *B. antiatlantica* (sub *Psoralea bituminosa* var. *rotundata*) as characteristic of a very peculiar and remarkable association exclusively occurring in a small area of the Anti Atlas range.

Etymology. The specific epithet refers to the Anti-Atlas range, where the species occurs.

Conservation status. Based on current knowledge, *Bituminaria antiatlantica* seems to have a scattered distribution over an area smaller than 2,000 km². Therefore, following the IUCN criteria (2014), this species should be classified as “Vulnerable” (VU B2). As regards the conservation policy of the growing site, it has been proposed its inclusion in the list of the UNESCO World Heritage Sites for its richness in endemic, rare or important plants, as well as for its breath-taking landscape (see <http://whc.unesco.org/en/tentativelists/1180/>).

Seed and pod micro-morphology. As emphasized by several authors (Barthlott 1981, Koul et al. 2000, Kirkbride et al. 2003, Celep et al. 2012, Gandhi et al. 2011



Figure 3. Distribution map of *Bituminaria antiatlantica* (red dots) based on herbarium specimens.

Brullo et al. 2011, 2013) seed coat micro-morphology plays an important role in the taxonomic survey at generic and specific level, especially in those rather critical groups. The seed testa sculptures of *Bituminaria* were investigated by Minissale et al. (2013), Giusso et al. (2015), Brullo et al. (2016) and Bogdanović et al. (2016), who highlighted the systematic relevance of these features providing additional information in order to discriminate among the allied species. In particular, the species hitherto examined are *B. bituminosa*, *B. palaestina*, *B. kyreniae*, *B. basaltica* and *B. plumosa*, which are characterized by different patterns of seed testa. In this study SEM investigations were carried out on the seed of *B. antiatlantica*, according to the protocol of Stork et al. (1980) using the terminology followed Bartholot (1981) and Gontcharova et al. (2009). The results revealed that seed coat sculptures of *B. antiatlantica* differ markedly from the species mentioned above. The seed testa of *B. antiatlantica* is characterized by a fine and inconspicuous reticulum, bordering the cells, which appears irregularly polygonal and 3.5–9(10) μm wide. The anticlinal walls are irregularly curved to straight, slightly grooved and smooth, while the periclinal walls are flat with the epidermis smooth to finely rugose (Fig. 5B–C). The pod corpus is characterized by minutely rugose surfaces, and the indumentum hairs are minutely papillose, with the longitudinal furrow broadly widened at the base (Fig. 5E–F).

