

# *Elaeocarpus firdausii* (Elaeocarpaceae), a new species from tropical mountain forests of Sulawesi

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## Abstract

Based on ongoing ecological research in mountain forests of Sulawesi, a new species, *Elaeocarpus firdausii* Brambach, Coode, Biagioni & Culmsee, **sp. nov.** is described and illustrated from mossy forests at > 2000 m and information provided on the species' distribution, ecology and pollen morphology. *Elaeocarpus firdausii* is similar to *E. luteolignum* Coode but differs from the latter in having glabrous terminal buds, leaves with black gland dots, 4-merous, larger flowers, and more numerous stamens.

## Keywords

*Elaeocarpus*, Elaeocarpaceae, Indonesia, Lore Lindu National Park, tropical mountain forest, Sulawesi

## Introduction

*Elaeocarpus* is the largest genus of the Elaeocarpaceae, comprising approximately 350 species in the Old World tropics and subtropics (excluding mainland Africa), from Madagascar and Mauritius in the west, to Japan in the north, Australia and New Zealand in the south and Polynesia including Hawai'i in the east (Coode 2004, Baba 2013). The greatest number of species is found in the Malesian region and taxonomic work on these is currently under way.

Some progress has been made in understanding infrageneric groupings: Already in the early 20<sup>th</sup> century, Schlechter (1916) defined several sections for Papuaasia, most of which still stand. Raymond Weibel worked on the whole genus, and made suggestions for sectional groupings, mostly in unpublished manuscripts at the Conservatoire in Geneva, copies of which have been put at the disposal of MC. In West Malesia (Sumatra, Peninsular Malaysia, Java, and Borneo), almost all species can be allotted to six major, morphologically defined groups. The “*Polystachyus* group” (Coode 1996c) is endemic to that area, while sect. *Acronodia* (Blume) Mast. (Coode 1996b) extends into the Lesser Sunda Islands. In Central and East Malesia, relationships are much less clear, although four of the groups from West Malesia are also represented here: sect. *Elaeocarpus* (Coode and Weibel 1994, Coode 1996a), sect. *Ganitrus* (Gaertn.) Brongn. & Gris (Coode 2010), sect. *Monocera* Mast. (Coode 2001c, 2007, 2014), and sect. *Coilopetalum* Schltr. (Coode 1978, 2001a).

Coode (1995) published 10 new species for Sulawesi. In this paper he drew attention to the contrast between Sulawesi and neighbouring Borneo: In Sulawesi, fewer species of *Elaeocarpus* are present (c. 70 in Borneo vs. c. 35 in Sulawesi), but they belong to a greater number of groups (6 in Borneo vs.  $\geq 8$  in Sulawesi). In addition to the four widespread groups mentioned above, three more with a more Eastern distribution are found: sect. *Dactylosphaera* Schltr. (Coode 1978), distributed from Sulawesi to New Guinea, sect. *Fissipetalum* Schltr. (Coode 1978, 2001b), from Sulawesi to Australia, and sect. *Oreocarpus* Schltr. (Coode 1978, 1984) which extends from the Philippines to Australia. Yet other species appear to be endemic, although their placement in any of the groups based on morphology has so far not been achieved. Coode (1995) suggested that some of these species from Sulawesi might be related to the *Polystachyus* group in Borneo.

Work on DNA samples at the Australian Tropical Herbarium (ATH), James Cook University in Cairns (e.g. Baba 2013), has established a molecular phylogenetic framework, within which, well-supported species-level relationships are beginning to emerge (Darren Crayn, ATH, personal communication).

Many of the recently described *Elaeocarpus* species from Sulawesi grow in montane forests above c. 1500 m (Coode 1995, 1996a, 2001a). Lore Lindu National Park (LLNP) is the protected area covering the largest portion of montane environments on the island. It is located within the large, contiguous upland area that occupies most of the central part of Sulawesi roughly between the city of Palu and the central part of the Southern peninsula (Fig. 1). We will refer to this area as Central Sulawesi Mountains (CSM) throughout the manuscript.

Recent research on tree diversity and composition in LLNP (Culmsee and Pito-pang 2009, Culmsee et al. 2011), has improved our knowledge of the flora and vegetation of Sulawesi’s mountain forests. The continued research and new fieldwork in 2011–2012 have yielded material for 17 species of *Elaeocarpus*. One of them could not be assigned to any previously published species and is therefore proposed as new here.

## Methods

### Morphological observations

The relevant published identification keys for *Elaeocarpus* (Coode and Weibel 1994, Coode 1995, 1996a, 1996c, 2001a, 2001b, 2007) have been consulted, as well as herbarium collections of B, BO, GOET, K and L (herbarium acronyms follow Thiers (continuously updated): <http://sweetgum.nybg.org/science/ih/>) and online databases of digitized herbarium specimens (JSTOR 2015, RBG Kew 2015, Wieringa 2015). We also recorded the character states of our specimens in a DELTA matrix (Dallwitz et al. 2010) for *Elaeocarpus* in Malesia developed and maintained by MC. Most specimens of *Elaeocarpus* from the Malesian region in K and L have been seen by MC during his work on the genus over the last decades, so relatively few specimens remain unnamed. Our description is based solely on the material gathered during our (FB and HC) fieldwork in Central Sulawesi in 2011–2012, as no further matching specimens were found in herbaria. All our specimens were collected from permanently tagged trees in inventory plots. Duplicates of relevant specimens, including the type, were deposited in the Indonesian herbaria BO and CEB. All specimens seen by us for the description of the new species are marked with an exclamation mark in the present paper.

For the description, we boiled up flowers in dilute detergent for 5 minutes and dissected them afterwards. Dimensions were measured using a ruler with 0.5 mm accuracy. All colours and measures given refer to dried and pressed material unless stated otherwise. Photographs were taken in the field using a Canon EOS 500D camera with a Tamron AF 18-200mm f/6.2-38 lens.

Wood density (oven-dry mass per fresh volume) was determined from three wood cores extracted with increment borers and belonging to the specimens *Brambach et al.* 0721, 0973, and 2041, respectively. The samples' fresh volume was measured by Archimedes' principle and weight was noted from the same samples after oven-drying for 48h at 105°C.

### Pollen morphology

One closed flower bud (from the specimen *Brambach et al.* 2041) was processed for the description of the pollen morphology. The pollen grains were treated following standard Erdtman's acetolysis method (Erdtman 1960, Faegri et al. 1989). The samples were mounted on permanent slides with Kaiser's glycerol gelatine and the slides were analysed under a Nikon Eclipse H550L photomicroscope at a magnification of 100×. Descriptions of the pollen grains were compiled following the terminology defined by Punt et al. (2007). The shape was described based on the measurements of the ratio between polar axis (P) and equatorial diameter (E) in equatorial view. Size values are based on a total of 10 grains measured, mean are shown with minima and maxima in parentheses.

## Conservation Assessment

With only three known collection localities (see “Distribution”), a meaningful calculation of the extent of occurrence (EOO) and area of occupancy (AOO) (IUCN Standards and Petitions Subcommittee 2014) as basis for the conservation assessment is not feasible. We, therefore, attempted to estimate the extent and location of potential habitats for the proposed species based on its known habitat preferences. For that, we used the CGIAR digital elevation model (Jarvis et al. 2008) in QGIS (QGIS Development Team 2015) to quantify land areas in Sulawesi above the elevation threshold of 2000 m. We defined this threshold based on our field observation of a marked and easily observable transition from mid-montane to upper montane (mossy) forest around this elevation. The proposed new species has so far only been recorded in upper montane forest at > 2000 m elevation (see “Habitat” below). We then assessed the forest condition at elevations  $\geq$  2000m using data from Cannon et al. (2007) and only used areas classified as “good” or “old-growth” by them for further analysis. As the proposed species has so far been recorded in the CSM and possibly the Eastern peninsula of Sulawesi, we also excluded all upper montane areas from the Northern and Southeastern peninsulas and the tip of the Southern peninsula (Fig. 1). The resulting potential habitats were used for the calculation of the extent of occurrence (EOO) and area of occupancy (AOO, grid cell size of  $2 \times 2$  km) following the recommendations of IUCN Standards and Petitions Subcommittee (2014).

## Species description

### *Elaeocarpus firdausii* Brambach, Coode, Biagioni & Culmsee, sp. nov.

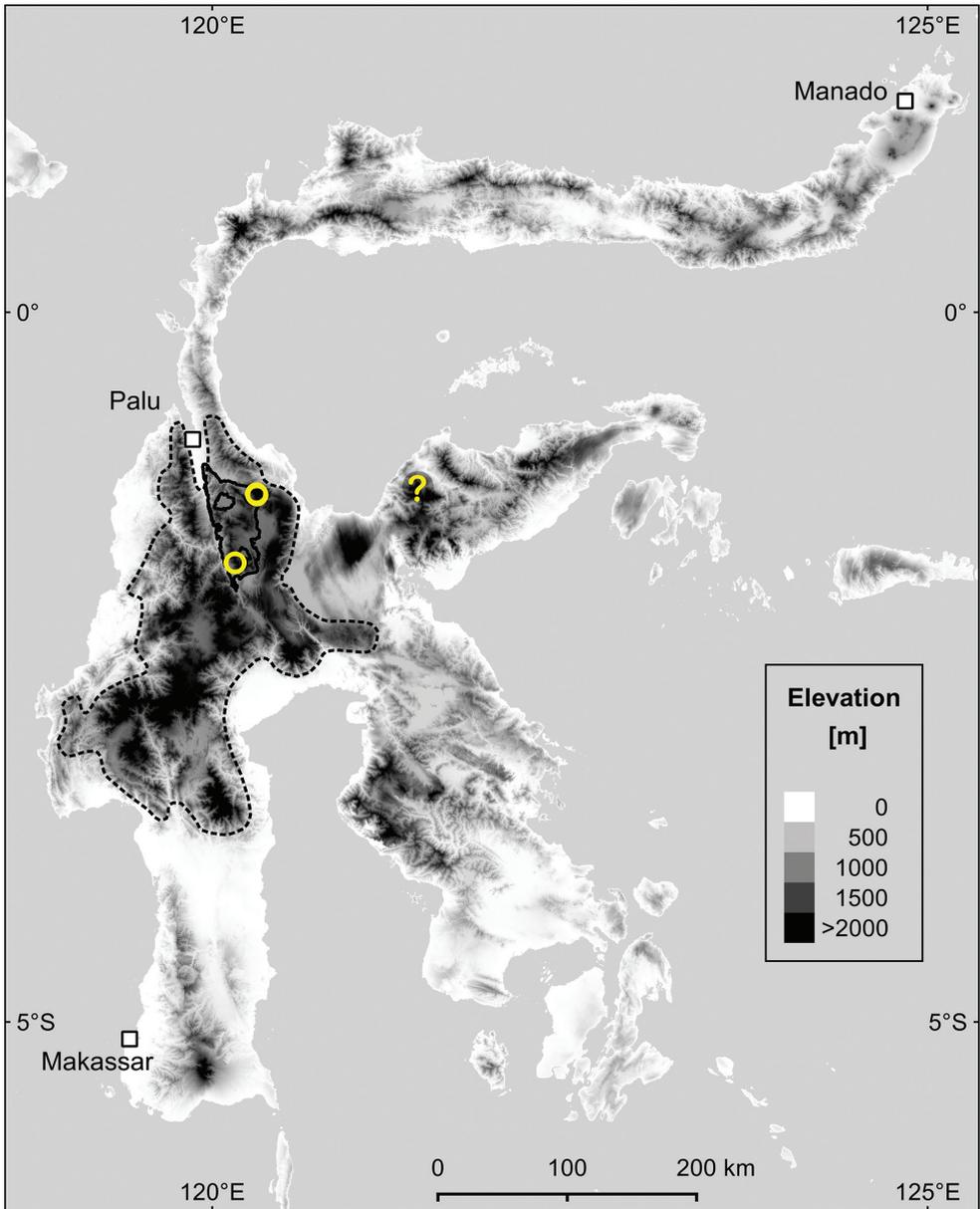
urn:lsid:ipni.org:names:77153914-1

Figures 1–4

**Diagnosis.** Similar to *Elaeocarpus luteolignum* Coode, but differing from that species in glabrous (vs minutely adpressed-hairy) terminal buds and young twigs, leaf blades with black gland dots (vs leaf blades without dots), 5-merous (vs 4-merous) flowers, larger flowers (e.g. sepals  $5-8 \times 1.5-2.5$  vs  $3-4 \times 1.5$  mm) and more numerous stamens (29–31 vs 20).

**Type.** INDONESIA. Central Sulawesi (Sulawesi Tengah): Lore Lindu National Park, Kabupaten Poso, Kecamatan Lore Utara, 7.7 km NNE of village Sedoa, Mt Rorekautimbu, tree-inventory plot “Bulu Torenali”,  $1^{\circ}17.2'S$ ,  $120^{\circ}18.7'E$ , 2350 m, 21–24 Apr 2012: *Brambach F*, *Mangopo H*, *Firdaus*, *Faber M*, *Tiranda R* 1953 (flowers; holotype: K, 2 sheets, [K000720760]!, [K000720898]!; isotypes: BO (BO 1926842)!, CEB, L [L.2055441]!).

**Description.** *Trees* 8–25 m tall, dbh  $\leq$  40 cm, without buttresses or stilt roots, flowering when full-grown. Outer bark reddish brown, verrucose; inner bark pinkish with white streaks, granular, innermost layer yellow, easily detachable from wood, wood cream to white.



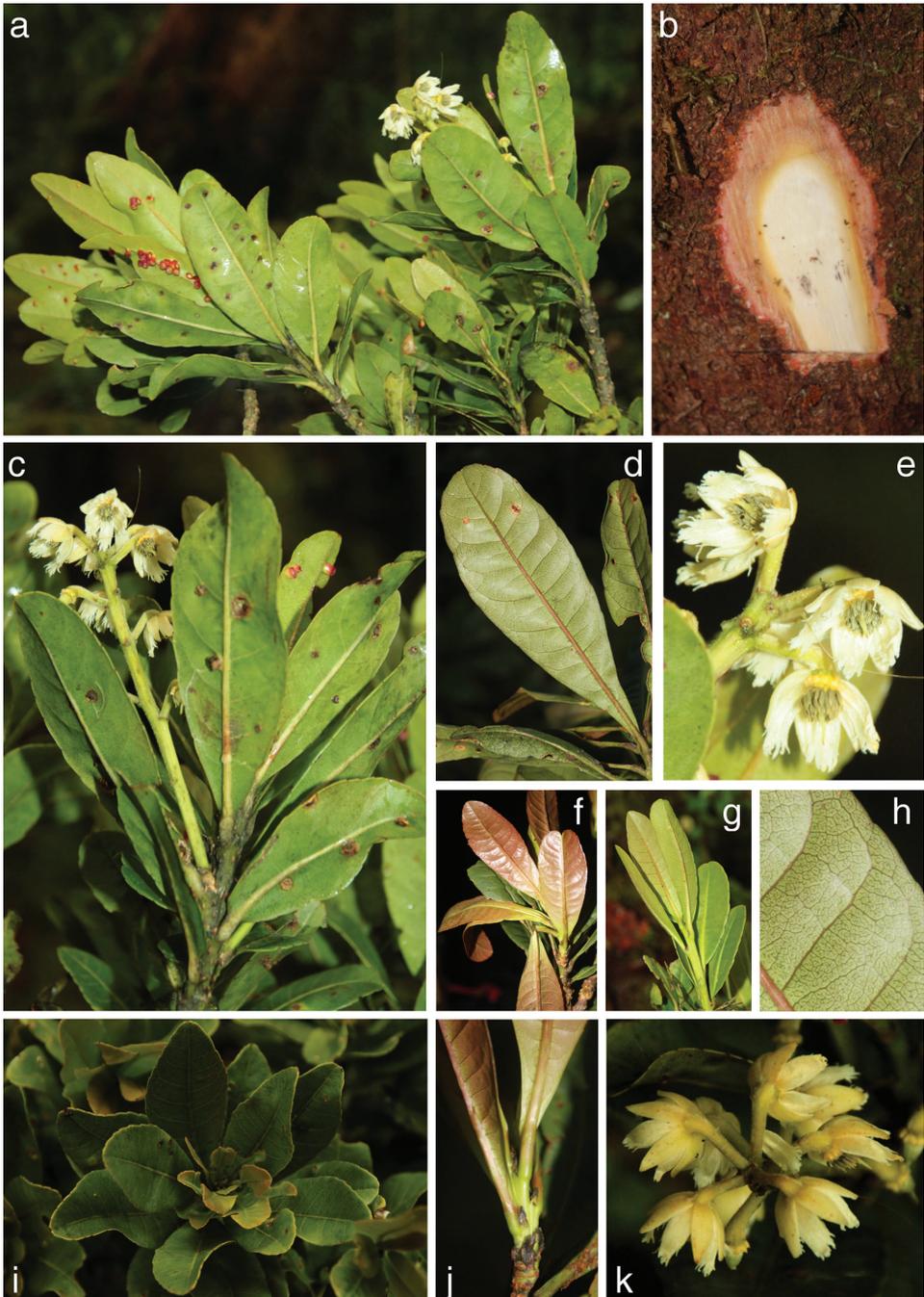
**Figure 1.** Map of known occurrences of *Elaeocarpus firdausii* in Sulawesi. Collecting localities are shown as yellow circles: Mt Rorekautimbu and Mt Malemo, both in Lore Lindu National Park (solid black line). The record on Mt Katopas on the Eastern peninsula (?) is based on a sighting without specimen. Most of the montane environments on the island are concentrated in the Central Sulawesi Mountains (CSM, dashed black line) stretching from near Palu into the Southern peninsula. Areas above 2000 m a.s.l. are shaded black. Map created with QGIS (QGIS Development Team 2015) using the digital elevation model of Jarvis et al. (2008).

*Twigs* glabrous, strongly angulate at first, later terete, twig bark longitudinally cracking, forming a net-like pattern, with large conspicuous leaf scars and many prominent lenticels, gummy-resinous where cut, 2.5–4.0 mm thick towards the tip, with gummy-resinous, glabrous terminal buds. *Stipules* caducous, linear-subulate to narrow-triangular, glabrous, often gummy, 1.5–5.0 mm long, tapering, entire.

*Leaves* spirally arranged, loosely to  $\pm$  tightly grouped towards twig tips in older trees, in juveniles often scattered, appearing in flushes, leaves of one flush  $\pm$  equal in size. Fresh leaves brownish-red when young, later dark green with contrasting paler midrib above, much lighter green and with contrasting darker green venation and the sometimes red midrib beneath, dying red. *Petioles* 2–14 mm long, 1–3 mm thick, glabrous or almost so, sometimes verrucose when mature, often longitudinally finely striate, usually flat in apical third above, sometimes rounded or slightly channelled above, distinct from or merging into decurrent leaf base (variable within a specimen), pulvinous or not on both ends, without pegs at apex, sometimes with elongate glands at the junction of petiole and lamina-margin, geniculate. *Blades* chartaceous to coriaceous, mostly oblong-obovate, some oblong-elliptic or obovate, 2.1–4.0 times as long as wide, (5–) 6–13 (–15.5)  $\times$  1.5–5.0 (–6.5) cm, acute to obtuse (80–110°) to rounded at apex, the very tip notched and with a (sometimes fused) pair of black glands, cuneate at base or tapering towards a broadly cuneate base (the larger leaves more narrowly cuneate), occasionally rounded, surface sometimes bullate, dull and glabrous above, glabrous or sometimes with some short adpressed hairs on the midrib beneath when young and then soon glabrescent, glabrous and not verrucose beneath when mature, with minute black gland dots on both sides. Midrib darker than lamina, prominent but widened and flattened towards base above, strongly prominent beneath, with 8–16 pairs of main lateral veins, diverging at 60–80° from midrib, straight for most of their length or curved, breaking up  $3/4$  to  $7/8$  inside margin, looping forward and mostly joining up; usually with intermediate veins in between,  $\pm$  prominent and of same colour as or paler than lamina above and below, higher-order veins reticulate, obscure or  $\pm$  clear and raised above and below, of same colour as lamina, areoles squarish, < 2 mm across, domatia absent. Margins  $\pm$  entire to weakly glandular-serrate, sometimes less serrated in lower half, the teeth 2–11 mm apart, glands present regardless of serration, 0.5 mm long, spindle- or claw-shaped, sometimes elongate along margin, black.

*Inflorescences* in the axils of current leaves, solitary, racemose,  $\pm$  of same length as subtending leaf, 3–8 cm long, axis angular, 1.2–1.5 mm thick at about halfway, with sparse, short, straight hairs between adpressed and spreading, 5–9-flowered.

*Flowers* bisexual, 5-merous (once 6-petalled), spiral or almost whorled on inflorescence, bracts early caducous, not seen, pedicels 6–18 mm long and 0.5–1 mm thick in flower, bent downwards and thickened at apex, buds ovoid, acute at apex. *Sepals* 5–8  $\times$  1.5–2.5 mm, cream-coloured when fresh, not verrucose and  $\pm$  pale adpressed-sericeous outside, densely white-velutinous next to the margins inside, otherwise short-sericeous inside but glabrous in the basalmost 1.5 mm, keeled inside for whole length. *Petals* thick and opaque, ivory-coloured on account of the hairs when fresh, oblong, parallel-sided almost to base, rounded to a narrow (1 mm wide) base, 6.5–7.5 mm long, 2.0–



**Figure 2.** *Elaeocarpus firdausii*. **a** branch with leaves and flowers (note red leaf-galls) **b** bark slash **c** branch apex with inflorescence **d** underside of mature leaf **e** flowers with golden disc and grey anthers **f** reddish-brown young leaves **g** green young leaves **h** conspicuous reticulation on underside of mature leaf **i** clustered arrangement of leaves; **j** young twig with stipules **k** flowers on apically bent pedicels. **a**, **c**, **e**, **g**, **i**, and **k** from the type collection (*Brambach et al. 1953*); **b**, **d**, **f**, **h**, and **j** from *Brambach et al. 2041*.

2.5 mm wide at widest point of limb, rounded at apex and divided into 9–12 narrow-triangular apical divisions 0.3–1.0 mm long, divisions unequal in length and grouped into lobes and acute at tip, not verrucose in dried material, densely white-sericeous outside, margins velvety or densely short-hairy throughout, densely short-hairy inside except for glabrous patch near base, with a low, narrow keel inside running for most of limb length,  $\pm$  flat at midpoint and flat at base, without any infolding of margins. *Disk* golden when fresh,  $\pm$  annular, 10-toothed, 0.5–0.8 mm high, densely covered with short, straight, golden hairs. *Stamens* 29–31, inserted in a  $\pm$  single ring between disk and ovary; filaments 0.6–1.8 mm long, straight to somewhat incurved tapering from base to apex, glabrous or with a few minute hairs; anthers 1.6–2.5 mm long, khaki when fresh, minutely hairy, with outer tooth clearly much longer than inner and with a beak 0.2–0.5 mm long, beak glabrous or with a few minute hairs without setae at tip. *Ovary* placed above the disk, shape clearly narrowed at base, 2.0–2.5 mm long, densely short- to medium-hairy, 2–3-locular; ovules 8–12 per locule; style 2.5–3.5 mm long, stout, tapering to a point, glabrous except for the very base.

*Fruits* unknown.

**Phenology.** Flowering was observed in April. No fruiting was observed.

**Pollen morphology and dimorphism.** The pollen of *E. firdausii* is dimorphic as two distinct morphological pollen grains were observed in the sample. The most common one is a 3-aperturate pollen grain, typical of the family Elaeocarpaceae (Coode 2004). The second, less common (4%), type presents a 2-aperturate morphology and it is clearly distinguishable from the first (Fig. 4). The two pollen types are described as follows:

3-colporate type (Fig. 4a–b):

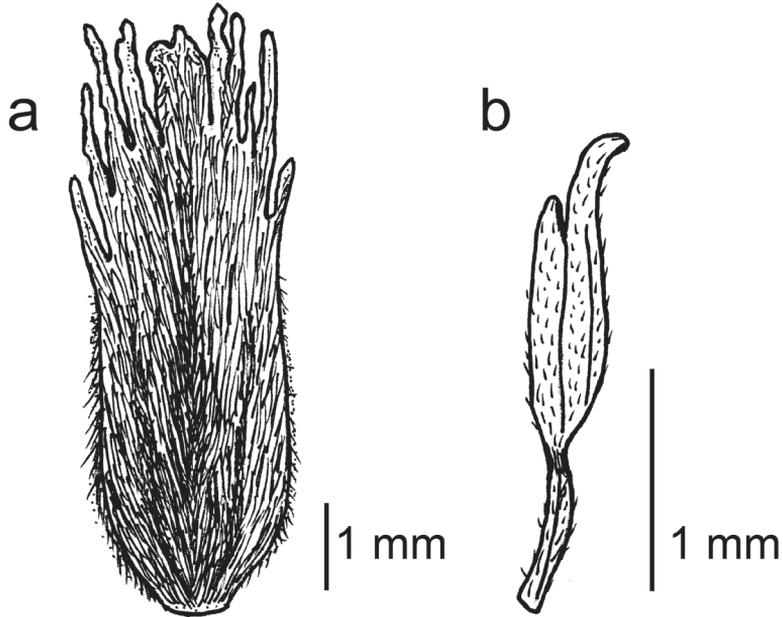
Prolate spheroidal to spheroidal pollen grains; outline in polar view (amb) rounded semi angular; psillate; P/E: 1.0 (0.9–1.1); polar axis (P): 12.2 (11.2–13.3)  $\mu\text{m}$ ; equatorial axis (E): 11.9 (10.4–13.1)  $\mu\text{m}$ ; apocolpium index 3–4  $\mu\text{m}$ . Colpi 7.1–11.2  $\times$  1–2  $\mu\text{m}$  long with indistinct ends. Endoaperture lalongate, c. 1  $\mu\text{m}$  in diameter. Exine c. 1  $\mu\text{m}$  thick, sexine as thick as nexine.

2-colporate type (Fig. 4c):

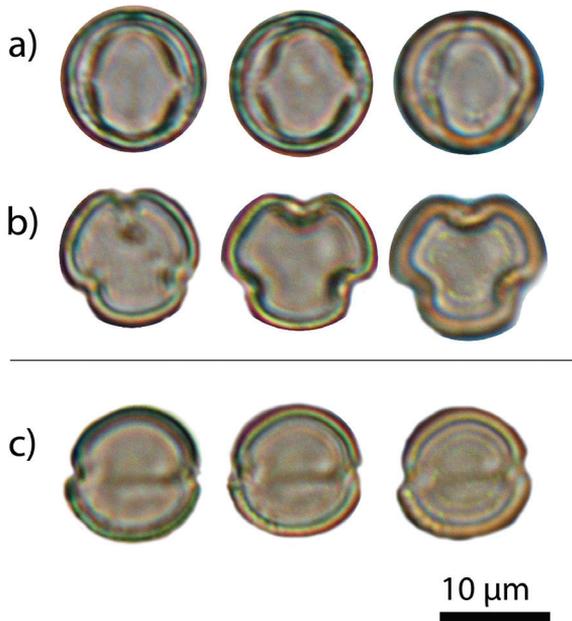
Outline in polar view (amb) circular-elliptical; equatorial axis (E): 11.6 (10.5–12.7)  $\mu\text{m}$ . Remaining characteristics as the 3-colporate type.