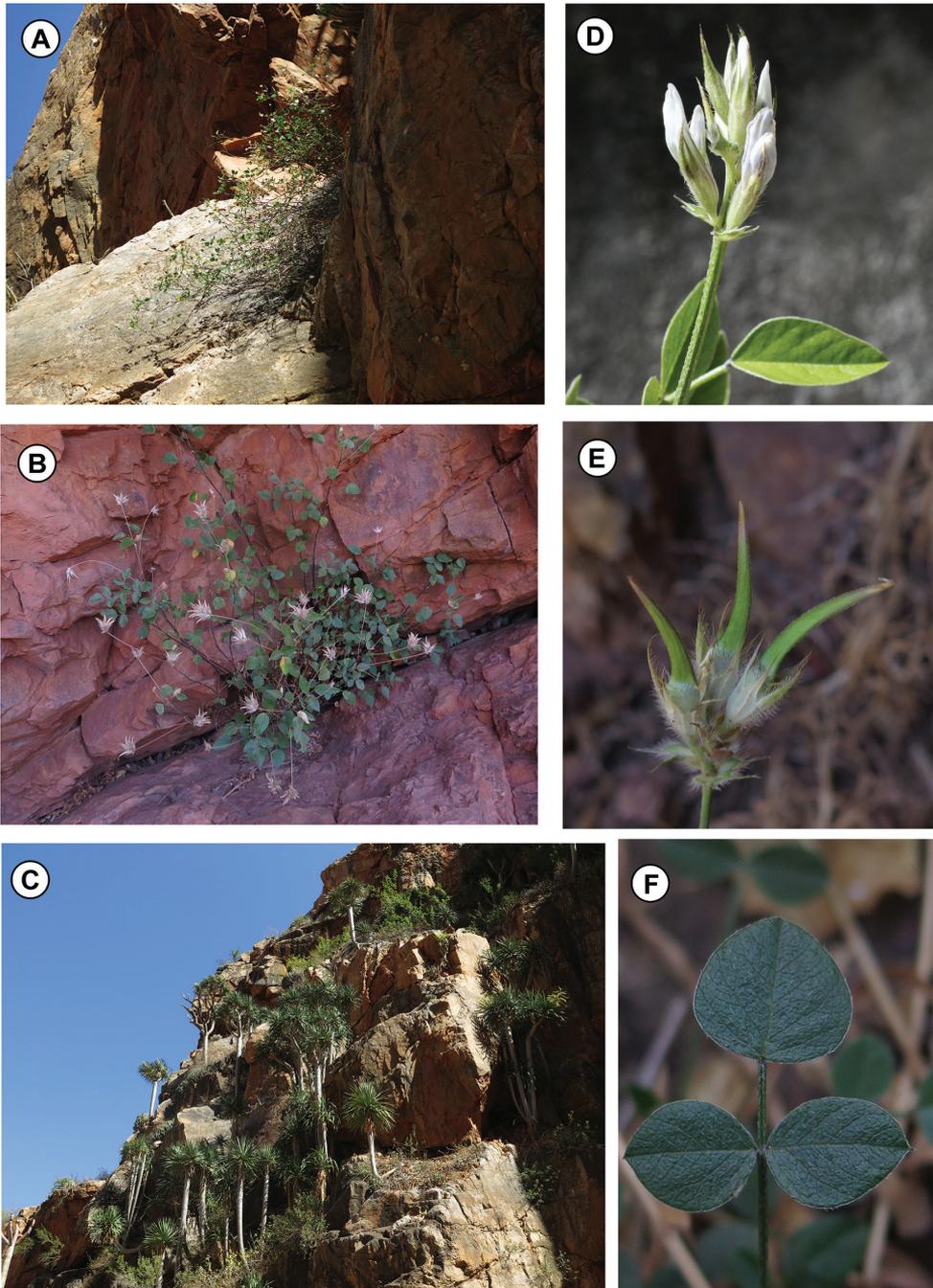


Figure 4. Phenological features of *Bituminaria antiatlantica* **A** Natural habitat with *Bituminaria antiatlantica* in Djebel Imzi (Morocco) **B** Habit of *B. antiatlantica* in Mount Tachilla (Morocco) **C** Natural habitat of *B. antiatlantica* with *Dracaena draco* L. subsp. *ajgal* in Djebel Imzi (Morocco) **D** Inflorescence detail of *B. antiatlantica* **E** Fructified inflorescence of *B. antiatlantica* **F** Leaf detail of *B. antiatlantica* (Photos by S. Cambria).

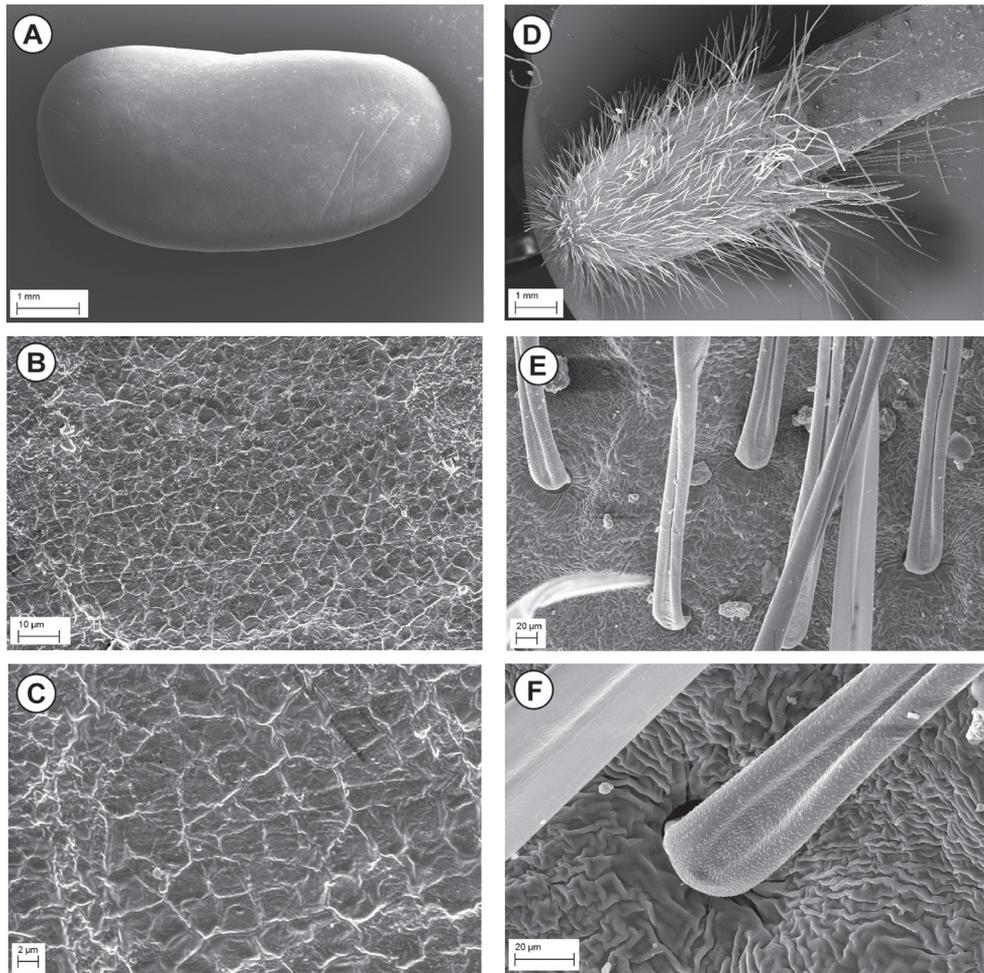


Figure 5. SEM micrographs of seed testa (**A–C**) and pod hairs (**D–F**) of *Bituminaria antiatlantica* from Mount Tachilla in Morocco. **A** Seed at low magnification ($\times 15$) **B** Seed testa at medium magnification ($\times 1000$) **C** Seed testa at high magnification ($\times 2500$) **D** Pods at low magnification ($\times 10$) **E** Pod hairs at medium magnification ($\times 250$) **F** Pod hairs at high magnification ($\times 700$).

Pollen morphology. Previous studies of pollen morphology of *Bituminaria* included those by La Serna Ramos and Gó Mez Ferreras (2006) and Halbritter and Weis (2015), who published a SEM picture of *B. bituminosa* s.l., while Brullo et al. (2016) examined the pollen grains of *B. bituminosa* s.str. and *B. palaestina*, pointing out distinctive morphological differences between the pollen of the two species. In this study pollen grains of *B. antiatlantica* were excised from flower buds in ahydrated state and were examined according to Walker and Doyle (1975), Punt et al. (1994, 2007) and Hesse et al. (2009). The pollen grains are very similar to that of *B. bituminosa* sensu stricto from Sicily, which has been examined in detail by Brullo et al. (2016), although there are differences in size and ornamentations which