So far, only one other case of pollen dimorphism has been documented for the genus *Elaeocarpus* (Huang 1972). In *E. firdausii*, the low percentage (ca. 4%) of the 2-colporate type as compared to the 3-colporate suggests the former is an aberrant morphology, possibly associated with hybridism as reported in other species (e.g. Bhowmik and Datta 2012).

**Distribution.** Endemic to the central part of Sulawesi. The species is so far recorded with certainty from Mt Rorekautimbu and Mt Malemo at elevations from 2150 to 2400m (Fig 1). Both mountains are located within LLNP. During our ecological



**Figure 3.** Flower details of *Elaeocarpus firdausii*. **a** petal with hairy outer surface and apical divisions **b** stamen with clearly longer outer anther-tooth to the right. Drawing by Heike Culmsee from *Brambach et al. 1953* (isotype, L!).



**Figure 4.** Pollen of *Elaeocarpus firdausii*. **a** the 3-colporate pollen type in equatorial view **b** same in polar view **c** the 2-colporate pollen type in polar view.

fieldwork, we recorded *E. firdausii* in all three inventory plots at > 2000 m, although with rather few individuals at each site. Because of its apparent association with a distinct habitat (upper montane or mossy forest above c. 2000 m) and the general lack of information from montane habitats in Sulawesi, we consider it very likely that *E. firdausii* occurs in many of the upper montane forests of the CSM (Fig 1).

FB observed a sterile sapling matching all vegetative characters of *E. firdausii* on Mt Katopas, c. 130 km east of the other two sites (1°12.7'S, 121°26.0'E, 2450 m, 6 Sep 2014), indicating a possible occurrence on Sulawesi's Eastern peninsula (Fig 1, question mark).

**Habitat.** Based on the morphological information available *E. firdausii* is a regular component of upper montane (mossy) forests, where its individuals can form part of the canopy. These forests occur from c. 2000 m upwards in the LLNP area and are easily distinguished because of the dominance of conifers (Podocarpaceae, mostly *Dacrycarpus imbricatus* (Blume) de Laub. and *Phyllocladus hypophyllus* Hook.f.). They have a thick layer of epiphytic mosses and ferns on trunks and branches of the trees, ± abundant undergrowth, c. 20 m tall canopies with emergents reaching > 30 m and large amounts of dead wood. The soils are characterized by excess of moisture and heavy accumulation of organic matter. They were classified as Folic Gleysols, Folic Histosols and Folic Cambisols according to the WRB classification (IUSS Working Group WRB 2014). Dominant families besides conifers include Myrtaceae (e.g. *Syzygium* spp., *Xanthomyrtus angustifolia* A.J.Scott), Fagaceae (e.g. *Lithocarpus havilandii* (Stapf) Barnett), Paracryphiaceae (e.g. *Quintinia apoensis* (Elmer) Schltr.), and other Elaeocarpaceae (e.g. *Elaeocarpus steupii* Coode, *E. teysmannii* Koord. & Valetton subsp. *domatiferus* Coode).

**Etymology.** The specific epithet honours our colleague Firdaus Dg. Matta (born 1984), formerly with Herbarium Celebense in Palu, Sulawesi, who collected the type specimen and contributed greatly to the success of our fieldwork with his skills in plant collection and identification.

**Conservation status.** Based on the locations of the estimated potential habitat for *E. firdausii* we calculated an EOO of 58 534 km<sup>2</sup> and an AOO of 5 760 km<sup>2</sup>. The latter is presumably an overestimate as not all potentially suitable sites will necessarily be occupied by the species. Nevertheless, occurrence over a relatively wide range is plausible, given the large distance (c. 55 km) between two of the collection sites. It is thus unlikely that either EOO or AOO will fall below the thresholds of criteria B1 or B2 for IUCN category VU (IUCN 2012). While deforestation is an ongoing threat to Sulawesi's forests, upper montane forests are usually less affected because of their remote locations and difficult access (Cannon et al. 2007). Hence, we do not consider habitat destruction or exploitation by humans as an imminent threat to population levels. Given (1) the uncertainties in the estimated EOO and AOO, and (2) the recommendation to use a precautionary attitude in conservation assessments (IUCN Standards and Petitions Subcommittee 2014), we propose a preliminary extinction risk assessment of "Near Threatened" (NT) following the IUCN Red List Categories and Criteria (IUCN 2012).

**Notes.** Based on the morphological information available, *E. firdausii* is probably related to *E. luteolignum*, *E. gambutanus* Coode and *E. linnaei* Coode; this assemblage may be sister to the *Polystachyus* group from Western Malesia.

In addition to the morphological differences between *E. firdausii* and *E. luteolignum* mentioned in the diagnosis above, according to our present knowledge there are differences in habitat preference: *E. firdausii* occurs in mossy forest at higher elevations while *E. luteolignum* is known from lower to mid-montane forest dominated by Fagaceae at 1200–1800 m (Coode 1995).

Both observations in the field and examination of dried specimens show that there are morphological differences between smaller understory plants and mature canopy-forming individuals. The former have less-clustered, longer, thicker and relatively narrower leaves with more clearly bipulvinate petioles, less-rounded tips and more clearly serrate margins. We do not know whether these differences are related to age or rather to environmental factors, e.g. stronger radiation and transpiration in the canopy. Seedlings have even narrower leaves but the very short petioles are only swollen at the base. Conspicuous cup-shaped leaf galls or their presumed scars (Fig. 2) were present in all collected specimens. All sepals and petals have a glabrous patch at the base of the otherwise hairy inner surface. These glabrous portions are apparently pressed against the 10-lobed disc before anthesis. Wood density, based on three specimens, varied from 0.45–0.56 g/cm<sup>3</sup>.

**Specimens examined.** Accession numbers are given in parentheses, barcode numbers in square brackets. Barcodes of specimens in K and L link to specimen records in the respective databases (RBG Kew 2015, Wieringa 2015).

INDONESIA. Central Sulawesi (Sulawesi Tengah), Lore Lindu National Park:

Kabupaten Poso, Kecamatan Lore Utara, 8.7 km NNE of village Sedoa, Mt Rorekautimbu, tree-inventory plot “Rorekautimbu”, 1°16.7'S, 120°18.6'E, 2400 m:

*Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0721* (18–30 Jul 2011, sterile, BO (BO 1926844)!, CEB, GOET [GOET014481]!, K [K000720899]!, L [L.2055437]!);

*Culmsee H 2152* (Aug–Sep 2007, sterile, GOET [GOET014482]!).

Kab. Poso, Kec. Lore Utara, 7.7 km NNE of village Sedoa, Mt Rorekautimbu, tree-inventory plot “Bulu Torenali”, 1°17.2'S, 120°18.7'E, 2350 m, 21–24 Apr 2012:

*Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 2041* (flowers, BO (BO 1926843)!, CEB, GOET [GOET014478]!, K [K000720902]!, L [L.2055436]!);

*Mangopo H, Firdaus, Brambach F 11* (seedling, L [L.2055440]!).

Kab. Sigi, Kec. Kulawi Selatan, 7.7 km ENE of village Moa, Mt Malemo, tree-inventory plot “Tutu Malemo”, 1°45.9'S, 120°09.6'E, 2150 m, 18–23 Oct 2011:

*Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0937* (sterile, CEB, GOET [GOET014480]!);

*Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 0998* (sterile, CEB, K [K000720900]!, L [L.2055438]!),

*Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1026* (sterile, CEB, L [L.2055439]!),

*Brambach F, Mangopo H, Firdaus, Faber M, Tiranda R 1028* (sterile, CEB, GOET [GOET014479]!, K [K000720901]!).

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# *Sonerila nairii* (Melastomataceae) – a new species from the southern Western Ghats, India

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## Abstract

The new species *Sonerila nairii* (Melastomataceae) is here described from Pothumala of the Nelliampathy hill ranges of Western Ghats of Kerala, India. Morphologically it most closely resembles *Sonerila erecta* and *Sonerila pulneyensis* from which differs by the form of the stem, leaves, peduncle, pedicel, inflorescence, pubescence of the stem, leaves and hypanthium, and by the form of stamens and stigma.

## Keywords

*Sonerila*, Kerala, Nelliampathy, Palakkad, Western Ghats, India, critically endangered

## Introduction

The genus *Sonerila* Roxb. (Melastomataceae) consists of erect or creeping and rhizomatous terrestrial low epiphytic herbs or semi-woody shrubs, occasionally acaulescent with a distribution in tropical Asia (Clausing and Renner 2001). The genus is classified under the tribe Sonerileae (Triana 1866) and is clearly delineated from other genera in having trimerous flowers and mostly uniparous scorpioid cymes (Sunil et al. 2014).

In Hooker's Flora of British India, Clarke (1879) recognised 43 species and Gamble (1919) recognised 13 species of *Sonerila*. Lundin (1998) made an extensive documentation of Melastomataceae with special emphasis on *Sonerila* of South India. Lundin and Nordenstam (2009) considered the genus to have about 175 species distributed from

Sri Lanka and India to the Indo-Pacific. As per recent assessment by considering the works published after Gamble's 1919 treatment, the genus is represented by 52 species in India and Western Ghats has the highest species diversity with about 35 species (Nayar 1976, Giri and Nayar 1985, 1986a,b, 1987, Prakash and Mehrotra 1988, Gopalan and Henry 1989, Giri et al. 1992, Ravikumar 1999, Murugan and Manickam 2002, Josephine et al. 2003, Lundin and Nordenstam 2009, Murugesan and Balasubramaniam 2011, Narayanan et al. 2013, 2014a, b, Deepthikumary and Pandurangan 2014, Sunil et al. 2014, Narayanan et al. 2015).

During the field exploration in the Kollengode range of Nemmara forest division, an interesting *Sonerila* was collected from the Pothumala region of Nelliampathy hills of Palakkad district during October 2015, at an altitude of about 1140–1160 m. Critical analysis of the specimen and comparison with protologues and digital images of herbarium specimens of the closely allied species, *Sonerila erecta* Jack (Barcode id: K000867797) and *Sonerila pulneyensis* Gamble (Barcode id: K00867655) deposited at Kew Herbarium revealed its distinctiveness from these and other allied species. Therefore this taxon is here described as the new species *S. nairii*.

## Description of the new species

### *Sonerila nairii* Soumya & Maya, sp. nov.

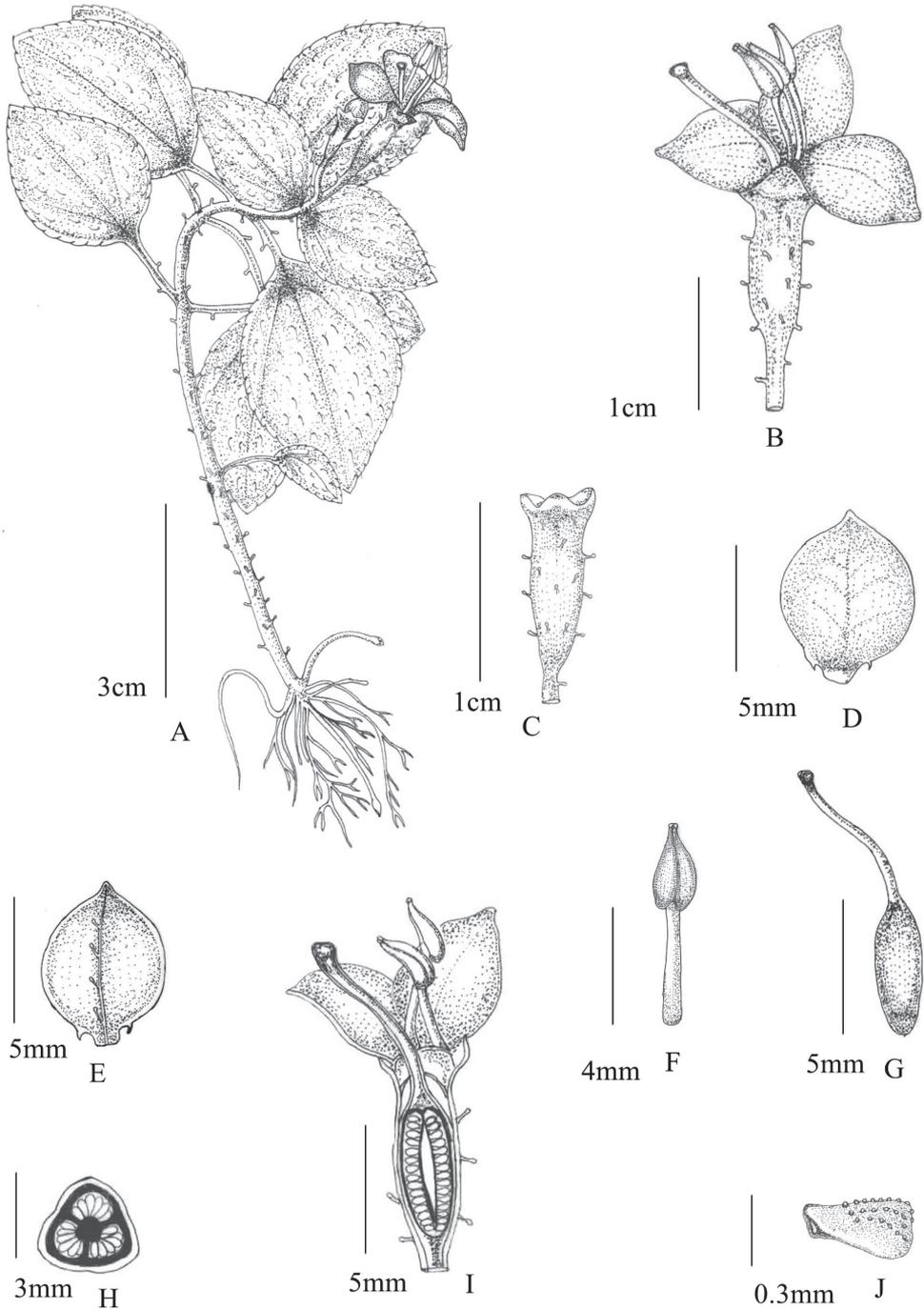
urn:lsid:ipni.org:names:77153915-1

Figs 1, 2

**Diagnosis.** The new species is distinguished from *S. erecta* and *S. pulneyensis* by the decumbent unbranched stem, absence of a distinct peduncle, the cymose 1–2 flowered terminal inflorescence and by the anthers which are half the length of filament. (*Sonerila erecta* and *S. pulneyensis* have branched stem, a distinct peduncle, inflorescence consisting of more than 2 flowers in a cyme and anther having same the length of the filament.)

**Type.** INDIA. Kerala: Palakkad district, Pothumala, Nelliampathy hills, 10°30'09.6"N; 76°42'16.5"E, 1160 m 18 Oct 2015, *Soumya M. & Maya C. Nair 1185* (Holotype CALI!, isotypes MH!, ERRCH!, GVCH!)

**Description.** Decumbent, unbranched, delicate, succulent herbs attaining 6–10 cm height; the lower portion more or less trailing and bear perennating buds, while the upper portion curves upward and grows erectly. Stem translucent, fleshy, subterete with scattered multicellular and glandular trichomes which form a dense hairy nodal ring. Leaves opposite, fleshy, petiole 0.5–1.5 cm, adaxially grooved, with glandular trichomes; lamina ovate, 1.3–2.5 × 1–1.5 cm, base obtuse, green with pink tinge below, upper surface densely hirsute (0.08–0.09 × 0.03–0.06 cm), lower surface with scattered glandular trichomes (0.02–0.03 cm × 0.03–0.04 cm), margins finely serrate, acute at apex, prominently 3-nerved a pair of nerve obscurely seen near the margin. Inflorescence terminal, unbranched, condensed, a 1–2-flowered cyme. Peduncle more



**Figure 1.** *Sonerila nairii* **A** Habit **B** Single flower and flower bud **C** Calyx **D** Petal-Adaxial side **E** Petal-Abaxial side **F** Stamen **G** Gynoecium **H** Ovary TS **I** Flower LS **J** Seed (from Soumya. M & Maya. C. Nair 1185) Illustration by Soumya. M.



**Figure 2.** *Sonerila nairii* **A** Habitat **B** Habit **C** Single flower and flower bud **D** Calyx **E** Petal-Adaxial side **F** Stamen **G** Gynoecium **H** Ovary TS **I** Flower LS **J** Seed (from Soumya. M & Maya. C. Nair 1185)  
Photos by Soumya. M & Maya. C. Nair.

or less absent. Flowers 3-merous, pedicel 0.5–0.7 cm with few glandular trichomes, shorter than hypanthium, light green. Hypanthium 0.8–0.9 cm long, campanulate with scattered glandular trichomes, light green. Calyx lobes 3, 0.15–0.2 cm long, triangular, non-caducous, with sporadic glandular trichomes and pink tinge. Petals 3, 0.8–0.7 × 0.5 cm–0.45 cm orbicular-obovate, acuminate at apex with 3–4 glandular trichomes on the midrib of the abaxial side. Stamens 3; filaments 0.4–0.42 cm long, glabrous, white; anthers yellow, 0.2–0.22 cm, cordate at base, glabrous. Style 0.8–0.9 cm long, curved, deep pink towards the tip, stigma capitate, glabrous. Capsule campanulate, 0.8–0.9 cm long and 0.45 cm wide with occasional glandular trichomes, green. Seeds many, 0.07 × 0.02 cm, minutely tubercled, brown.

**Phenology.** October–December.

**Etymology.** The specific epithet honours Dr. P.K.K. Nair (1930–), eminent scientist, renowned as father of Indian palynology and founder director of the Environmental Resources Research Centre (ERRC), Thiruvananthapuram.

**Distribution and ecology.** *Sonerila nairii* grows at altitudes of 1140–1160 m in shady rock surfaces within moist loose soils and under the evergreen canopies along the Pothumala hill tract of Nelliampathy hills. In these habitats, *S. nairii* grows close association with crustose lichens. The new species seems to prefer more or less moist lithophytic habitats in contrast to *S. erecta* and *S. pulneyensis* which grow in evergreen and riparian forests respectively. The distribution of the three taxa has been summarized in Fig. 3.

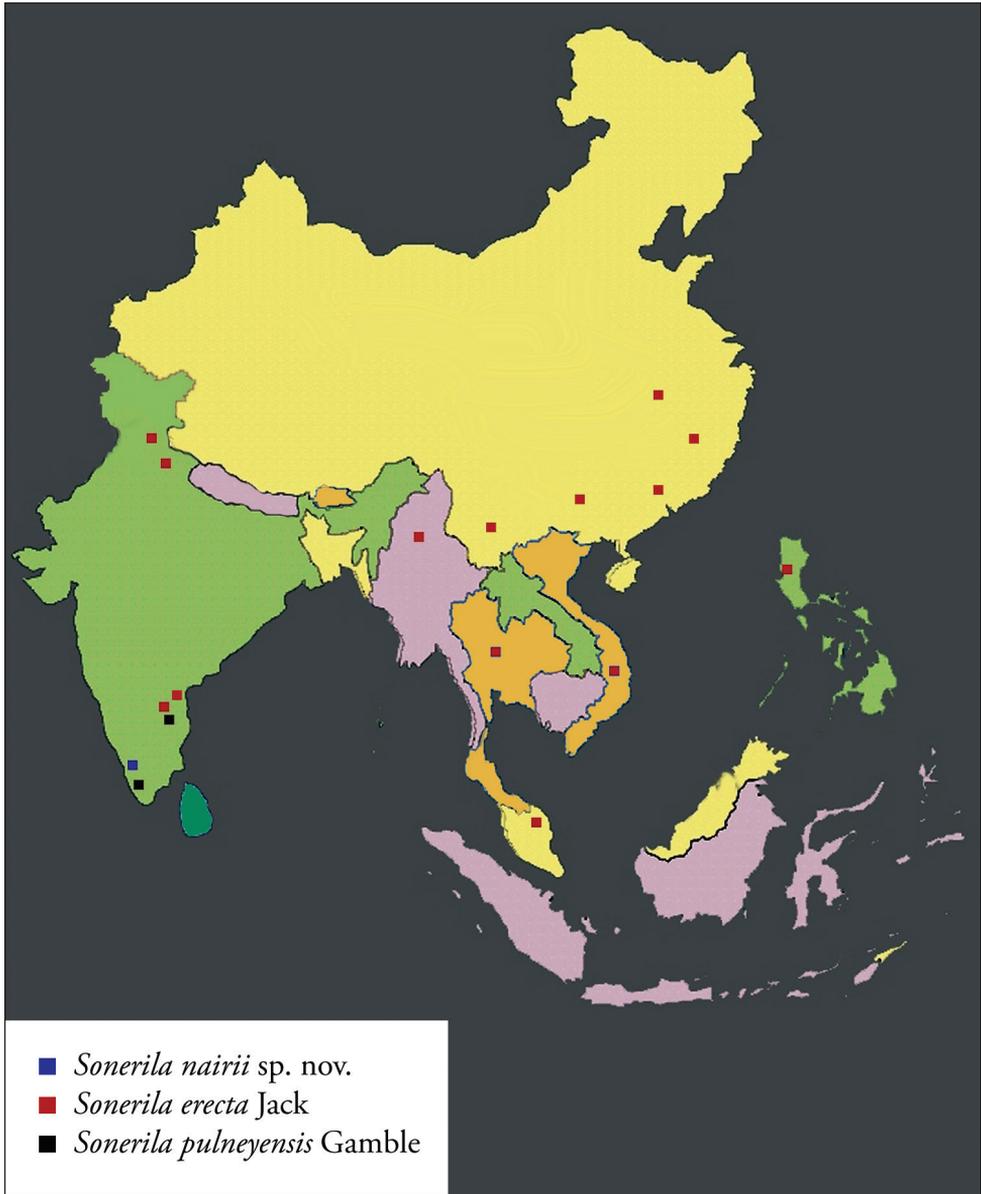
**Conservation status.** Two populations comprising only a few individuals (5–10) of the species were recorded growing within a distance (50 meters) of each other. Apart from the type locality, the species has yet to be found anywhere else. Because the number of mature individuals is less than 50 and the species has a very restricted area of occupancy, we assign the species, the status of Critically endangered using IUCN Strategies and criteria (IUCN 2014).

**Additional specimens examined (Paratypes).** INDIA. Kerala: Palakkad district, Pothumala, Nelliampathy hills, 1 Nov 2015 *Soumya M. & Maya C. Nair 1187* (ERRCH!) (Environmental Resources Research Centre Herbarium), 5 Nov 2015 *Maya C. Nair & Soumya M. 98* (GVCH!) 12 Nov 2015 *Maya C. Nair & Soumya M. 99* (GVCH!) (Government Victoria College Herbarium)

**Discussion.** *Sonerila nairii* differs from *S. erecta* by having an unbranched decumbent stem, leaf margins with pink tinge; by the absence of a peduncle, a condensed, cymose, 1–2-flowered, terminal inflorescence. The anthers are half the length of the filaments and the stigma is capitate. From *S. pulneyensis* Gamble it differs in having decumbent and sparse glandular trichomes on the stem and pedicel, dimorphic hairs on the leaves, by the absence of a distinct peduncle; by the terminal inflorescence of 1–2 flowers borne in a condensed cyme. The hypanthium is green-coloured and the anthers are half the length of the filaments. Further differences between *S. nairii*, *S. erecta* and *S. pulneyensis* are given in Table 1.

**Table 1.** Taxonomic delineation of *Sonerila nairii* from *S. erecta* and *S. pulneyensis*.

Taxonomic traits	<i>Sonerila nairii</i> sp. nov.	<i>S. erecta</i>	<i>S. pulneyensis</i>
Habitat	Shady rocks within evergreen forest	Evergreen forests	Riparian forests in high altitudes
Stem	Decumbent, sub-terete succulent, unbranched with sparse glandular trichomes	Erect, 4-angled, slender, branched with sparse glandular trichomes	Creeping, sub-succulent, branched, glabrous
Nodal region	Glandular trichomes arranged in a nodal ring	Not prominent	Absent
Leaf	Petiole 0.5–1.5 cm long, angular, sparsely with glandular hairs; lamina slightly coriaceous, ovate, 1.3–2.5 × 1–1.5 cm, prominently 3-nerved, an additional pair of nerve obscurely seen near the margin	Petiole 0.4–1.5 cm long; lamina membranous, narrowly elliptical to ovate, 1–2.5 × 0.4–1.6 cm, Secondary veins 2–3 pairs	Petiole 0.5–1.5 cm; lamina coriaceous, ovate 1-nerved, 2–5 × 1–3 cm
Nature of hairs on leaf lamina	Dimorphic hairs present, densely hirsute above and with sparse glandular trichomes below	Dimorphic hairs present, densely hirsute above and with sparse glandular trichomes below	Absent
Leaf margin	Narrowly serrate with pink tinge	Serrate without pink tinge	Broadly serrate with pink tinge
Position of Inflorescence	Terminal	Terminal	Axillary or terminal
Inflorescence	Usually 1-2 flowered compressed terminal cyme	Inflorescences occurs at the end of branches, in 1-5 (up to 11-flowered) terminal scorpioid cymes.	Axillary or terminal 5-flowered umbellate cyme
Peduncle	More or less absent	Up to 2cm, with sparse glandular hairs	3–4cm long, glabrous
Pedicel	Pedicel 0.5–0.7cm with sparse glandular trichomes shorter than hypanthium	Pedicel 0.2–0.7cm with sparse glandular trichomes, shorter than hypanthium	Pedicel 1cm long, glabrous, length equalling hypanthium
Hypanthium	Light green with sparse glandular trichomes	Green with sparse glandular trichomes	Pink, glabrous
Petals	Petals pink to purple, broadly ovate, slightly clawed on either side, 4–5 glandular trichomes on the mid rib below, tip acuminate	Petals pink to purple oblong-elliptic sparse glandular trichomes on the mid rib below, tip acute to acuminate	Petals rose, elliptic, glabrous, tip apiculate.
Stamen	Anthers half the length of filaments	Anthers as long as filaments	Anthers as long as filaments
Stigma	Capitate	Three lobed	Capitate
Capsule	Tubular, 3-sided with sparse glandular trichomes	Tubular, 3-sided with sparse glandular trichomes	Campanulate, glabrous



**Figure 3.** Map showing the distribution of *Sonerila nairii* sp. nov., *Sonerila erecta* Jack and *Sonerila pulneyensis* Gamble.

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# *Lachemilla mexiquense* (Rosaceae), a new species from Mexico

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## Abstract

A new species of *Lachemilla* (Rosaceae), *Lachemilla mexiquense* D.F. Morales-B., from Mexico is described and illustrated. This species is similar to *Lachemilla aphanoides* by its tripartite leaves and glomerulate inflorescence with entirely glabrous flowers, but it differs by its stoloniferous habit, persistent basal leaves and basal stipules, and smaller flowers with a campanulate-elongate hypanthium and single carpel. A key to the species of *Lachemilla* in Mexico is provided.

## Resumen

Una nueva especie de *Lachemilla* (Rosaceae), *Lachemilla mexiquense* D.F. Morales-B., de México se describe e ilustra. Esta especie es similar a *Lachemilla aphanoides* por sus hojas tripartitas e inflorescencias glomeruladas con flores completamente glabras, pero difiere por su hábito estolonífero, hojas basales y estipulas basales persistentes y flores de menor tamaño con hipantio campanulado-elongado con un solo carpelo. Se provee una clave para las especies de *Lachemilla* en México.