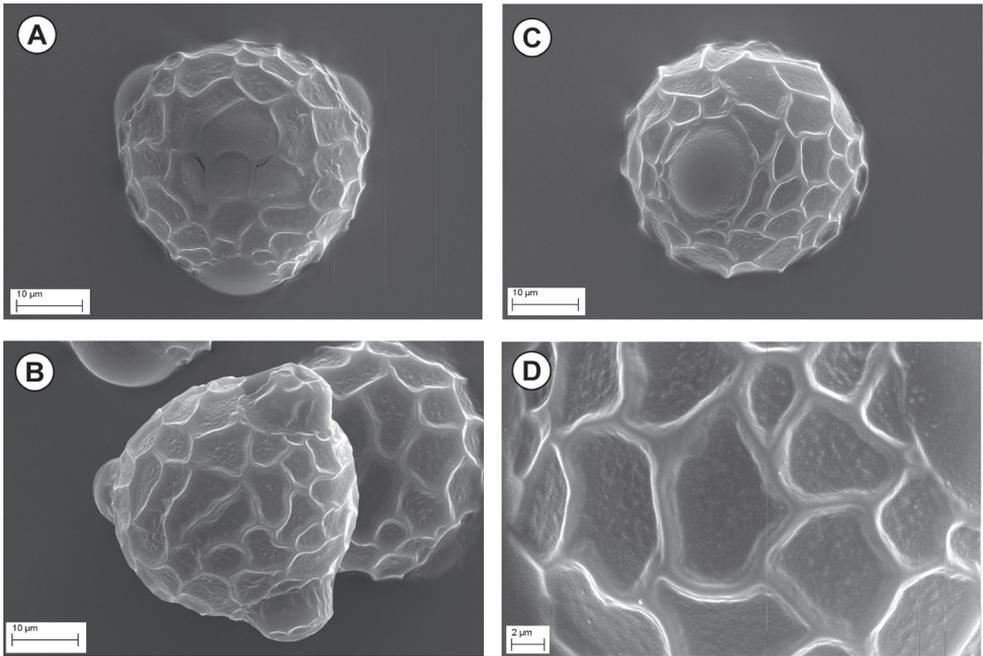


Figure 6. SEM micrographs of pollen grains of *Bituminaria antiatlantica* from Mount Tachilla. **A–B** Polar view ($\times 1600$) **C** Equatorial view ($\times 1600$) **D** Detail of pollen surfaces ($\times 4000$).

distinguishes clearly the pollens of the two species. Actually, The pollen grain of *B. bituminosa* (Brullo *et al.*, 2016, Fig. 6A) is smaller with a size of 25–30(34) μm , with larger brochi (4–17 μm) and fewer in number, showing a laxly papillose lumen and less deep (0.5–1 μm) and narrower (1–1.2 μm) muri. In *B. antiatlantica*, the pollen grain (Fig. 6) is slightly larger (37–38 μm) with smaller brochi (4.3–11 μm) and more numerous, with a lumen minutely papillose and muri deeper (1.4–1.8 μm) and larger (1.4–1.7 μm).

Discussion. *Bituminaria antiatlantica* shares some ecological and morphological characteristics with *B. flaccida*, a very rare species occurring in the semidesert countries of Jordan and Sinai in the Middle East; e.g., reduced leaflets, the size and few-flowered inflorescences, and flower colour. However, the latter differs from *B. antiatlantica* in several significant features (Table 1), such as its herbaceous habit, greyish-glaucous stems and leaves, obovate to linear-lanceolate and densely pubescent cauline leaflets, shorter calyx, longer and slightly retuse standard, shorter staminal tube, and feature of pod and seed.

Other specimens examined (paratypes). Morocco: Sulle rupi di quarzite arenacea del Jebel Tachilla a circa 200 m di altitudine, 16 June 2015, S. Cambria (CAT!); Sulle rupi di quarzite arenacea in una gola di Jebel Imzi, 300–400 m di altitudine, 19 June 2015, S. Cambria (CAT!); Sulle rupi di quarzite arenacea del Jebel Imzi a 1450 m di altitudine, 18 June 2015, S. Cambria (CAT!).

Table 1. Main diacritic features of *Bituminaria antiatlantica* and allied species.

	<i>B. antiatlantica</i>	<i>B. bituminosa</i>	<i>B. tunetana</i>	<i>B. basaltica</i>	<i>B. flaccida</i>	<i>B. palaestina</i>	<i>B. moristana</i>	<i>B. keyreniae</i>	<i>B. plumosa</i>
Stem habit	erect to ascending	erect (rar. prostrate)	erect to ascending	erect to ascending-erect	erect-ascending	erect	erect-ascending	erect-ascending	erect-ascending
Stem tallness (cm)	up to 60	up to 150	up to 50	up to 60	up to 40	100–200	up to 60	up to 50	up to 150
Stipule length (mm)	5–6	4–15	5–8	3–6	2–7	5–15	8–11	4–10	7–15
Leaf indumentum (abaxial side)	sparsely hair	hirsute	sparsely hairy	hirsute	hirsute	hirsute	sparsely hairy	sparsely hairy	densely villous
Leaf indumentum (adaxial side)	glabrous	hirsute	sparsely hairy	glabrous to subglabrous	hirsute	hirsute	glabrous to subglabrous	glabrous to subglabrous	densely villous
Leaf petiole length (cm)	1.8–6(7)	1.5–15	3–12	4–10	1–7.5	1.5–7	1.5–20	3–12	1.5–6(8)
Basal leaflet shape	rounded to ovate	rounded-elliptical to lanceolate	lanceolate to linear-lanceolate	rounded-elliptical to linear-lanceolate	suborbicular to obovate	widely ovate-subcordate	ovate-lanceolate to elliptical	ovate to lanceolate	ovate
Cauline leaflet shape	rounded to ovate	elliptical to lanceolate	lanceolate to linear-lanceolate	linear	obovate to linear-lanceolate	ovate-lanceolate to lanceolate	ovate-lanceolate to lanceolate	ovate to lanceolate	ovate-lanceolate
Leaflet apex	obtuse to acute	obtuse to retuse	rounded to acute	rounded, apiculate	rounded to acute	obtuse to acute	obtuse to acute	retuse to obtuse	rounded to acute
Leaflet micro (mm)	0.3–0.5	0.3–0.5	0.5–1.2	0.5–0.8	0.2–1	0.5–1	0.4–0.5	0.3–0.5	1–1.5
Leaflet length (mm)	10–35	3–90	20–70	8–55	4–30	20–55	27–42	12–60	12–65
Leaflet width (mm)	8–21	6–30	5–20	2–15	3–16	14–45	6–20	4–20	6–28
Peduncle raceme length (cm)	3.5–14	8–22	8–14	10–16	14–24	5–12	4–12	5–20	(6)8–21
Raceme shape	subspicate	capitate	subcapitate	capitate	capitate	subspicate	capitate to ovoid	sub-capitate	capitate
Raceme length (cm)	1.5–2	2–2.8	1.5–2	1–1.6	1.5–2	2.5–5	2.5–4.5	2–2.8	1.8–3
Raceme (number of flowers)	3–10	15–30	4–12	6–12 (16)	2–8	10–16	10–25	5–10	(10)15–25(30)
Bract length (mm)	5–8	6–15	5–8	6–8	3–5	5–15	6–9	5–12	5–15
Calyx length (mm)	12–13.5	14–18	11–12	10–13	9–12	12–16	15–18	12–16	15–16
Calyx tube length (mm)	5.5–6	6–7	4–5	4–5	5–5.5	(5.5)6–7	5–7	5–8	6–7

	<i>B. aniatlantica</i>	<i>B. bituminosa</i>	<i>B. tunetana</i>	<i>B. basaltica</i>	<i>B. flaccida</i>	<i>B. palaestina</i>	<i>B. moristana</i>	<i>B. leyreniae</i>	<i>B. plumosa</i>
Calyx lower tooth length (mm)	7–8	7–12	7–8	6–9	6–7	(5.5)6–7.5(8.5)	7–10	7–11	8–9
Calyx lateral teeth length (mm)	5.5–7	7–9	5.5–7	4–6	5–6	5.5–6(7.5)	6–8	5.5–9	6–7
Corolla (colour)	whitish-pink to whitish-lilac	blue-violet	pinkish-lilac	white	whitish-pink	pale violet	white-violet	blue-violet to violet	purplish-pink
Corolla/calyx ratio	longer	longer	longer	subequalling	longer	longer	longer	longer	longer
Standard shape	elliptical	ovate-elliptical	spathulate	spathulate	ovate-elliptical	oblanceolate	ovate-lanceolate	oblanceolate-spathulate	elliptical
Standard apex	obtuse	emarginate	slightly retuse	rounded to obtuse	slightly retuse	retuse	obtuse	usually rounded	emarginate
Standard length (mm)	16–16.5	15–20	13–14	11–13	16–19	(17)19–21(24)	18–23	16–24	19–20
Standard width (mm)	7–7.5	5–8	6–7	5–6	7–7.5	7–8(9)	6–8	6–8.5	7–7.5
Wing length (mm)	14–15	14–18	12–12.5	10–11	15.5–16.5	17.5–19	16–18	14–19	18–18.5
Wing limb width (mm)	3–4	2–3	3–3.2	2.5–3	4–4.5	3.4–3.7	3–4	2.8–4	4–4.2
Keel length (mm)	10.5–11	10–14	9–10	7.5–8.5	10–10.5	12–14	11–14	11.5–16	12–13
Keel limb width (mm)	2–2.3	1.8–2.5	1.8–2	1.5–1.8	2–2.2	2.4–2.6	2–2.5	2–2.6	2–2.2
Staminal tube (mm)	11–11.5	10–13.5	8.5–9	7–8	9.5–10	11.5–12.5	9–12	10–15	11–12
Pistil length (mm)	10–10.5	9–12	8–8.5	6–7	9.5–10	12–14	9–10	9–13	13–14
Pod length incl. beak (mm)	21–23	13–26	12–15	9–10	15–16	12–14(16)	18–26	16–22	16–18
Pod beak length (mm)	14–16	10–19	9–10	5.5–6	9–10	5–8(10)	12–19	11–17	10–12
Pod beak indumentum	pubescent	pubescent	subglabrous	glabrous	subglabrous	glabrous	pubescent	glabrous	sparsely hairy
Seed length (mm)	6–7	5–7	3.5–4.5	3.5–4	5.5–6	6.5–7	5–7	4.5–5.5	5–6
Seed width (mm)	3.4–4	3–4	2.8–3	2–2.2	2.7–3	3.7–4.2	3–4	2.4–2.6	4.5–4.8
Ecology	chasmophilous	terricolous xerophilous	terricolous xerophilous	terricolous xerophilous	chasmophilous	terricolous sub-hygrophilous	chasmophilous	chasmophilous	terricolous