## Keywords

*Lachemilla mexiquense*, *Lachemilla*, Rosaceae, Mexico, new species

## Introduction

*Lachemilla* Focke (Rydb.) is a morphologically highly variable group that includes perennial herbs, sub-shrubs, and shrubs. It comprises ca. 80 species and occurs between 2200 and 5000 m in elevation in the high mountains of the Neotropics, from northern Mexico to northern Argentina and Chile (Romoleroux 1996; Gaviria 1997), where it is one of the main elements of the páramo and superpáramo flora in South America. In Mexico the genus is represented by at least 10 species that can be found in sub-alpine and alpine habitats from the mountain pine forest to the high elevation zacatanales. *Lachemilla* has a nearly ubiquitous occurrence throughout the montane American tropics and remains a taxonomically complex group where species boundaries are often unclear and the infrageneric taxonomy is poorly defined. Since the only comprehensive revision of *Lachemilla* (Perry 1929), several works have tried to clarify its taxonomy (Rothmaler 1935, 1937; Notov and Kusnetzova 2004) and recently several regional treatments have been published (Romoleroux 2004; Barrie 2015), but a complete revision of the group is still needed. Recent taxonomic work aiming to produce a monographic treatment of *Lachemilla* has resulted in the description of several new species (Romoleroux 2009; Romoleroux and Morales-Briones 2012).

Here, a new species of *Lachemilla* is described and illustrated from Mexico. Material of the new species was collected in June 2015 during an expedition focusing solely on the genus *Lachemilla*. After detailed examination of the specimen, revision of species descriptions, and comparison with specimens at CAS, F, MEXU, MO, NY, TEX, and UC, it was established that the specimen collected in central Mexico represents a new species. The taxonomic treatment of this new species, including a key to species of *Lachemilla* in Mexico is provided.

## Taxonomic treatment

### *Lachemilla mexiquense* D.F. Morales-B., sp. nov.

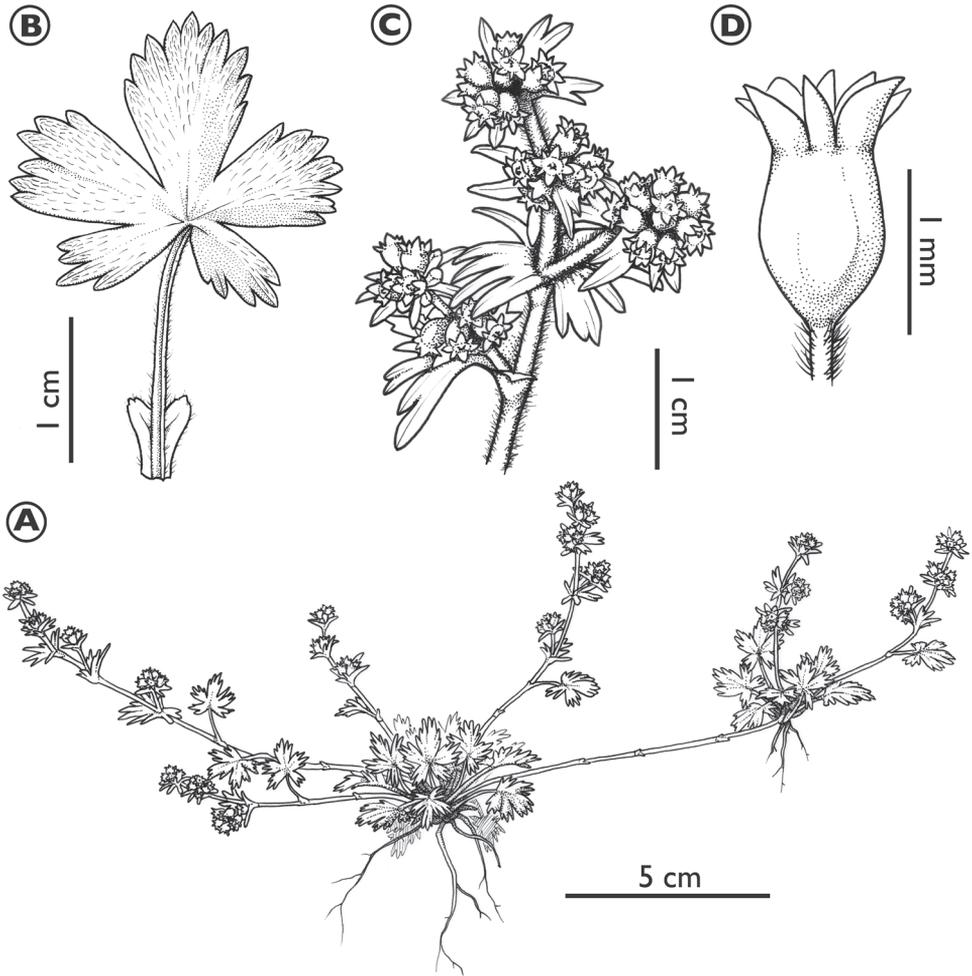
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Figures 1, 2A

**Diagnosis.** *Lachemilla mexiquense* differs from *Lachemilla aphanoides* (Mutis ex L. f.) Rothm. by its caespitose and stoloniferous habit, creeping stems, basal leaves and basal stipule persistent, campanulate-elongate hypanthium and the presence of a single carpel.

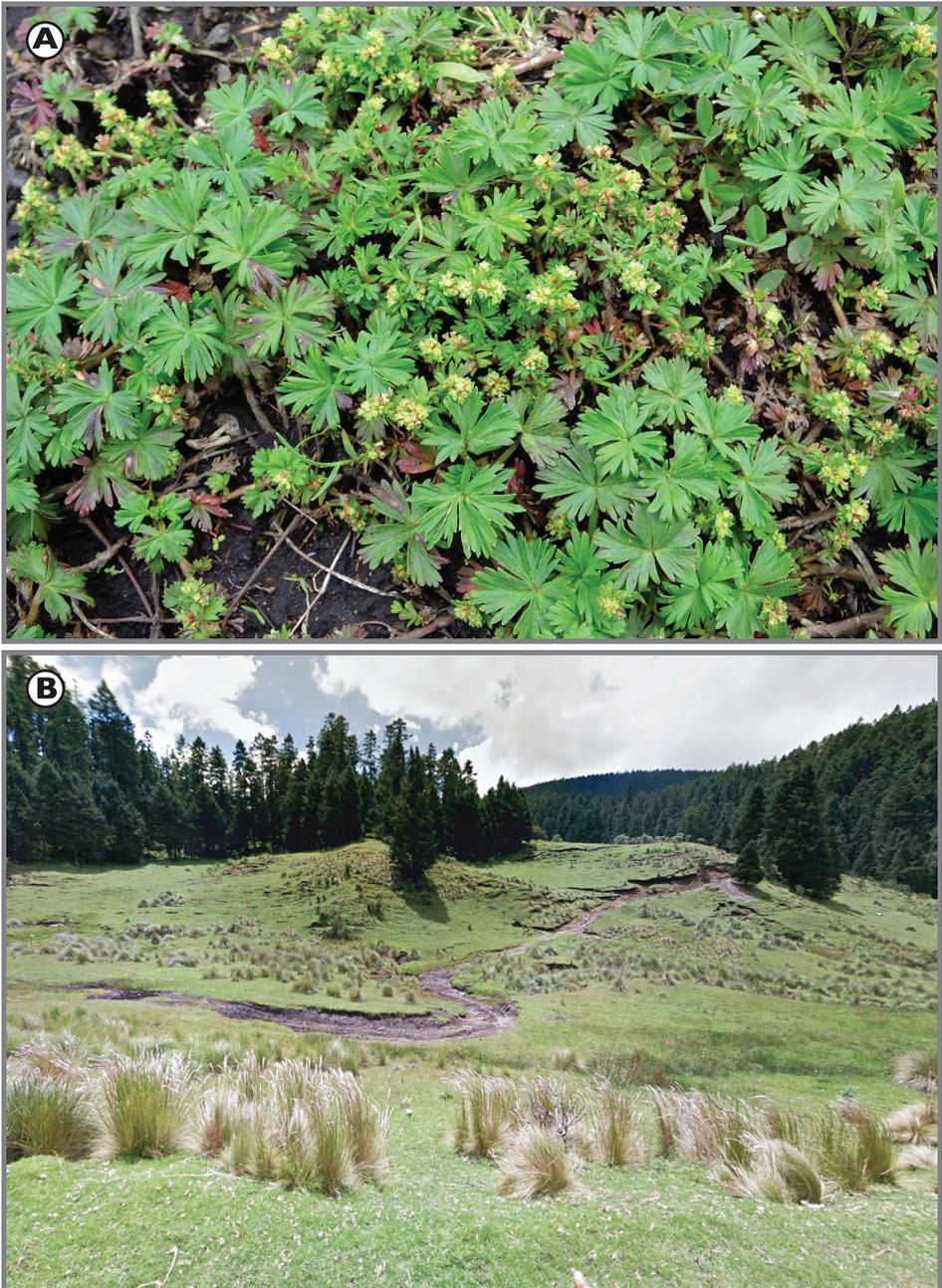
**Type.** MEXICO. Estado de México, Municipio Ocuilan, 4 km NE of Santa Martha on road Santa Martha–Huitzilac, 19.07567°N, 99.36215°W, alt. 3,050 m, 30 June, 2015, *Morales-Briones D. F. & Tenorio-Lezama P. 683*. (holotype: ID!; isotype: MEXU!, QCA!).

**Description.** Caespitose herbs, stoloniferous; stems creeping, mat-forming, branches sometimes rooting, pilose. Basal leaves 3-parted, 6–20 × 5–15 mm, chartaceous, lateral segments bifid, segments obovate to cuneate, margin incised-dentate, lower surface



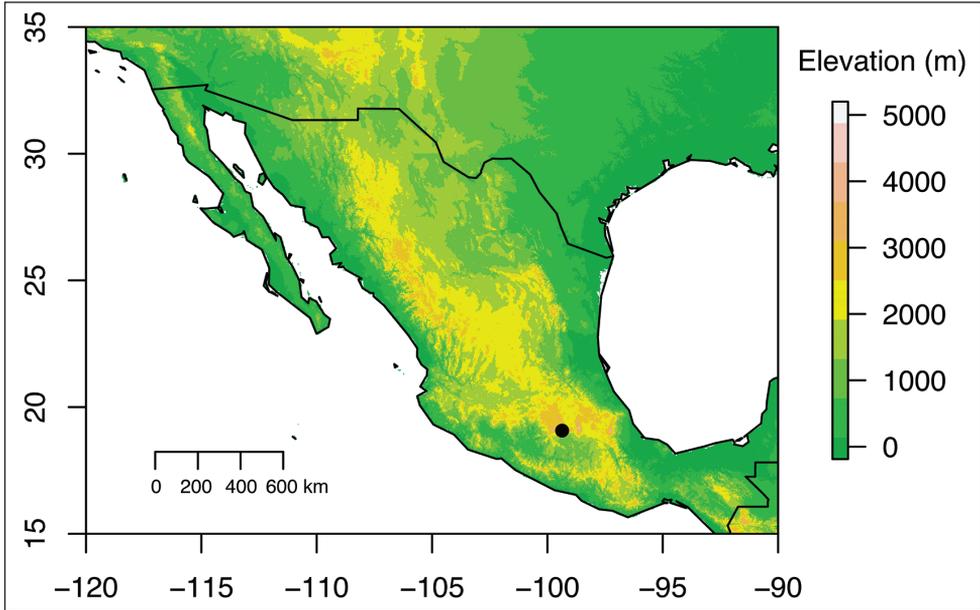
**Figure 1.** *Lachemilla mexiquense*. **A** Habit **B** Basal leaf and stipule **C** Flowering branch **D** Flower. Illustration by P. Lu-Irving.

pilose, upper surface sparsely pilose to glabrescent; petioles 12–35 mm long; stipules 5–15 mm long, adnate to the petiole at base, free, entire and acute at apex, membranaceous, greenish-white. Stem leaves 3-parted, 7–12 × 4–7 mm, chartaceous, lateral lobes entire or bifid, segments obovate to cuneate, margin deeply cleft, lower surface pilose, upper surface sparsely pilose to glabrescent; petioles 3–5 mm long; stipules 3–8 mm long, adnate to the petiole at base, free at apex, 6-lobed at apex, membranaceous and greenish-white at base, chartaceous and green at apex. Inflorescences axillary or terminal, glomerulate, 6–10 flowered cymes; floral bracts lobed, spreading; pedicels 1–1.5 mm long, pilose at apex. Flowers 1.2–1.5 mm long; hypanthium campanulate-elongate 1–1.2 × 0.6–0.8 mm, glabrous outside, glabrous inside, green when young, reddish at maturity; episeals 4, ovate, 0.6–0.7 × 0.5–0.7 mm, glabrous, apex acute; sepals 4,



**Figure 2.** *Lachemilla mexiquense*. **A** Habit **B** Type locality.

lanceolate,  $0.5\text{--}0.6 \times 0.2\text{--}0.3$  mm, glabrous, apex acute; stamens 2, filaments  $0.2\text{--}0.3$  mm long; carpels 1, stigma clavate. Achenes ovoid-globose,  $0.9\text{--}1.1 \times 0.6\text{--}0.8$  mm, glabrous, one-seeded. Seeds ovate,  $0.7\text{--}0.8 \times 0.4\text{--}0.6$  mm, pink, glabrous.



**Figure 3.** Geographic distribution of *Lachemilla mexiquense*.

**Distribution and ecology.** *Lachemilla mexiquense* is only known from the State of Mexico, municipality of Ocuilan, at ca. 3050 m altitude (Figures 2B, 3). *Lachemilla mexiquense* grows at the border of dense forest of various species of *Pinus*. This species lives in sympatry with *Lachemilla procumbens* (Rose) Rydb., *L. vulcanica* (Schltdl. & Cham.) Rydb., and *L. aphanoides* (Mutis ex L. f.) Rothm. It was collected in flower and fruit in late June.

**Etymology.** The specific epithet refers to the demonym for State of Mexico where the type specimen was collected.

**Conservation status.** *Lachemilla mexiquense* has a very limited geographic distribution, and is only known from the type locality (Figures 2B, 3). It occurs right outside the limits of the Cumbres del Ajusco National Park and Lagunas de Zempoala National Park. The type locality has been severely impacted by human activities, including conversion to agriculture (sheep and cow grazing). Following the IUCN (2014) guidelines, based on the reduced geographic distribution and altered land use at the type locality, this species should be categorized as endangered (EN), at least until other populations are discovered.

**Notes.** *Lachemilla mexiquense* resembles *L. aphanoides* by having tripartite leaves with bifid lateral segments and glomerulate inflorescence with entirely glabrous flowers. Nevertheless, *L. mexiquense* differs from *L. aphanoides* by its caespitose habit, creeping stems, and stolons that form dense mats. Also, the basal leaves and basal stipules are persistent, and flowers are smaller (1.2–1.5 mm long) with a campanulate-elongate hypanthium and single carpel. *Lachemilla rupestris* (Kunth) Rothm., a species from Andean South America with similar habit, differs from *L. mexiquense* by having

entire lateral segments of the leaves, yellow-brown membranaceous basal stipules, and larger flowers (2.5–3 mm long) with a turbinate-campanulate hypanthium, sericeous-hirsute pubescence, and 2–4 carpels.

In addition, phylogenetic analyses of chloroplast and nuclear DNA (Morales-Briones et al. unpubl. data) clearly separate *L. mexiquense* from *L. aphanoides* and *L. rupestris*. The chloroplast phylogeny place it as sister species of the ‘Orbiculate group,’ which encompasses species with stoloniferous habit, palmately lobed or cleft leaves, and flowers disposed in profuse terminal cymes, like *Lachemilla pectinata* (Kunth) Rothm. The nuclear phylogeny fails to confidently resolve the phylogenetic position of *L. mexiquense*, suggesting that it may be of hybrid origin, a common pattern seen throughout *Lachemilla*.

### Key to the species of *Lachemilla* in Mexico

**Notes.** Adapted from Standley and Steyermark (1946), Romoleroux (2004), and Barrie (2015). Accepted taxa and synonymy follows the regional revisions of Romoleroux (2004) and Barrie (2015), with the exception of *L. siboldiifolia* (Kunth) Rydb. and *L. pringlei* Rydb., which based on extensive field observations and the examination of herbarium material, are considered here as two distinct taxa.

- |   |   |                             |
|---|---|-----------------------------|
| 1 | Leaves pinnately divided .....  | <b><i>L. pinnata</i></b>    |
| – | Leaves simple or palmately divided or cleft .....   | <b>2</b>                    |
| 2 | Basal leaves 5–11-lobed or 5–7-cleft .....  | <b>3</b>                    |
| – | Basal leaves 3–5-cleft or 3–5-parted .....  | <b>4</b>                    |
| 3 | Leaves shallowly 5–11-lobed, lobes triangular .....   | <b><i>L. pectinata</i></b>  |
| – | Leaves deeply 5–7-cleft, lobes elliptical to ovate .....  | <b><i>L. venusta</i></b>    |
| 4 | Inflorescence of loose cymes; hypanthium pubescent within .....   | <b>5</b>                    |
| – | Inflorescence glomerulate, forming dense cymes; hypanthium glabrous within .....  | <b>6</b>                    |
| 5 | Leaves 3-parted with bifid lateral segments, appearing 5-parted; stipules lobed or incised-dentate .....                      | <b><i>L. procumbens</i></b> |
| – | Leaves 3-parted with entire lateral segments, not appearing 5-parted; stipules bifid .....                                    | <b><i>L. vulcanica</i></b>  |
| 6 | Plants pilose to glabrate; flowers glabrous .....   | <b>7</b>                    |
| – | Plants hirsute to sericeous; flowers pubescent, sometimes glabrate with age ...   | <b>8</b>                    |
| 7 | Stems decumbent, ascending or erect; basal leaves and basal stipules often.... caduceus; flowers 1.5–3.0 mm; 1–3 carpels..... | <b><i>L. aphanoides</i></b> |
| – | Stems creeping, stoloniferous; basal leaves and basal stipules persistent; flowers 1.2–1.5 mm; 1 carpel.....                  | <b><i>L. mexiquense</i></b> |
| 8 | Hypanthium densely pubescent with very short hairs; lower leaves short-petioled, the upper leaves sessile.....                | <b><i>L. velutina</i></b>   |

- Hypanthium sparingly pubescent with appressed hairs, lower and upper leaves petioled..... **9**
- 9 Leaves appearing 5-lobed, the lateral lobes bifid; achenes subacute or subobtusate..... *L. siboldiifolia*
- Leaves appearing 3-lobed, the lateral lobes not bifid; achenes tapering to an acute apex..... *L. pringlei*

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# *Callicarpa bachmaensis* Soejima & Tagane (Lamiaceae), a new species from Bach Ma National Park in Thua Thien Hue Province, Central Vietnam

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## Abstract

A new species, *Callicarpa bachmaensis* Soejima & Tagane, **sp. nov.**, is described and illustrated from Bach Ma National Park in Thua Thien Hue Province, Central Vietnam. This species has a characteristic liana habit, white corolla, and narrowly elliptic to narrowly lanceolate, entire, occasionally subequal leaves, by which it is clearly distinguished from the other previously known species of this genus.

## Keywords

Bach Ma National Park, *Callicarpa*, Lamiaceae, new species, Thua Thien Hue, Vietnam

## Introduction

The genus *Callicarpa* L. (Lamiaceae) comprises 154 species and 12 varieties (The Plant List 2013) of shrubs or small trees, rarely woody climbers, distributed in temperate and tropical regions. The center of species diversity of this genus is in the Old World, especially in Malesia where about 50 species occur (Bramley 2013). Common and

well-known species are found widely in secondary forests or in disturbed areas, but many species are restricted to small areas in primary forest (Bramley 2009, 2013). The genus is characterized by simple, opposite leaves, small white to pink or violet flowers in cymose or thyrsoid inflorescences, small globose drupes, and often stellate, plumose, or dendroid hairs on stems, leaves, calyces, and fruits (Chen and Gilbert 1994, Bramley 2009, 2013, Leeratiwong et al. 2009).

The species of Vietnam have been studied by de Loureiro (1790), Dop (1935), Ho (2003), and most recently by Phuong (2007) who enumerated 20 species. During a botanical survey of Bach Ma National Park in Thua Thien Hue Province, Central Vietnam in 2015, we found a species that was different from all the other known species of *Callicarpa*. This plant is described and illustrated as a new species, *Callicarpa bachmaensis* Soejima & Tagane.

## Taxonomy

### *Callicarpa bachmaensis* Soejima & Tagane, sp. nov.

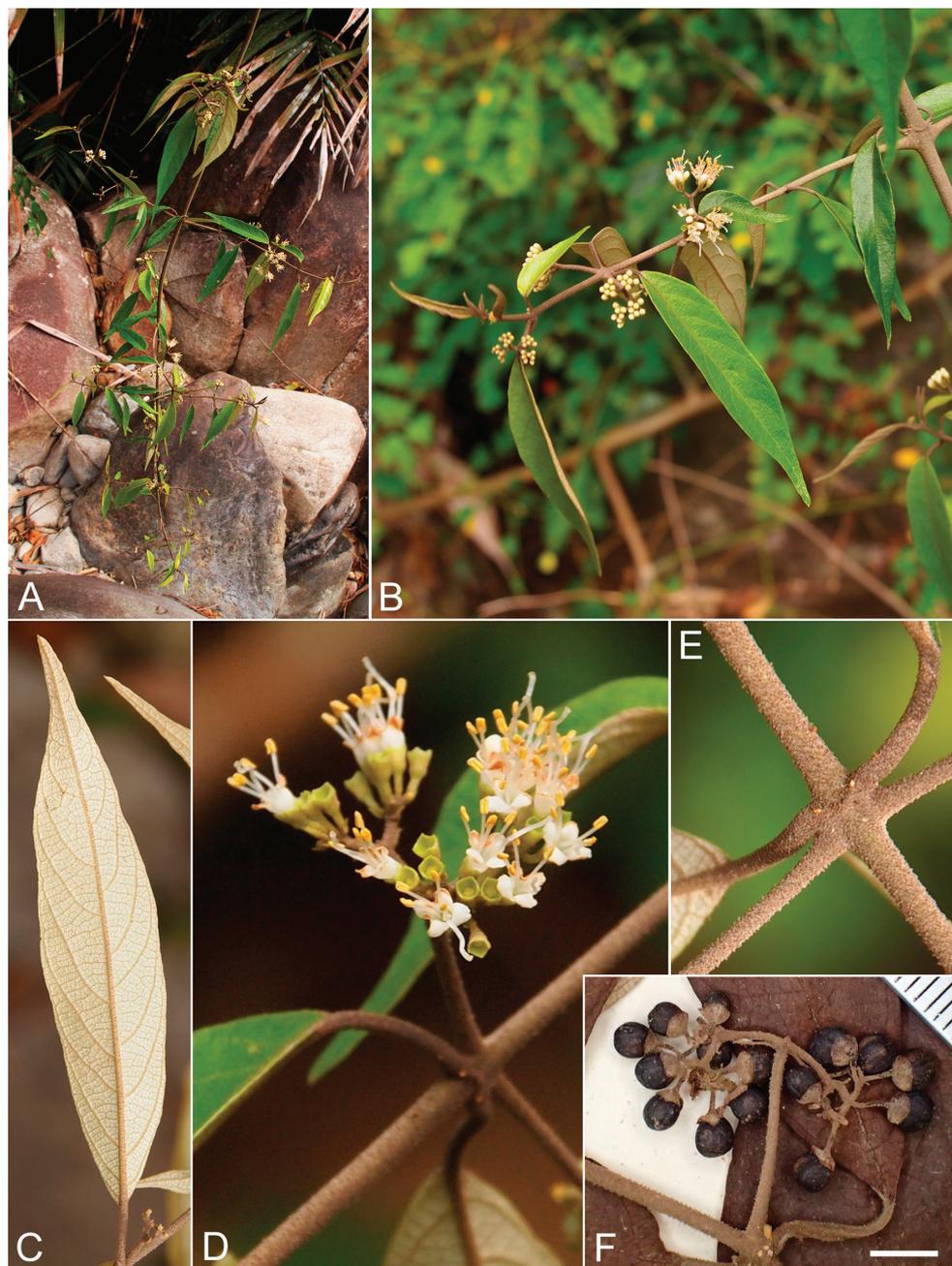
urn:lsid:ipni.org:names:77153917-1

Figs 1, 2

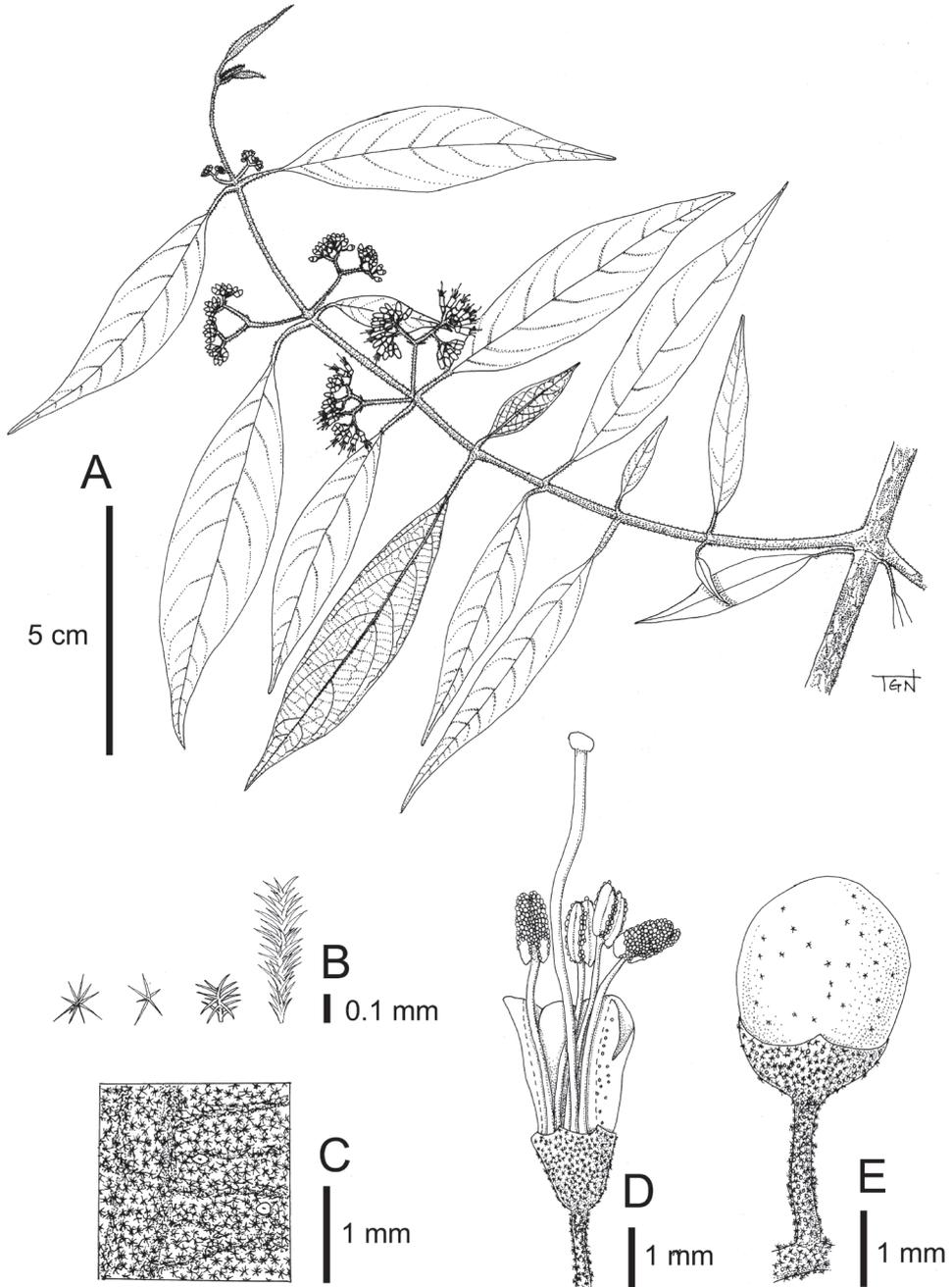
**Type.** VIETNAM. Thua Thien Hue Province, Bach Ma National Park, edge of evergreen forest along stream, 16°13'36.70"N, 107°51'07.22"E, alt. 414 m, 24 May 2015, with flowers, Tagane S., Toyama H., Yahara T., Ngoc Nguyen, Chinh Nguyen, Okabe N. V2677 (holotype KYO!, isotypes BKF!, DLU!, FU!, P!, VNM!, the herbarium of Bach Ma National Park!).

**Diagnosis.** *Callicarpa bachmaensis* is distinguishable from the other species of *Callicarpa* by a combination of its liana habit, white flowers and narrowly elliptic to narrowly lanceolate, entire, occasionally subequal leaves. *Callicarpa angusta* Schauer, endemic to Philippines, and *C. angustifolia* King & Gamble, distributed in China, Cambodia, Thailand, Vietnam, and Peninsular Malaysia, resemble to *C. bachmaensis* in possessing narrowly elliptic leaves. However, they differ from *C. bachmaensis* in having a shrubby habit and serrate leaves. Additionally, *C. angusta* differs in having hairy corollas, and *C. angustifolia* differs in having larger leaves (more than 9 cm long in *C. angustifolia* vs. less than 9 cm long in *C. bachmaensis*) and larger corollas (ca. 3 mm long vs. 2–2.2 mm long).

**Description.** Liana-like small tree, ca. 3 m tall. Branches sweeping with gradual curve and overhanging distally. Twigs with a dense indumentum of short plumose or dendroid brown hairs, slightly 4-angular when young, later becoming terete, woody and glabrous, lenticellate; internode 8.7–13 cm long in main stems, 1.4–3 cm long in axial ones. Leaves opposite, occasionally subequal; blades narrowly elliptic to narrowly lanceolate, (2.6–)5–8 × (0.4–)0.8–2 cm in larger leaves, 1.1–4 × 0.2–1 cm in smaller ones, base acute to cuneate, apex acuminate, margin entire, upper surface with short stellate hairs or sometimes almost glabrous, also with small yellow sessile glands and a



**Figure 1.** *Callicarpa bachmaensis* Soejima & Tagane, sp. nov. **A** Branch apex **B** Flowering branch **C** Abaxial surface of lamina **D** Inflorescences **E** Twigs and base of petiole, **F** Infructescence [*Binh & Cuong VN1985* (HN)]. Scale bar E = 5 mm).



**Figure 2.** *Callicarpa bachmaensis* Soejima & Tagane, sp. nov. **A** Flowering branch **B** Stellate and dendroid hairs on calyx (left three) and lower surface of leaves (right) **C** Abaxial surface of lamina **D** Flower with the corolla dissected to show filaments and style **E** Fruit. Materials: *Tagane et al.* V2677.

few larger sessile glands, lower surface densely covered with white stellate or sometimes pale brownish fringed peltate scale-like hairs and a few larger sessile glands, chartaceous to subcoriaceous, green and slightly lustrous above, white hairy below; midrib slightly sunken above, prominent below, secondary veins 6–10 pairs, prominent below, tertiary veins scalariforming-reticulate; petioles 0.8–1.1 cm long, with indumentum as branches. Inflorescence axillary, cymose, entirely covered with indumentum as branches, peduncles 0.8–1 cm long; bracts linear, 1.5–2 mm long; pedicels ca. 0.5 mm long. Calyx cup-shaped, 1–1.5 mm long with 4 (or 5) shallow lobes, outer surface covered with stellate or short dendroid hairs and small yellow sessile glands, inner surface almost glabrous. Corolla white, 2–2.2 mm long, divided into four lobes, tube ca. 1 mm long, lobes oblong-ovate, <1 mm long, apex rounded, outer surface with yellow sessile glands, inner surface almost glabrous. Stamens 4, ca. 1 mm long exerted from corolla, filaments 2.5–3 mm long, glabrous, anthers elliptic, ca. 1 mm long, with many yellow sessile glands near connectives, dehiscing through longitudinal slits. Stigma capitate, style ca. 6 mm long, glabrous. Fruits drupaceous, spherical, 2.5–3 mm in diameter, dark purple, sparsely covered with stellate hairs.

**Specimen examined.** VIETNAM. 20 June 1976, with fruits, *Ly Quoc Anh 106* (HN!); Lao Cai Province: Liem Phu, Van Ban, 10 June 2008, with flowers, *Binh N.Q. & Cuong D.D. VN1985* (HN!); Quang Nam-Da Nang Province: Hà ra, Giãng village, 13 July 1986, with fruits, *LX-VN 2958* (HN!); Vinh Phuc Province: Me Linh Biodiversity Station, Ngoc Thanh Commune, 24 Oct. 2001, with fruits, *Phuong et al. 4611* (HN!).

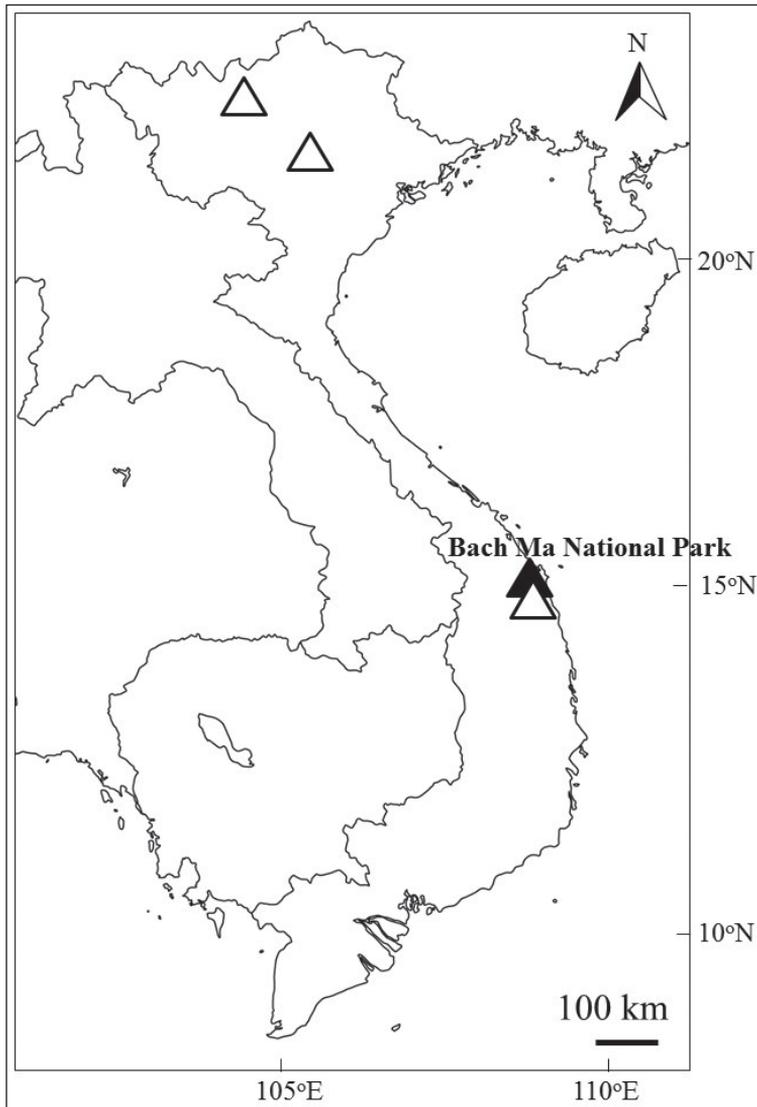
**Phenology.** Flowering specimens were collected in May and June; fruiting in June, July, and October.

**Distribution and habitat.** VIETNAM: Northeast (Lao Cai and Vinh Phuc Province) and Central coast (Thua Thien Hue, Quang Nam and Da Nang Province) (Fig. 3). In the type locality, Bach Ma National Park, Thua Thien Hue Province, a small population was found at the edge of humid broad-leaved evergreen forest along a stream, at altitude ca. 400 m, in which *Dipterocarpus hasseltii* Blume (Dipterocarpaceae), *Croton argyratus* Blume (Euphorbiaceae), *Vitex axillariflora* (Merr.) Bramley (Lamiaceae), *Beilschmiedia henghsienensis* S. K. Lee & Y. T. Wei (Lauraceae), *Litsea balansae* Lecomte (Lauraceae), *Heritiera augustata* Pierre (Malvaceae), *Syzygium diospyrifolium* (Wall. ex Duthie) S. N. Mitra (Myrtaceae), *S. siamense* (Craib) Chantar. & J. Parn. (Myrtaceae), *Adina pilulifera* (Lam.) Franch. ex Drake (Rubiaceae) dominate.

**GenBank accession no.** *Tagane et al. V2677*: LC120829 (*rbcl*), LC120830 (*matK*).

**Etymology.** The specific epithet *bachmaensis* reflects the name of the locality where the type specimen was collected.

**Conservation status.** Data Deficient (DD). *Callicarpa bachmaensis* is collected from north and central Vietnam. In the type locality, Bach Ma National Park, the number of individuals is likely stable, but at present we have no reliable information on its abundance and range. Further investigations are needed to accurately assess its status in the natural habitat.



**Figure 3.** Distribution of *Callicarpa bachmaensis* Soejima & Tagane. Black triangle: type locality in Bach Ma National Park; white triangle: other collection sites in Vietnam.

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# New distribution records of two bamboo species in Yunnan, China with description of the inflorescence for *Melocalamus yunnanensis* (Poaceae, Bambusoideae)

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## Abstract

*Ampelocalamus actinotrichus* (Merrill & Chun) S. L. Chen, T. H. Wen & G. Y. Sheng and *Neomicrocalamus prainii* (Gamble) P. C. Keng are reported with new distribution records in southern and southeastern Yunnan, China, respectively. *Ampelocalamus actinotrichus* was previously recorded to be endemic to Hainan, China, and *Neomicrocalamus prainii* to be distributed in southern Tibet and western Yunnan in China, northeastern India, and Burma. The identities of individuals collected in southern and southeastern Yunnan of these two species are confirmed by molecular evidence. The new distribution record of *Ampelocalamus actinotrichus* provides a case at the species level for confirming floristic affinities of southern Yunnan and Hainan Island in south China. The disjunct distribution of *Neomicrocalamus prainii* in Yunnan is concordant with the ecogeographical diagonal line from northwestern Yunnan to southeastern Yunnan and this may imply a tropical origin of this species. In addition, the inflorescence of *Melocalamus yunnanensis* (T. H. Wen) T. P. Yi is described.

## Keywords

*Ampelocalamus actinotrichus*, *Neomicrocalamus prainii*, biogeographic implications, molecular discrimination, inflorescence

## Introduction

Although morphological descriptions, distributions, and pictures of most bamboo species and genera in China have been recorded in the *Flora Reipublicae Popularis Sinicae* (FRPS) (Keng and Wang 1996), the *Flora of China* (Li et al. 2006), and the *Iconographia Bambusoidearum Sinicarum* (Yi et al. 2008), there are still many aspects that need to be changed incorporating findings from molecular phylogenetic analyses, the re-evaluation of morphological characters, and additional field investigations. During our field work from 2012 to 2014, two distinct bamboo species were noted. One occurs in Xishuangbanna, southern Yunnan, China, which was initially identified as “*Ampelocalamus menglaensis*” Hsueh & F. Du *nom. nud.* (Du et al. 1999), but closely resembled *A. actinotrichus* (Merrill & Chun) S. L. Chen, T. H. Wen & G. Y. Sheng. The other is distributed in Malipo, southeastern Yunnan, China, where it is called “*teng zhu*” (climbing bamboo) by local people, and was tentatively identified as *Neomicrocalamus prainii* (Gamble) P. C. Keng.

*Ampelocalamus actinotrichus*, the type species of the genus *Ampelocalamus* S. L. Chen, T. H. Wen & G. Y. Sheng (Chen et al. 1981), belongs to the tribe Arundinarieae (BPG 2012), and is endemic to the island of Hainan, China, according to the FRPS and the *Flora of China*. *Neomicrocalamus prainii* is the type species of the genus *Neomicrocalamus* P. C. Keng which belongs to the subtribe Bambusinae (Bambuseae) (Keng 1983, BPG 2012), and is distributed in southern Tibet and western Yunnan of China (Keng and Wang 1996, Li et al. 2006), and northeastern India (Meghalaya and Nagaland) (Ohrnberger 1999, Kumari and Singh 2013). If the two species discovered in southern and southeastern Yunnan, are indeed *Ampelocalamus actinotrichus* and *Neomicrocalamus prainii*, respectively, their collections would represent new distribution records in China for those species.

In order to further confirm the identities of these two species in southern and southeastern Yunnan, molecular phylogenetic analyses were carried out. Previous molecular phylogenetic studies demonstrated that plastid regions had low resolution at species and generic levels in Arundinarieae (Triplett and Clark 2010, Zeng et al. 2010), and conspicuous conflicts between plastid and nuclear phylogenetic tree topologies have been found (Zhang et al. 2012, Yang et al. 2013). Moreover, nuclear phylogenies were more congruent with morphology-based classifications and had higher resolutions than plastid phylogenies. Therefore, we selected one nuclear gene *LEAFY* (Yang et al. 2013) for the molecular identification of the “*Ampelocalamus menglaensis*” sample. The standard DNA barcoding plastid regions had been found to possess a certain discriminative power at species and generic levels in the subtribe Bambusinae and can be obtained by direct sequencing, while obtaining nuclear genes may involve cloning which requires more time and resources (Yang et al. 2010, Goh et al. 2013). Given their convenience and efficiency, we selected four plastid regions (*rbcL-psaI*, *rpl32-trnL*, *trnG-trnT(g)*, *trnG-trnT(t)*) that show higher levels of variation than standard DNA barcoding markers (Zhang et al. 2013), for identifying the “*teng zhu*” sample.

In addition to the two distinct bamboo species, we collected flowering specimens of *Melocalamus yunnanensis* (T. H. Wen) T. P. Yi in the field and the Bamboo Garden of Xishuangbanna Tropical Botanical Garden. The inflorescence of this species is described in this paper, and its identity as a member of the genus *Melocalamus* Benthham reconfirmed.

## Materials and methods

### Field collections

Specimens for morphological observations and silica gel-dried leaf samples of “*Ampelocalamus menglaensis*” and *Melocalamus yunnanensis* were collected in August 2012 and April 2013 in southern Yunnan (Mengla, Xishuangbanna) and of “*teng zhu*” in October 2013 and August 2014 in southeastern Yunnan. The distribution map was created using DIVA-GIS (<http://www.diva-gis.org>).

### Morphological observations

The specimens collected in southern Yunnan were compared with specimens of *Ampelocalamus actinotrichus* from Hainan Island. The specimens of “*teng zhu*” from southeastern Yunnan were compared with those of *Neomicrocalamus prainii* from northwestern Yunnan and southern Tibet.

The inflorescence of *Melocalamus yunnanensis* from the Bamboo Garden of Xishuangbanna Tropical Botanical Garden was compared with specimens of this species from Jiangcheng, southern Yunnan. The glumes, lemma, palea, ovary, style, and stamens were observed under a hand-lens (30×).

### Taxon sampling

The phylogeny of Arundinarieae based on *LEAFY* indicated that the genus *Ampelocalamus* is monophyletic, except for *A. calcareus* C. D. Chu & C. S. Chao, and sister to *Drepanostachyum* P. C. Keng and *Himalayacalamus* P. C. Keng (Yang et al. 2013). Thus, samples of the latter two genera were used as outgroup in our study. We aimed to elucidate the identity of “*A. menglaensis*”, not to infer phylogenetic relationships. Therefore, only those taxa closely related to *A. actinotrichus* were included (Table 1).

In order to confirm the identity of “*teng zhu*”, representatives of the subtribe Bambusinae were chosen according to Yang et al. (2008), including taxa of *Bambusa* Schreber, *Bonia* Balansa, *Dendrocalamus* Nees, and *Melocalamus* Benthham (Table 1).

Voucher specimens of all samples are deposited at the herbarium of the Kunming Institute of Botany, Chinese Academy of Sciences (KUN).

Table 1. Plant materials, voucher information, and GenBank accession numbers of the samples used in the phylogenetic analyses.

Taxon	Voucher	Locality	GenBank accession number			
			Leafy	<i>rbcL-psaI</i>	<i>rpl32-trnL</i>	<i>trnC-trnT</i> (g)
<b>Arundinarieae Nees ex Asch. &amp; Graebn.</b>						
<i>Ampelocalamus actinotrichus</i> (Merr. and Chun) S.L. Chen et al.	MPF10001	Ledong, Hainan, China	KM264728	—	—	—
<i>Ampelocalamus actinotrichus</i> (Merr. and Chun) S.L. Chen et al.	MPF10003	Ledong, Hainan, China	KM264729 KM264730	—	—	—
<i>Ampelocalamus actinotrichus</i> (Merr. and Chun) S.L. Chen et al.	12167	Mengla, Yunnan, China	KR057489	—	—	—
<i>Ampelocalamus actinotrichus</i> (Merr. and Chun) S.L. Chen et al.	13007	Mengla, Yunnan, China	KR057490	—	—	—
<i>Ampelocalamus actinotrichus</i> (Merr. and Chun) S.L. Chen et al.	13012	Mengla, Yunnan, China	KR057491	—	—	—
<i>Ampelocalamus luodianensis</i> T.P. Yi & R.S. Wang	MPF10052	Luodian, Guizhou, China	KM264732 KM264733	—	—	—
<i>Ampelocalamus melicoides</i> (P.C. Keng) D.Z. Li & Stapleton	MPF10142	Nanchuan, Chongqing, China	KM264735	—	—	—
<i>Ampelocalamus microphyllus</i> (Hsueh & T.P. Yi) Hsueh & T.P. Yi	MPF10123	Wuxi, Chongqing, China	KM264734	—	—	—
<i>Ampelocalamus patellaris</i> (Gamble) Stapleton	Zhang07075	Lvchun, Yunnan, China	KM264785	—	—	—
<i>Drepanostachyum ampullare</i> (T.P. Yi) Demoly	GLM081860	Shannan, Xizang, China	KM264793	—	—	—
<i>Himalayacalamus falconeri</i> (Munro) P.C. Keng	GLM081524	Jilong, Xizang, China	KM264791 KM264792	—	—	—
<b>Bambuseae Kunth ex Dumort.</b>						
<i>Bambusa lapidea</i> McClure	12152	Jiangcheng, Yunnan, China	—	KF764854	KF764906	KF765025
<i>Bambusa teres</i> Buchanan-Hamilton ex Munro	12204	Yingjiang, Yunnan, China	—	KF764853	KF764907	KF765026
<i>Bonia amplexicaulis</i> (L. C. Chia et al.) N. H. Xia	12329	Pingxiang, Guangxi, China	—	KF764851	KF764908	KF765051
<i>Bonia saxatilis</i> (L. C. Chia et al.) N. H. Xia var. <i>saxatilis</i>	12327	Bama, Guangxi, China	—	KF764852	KF764909	KF765028
<i>Dendrocalamus barbatus</i> Hsueh & D. Z. Li	12151	Jiangcheng, Yunnan, China	—	KF764849	KF764912	KF765055
<i>Dendrocalamus brandisii</i> (Munro) Kurz	12142	Jiangcheng, Yunnan, China	—	KF764848	KF764914	KR057481
<i>Melocalamus yunnanensis</i> (T. H. Wen) T. P. Yi	12153	Jiangcheng, Yunnan, China	—	KR057474	KR057467	KR057482
<i>Neomicrocalamus prainii</i> (Gamble) P.C. Keng	LL07236	Motuo, Xizang, China	—	KR057476	KR057469	KR057483
<i>Neomicrocalamus prainii</i> (Gamble) P.C. Keng	LL07567	Linzhi, Xizang, China	—	KR057477	KR057470	KR057485
<i>Neomicrocalamus prainii</i> (Gamble) P.C. Keng	ZXZ11027	Gongshan, Yunnan, China	—	KR057480	KR057473	KR057488
<i>Neomicrocalamus prainii</i> (Gamble) P.C. Keng	13045	Malipo, Yunnan, China	—	KR057475	KR057468	KR057483
<i>Neomicrocalamus prainii</i> (Gamble) P.C. Keng	YXY150	Malipo, Yunnan, China	—	KR057478	KR057471	KR057486
<i>Neomicrocalamus prainii</i> (Gamble) P.C. Keng	YXY151	Xichou, Yunnan, China	—	KR057479	KR057472	KR057487

## DNA isolation, amplification, and sequencing

Total genomic DNA was extracted from silica gel-dried leaves using a modified CTAB procedure (Doyle and Doyle 1987). Primers and protocols for the PCR amplification of the nuclear gene *LEAFY* and four plastid regions (*rbcL-psaI*, *rpl32-trnL*, *trnG-trnT(g)*, *trnG-trnT(t)*) followed prior studies (Yang et al. 2013, Zhang et al. 2013). PCR products were checked on 1% agarose gels, and purified using ExoSAP-IT (USB, Cleveland, OH, USA). Double-stranded and purified PCR products were sequenced by the dideoxy chain termination method with ABI PRISM BigDye Terminator Cycle Sequencing Ready Reaction Kit with AmpliTaq DNA polymerase FS (Perkin Elmer, Waltham, MA, USA). PCR reactions and programs were chosen according to the recommendations of the handbook, with slight modifications in some cases. Bidirectional sequencing was performed on an ABI 3730xl automated sequencer.

## Phylogenetic analyses

Sequences were assembled and edited with SeqMan (DNA STAR package; DNA Star Inc., Madison, WI, USA), aligned by MUSCLE (Edgar 2004), and adjusted manually where necessary. Informative indels introduced by the sequence alignment were coded as binary characters using the simple indel coding method of Simmons and Ochoterena (2000). Due to no obvious conflicts among individual plastid trees, we used a combined data set of four plastid regions for phylogenetic analyses. All data matrices are available on request from the first author. Sequences newly obtained in this study have been deposited in GenBank (Table 1). Accession numbers initialed with 'KM' and 'KF' were downloaded directly from GenBank, and the others were obtained in this study.

For phylogeny reconstructions, we used three methods, namely maximum parsimony (MP), maximum likelihood (ML), and Bayesian inference (BI). The MP and ML analyses were conducted with PAUP\* version 4.0b10 (Swofford 2002). For the ML analyses, the best-fitting models were selected using jModeltest v2.1.4 under the Akaike Information Criterion (AIC) (Darriba et al. 2012). The TIM3 model and TPM1uf+G model were selected for *LEAFY* and combined plastid regions, respectively. MP and ML analyses were conducted with the same parameter setting for the heuristic search and the bootstrap calculation. The heuristic search was performed with 1000 random addition sequence replicates and TBR branch swapping, MULTREES option in effect. Strict consensus trees were calculated for all MP analyses. Branch support was estimated with 1000 bootstrap replicates (Felsenstein 1985) using the heuristic search method as described above (with 100 random addition sequence replicates). The same models were used for Bayesian analyses with MrBayes version 3.2.5 (Ronquist et al. 2012). Two independent runs were conducted simultaneously starting with random trees, and each run consisted of one cold and three hot chains. Chains were run for 150000 generations for *LEAFY* and 200000 generations for the combined plastid data set, and trees sampled every 100 generations. The average standard deviation of split frequencies between both runs reached a value below 0.01. The convergence of the chains and the number

of trees to be discarded were determined using Tracer version 1.6 (<http://tree.bio.ed.ac.uk/software/tracer>). The initial 25% trees were discarded as burn-in, and the remaining trees were used to construct a 50% majority-rule consensus trees. MP and ML bootstrap values  $\geq 50\%$  and BI posterior probabilities  $\geq 0.95$  were labeled on the tree branches.

## Results

### Phylogenetic analysis

The aligned length of *LEAFY* was 738 bp, and six indels were coded as additional absent/present (0/1) characters, giving a total of 744 characters in the MP matrix, of which 26 were parsimony-informative. Sequences of the four plastid regions were obtained for all samples, except *trnG-trnT*(t) for the sample ZXZ11027. The combined plastid matrix was 3737 bp long and included 14 indel characters in the MP matrix, 113 of which were parsimony-informative. There were inversions in the *rbcL-psaI* and *rpl32-trnL* sequences (Zeng et al. 2010, Zhang et al. 2013) and gaps were introduced to separate the inverted regions to avoid overweighting the inversions. Those gaps were not scored and treated as missing data.

The 50% majority-rule consensus tree from BI for *LEAFY* is presented in Fig. 1. The ML tree and the MP strict consensus tree were consistent with the Bayesian tree except for a few branches with very low support (not shown). The statistical support was shown along the branches (MP/ML/BI). All individuals of *Ampelocalamus* formed a clade with high support (MP/ML/BI = 98/98/1.00). The samples of “*A. menglaensis*” (voucher numbers 12167, 13007, and 13012) fell with the *Ampelocalamus actinotrichus* samples collected from Hainan.

The 50% majority-rule consensus tree from BI for the combined plastid data set is presented in Fig. 2. The ML tree and the MP strict consensus tree were the same with the Bayesian tree. The statistical support is shown along the branches (MP/ML/BI). Individuals of “*teng zhu*” collected from southeastern Yunnan and *Neomicrocalamus prainii* ZXZ11027 from northwestern Yunnan fell in one clade with high support (MP/ML/BI = 89/89/1.00), and they subsequently formed a monophyletic group with *N. prainii* from Tibet (MP/ML/BI = 100/100/1.00).