Key to the species of *Bituminaria* subgen. *Bituminaria*

- 1 Cauline leaflets linear; corolla pure white, 11–13 mm long, subequaling the calyx; staminal tube 7–8 mm long, pod (including beak) 9–10 mm long *B. basaltica*
- Cauline leaflets wider (not linear), corolla whitish-pink to blue-violet 15–24 mm long, longer than calyx; staminal tube 9–15 mm long, pod (including beak) 12–26 mm long..... **2**
- 2 Raceme 2–10 flowered..... **3**
- Raceme 10–30 flowered..... **5**
- 3 Corolla blue-violet to violet, oblanceolate-spathulate, pod beak thin and soft..... *B. kyreniae*
- Corolla whitish-pink to whitish-lilac, elliptical to ovate-elliptical, pod beak thick and rigid **4**
- 4 Stems and leaves greyish-glaucous, hirsute, cauline leaflets obovate to linear, calyx 9–12 mm long, pod (including beak) max 15–16 mm long ... *B. flaccida*
- Stems and leaves dark green, sparsely hair to glabrous, cauline leaflets semi-rotund to ovate, calyx 12–13.5 mm long, pod (including beak) 21–23 mm long..... *B. antiatlantica*
- 5 Stems with patent hairs, basal leaflets widely ovate-subcordate, up to 45 mm wide, raceme mainly in fruit lax and subspicate, pod beak 5–8 (10) mm long *B. palaestina*
- Stems with appressed hairs, basal leaflets different shape, max 30 mm wide, raceme always compact and capitate or subcapitate, pod beak 10–19 mm long **6**
- 6 Stems and leaves densely villous, leaflet mucro 1–1,5 mm long, corolla purplish-pink, pod beak 10–12 mm *B. plumosa*
- Stems and leaves hirsute to subglabrous, leaflet mucro 0.3.0.5 mm long, corolla white-violet to blue-violet, pod beak (10) 12–19 mm long **7**
- 7 Leaflets sparsely hairy to glabrous, max 42 mm long; raceme 3–4.5 mm long; corolla white- violet, with standard ovate-lanceolate, obtuse *B. morisiana*
- Leaflets hirsute, up to 90 mm long; raceme 2–2.8 mm long; corolla blue-violet, with standard ovate-elliptical, emarginate *B. bituminosa*

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Corrigenda: *Premna bhamoensis* (Lamiaceae, Premnoideae), a new species from Kachin State, northeastern Myanmar

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A new *Premna* species, named as *Premna bhamoensis* Y.T. Tan & B. Li, was recently described in Tan et al. (2017), however an overlooked spelling error emerged in the authorship of this new species. The name abbreviation of the first author, Yunhong Tan, should be Y. H. Tan, not as originally published Y.T. Tan. Here we correct the authorship of *Premna bhamoensis* as Y.H. Tan & B. Li.

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Tan Y, Li D, Chen Y, Li B (2017) *Premna bhamoensis* (Lamiaceae, Premnoideae), a new species from Kachin State, northeastern Myanmar. PhytoKeys 83: 93–101. <https://doi.org/10.3897/phytokeys.83.12869>