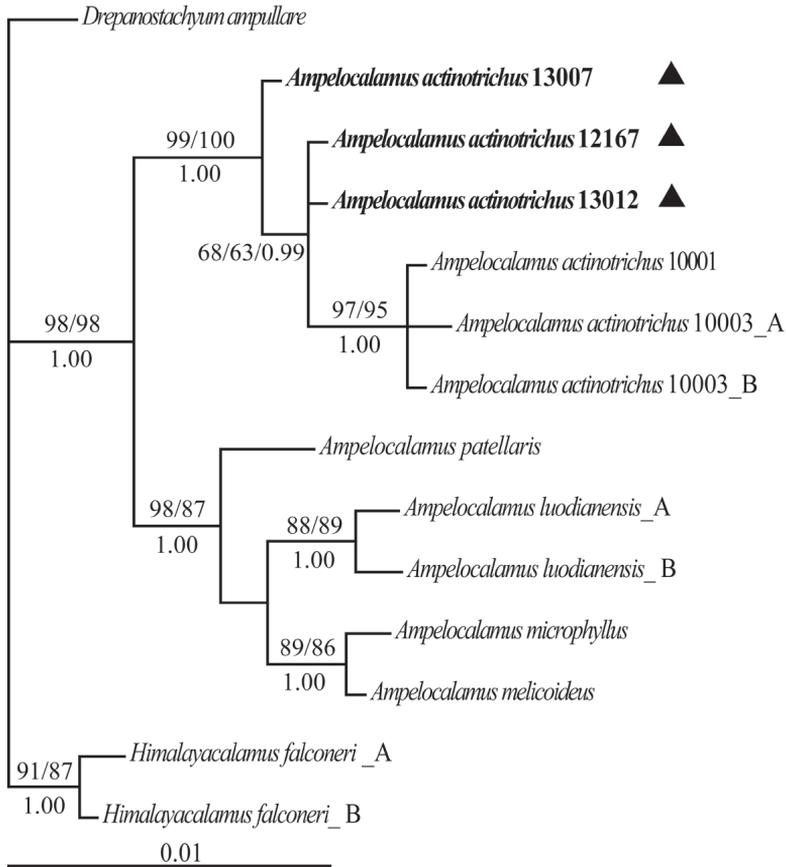
### Description of the inflorescence of *Melocalamus yunnanensis*

#### *Melocalamus yunnanensis* (T. H. Wen) T. P. Yi, 2007

Fig. 3

*Racemobambos yunnanensis* T. H. Wen, *J. Bamboo Res.* 5: 11. 1986; *Neomicrocalamus yunnanensis* (T. H. Wen) Ohrnberger, *The Bamboos of the World: Introduction to the Work*, 4: 19.1997.

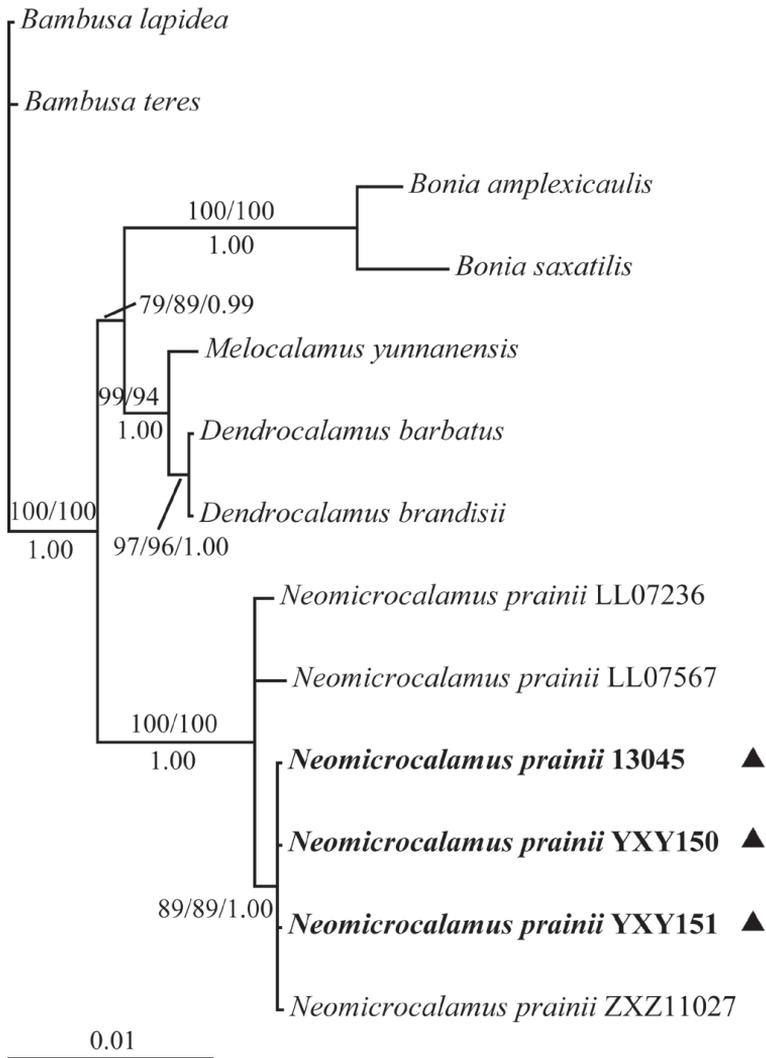
*Melocalamus yunnanensis* (T. H. Wen) T. P. Yi, *J. Sichuan Forest. Sci. Tech.* 28: 18. 2007.



**Figure 1.** Phylogram of the 50% majority-rule consensus tree from Bayesian analysis of *LEAFY* sequences. Bootstrap values over 50% and Bayesian posterior probabilities over 0.95 are shown along branches (MP/ML/BI). Individuals of *Ampelocalamus actinotrichus* from Yunnan are in bold and indicated by solid triangles. Letters **A** and **B** after taxon names denote different alleles of *LEAFY*.

**Type.** CHINA. Yunnan: Jinping, *W. W. Zhou ZP. 83311* (holotype, ZJFI).

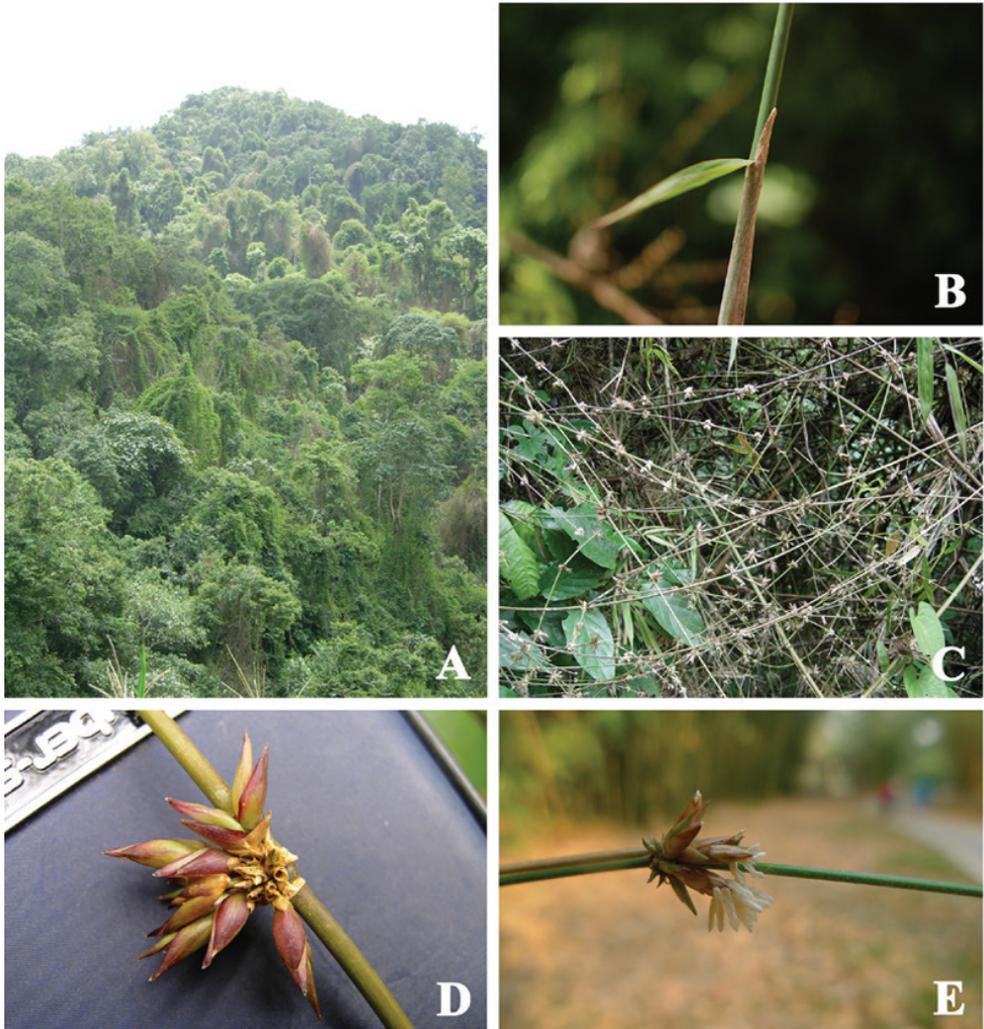
Culms scrambling, 6–15 m, 5–10 mm in diam.; internodes 20–60 cm, smaller culms solid or nearly so, white pubescent, especially dense below corky nodes. Dominant branches equal in size to culm, other branches slender and many. Culm leaf sheaths brown scabrous, lower portion very tough, upper papery and thin, margins glabrous, shoulders protruding conspicuously; ligules inconspicuous; auricles and oral setae absent; blades lanceolate, recurved. Leaves 3–4 per ultimate branch; leaf sheaths slightly pubescent, margins ciliate; ligules 1–1.5 mm; auricles absent; oral setae erect to spreading, short; blades lanceolate, 4–7 × 0.8–1.3 cm, glabrous, veins 4 pairs, without tessellation. Flowering branches with or without leaves, internodes with dense white pubescence. Pseudospikelets 0.8–1.2 cm, several to many clustered on nodes, glomerate, 2–3 florets for each pseudospikelet with the top one sterile; rachilla ca. 1.5 mm;



**Figure 2.** Phylogram of the 50% majority-rule consensus tree from Bayesian analysis of the combined plastid data set (*rbcL-psaI*, *rpl32-trnL*, *trnG-trnT*(g), and *trnG-trnT*(t)). Bootstrap values over 50% and Bayesian posterior probabilities over 0.95 are shown along branches (MP/ML/BI). Individuals of *Neomicrocalamus prainii* from southeastern Yunnan are in bold and indicated by solid triangles.

glumes 2, 2–4 mm; lemma purple red, 5–6 mm, glabrous; palea a little longer than lemma, purple red, 6–7 mm, 2-keeled, glabrous; lodicules 3, nearly equal, margins ciliate; stamens 6, yellow; ovary ovate-lanceolate; style 1, stigmas 2, plumose. Caryopsis unknown.

**Voucher specimens. CHINA. Yunnan:** Jiangcheng, 860 m, 22°28.429'N, 101°29.938'E, 12 August 2012, Y. X. Zhang, Y. X. Xu & M. Y. Zhou 12153, 12154 (KUN); Mengla, 790 m, 21°36.55'N, 101°33.683'E, 8 April 2013, Y. X. Zhang & Y.



**Figure 3.** *Melocalamus yunnanensis*. **A** Habitat (12153) **B** Culm leaf (12153) **C** Flowering branches (12154) **D–E** Pseudospikelets (**D** 12154, **E** C130104).

*X. Xu* 13006, 13009 (KUN); Menglun, the Bamboo Garden of Xishuangbanna Tropical Botanical Garden (cultivated), 12 March 2012, *P. Y. Wang* C130104 (HITBC).

## Discussion

### *Ampelocalamus actinotrichus* in southern Yunnan and its biogeographic implications

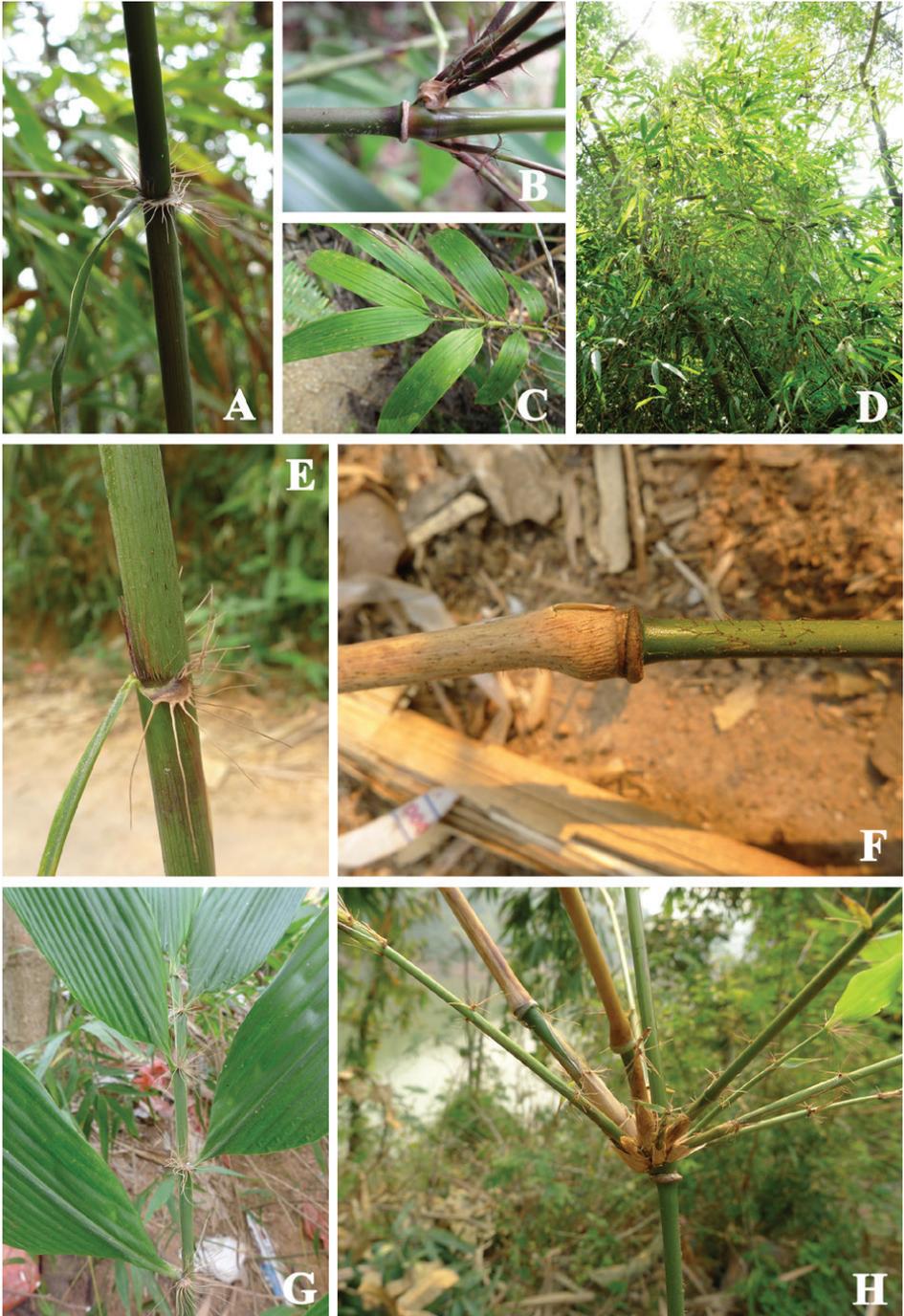
Our collections (specimens 12167, 13007, and 13012) were identified as *Ampelocalamus menglaensis* *nom. nud.* by bamboo taxonomists. This species was initially published

without proper description and designation of the type specimen, and it was reported that this bamboo was originally distributed in Mengla, Yunnan, China (Du et al. 1999). In the *Flora Yunnanica* (Sun et al. 2003), it was suggested that this species could represent a misidentification of *Dinochloa puberula* McClure and was not included in the genus *Ampelocalamus*. Later, Wang (2004) described this species briefly in Chinese with two colored photos in his book *Ornamental Bamboos*. Based on the brief description and our observations in the field, we inferred that this species should be *Ampelocalamus actinotrichus*. Major morphological diagnostic characters included: culms pendulous or scrambling; rhizomes pachymorph; internodes with sparsely brown setae initially; nodal sheath scars prominent; branches two to several, occasionally with one dominant branch replacing the main culm and scrambling to other plants; culm leaves tardily deciduous, much shorter than internodes, sheaths with sparse setae abaxially, auricles ovate, oral setae radiate and initially purple, margins of ligules with long and purple hairs, blades lanceolate; leaf sheaths glabrous or with sparse setae abaxially, auricles kidney-shaped, oral setae radiate and initially purple, ligules fimbriate, blades with long pubescence on both epidermises (Fig. 4).

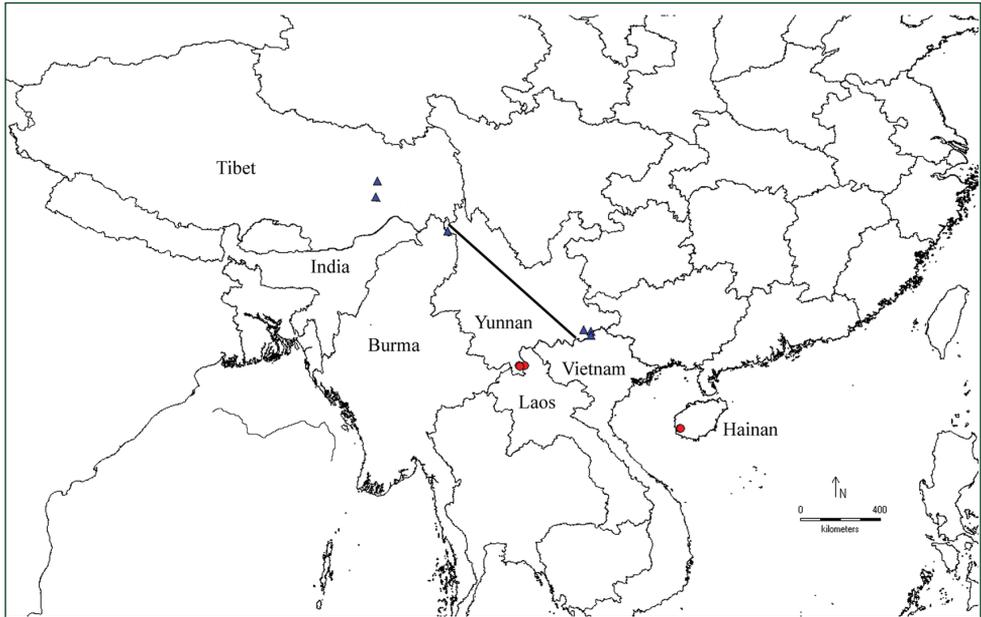
Yang (2005) analyzed the anatomy of leaves and roots of 13 species of *Drepanostachyum* P.C. Keng and *Ampelocalamus*, including *A. actinotrichus* and *A. menglaensis* nom. nud. *Ampelocalamus actinotrichus* and *A. menglaensis* nom. nud. had similar features but distinct from other species, such as two layers of mesophyll cells in leaf transverse sections, large fusoid cells, fewer prickles on abaxial and adaxial epidermises, microhairs developed. Moreover, our molecular phylogenetic analyses demonstrated that our collections from Yunnan grouped together with *Ampelocalamus actinotrichus* from Hainan, and there was a little genetic divergence between these two biogeographic entities (Fig. 1). On grounds of the aforementioned evidence we can confirm that *Ampelocalamus menglaensis* nom. nud. is conspecific with *A. actinotrichus*.

*Ampelocalamus actinotrichus* was recorded to occur only on the island of Hainan before our confirmation of its occurrence in southern Yunnan (Fig. 5). During our field investigations in Mengla, Xishuangbanna, southern Yunnan we went to the border of China and Laos (collecting voucher specimens 13012 and 13013; 13013 was not used here for the molecular analyses). We were told by the local people that this bamboo could also be found in northern Laos. Chen and Wen (2008) reported that this bamboo is distributed in tropical montane rainforests of Mengsong, southern Yunnan, which is adjacent to Burma. It suggests that *Ampelocalamus actinotrichus* may be distributed in Burma. Additional field explorations are needed to clarify whether this species is more widely distributed on the Indo-China peninsula. The new distribution record of this species has a great significance in resolving the origin and divergence of the genus *Ampelocalamus*.

Mengla and Mengsong are both parts of Xishuangbanna, in southern Yunnan. The flora of Xishuangbanna is part of the Indo-Malesian flora, and has a close affinity with floras of adjacent areas (i.e., southern China including tropical Guangxi and Hainan, Burma, Laos, Thailand, and Vietnam) (Zhu 1994, Zhu et al. 2001, Zhu and Roos 2004). The distribution of *Ampelocalamus actinotrichus* in both Hainan and southern



**Figure 4.** *Ampelocalamus actinotrichus* from Hainan and Yunnan, China. **A–C** Individuals from Hainan **A** Culm leaf (MPF10001) **B** Branches and young culm (MPF10001) **C** Leaves (MPF10003) **D–H** Individuals from Yunnan **D** Culms climbing on trees (13012) **E** Culm leaf (13001, collected at the same locality with 12167) **F** Young culm (13001) **G** Leaves (13001) **H** Branches (13001).



**Figure 5.** Distribution of *Ampelocalamus actinotrichus* and *Neomicrocalamus prainii* in China (based on specimens cited in this paper). Solid triangles: *N. prainii*; solid circles: *A. actinotrichus*; the solid line: the ecogeographical diagonal line from northwestern Yunnan to southeastern Yunnan (Li 1994).

Yunnan (and likely in Burma and Laos) provides a case at the species level for confirming the affinity of floras across southern China including Xishuangbanna (and likely adjacent areas).

### *Neomicrocalamus prainii* in southeastern Yunnan and its biogeographic implications

From the point of view of morphology, individuals of “*teng zhu*” (specimens 13045, YXY150, YXY151) from southeastern Yunnan share many features of *Neomicrocalamus prainii*, including culms scrambling, nearly solid, branches many with the dominant branch equal in size to the culm and other small branches seldom branching again, culm leaf sheaths with purple–brown spots and white pubescence abaxially, culm leaf blades acicular, and others (Fig. 6). The habitats of “*teng zhu*” in southeastern Yunnan are mainly rocky mountains which are similar to those we found in Gongshan, northwestern Yunnan (voucher No. ZXZ11027). The molecular phylogenetic analyses illustrated that those individuals fell with *Neomicrocalamus prainii* from southern Tibet and northwestern Yunnan, especially close to the individual from northwestern Yunnan (voucher No. ZXZ11027) (Fig. 2). Based on molecular and morphological evidence, we concluded that “*teng zhu*” should be identified as *Neomicrocalamus prainii*.



**Figure 6.** *Neomicrocalamus prainii* (YXY150). **A** Habitat **B** Branches **C–D** Culm leaves.

Li (1994) inferred that an ecogeographical diagonal line from northwestern Yunnan to southeastern Yunnan was caused by a northward and clockwise rotation of the Shan–Malay Plate (Burma–Malaya Geoblock) since the Miocene, and that northwestern and southeastern Yunnan were once at the same latitude both with a tropical environment. One of the biological effects of this plate movement was that some species were discontinuously distributed at both ends of the diagonal and some were concentrated on the southwestern side (Li et al. 1999, Zhu and Yan 2002). The disjunct distribution of *Neomicrocalamus prainii* in northwestern and southeastern Yunnan are concordant with this biogeographical line (Fig. 5). *Neomicrocalamus prainii* is distributed at both ends of the diagonal. The distribution pattern of *N. prainii* may imply that this species has a tropical origin, and it provides another example for verifying the reality of the ecogeographical diagonal line in Yunnan.

### *Melocalamus yunnanensis*

This species was initially described as *Racemobambos yunnanensis* based on incomplete, poor specimens (Wen 1986). However, it is easily identified by observing the peculiar culm leaves. It was transferred to the genus *Neomicrocalamus* (Ohrnberger 1999), and subsequently subsumed into *Melocalamus* (Yi et al. 2007). Molecular studies also showed that it was not a member of *Racemobambos* or *Neomicrocalamus* and had a

close relationship with *Melocalamus* (Yang et al. 2008). Main inflorescence features of *Melocalamus* include pseudospikelets 2-flowered, glumes 2, palea 2-keeled, lodicules 3, stamens 6, stigmas 2 or 3, plumose. *Melocalamus yunnanensis* as a member of the genus *Melocalamus* was confirmed by inflorescence characters reported in the current paper.

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# ***Cardamine occulta*, the correct species name for invasive Asian plants previously classified as *C. flexuosa*, and its occurrence in Europe**

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## **Abstract**

The nomenclature of Eastern Asian populations traditionally assigned to *Cardamine flexuosa* has remained unresolved since 2006, when they were found to be distinct from the European species *C. flexuosa*. Apart from the informal designation “Asian *C. flexuosa*”, this taxon has also been reported under the names *C. flexuosa* subsp. *debilis* or *C. hamiltonii*. Here we determine its correct species name to be *C. occulta* and present a nomenclatural survey of all relevant species names. A lectotype and epitype for *C. occulta* and a neotype for the illegitimate name *C. debilis* (replaced by *C. flexuosa* subsp. *debilis* and *C. hamiltonii*) are designated here. *Cardamine occulta* is a polyploid weed that most likely originated in Eastern Asia, but it has also been introduced to other continents, including Europe. Here data is presented on the first records of this invasive species in European countries. The first known record for Europe was made in Spain in 1993, and since then its occurrence has been reported from a number of European countries and regions as growing in irrigated anthropogenic habitats, such as paddy fields or flower beds, and exceptionally also in natural communities such as lake shores.

## **Keywords**

Asian *Cardamine flexuosa*, Brassicaceae, *Cardamine flexuosa* subsp. *debilis*, *Cardamine hamiltonii*, *Cardamine occulta*, China, Cruciferae, Europe, invasive species, typification

## Introduction

*Cardamine flexuosa* (Cruciferae) was described by Withering (1796) from the locality “Rookery at Edgbaston” in England. Recently, this name was lectotypified by Post et al. (2009) by the illustration (Fascicle. 4, Table no. 48, alternatively numbered no. 277) in Curtis’ *Flora Londinensis or, plates and descriptions of such plants as grow wild in the environs of London* (1781). Schulz (1903), in his monograph of the genus *Cardamine*, treated *C. flexuosa* in a wide sense with a number of subspecies, varieties and forms. Out of the infraspecific taxa recognized by Schulz (1903), *C. scutata* Thunb., *C. fallax* (O.E. Schulz) Nakai and *C. pennsylvanica* Willd. are now generally recognized as separate species. The remaining part of *C. flexuosa* had until recently been treated as a single species distributed worldwide without the recognition of any infraspecific taxa (Jalas and Suominen 1994, Zhou et al. 2001, Al-Shehbaz et al. 2006).

It was not until the phylogenetic paper by Lihová et al. (2006) that it was realized that European and Eastern Asian populations traditionally treated as *C. flexuosa* belong to two different taxa. Both DNA sequence and chromosome number data demonstrated that they represent two distinct evolutionary lineages. While the native European species *C. flexuosa* is tetraploid ( $2n = 32$ , Marhold 1994, Kučera et al. 2005), Eastern Asian plants, informally treated by Lihová et al. as “Asian *C. flexuosa*”, are octoploid ( $2n = 64$ , Lihová et al. 2006, T. Mandáková, Brno, unpublished data, Marhold et al., unpublished data, contrary to the assumed hexaploid level based on flow-cytometric evidence by Bleeker et al. 2008). Multiple hypotheses about the parentage of tetraploid European *C. flexuosa* have been put forward, invoking both auto- and allopolyploidy (reviewed by Lihová et al. 2006 and Mandáková et al. 2014). Only recently, the cytogenetic approach (combining genomic *in situ* hybridization and comparative chromosome painting, CCP/GISH) provided unequivocal evidence that this taxon is an allopolyploid originating from the diploids *C. amara* L. and *C. hirsuta* L. (Mandáková et al. 2014). In turn, CCP/GISH (Mandáková et al., in prep.) revealed allopolyploidy also in Eastern Asian *C. flexuosa* (as inferred earlier from molecular data, Lihová et al. 2006), but with a different parentage. Three distinct diploid genomes were identified within this octoploid, corresponding to *C. amara*, *C. parviflora* L. (or perhaps their unknown close relatives) and another, as yet unidentified taxon.

Morphological characters of Eastern Asian populations treated as *C. flexuosa* and their differences from European populations are presented by a number of authors (e.g., Rosenbauer 2011, Hepenstrick and Hoffer-Massard 2014, Dirkse et al. 2015). Most of their descriptions, however, do not encompass the whole variation of the two taxa, and none consider differences from other Asian relatives, such as *C. scutata*, so a thorough morphometric study of *C. flexuosa* and related Eastern Asian taxa is required (Marhold et al. in prep.). These two taxa also show considerable differences in their ecological requirements. European *C. flexuosa* occurs mostly in forest plant communities along wet forest roads or in various open habitats and is only seldom found as a

weed in flower beds (often introduced with mulch of bark chips) or in greenhouses (Kudoh et al. 2006). Eastern Asian *C. flexuosa*, by contrast, is primarily a weed of rice paddy fields, and perhaps only secondarily occurs in other open habitats (Kudoh et al. 1993, Yatsu et al. 2003). It was hypothesized by Lihová et al. (2006) that the origin and spread of this latter taxon are associated with the establishment of suitable man-made habitats (e.g. paddy fields). Based on morphology and molecular data, Lihová et al. (2006) reported Eastern Asian *C. flexuosa* from Japan, China, Taiwan, Thailand, Vietnam, Australia, Canada, USA and Mexico.

As a consequence, based on their genetic divergence, different ploidy, allopolyploid origins, morphology, ecological requirements and distribution patterns, we are of the opinion that European and Eastern Asian populations previously treated as *C. flexuosa* should be classified as two different taxa at the species level. The concept of two taxa is also adopted in the Flora of North America (Al-Shehbaz et al. 2010) and is followed by other authors reporting plants corresponding to Eastern Asian *C. flexuosa* from different parts of the world, particularly Europe. Several names have been used for this taxon, namely *C. flexuosa* subsp. *debilis* O.E. Schulz (e.g., Rankin Rodríguez and Greuter 2009, Lazzeri et al. 2013, Ardenghi and Mossini 2014, Hohla 2014a,b), *C. hamiltonii* G. Don (e.g., Bomble 2014, Ardenghi et al. 2015, Dirkse et al. 2015, Hohla 2015) [both replacement names based on illegitimate *C. debilis* D. Don (non *C. debilis* Banks ex DC.)] and *C. occulta* Hornem. (Klinkenberg 2015).

None of the above-mentioned names were properly typified or used unequivocally, which necessitated a thorough search for the correct species-level name for “Asian *Cardamine flexuosa*”. Here we present a nomenclatural survey of all relevant names and highlight the increasing number of records of “Asian *Cardamine flexuosa*” across Europe.

## Materials and methods

For the purpose of typifying names, herbarium specimens, especially types and authentic collections, were searched for in relevant herbaria (B, BM, C, E, KW, LINN, P, TI and UPS), and protologues were studied in relevant publications. Bibliographical citations in databases, such as IPNI (The International Plant Names Index; [www.ipni.org](http://www.ipni.org)), Tropicos ([www.tropicos.org](http://www.tropicos.org)) and The Plant List ([www.theplantlist.org](http://www.theplantlist.org)), were also checked, and for species, links to IPNI LSID metadata are provided. In cases when specimen images were available online, stable identifiers for specimens (Hyam et al. 2012, Güntsch and Hagedorn 2013, Hagedorn et al. 2013; herbaria B, SAV), other permanent links (herbarium P) or links via JSTOR Global Plants (<https://plants.jstor.org/>; herbarium KW) are provided. In designating types of names of taxa, we strictly followed the International Code of Nomenclature for algae, fungi, and plants (McNeill et al. 2012). We also surveyed all relevant literature sources and gathered the first records of “Asian *C. flexuosa*” in European countries and their larger administrative divisions.

## Results and discussion

### Nomenclature

The type status of species names corresponding to “Asian *C. flexuosa*” in the sense of Lihová et al. (2006) has been determined, and justifications for their typifications are presented. *Cardamine occulta* is the oldest name applicable to populations of “Asian *C. flexuosa*”.

***Cardamine occulta*** Hornem., Suppl. Hort. Bot. Hafn.: 71. 1819 (urn:lsid:ipni.org:names:280533-1:1.2) ≡ ***Cardamine flexuosa* var. *occulta*** (Hornem.) O.E.Schulz, Bot. Jahrb. Syst. 32: 479 (1903) (<http://biodiversitylibrary.org/page/185332>). Described from: “*Hab.* in China. C. intr. 1817”. **Lectotype (designated here, or perhaps holotype):** *Cardamine occulta* mihi, sponte provenit in terra e China al[.]ata, ex h. b. Hafn. *Hornemann s.n.* – C! (ex herb. Hornemann, C10021749). Epitype (designated here): China, Zhejiang Province, Linhai County, Kuocang Mountains (括苍山), ditch along the road, 28°50.35'N; 120°58.90'E, 79 m, 18 April 2014, *K. Marhold CH18/12/2014, Yunpeng Zhao 赵云鹏, & Ming Jiang 蒋明* – SAV! (SAV0006529 [<http://ibot.sav.sk/herbarium/object/SAV0006529>]).

There is a single specimen available in herbarium C originating from Hornemann’s collection that undoubtedly represents the single remnant of the original material for the name *C. occulta*. As Hornemann (1819) referred to the specimen in the garden and not to the herbarium sheet, and as we cannot exclude that there was originally more than one specimen of this taxon in his collection, we designate the specimen as a lectotype of the name *C. occulta* (admitting that the specimen might well represent the holotype). The plant on the type herbarium sheet was apparently grown from seeds at the Copenhagen Botanical Garden (“ex h[ortus] b[botanicus] Hafn[iensis]”). Perhaps cultivation at the garden might be the reason why the specimen cannot be reliably and unequivocally identified as “Asian *C. flexuosa*” for the purposes of the precise application of the name *C. occulta* to this taxon (especially considering the occurrence of a number of closely related taxa in China; Zhou et al. 2001). Therefore, in order to fix the application of the name *C. occulta*, we designate here an epitype of this name from a cytogenetically investigated population from Eastern China with a known chromosome number ( $2n = 64$ ; Mandáková et al., in prep.).

= ***Cardamine debilis*** D. Don, Prodr. Fl. Nepal. 201. 1825 [26 Jan-1 Feb 1825], (urn:lsid:ipni.org:names:280260-1:1.3; <http://biodiversitylibrary.org/page/393098>), nom illeg., non Banks ex DC. Syst. Nat. 2: 265. 1821 [late May 1821] (urn:lsid:ipni.org:names:280259-1:1.4; <http://biodiversitylibrary.org/page/39512107>). Described from: “*Hab.* in Nepaliâ ad Narainhetty. *Hamilton.*” **Neotype (designated here):** [India, West Bengal] Botanical Garden Darjeeling, weed, 18. 6. 1959, *Lövkvist C-336-3* – UPS! (GUID UPS:BOT:V-194865) ≡ ***C. hamiltonii*** G. Don, Gen. Hist. 1: 167. 1831 [early Aug 1831] (urn:lsid:ipni.org:names:280357-1:1.2.2.1.1.1; <http://>

biodiversitylibrary.org/page/389972) ≡ *C. flexuosa* subsp. *debilis* O.E. Schulz, Bot. Jahrb. Syst. 32: 478. 1903 (<http://biodiversitylibrary.org/page/185331>).

The name *C. debilis* D. Don is based on data in the manuscript of Francis Buchanan-Hamilton (referred to as “Hamilton MSS”; Don 1825: 201), and it is unclear whether D. Don studied any specimen collected by Buchanan-Hamilton. Although Hara and Williams (1979) mentioned the type of *C. debilis* [when indicating localities of *C. scutata* subsp. *flexuosa* (With.) Hara in Nepal], in Shrestha and Press (2000), the type specimen is listed as “not found”. In any case, a thorough search in the herbaria BM, E, LINN-Smith (Roy Vickery, John Edmondson, Mark Watson, personal communication) did not reveal any original material of this name. There is a specimen corresponding to the description of *C. debilis* D. Don and to “Asian *C. flexuosa*”, collected in the neighbouring area of West Bengal, with a chromosome number counted by B. Lövkvist ( $2n = 64$ , unpublished data, deposited at UPS). This specimen is selected here as a neotype to fix the application of the name.

= *Cardamine brachycarpa* Franch., Bull. Soc. Bot. France 26: 83. 1879, nom. illeg. (urn:lsid:ipni.org:names:280196-1:1.4; <http://biodiversitylibrary.org/page/260368>), non Opiz, Naturalientausch 11: 411. 1826 (urn:lsid:ipni.org:names:280195-1:1.3). Described from: [JAPAN] “Insul. Nippon, prov. Etchigo, circa Niigata, secus vias humidas (R. P. Faurie)”. Lectotype (designated by Marhold et al. 2015: 11): [JAPAN, Prefecture Niigata], “Nippon, Niigata, secus vias, [U. J.] Faurie 23” – P! (P00747512 [<http://coldb.mnhn.fr/catalognumber/mnhn/p/p00747512>]); Isolectotype – P! (P00747513 [<http://coldb.mnhn.fr/catalognumber/mnhn/p/p00747513>]) ≡ *C. koshiensis* Koidz., Fl. Symb. Orient.-Asiat. 43. 1930 (urn:lsid:ipni.org:names:280422-1:1.2.1.2).

= *Cardamine arisanensis* Hayata, Icon. Pl. Formosan. 3: 20. 1913 [25 Dec 1913] (urn:lsid:ipni.org:names:280161-1:1.3). Described from: “In Monte Morrison, ad 10000-11000 ped. alt., leg. T.Kawakami et U.Mori, 1906, Oct. (No.2252); in Montibus Centralibus, Feb. 1908”. Lectotype (Ohwi 1934: 50, see also Al-Shehbaz and Peng 2000: 237): [TAIWAN] “Kagi, Arisan (Chiayi, Alishan), Taiwan Sotoku-fu, Industry Bureau, Plant Specimens, no. 3631, 25 March 1908, *T. Kawakami* & *S. Mori s.n.*” (TI) ≡ *Barbarea arisanense* (Hayata) S.S.Ying, Alp. Pl. Taiwan in Color 2: 170. 1978.

= *Cardamine autumnalis* Koidz. Bot. Mag. (Tokyo) 43: 404. 1929 (urn:lsid:ipni.org:names:280169-1:1.3) – Described from: “Nippon: Yokosuka (lg. Wichura, Oct. 18, 1860) Mus. Bot. Berol.-Dahlem”. Holotype: “Japan, Jokohama, 19. [sic!] 10. 1860, [M. E.] Wichura 1064 [1069?]” B! (B 10 0241388 [<http://herbarium.bgbm.org/object/B100241388>]).

The species *C. autumnalis* was described with a reference to “*Cardamine flexuosa* ssp. *debilis* Schultz (pro. parte) in Engl. Bot. Jahrb. 32. (1903) s. 479, (quoad specim. ex Yokoska)”. Indeed, there is a specimen marked “Japonia: ... pr. Jokohama leg. Wichura 1860” referred to by Schulz (1903: 479) as *Cardamine flexuosa* subsp.

*debilis* deposited in B. The specimen bears a revision label by Schulz with the name “*Cardamine flexuosa* With. subsp. *debilis* Don var. *occulta* (Hornem.) O. E. Sch.”, dated 25. 4. 1902. Although this specimen was identified by Schulz as var. *occulta*, it should be noted that there is no specimen referred to by Schulz (1903: 480) identified as *Cardamine flexuosa* subsp. *debilis* var. *occulta* from Japan.

The usual life cycle of *C. occulta* in Eastern Asian rice fields includes flowering in early spring before rice is planted and the fields are flooded by water. Nevertheless, there are also exceptions such as the nomenclatural type of the name *C. autumnalis*, which represents an autumn-flowering plant of *C. occulta*. Kudoh et al. (1993: fig. 8) reported such plants from paddy fields in the autumns of years in which rice was not cultivated (no water flooding during summer).

– *Cardamine aff. flexuosa* sensu I. Thomps., *Flora of Victoria* 3: 434–442. 1996.

There are two other names at the species level that are potentially applicable to “Asian *C. flexuosa*”, namely:

*Cardamine nasturtioides* D. Don, *Prodr. Fl. Nepal.*: 201. 1825. [26 Jan-1 Feb 1825] (urn:lsid:ipni.org:names:280509-1:1.3; <http://biodiversitylibrary.org/page/393098>) – Described from: “*Hab.* in Nepaliâ. *Hamilton.*”

*Cardamine decurrens* (Blume) Zoll. et Moritzi in Moritzi, *Syst. Verz.*: 35. 1846 (urn:lsid:ipni.org:names:280262-1:1.3.2.2; [http://reader.digitale-sammlungen.de/de/fs1/object/display/bsb10302557\\_00051.html](http://reader.digitale-sammlungen.de/de/fs1/object/display/bsb10302557_00051.html)) ≡ *Pteroneurum decurrens* Blume, *Bijdr. Fl. Ned. Ind.* 2: 51. 1825 [12 Jun-2 Jul 1825] (urn:lsid:ipni.org:names:288262-1:1.1.2.2.1.2; <http://biodiversitylibrary.org/page/428177>). – Described from: “in altis paludosis montis Burangrang Provinciae Krawang.”

The location of the original material of these two names is as yet unknown, and it remains to be ascertained whether they are synonyms of *C. occulta* or represent other taxa. In any case, both these names are later than *C. occulta*, which has priority among all species names applicable to “Asian *C. flexuosa*”.

The name *C. zollingeri* Turcz. was sometimes considered to be a synonym of *C. flexuosa* in a wide sense (e.g., Zhou et al. 2001, Al-Shehbaz et al. 2006, Al-Shehbaz and Watson 2012) or of *C. flexuosa* subsp. *debilis* (Schulz 1903: 479). Nevertheless, it is morphologically different from both *C. flexuosa* and *C. occulta* in the circumscriptions presented here and likely represents a separate taxon that requires further study:

*Cardamine zollingeri* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 27(2): 294. 1854 (urn:lsid:ipni.org:names:280762-1:1.3) ≡ *Nasturtium obliquum* Zoll. & Moritzi, *Natur-Geneesk. Arch. Ned.-Indië* 2: 580. 1845 (urn:lsid:ipni.org:names:287528-1:1.4; <https://archive.org/stream/natuurengeneesku02bata#page/580/mode/2up>) – Described from: “[Java] *Nasturtium obliquum* Z. et M. Herb. N. 2211 ... Legi in

arenosis et glareosis vulcanicis ad fluviorum ripas e. g. prope *Trawas* prov. *Modjokerto* VIII.1844. p. m. 3000' s. m." **Lectotype (designated here):** [INDONESIA, Java], "Planta Javanica a cl. Zollinger lecta no. 2211" *Zollinger 2211* KW! (KW001000851 [<https://plants.jstor.org/stable/10.5555/al.ap.specimen.kw001000851>]); Isolectotype: P! (P00747614 [<http://coldb.mnhn.fr/catalognumber/mnhn/p/p00747614>]).

## Occurrence of *Cardamine occulta* in Europe

*Cardamine occulta* most likely originated in Eastern Asia. It is unclear whether it naturally occurs or ever occurred in any natural plant community. The localities that we know from Japan and Eastern China and which are referred to on herbarium specimens represent solely man-made habitats, most often rice paddies, orchards or various other kinds of synanthropic vegetation. This is why we (Lihová et al. 2006) hypothesized that the origin and spread of this polyploid species might have been connected with the occurrence of man-made habitats.

As stated above, Lihová et al. (2006) reported plants corresponding to *C. occulta* from Japan, China, Taiwan, Thailand, Vietnam, Australia, Canada, USA and Mexico. Other previously published data corresponding to *C. occulta* than those that were referred to by Lihová et al. (2006) were the report of *C. debilis* D. Don from North America as an introduced weed (Rollins 1993) and *C. aff. flexuosa* from Australia (Thompson 1996). Subsequently, this taxon was published also for Cuba (Rankin Rodríguez and Greuter 2009, as *C. flexuosa* subsp. *debilis*).

When Lihová et al. (2006) suggested that European and Asian *C. flexuosa* should be treated as separate taxa, no record corresponding to Asian *C. flexuosa* plants was known from the European territory. Nevertheless, a number of records from Europe have been published since 2007, and we can trace the spreading of this invasive plant throughout the continent (see Table 1, Fig. 1). To the best of our knowledge, the earliest record of *C. occulta* from Europe dates back to 1993, when this species was collected in the Spanish province of Alicante and originally identified as *C. flexuosa*. Its true taxonomic identity was, however, clarified much later (Crespo et al. 2013). In 2007 the first author of this paper received for identification a specimen collected in 2003 in a rice field ditch in the province of Piedmont, Italy (Vercelli, Arborio) by Michel Desfayes (Fully, Switzerland). This specimen undoubtedly belongs to *C. occulta* and might have been introduced together with rice from Eastern Asia. From the same broad locality, the occurrence of this taxon was reported by Thomas Götz (a specimen collected in 2005, published by Dienst 2007) and more recently by Verloove and Ardenghi (2015; as *C. hamiltonii*).

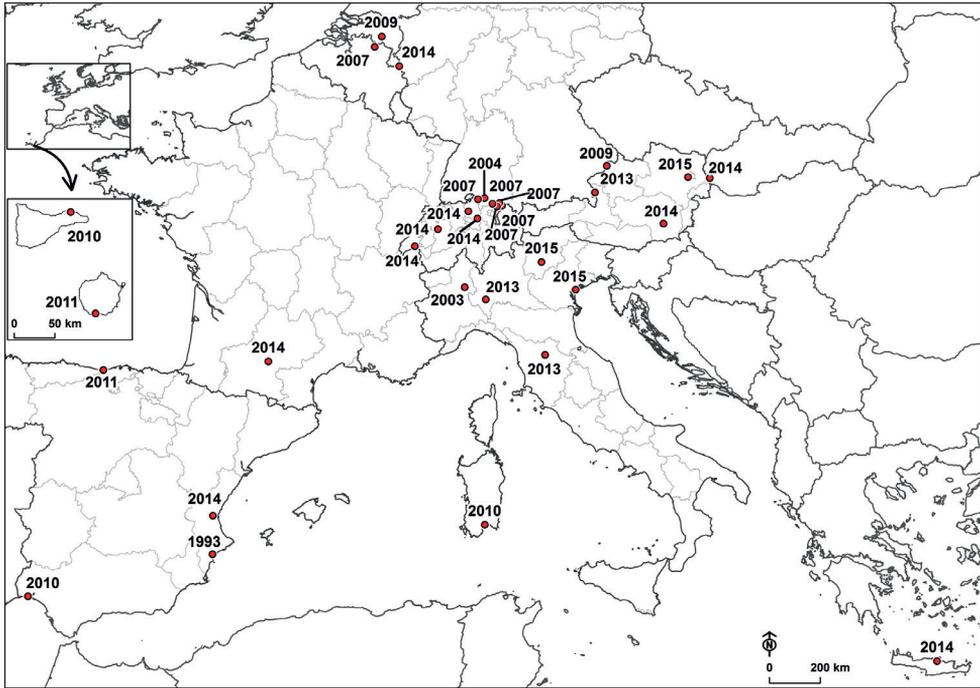
The third spot in Europe where *C. occulta* was reported from are the shores of Lake Constance (Bodensee) in Germany. In spring 2004, an unknown *Cardamine* species was detected there at the Reichenau dam (observed by W. Ostendorp, M. Dienst and E. Klein; Dienst 2007). The identity of these plants was confirmed by DNA sequenc-

**Table 1.** First records of *Cardamine occulta* Hornem. for European countries and their administrative divisions (if multiple records for a given region are dated to the same time, one representative is chosen). Information in square brackets was derived by the authors of the present paper. The records were reported under (1) *Cardamine flexuosa* auct. non With. (Asian *C. flexuosa*), (2) *Cardamine flexuosa* auct. non With., (3) *Cardamine flexuosa* subsp. *debilis* O.E. Schulz, (4) *Cardamine hamiltonii* G. Don, and (5) *Cardamine occulta* Hornem.

Country	Admin. division	Year	Locality	Reported by (Reported as)
Austria	Vorarlberg	2007	Lake Constance, [Bregenz, shore of the lake, 47°30'N; 9°44'E], 2007	Bleeker et al. 2008 (2)
Austria	Upper Austria	2009	Schärding, Stadtplatz square, in flower pots and between cobblestones (7546/2), ca. 320 m, [48°27.41'N; 13°25.9'E], 7.6.2009, <i>M. Hohla</i> (LI 100238232)	Hohla 2012 (3)
Austria	Salzburg	2013	Salzburg City, Lieferung, Oberer Bonau-weg Street, in the nursery as a weed, ca. 410 m (8144/3) [47°49.38'N; 13°0.78'E], 23.8.2013, <i>P. Pils!</i> (Herbarium Pils), conf. M. Hohla	Hohla 2015 (4)
Austria	Styria	2014	Graz, Jakominiplatz square, in flower beds (8958/2), [47°4.05'N; 15°26.5'E], 27. 09. 2014, <i>M. Hohla</i> (LI)	Hohla 2014b (3)
Austria	Vienna	2015	Vienna, West Railway station (Westbahnhof), ca. 210 m, (7864/1) [48°11.53'N; 16°18.76'E], 8.12.2015, M. Hohla (LI).	Hohla 2015 (4)
Belgium		2007	Antwerp, Mol, [Lostraat st., cemetery], 51°12.05'N; 5°12.78'E, 29. 03. 2007, <i>R. Barendse</i> (observation)	<a href="http://waarnemingen.be/waarneming/view/45438666">http://waarnemingen.be/waarneming/view/45438666</a> (4)
France	Midi-Pyrénées	2014	Toulouse, [Square Charles de Gaulle square], urban vegetation, 43°36.28'N; 1°26.7'E, 12. 04. 2014, <i>E. Sloatweg</i> (observation)	<a href="http://observation.org/waarneming/view/83277183">http://observation.org/waarneming/view/83277183</a> (4)
Germany	Baden-Württemberg	2004	Lake Constance, Reichenau, Reichenauer Damm dam, [47°41.2'N; 9°6'E], spring 2004, <i>W. Ostendorf</i> , <i>M. Dienst</i> & <i>E. Klein</i>	Dienst 2007 (2)
Germany	Bavaria	2007	Lake Constance, [Wasserburg, shore of lake, 47°34'N; 9°38'E], 2007	Bleeker et al. 2008 (1)
Germany	North Rhine-Westphalia	2014	Aachen, Soers, Garden Center (5202/21), [50°46'N; 6°5'E], 14. 03. 2014, <i>F. W. Bomble</i> & <i>S. Bomble</i>	Bomble 2014 (4)
Greece		2014	Crete, Nomos of Iraklion, Eparchia of Temenos, 1821 Street, near entrance of the "El Greco Hotel", edge of flower bed with a cultivated tree, 35°20.28'N; 25°7.96'E, 17. 06. 2014, <i>N. M. G. Ardenghi</i> & <i>P. Cauzzi</i> (MSNM)	Ardenghi et al. 2015 (4)
Italy	Piedmont	2003	Prov. Vercelli, Arborio [45°29.6'N; 8°24'E], 25. 08. 2003, <i>M. Desfayes</i> (SAV)	M. Desfayes, unpubl. data

Country	Admin. division	Year	Locality	Reported by (Reported as)
Italy	Sardinia	2010	Cagliari, near the building of the Department of Botany at Viale Sant'Ignazio da Laconi, 56 m, 39°13.3'N; 9°6.7'E, 03. 2012, V. Lazzeri	Lazzeri et al. 2013 (3)
Italy	Lombardy	2013	Pavia, Piazzale della Stazione square, public flowerbed, 45°11.3'N; 9°8.68'E, 11.12.2013, N. M. G. Ardenghi (MSNM)	Ardenghi and Mossini 2014 (3)
Italy	Tuscany	2013	Florence, W side of Piazza di Santa Maria Novella square, public flower bed, 43°46.41'N; 11°14.94'E, 09. 12. 2013, N. M. G. Ardenghi & S. Mossini (MSNM)	Ardenghi and Mossini 2014 (3)
Italy	Trentino-South Tirol	2015	Trento, Corso del Lavoro e della Scienza, 191 m, [46° 3.57'N; 11°6.95'E], 20. 11. 2015, V. Lazzeri (FI)	Lazzeri and Marhold 2016 (5)
Italy	Veneto	2015	Venice, [Campo San Maurizio], 45°25.97'N; 12°19.90'E, 11. 09. 2015, W. Mejjer (observation)	<a href="http://observation.org/waarneming/view/110617765">http://observation.org/waarneming/view/110617765</a> (4)
Slovakia		2014	Bratislava, Brmianska street, flower pot with a shrub at restaurant Patrónsky pivovar, 320 m, 48°9.96'N; 17°4.84'E, 10. 06. 2014, K. Marhold (SAV), SAV0006528; <a href="http://ibot.sav.sk/herbarium/object/SAV0006528">http://ibot.sav.sk/herbarium/object/SAV0006528</a> )	K. Marhold, unpubl. data
Spain	Valencia, Alicante	1993	San Vicente del Raspeig, Partida Canastell, flower pot, (UTM 30SYH1455), 170 m, [38°24'N; 0°32'W], J. C. Cristóbal (ABH 5166)	Crespo et al. 2013 (3)
Spain	Canary Islands, Tenerife	2010	Bajamar, TF-13 road, close to Barranco Perdomo, Pelargonium plantation in roundabout, [28°32.8'N; 16°20.9'W], 15. 09. 2010, F. Verloove 8433 (ORT 41743)	Verloove and Reyes-Betancort 2011 (2)
Spain	Andalusia, Huelva	2010	Nuevo Portil, golf course (UTM 29SPB7220), [37°12.8'N; 7°4'W], 11. 08. 2010, E. Sánchez Gullón (priv. herb. ESG 263; dupl. BR)	Verloove and Gullón 2012 (3)
Spain	Canary Islands, Gran Canaria	2011	San Agustín, Las Burras, close to the beach, irrigated lawn, [27°46.1'N; 15°32.5'W], 06. 11. 2011, F. Verloove 9215 (LPA)	Verloove 2013 (3)
Spain	Cantabria	2011	San Vicente de la Barquera, 43°22.9'N; 4°23.9'W; 09. 06. 2011, M. Lysák (SAV), SAV0006530, SAV0006531; <a href="http://ibot.sav.sk/herbarium/object/SAV0006530">http://ibot.sav.sk/herbarium/object/SAV0006530</a> , <a href="http://ibot.sav.sk/herbarium/object/SAV0006531">http://ibot.sav.sk/herbarium/object/SAV0006531</a> )	M. Lysák, unpubl. data

Country	Admin. division	Year	Locality	Reported by (Reported as)
Spain	Valencia	2014	Valencia, Quart de Poblet, Mas de les Fites, 96 m, gardens of Centro para la Investigación y Experimentación Forestal de la Generalitat Valenciana (UTM 30SY134726) [39°28.44'N; 0°31.25'W], 19. 08. 2014, <i>C.J. Mansanet, P.P. Ferrer &amp; E. Laguna</i> (VAL. 222275)	Mansanet-Salvador et al. 2015 (3)
Switzerland	Schaffhausen	2007	Lake Constance, [Stein am Rhein, shore of lake, 47°39.4'N; 8°52'E], 2007	Bleeker et al. 2008 (1)
Switzerland	St. Gallen	2007	Lake Constance, [Staad, shore of the lake, 47°29'N; 9°32'E], 2007	Bleeker et al. 2008 (1)
Switzerland	Thurgau	2007	Lake Constance, [Salmsach, shore of the lake, 47°33'N; 9°22.8'E], 2007	Bleeker et al. 2008 (1)
Switzerland	Bern	2014	Bern, 598751/199269, flower pots, [46°56'N; 7°27'E], 2014	Hepenstrick and Hoffer-Massard 2014 (3)
Switzerland	Schwyz	2014	Lachen, 707088/227808, between cobblestone, 2014, [47°11'N; 8°51'E], 2014	Hepenstrick and Hoffer-Massard 2014 (3)
Switzerland	Vaud	2014	Lausanne, Av. de Florimont, 538763/152550, between paving stones, [46°30.9'N; 6°38.3'E], 2014	Hepenstrick and Hoffer-Massard 2014 (3)
Switzerland	Zürich	2014	Zürich, 681596/248874, gravel, [47°22'N; 8°32'E], 2014	Hepenstrick and Hoffer-Massard 2014 (3)
The Netherlands		2009	North Brabant, Eindhoven, [51°26'N; 5°28'E], 2009, <i>R. Barendse</i>	Dirkse et al. 2015 (4)



**Figure 1.** Localities of the first occurrences of *Cardamine occulta* Hornem. for European countries and their administrative divisions. The year of the first occurrence at each locality is given. The inset shows Tenerife and Gran Canaria of the Canary Islands.

ing (Bleeker et al. 2008). Until 2007, 95 locations on the shores of Lake Constance had been known. Localities were found around the lake in Germany (Baden-Württemberg and Bavaria), Austria (Vorarlberg) and Switzerland (cantons Schaffhausen, Thurgau, and St. Gallen; Bleeker et al. 2008). Bleeker et al. (2008) noted that *C. occulta* was more frequent on fine-grained and nutrient-rich sediments than on nutrient-poor gravel shores. It is likely that this species may change the community structure of ephemeral vegetation on bare and organic sediments.

*Cardamine occulta* was later reported also from continental Spain, the Canary Islands, France, parts of Germany, Switzerland and Austria other than the shores of Lake Constance, from Belgium, the Netherlands, Slovakia, and Crete (Table 1). It is nevertheless likely that the species is currently present, but still overlooked, also in other European countries. It should be noted that most records mentioned in Table 1 refer to urban vegetation. *Cardamine occulta* grows in flower beds and pots, at the edges of roads, among cobblestones or paving stones, or on pavements, often in irrigated places. In most cases, it was apparently introduced as a weed, often with mulch, from plant nurseries where it finds appropriate growing conditions (as reported from North America by Post et al. 2011). However, the species was also found in rice fields in northern Italy, where it was most likely introduced with rice from Eastern Asia.

There are only a few known occurrences of *C. occulta* in European natural plant communities, and it seems that such reports are restricted to the surroundings of Lake Constance. Bleeker et al. (2008) hypothesized that this species might have been introduced to the lake from rice fields of northern Italy by migrating birds or directly from Japan by tourists.

For most of the countries and administrative divisions presented in Table 1, only one or few localities of *C. occulta* are known. There are numerous observational records of *C. occulta* from the Netherlands and Belgium in the databases presented at [observation.org](http://observation.org), [waarneming.nl](http://waarneming.nl) and [waarnemingen.be](http://waarnemingen.be) (referred to as *C. hamiltonii*), perhaps because botanists in these countries were encouraged to search for it. Nevertheless, there are no voucher specimens documenting these data, and some of them are not even documented by photographs. According to the photographic documentation, some records are apparently based on misidentifications of *C. hirsuta* and tetraploid *C. flexuosa*. A number of photographic records document juvenile plants that are hard to identify reliably. For future mapping of the distribution of *C. occulta*, all records should be documented by vouchers deposited in public herbaria.

It is apparent that, unlike European *C. flexuosa*, *C. occulta* represents an invasive species that is quickly spreading from its area of origin in Eastern Asia to other continents. The characteristics of seed dormancy and germination of *C. occulta* are likely to enhance its invasiveness, especially in wet and occasionally submerged habitats. It has been reported that seeds of *C. occulta* can survive both in dry and submerged conditions for more than three months (Yatsu et al. 2003). The combination of seed dormancy in dry soil and dormancy release by submergence (Yatsu et al. 2003) is likely to enhance the transportation of *C. occulta* seeds with soils and the establishment of invasive populations in seasonally submerged habitats such as paddy field, dams or lake shores and in regularly irrigated flower beds and other urban habitats. Diploid *C. hirsuta* is in fact another example of the invasive potential of *Cardamine* species. This species originated in Europe and is now widely distributed on all continents, particularly in drier conditions. The speed of its spreading can be illustrated on the example of the Japanese archipelago. While the first record of this species for Japan dates to 1974 (Kudoh et al. 1992), already in 2006 it became a common roadside weed across most of Honshu Island, the main island of Japan, and was spreading also to Kyushu and Hokkaido Islands (Yatsu et al. 2003, Kudoh et al. 2007).

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# *Selliguea kachinensis* (Polypodiaceae), a new fern species of uncertain affinity from Northern Myanmar

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## Abstract

We describe *Selliguea kachinensis* as a new species from Northern Myanmar and discuss its generic placement in either *Selliguea* or *Arthromeris*. The conservation status is assessed as Data Deficient. In addition, we make the new combination *Selliguea erythrocarpa* (Mett. ex Kuhn) Hovenkamp, S. Linds., Fraser-Jenk.

## Keywords

New species, new combination, generic placement, conservation status, taxonomy, morphology, *Arthromeris*, Southeastern Himalaya

## Introduction

During exploration of the “northern forest complex” on the eastern slope of the Myanmar-India watershed (Kachin State, Myanmar), between November 2013 and October 2014, Khine et al. and Miehe et al. collected an epiphytic fern that could be assigned to the Polypodiaceae but not be to any known species, or even easily placed in an existing

genus of Polypodiaceae. After comparing it with all known species of the morphologically closest genera *Selliguea* Bory and *Arthromeris* (T. Moore) J. Sm. we have come to the conclusion that it represents a new species, but we have decided not to erect a new genus to accommodate it. The new species is here described in the genus *Selliguea*.

## Material and methods

Morphological characters were examined in the field and on herbarium specimens, and using Light (LM) and Scanning Electron microscopy (SEM). For LM, small parts of rhizome and lamina were boiled in water until they sank, and then either sectioned on a Reichert slide microtome or mounted whole without staining in glycerine jelly, and photographed using a Zeiss V20 or a Zeiss AxioImager M2 with an MRC5 digital camera and AxioVision software (Zeiss). For SEM spores were sputter-coated with 10 nm Platinum/Palladium (80/20) in a Quorum Q150TS sputter-coater, and observed with a Jeol JSM 7600F FEG-SEM. For the conservation assessment, Area of Occupancy (AOO) and Extent of Occurrence (EOO) were estimated using GeoCAT (Bachman et al. 2011), with default settings for grid size. The specimens collected by Khine et al. and Miehe et al. are kept at the Faculty of Geography, Philipps University of Marburg, with duplicates distributed to L, RAF and SING (abbreviations according to Thiers, continuously updated).

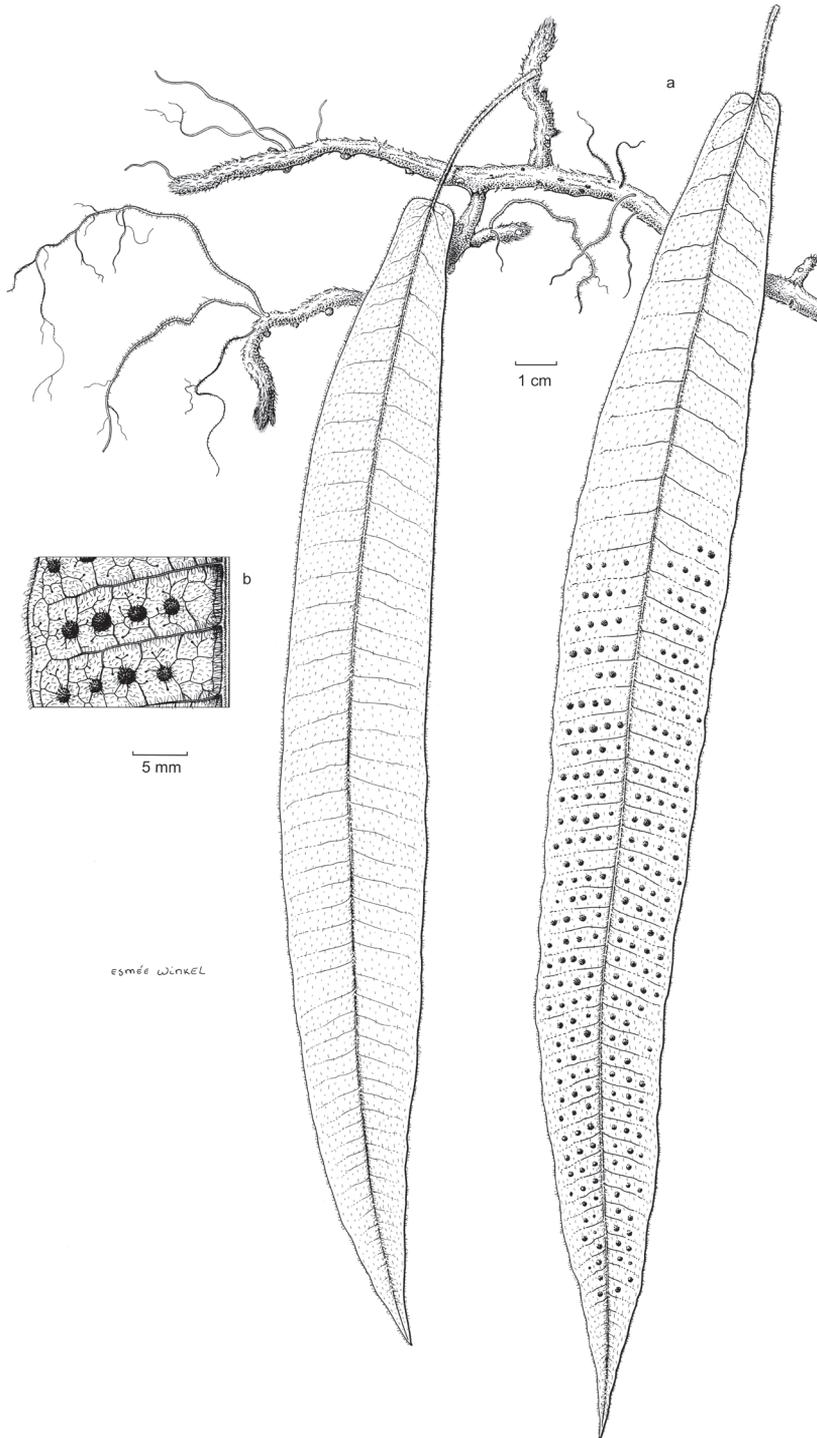
## Results

### *Selliguea kachinensis* Hovenkamp, S. Linds., Fraser-Jenk., sp. nov.

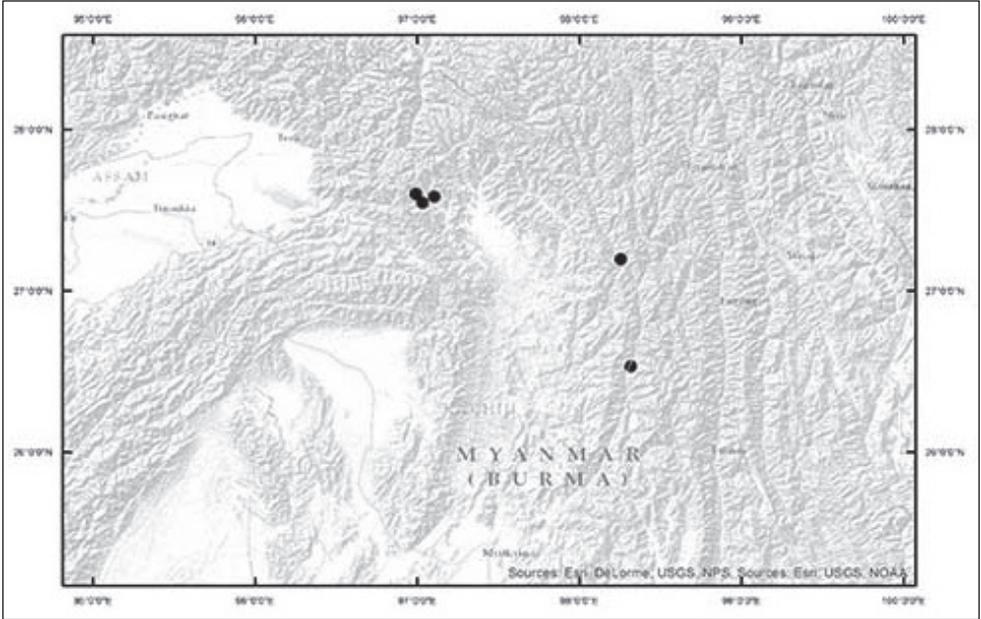
urn:lsid:ipni.org:names:77153918-1

**Type.** Myanmar, Kachin State, Hponyin Razi, Quercus-Magnolia-Araliaceae forest, epiphyte. 27.601421°N, 96.988873°E, 1715 m, G. Miehe, P.K. Khine [“Kine”], L. Shein, M. Kyaw, P. Ma, S. Lan Wan 13-094-159, 19 Nov. 2013 (holotype: L; isotype: SING).

**Epiphytic.** Rhizome long-creeping, branched, 3.2–4.5 mm diam. when dry (c. 6 mm diam. after soaking in boiling water), black and shiny when dry with a glaucous waxy layer, the younger parts densely covered with scales, irregularly rooting from the ventral side, in cross-section with scattered sclerification in the peripheral, epidermal and subepidermal region; phyllopodia c. 2 cm distant, c. 1–3 mm high. Scales deciduous, mostly absent from older parts of the rhizome, basifixed and slightly to strongly auriculate, or pseudopeltate, or sometimes fully peltate, c. 0.5 × 2.0–3.5(–4.0) mm, gradually narrowed from the base to a long narrow acumen, brown or blackish near the attachment, central region brown and thick, the margin and acumen thinner and lighter, margin irregularly dentate, more strongly so towards the base. Fronds pendent, simple, monomorphic, stipitate, all parts densely hairy with multicellular, uniseriate, soft hairs to 1.5(–1.7) mm long, the longest hairs inserted on midrib and veins; sparse,



**Figure 1.** *Selliguea kachinensis*. **A** habit **B** detail showing venation pattern. After Kine *et al.* 14-047-022 (L). Drawing by Esmée Winkel.



**Figure 2.** *Selligiea kachinensis* – Distribution.



**Figure 3.** Habitat of *Selligiea kachinensis*: a thick bryophyte covered trunk in Hponyin Razi at about 1,700 m (photograph by P. K. Khine).

long narrow pale strongly toothed scales present among the hairs on the abaxial midrib (particularly towards the base of the lamina), stipe 0.8–5.0 cm long, c. 1 mm thick; lamina 18–58 × 3.3–7.2 cm, oblong – narrowly elliptic, the basal 1–6 cm often narrowed, base truncate to cordate, apex acuminate, texture thin-herbaceous, glaucous when fresh, translucent when dry, margin very narrowly hyaline, without notches. Venation anastomosing, primary veins straight or slightly curved, at 60–90 degrees to the midrib, secondary veins hardly distinct, delimiting c. 5–6 rows of rectangular areoles with anastomosing tertiary veins and free veins in all directions, ending in hydathodes. Sori in a single row between each pair of primary veins, usually one per areole, but sometimes absent from the first one or two areolae closest to the midrib and occasionally two in areolae closest to the margin, c. 2 mm in diameter when ripe. Sporangia long-stalked, capsules c. 0.2 mm long, bearing 2–6 uniseriate, c. 0.4–0.8 mm long hairs, annulus with 14–16 indurated cells. Spores 29–46 × 25–34 μm in lateral view, perispore with a 0.1–0.3 μm thick, finely colliculate basal layer, rather densely set with narrow, fragile spines, spines c. 2 μm long by 0.5 μm thick at the base, somewhat narrowed to a blunt apex, apparently easily breaking off at the base leaving a low round scar.

**Additional specimens seen.** Myanmar, Kachin State. Hponyin Razi: G. Miehe, P.K. Khine [“Kine”], L. Shein, M. Kyaw, P. Ma, S. Lan Wan 13-096-034, 23 Nov. 2013, above 1300 m, road site (L); G. Miehe, P.K. Khine [“Kine”], L. Shein, M. Kyaw, P. Ma, S. Lan Wan 13-131-013, 11 Nov. 2013, 1600 m, road site (SING).

Hponkan Razi: P.K. Khine [“Kine”], J. Kluge, A.S. Lanwan, D.R. Lanwan, P. Lanwan 14-031-020, 14 Oct. 2014, 27.548702 N, 97.032742 E, 1565 m, evergreen broadleaved (L). Above Ziadam: P.K. Khine [“Kine”], J. Kluge, A.S. Lanwan, D.R. Lanwan, P. Lanwan 14-047-022, 21 Oct. 2014, 27.585061°N, 97.104085°E, 1448 m, evergreen broadleaved (L, SING). Pisa District: Wang Jun & Zhou Lian Xuan 5431, 18 Apr. 2009, Pangjia (26°31.589'N, 98°18.473'E, 717 m) to Wuru (26°31.589'N, 98°18.473'E), in forest on a tree (CDBI). Ridan: Xia Nianhe, Deng Yunfei, Zhou Wei & Wu Linfang 1519, 20 Mar. 2009, around the Waqkure village, c. 2 miles from Ridan, E. side of Namai Kha river, 27°11.876'N, 98°15.165'E, 1400 m., in forest (CDBI).

**Etymology.** The name derives from Kachin State, where the species is found.

**Ecology.** Based on the specimens collected in the “northern forest complex”, *Selliguea kachinensis* grows on heavily moss-covered trees in primary evergreen broadleaved forest (dominated by *Fagaceae*, *Lauraceae*, *Araliaceae*, and *Magnoliaceae*) between 1300 m and 1715 m. It was found occasionally on trunks at 4 m from the ground (Figure 3), more frequently in the moss cover of trunks and thicker branches above 8 m and in the tree crowns, but is absent in the outer canopy. It is locally abundant together with *Drynaria propinqua* (Wall. ex Mett.) J.Sm. (Figure 4). It was not found growing on steep rock cliffs or open banks along trails. During our visits in November 2013, and October 2014 we did not observe any wilting of the fronds (in contrast to *Oleandra neriiformis* Cav. and *O. wallichii* C.Presl which are lithophytes/epiphytes with a somewhat similar habit) and so could not assess whether it is deciduous or evergreen, but the herbaceous texture suggests that it is deciduous.



**Figure 4.** Habitat of *Selliguea kachinensis*: a thick branch covered with other Polypodiaceae such as *Drynaria propinqua*, and Orchidaceae in Hponkan Razi at 1,600 m (photograph by P. K. Khine).

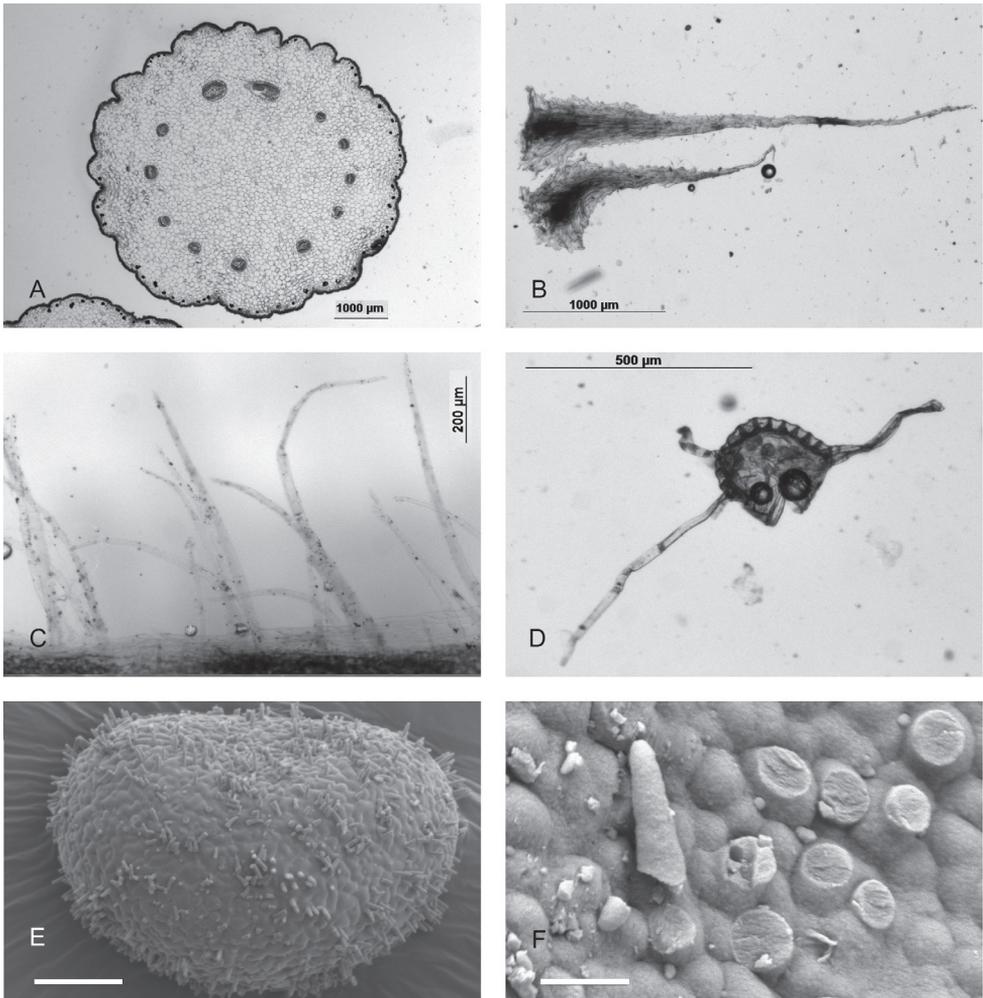
**Climate.** The climate station nearest to the collection sites is Putao (450 m a.s.l.) in an intramontane basin 50 km to the southeast. It records approximately 4000 mm rainfall between May and October with a pronounced dry season from November to January. We expect that the annual rainfall at altitudes between 1400 and 1800 m a.s.l. exceeds 5000 mm plus an unknown amount of fog precipitation from clouds shrouding the mountains between April and November.

**Distribution, conservation and threats.** *Selliguea kachinensis* is currently known from five locations, all in the north of Kachin State, Myanmar. On the basis of these occurrences, the Extent of Occurrence is 4738 km<sup>2</sup>, while the known Area of Occupancy is 20 km<sup>2</sup>. However, as exploration of the area has been very fragmentary, we have little information on the actual occurrence of this species, which could well be more widely distributed along the rim of the Mali Kha / Irawaddy River basin. To date, forests where *S. kachinensis* is found are among the least disturbed submontane evergreen broadleaved forests of the Southeastern Himalaya. Drastically increased population could extend swidden farming and might lead to a reduction of the population, but we have no information on any concrete and current threats to the habitat of the species. Accordingly, we propose a status of Data Deficient (IUCN 2014).

**Table 1.** Comparison of morphological characteristics of *S. kachinensis* with *Selliguea* and *Arthromeris*.

	<i>Selliguea</i>	<i>S. kachinensis</i>	<i>Arthromeris</i>
Rhizome with scattered sclerification	Absent or central	Peripheral	Absent or central
Rhizome with continuous sclerified band	Often	No	No
Lamina shape	Simple to pinnate	Simple	Pinnate, pinnae articulate
Lamina texture	Mostly coriaceous	Thin-herbaceous	Thin-herbaceous to herbaceous
Lamina indument	Glabrous to short-hairy	Soft hairy	Glabrous to densely soft-hairy
Lamina margin	Mostly cartilaginous, often notched	Not differentiated	Often distinctly flat-cartilaginous, not notched
Sporangial indument	Rarely present, short stiff hairs	Soft long hairs	Absent

**Discussion: generic placement.** *Selliguea kachinensis* does not fit easily into the genus *Selliguea*, which contains mostly species with a more coriaceous texture and a distinctly cartilaginous, often notched, margin (although a thin-herbaceous texture is notably present in *S. pui* Hovenkamp). An alternative position would be in the related genus *Arthromeris*. This would agree with the rather distinctive, glabrescent rhizome, which is similar to that of *A. lehmannii* (Mett.) Ching or *A. tomentosa* W.M.Chu, and with a number of other characters (Table 1) but it would seriously weaken the diagnostic value of that genus, as all species so far placed in *Arthromeris* have imparipinnate fronds with articulate pinnae (Lu and Hovenkamp 2013; Tagawa and Iwatsuki 1989). There are several distinctive characters in *Selliguea kachinensis* that argue against placement in either of these genera, and for the erection of a new genus. The often somewhat lyrate base of the lamina of *Selliguea kachinensis* is distinctive and not encountered in any other species of either *Selliguea* or *Arthromeris*. The rhizome of *Selliguea kachinensis* is also distinct in that the cross-section shows sclerification only in the peripheral, subepidermal region (Figure 5a). Sclerification occurs frequently in *Selliguea*, rarely in *Arthromeris*, but in both cases takes the form of sclerified strands in the central part of the rhizome, or a continuous, sclerified band well below the epidermis. The rhizome scales (Figure 5b) do not show any distinctive characters. A dense indument of long hairs similar to the indument of *S. kachinensis* (Figure 5c, d) occurs in some species of *Arthromeris*, but in *Selliguea*, *S. trisecta* (Baker) Fraser-Jenk. and *S. erythrocarpa* (Mett. ex Kuhn) Hovenkamp, *S. Linds.*, Fraser-Jenk. *comb. nov.* (basonym: *Polypodium erythrocarpum* Mett. ex Kuhn, Linnaea 36: 135. 1869) are also hairy, while *S. chrysotricha* (C.Chr.) Fraser-Jenk. also has hairs (albeit short and stiff ones) on the capsules of the sporangia. The spore ornamentation (Figure 5e, f) is matched in *Selliguea* by e.g. *S. quasidivaticata* (Hayata) H. Ohashi & K. Ohashi and *S. yakushimensis* (Makino) Fraser-Jenk. and in *Arthromeris* by e.g. *A. tenuicauda* (Hook.) Ching and *A. lehmannii* (Mett.) Ching (Tryon and Lugardon 1991). Thus, there are



**Figure 5.** *Selligaea kachinensis*. **A** cross section of rhizome **B** rhizome scales **C** lamina margin **D** sporangium **E** spore **F** detail of spore, scale bar. All from the holotype, Miehe *et al.* 13-094-159 (L). Scale bar: 10 µm (**A–E**); 1 µm (**F**).

arguments both for and against placement in *Selligaea* or in *Arthromeris* and there are arguments in favour of erecting a new genus. We have decided not to do the latter, as the generic taxonomy of the Selligieoid ferns is at the moment unsettled, has been burdened already by the erection of numerous small genera (Hovenkamp 1998), and it is beginning to become clear that the best option to avoid paraphyletic groups may be to accept a large genus *Selligaea* (He *et al.* in prep.). As alternative to a monotypic genus, we prefer a placement in the genus *Selligaea* over one in *Arthromeris* in anticipation of a generic reorganization along these lines.

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# *Allium ekimianum*: a new species (Amaryllidaceae) from Turkey

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## Abstract

*Allium ekimianum* is described here as a new species. This taxon belongs to the genus *Allium* section *Allium* and grows in Elazığ Province (East Anatolia, Turkey). It is a narrowly distributed species and morphologically most similar to *A. asperiflorum* and *A. sintenisi*, and *A. erzincanicum* but it is clearly differentiated due to the curved stem, smooth pedicel surfaces, bracteole arrangements at pedicel bases, tepal lengths and surfaces. In this study, a comprehensive description, distribution map of *A. ekimianum*, identification key, and detailed illustrations are provided for *A. ekimianum* and related taxa.

## Keywords

*Allium*, section *Allium*, endemic species, taxonomy, Turkey

## Introduction

The genus *Allium* L. is one of the largest monocotyledonous genera with c. 900 species distributed world-wide (Govaerts et al. 2013, Keusgen et al. 2011). The genus was formerly included in the Liliaceae family, but the Angiosperm Phylogeny Group (APG) reassessed the taxonomic position of this genus and finally *Allium* was placed in the Amaryllidaceae family (APG III 2009). The primary evolution center of the genus extends across the Irano–Turanian biogeographical region, and the Mediterranean basin and western North America are secondary centres of diversity (Friesen et al. 2006).

Based upon these centres, *Allium* species have scattered widely all over the northern hemisphere (Hanelt 1990, Fritsch and Friesen 2002). The genus is characterized by having bulbs enclosed in membranous (sometimes finally fibrous) tunics, terminal umbel, free or almost free, 1-veined tepals, often a subgynobasic style and loculicidal capsule with one or two seeds per loculus (Kollmann 1984).

Following the results of recent molecular investigations, *Allium* is divided into 15 subgenera and 56 sections (Friesen et al. 2006). Subgenus *Allium* is the largest, comprising approximately 280 species (Hanelt et al. 1992), 114 of which compose its largest section, *Allium* (Mathew, 1996). Section *Allium* encompasses those species of *Allium* that have a well-developed bulb, stem (never basal) leaves, campanulate to cup-shaped (never stellate) flowers, and filaments in two distinct whorls, the outer three nearly always simple and the inner three markedly tricuspidate (rarely 5-7 cuspidate) with the anther attached to the median cusp. This section includes economically important species, such as garlic (*A. sativum* L.) and leek (*A. ampeloprasum* L.), as well as other minor crops of local importance, such as great headed garlic, and kurrat (Block 2010). Despite the major importance of the section *Allium*, it has not been subjected to a comprehensive molecular taxonomic evaluation; only partial molecular genetic studies that involved a limited set of species have been published (Kik et al. 1997; Havey and Leite 1999; Bohanec et al. 2005; Hirscheegger et al. 2010). Interspecific and infraspecific relationships within this section still remain unresolved. As reviewed by Mathew (1996), polyploidy is a common feature in section *Allium*. However, to a certain extent, it has been left unexplored, leaving the origin of polyploid species undetermined (Hirscheegger et al. 2010).

Turkey has approximately 190 *Allium* taxa in 14 sections, c. one-third endemic, demonstrating that it is a prominent part of the southeastern Asian center of *Allium* diversity (Ekşi et al. 2015; Özhatay and Kandemir 2015; Koyuncu 2012). Section *Allium* remains the most species-rich section of the genus (Friesen et al. 2006).

Turkey has four reasons for having an exceptionally rich flora. First, it is the meeting point of three phytogeographical regions, the Euro–Siberian, Mediterranean and Irano–Turanian regions. Second, Anatolia (Asian part of Turkey) is a passageway and a migration route between Southern Europe and the flora of South–West Asia allowing the penetration of Asiatic elements into South Europe. Third, many taxa have their center of origin and/or center of diversity in Anatolia. Fourth, the endemism ratio is high, presumably connected with the climatic and topographical diversity of the country (Davis 1965, 1971).

During the revision of the treatment of *Allium* in Turkey, individuals of a new species were collected by Prof. Dr. Mehmet Koyuncu in 1983 from Eastern Anatolia. They belong to *Allium* section *Allium* due to ovoid bulb, linear leaves, campanulate to ovoid perigon; 3-cuspidate inner filaments, distinct nectariferous pores on ovary, ovule numbers in per loculus (Kollmann 1984). The initial evaluation suggested this collection was a form of *A. asperiflorum* Misch. However, detailed examination of herbarium material and a review of the literature indicated this represented an undescribed species. The present study is focused on the morphological characters for distinguishing

a new species in *Allium* section *Allium*. Investigations on living and herbarium specimens suggest that this new species is morphologically most similar to *A. asperiflorum*, *A. erzincanicum* N. Özhatay & Kandemir and *A. sintenisii* Freyn.

## Materials and methods

The overall morphology of the new species was examined by stereo binocular microscope (Leica Zoom 2000). For morphological comparisons, we consulted dry herbarium material kept in AEF, ANK, E, GAZI, and ISTE (acronyms according to Thiers 2015). The *Flora of Turkey* and floras of the neighbouring regions including Iran, Iraq, and Syria were also consulted (Boissier 1882, Feinbrun 1948, Wendelbo 1971, 1985, Kollmann et al. 1983, Kollmann 1984, Mathew 1996, Özhatay and Tzanoudakis 2000). The diagnostic traits of the new species and its three most similar relatives are presented in Table 1. Distribution map of compared taxa is provided according to the Grid classification system developed by Davis (1965) in Figure 1. IUCN conservation assessment and justification is proposed according to the criteria established by IUCN (IUCN 2003). In addition, an identification key is provided to distinguish new species and closely related taxa.

## Taxonomic treatment

### *Allium ekimianum* Ekşi, Koyuncu & Özkan, sp. nov.

urn:lsid:ipni.org:names:60471703-2

Figure 2

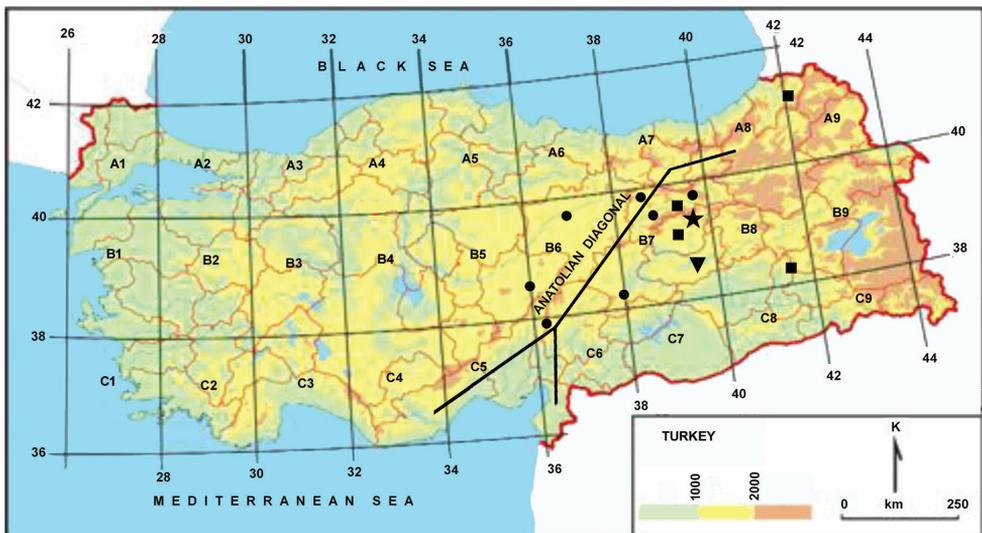
**Note.** Diagnostic characters for *Allium ekimianum* include curved stem, smooth pedicels, united bracteoles, verrucose–scabrid and straight outer tepal, smooth inner tepal, longer inner tepal.

**Type.** Turkey. Elazığ: Fırat University, steppe, c. 1150 m, 02.07.1983, *Koyuncu 7847* (holotype: AEF!, isotype: GAZI!).

**Description.** Bulb ovoid, 0.7–1.2 × 1–1.5 cm; outer tunics membranous, brownish, ± breaking into parallel fibres; inner tunics white; bulblets absent. Stem 15–35 cm, curved, often purplish below. Leaves 2–3, linear, 1–2 mm broad, flat, shorter than scape, sheathing lower ½ of stem. Umbel globose–subglobose, 1.5–3 cm diameter, dense, 20–60 flowered. Spathe caducous. Pedicels smooth, unequal, not elongating in fruit; up to 2.5 × perigon; bracteoles present, united at the base of outer pedicels, splitting into several lobes at apex, c. 5 mm. Perigon ovoid, campanulate; tepals purple, pale pink; outer tepals straight, 5 × c. 3.5 mm, obovoid, verrucose–scabrid, acute–subacute, obtus at apex; inner tepals c. 4 × 2 mm, narrowly oblong, smooth, obtus at apex. Stamens included; filaments ciliate at base; inner filaments 4 × 2 mm; median cusps c. 1 mm, slightly shorter than lateral cusps (c. 1.5 mm); basal lamina c. 3 mm, 3

**Table 1.** Main differences between *A. asperiflorum*, *A. ekimianum* and *A. sintenisii*, *A. erzincanicum*.

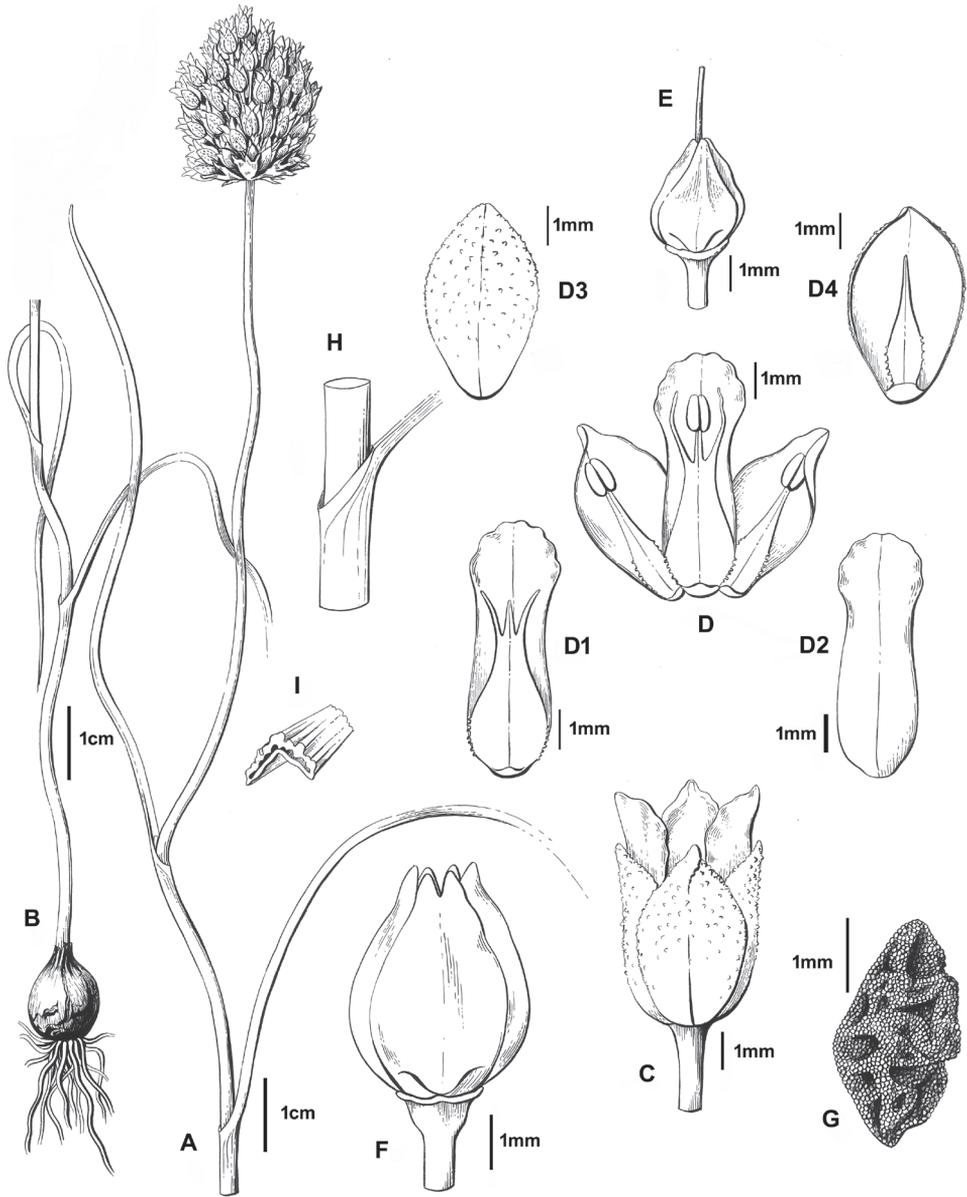
	<i>A. asperiflorum</i>	<i>A. ekimianum</i>	<i>A. sintenisii</i>	<i>A. erzincanicum</i>
Outer bulb tunics	membranous	membranous	membranous	reticulate-fibrous
Stem	erect	curved	almost erect	erect
Leaves	densely scabrid	glabrous	densely scabrid	glabrous or almost glabrous
Bracteoles	solitary at the base of each pedicel	outer ones with united bracteoles at base	outer ones with united bracteoles at base	outer ones with united bracteoles at base
Pedicel surface	papillose	smooth	scabrid near the base of perianth	smooth
Outer tepal	densely papillose, keeled	verrucose–scabrid, straight	loosely bearded with long white papillae at whole surface, keeled	loosely bearded with long white papillae just on the midvein, keeled
Inner tepal	papillose, 5–7 × 2.5 mm, equal to outer tepal	smooth, c. 4 × 2 mm, distinctly longer than outer tepal	smooth, 7–10 × 3 mm, almost equal to outer tepal	loosely bearded with long white papillae just on the midvein, 4–5 × 1–2 mm, equal to outer tepal

**Figure 1.** Distribution map of *A. ekimianum*, *A. asperiflorum*, *A. sintenisii*, *A. erzincanicum*.

times longer than median cusps. Anther 1 mm, yellow. Pistil c. 3–5 mm; style c. 1–2 mm; ovary c. 2–3 × 1.5–2 mm, ovoid, smooth. Capsule 4 × 3.5 mm, ovoid; valves emarginate–bilobate at apex; seed 3 × 1.5 mm, black.

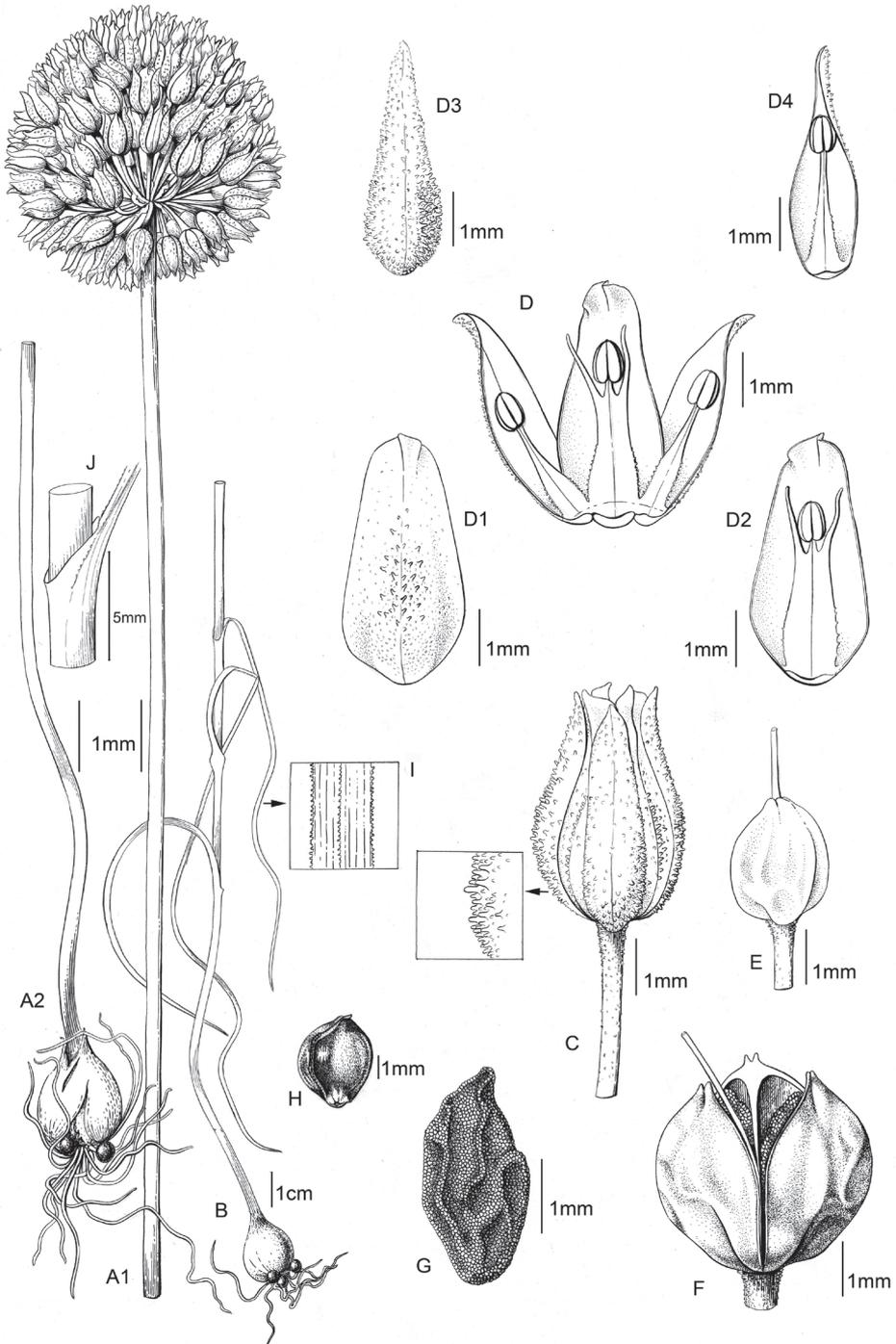
**Etymology.** The species is named in honor of the eminent Turkish botanist Prof. Dr. Tuna Ekim, who dedicated his life to Turkish Flora, was retired from İstanbul University.

**Distribution and ecology.** The distribution of *Allium ekimianum* is restricted to Province of Elazığ from East Anatolia, where it grows on steppe between 1100–

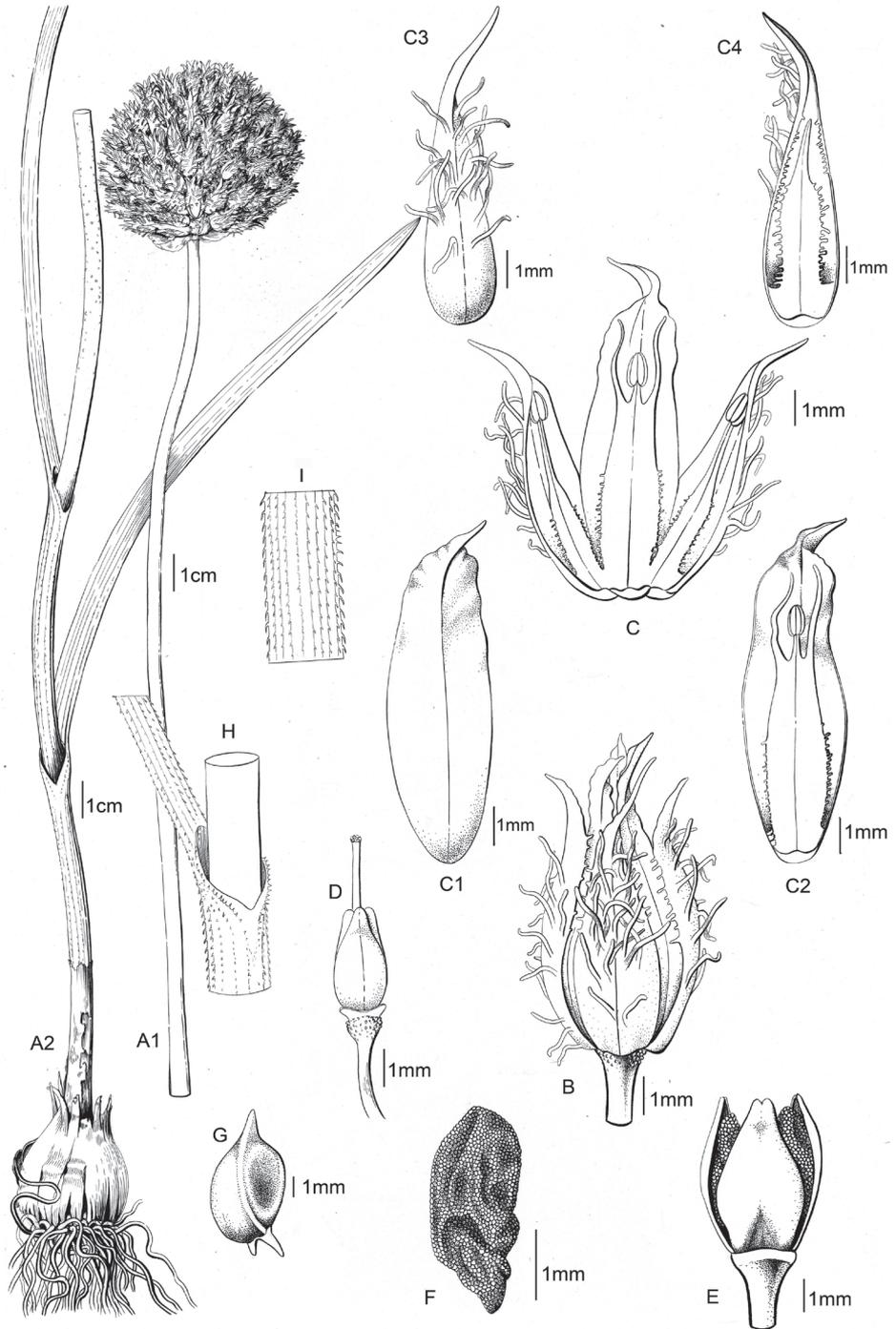


**Figure 2.** *Allium ekimianum* (Koyuncu 7847/Elazığ). Plant (**A, B**), flower (**C**), flower longitudinal section (**D**), inner tepal (**D1, D2**), outer tepal (**D3, D4**), pistil (**E**), capsule (**F**), seed (**G**), leaf sheathing (**H**), leaf cross section (**I**). (Drawn by Gülnur Ekşi).

1200 m of elevation. Species associated with *A. ekimianum* include *Campanula stricta* L., *Silene italica* (L.) Pers., *Silene vulgaris* (Moench) Garcker, *Euphorbia macroclada* Boiss., *Papaver rhoeas* L., *Crataegus monogyna* Jaq., *Rosa canina* L., *Rosa × dumalis* Bechst., *Potentilla erecta* L., *Sanguisorba minor* Scop., *Achillea millefolium* L., *Allium*



**Figure 3.** *Allium asperiflorum* (Koyuncu 10539/Artvin). Plant (A1, A2, B), flower (C), flower longitudinal section (D), inner tepal (D1, D2), outer tepal (D3, D4), pistil (E), capsule (F), seed (G), bulblet (H), leaf surface (I), leaf sheathing (J). (Drawn by Gülnur Ekşi).



**Figure 4.** *Allium sintenisii* (Koyuncu 9692/Kahramanmaraş). Plant (A1, A2), flower (B), flower longitudinal section (C), inner tepal (C1, C2), outer tepal (C3, C4), pistil (D), capsule (E), seed (F), bulblet (G), leaf sheathing (H), leaf surface (I). (Drawn by Gülnur Ekşi).

*scorodoprasum* L., *Vicia cracca* L., *Crepis foetida* L., *Eryngium campestre* L., *Salvia verticillata* L., *Avena sterilis* L. Elazığ is located on the east of Anatolian diagonal, in the skirts of South-Eastern Taurus Mountains (Çakılcıoğlu et al. 2008), in the Upper Euphrates Region of the Eastern Anatolia Region (Şengün 2007). Elazığ belongs to the Irano-Turanian Plant Geography Region and falls within the B7 grid square (Davis 1965). The Irano-Turanian Region is confined to Central and East Anatolia. This great region of steppe, mountain steppe and semi-desert is also characterized by the existence of a hypothetical oblique line that runs from Bayburt-Gümüşhane south-westwardly to Anti-Taurus where it bifurcates with one prong leading to the Amanus and the other to the Cilician Taurus. This line is called “Anatolian Diagonal” (Figure 1). The flora of central Anatolia as the western side of the Diagonal is floristically different from the rest of the Irano-Turanian region to the east. According to the plant distribution patterns in eastern Anatolia, many endemics are restricted to part of the Diagonal belt, or extend right along it (Davis 1965, Davis 1971).

**IUCN Conservation Assessment and Justification.** Following the criteria established by IUCN (IUCN 2003), an initial provisional assessment of Critically Endangered (CR) (criteria B2a + B2biii) is suggested for this new taxon. This species occurs only in Elazığ University campus area in Elazığ province (East Anatolia) at 1100–1200 m. The area is under subversive people activities such as new constructions of buildings. As a result, the habitat of *Allium ekimianum* is highly threatened of vanishing by people activities. The area of *A. ekimianum* occupancy (AOO) is less than 10 km<sup>2</sup> with the number of mature individuals which is under reduction and being less than 50.

**Related species.** *Allium ekimianum* is closely related to *A. asperiflorum* and *A. sintenisii* and *A. erzincanicum*. All four species share traits of ovoid bulb, globose to subglobose umbel, campanulate to ovoid perigon, rough outer tepal surfaces, stamens shorter than perigon, ovoid ovary. *Allium ekimianum* differs from *A. asperiflorum*, *A. sintenisii* and *A. erzincanicum* in its outer tunics, stem, leaves, bracteoles, pedicel surface, outer tepal, and inner tepal characters. The three species are compared in Table 1 and these traits are illustrated in Figures 2–4.

#### Key for identification of *Allium* species related to *A. ekimianum*

- 1 Outer perianth segments loosely bearded at whole surface or along midvein with long white papillae, pale pink, more intensely pink at tip.....**2**
- Outer perianth segments not bearded on whole surface or along midvein...**3**
- 2 Perigon 7–10 mm; outer tunics membranous; leaves scabrid; pedicels scabrid near the base of perianth; outer tepal loosely bearded with long white papillae at whole surface; inner tepal smooth.....***A. sintenisii***
- Perigon 4–5 mm; outer tunics reticulate fibrose; leaves glabrous or almost glabrous; pedicels smooth; outer tepal loosely bearded with long white papillae just on the midvein; inner tepal bearded on the midvein .....***A. erzincanicum***

- 3 Stem erect; involucre-like structure absent; outer tepal keeled, surface densely papillose; inner tepal surface scarcely papillose; leaves densely scabrid; pedicels densely papillose; bulblets numerous .....***A. asperiflorum***  
 – Stem curved; involucre-like structure present; outer tepal not keeled, surface verrucose-scabrid; inner tepal surface glabrous; leaves glabrous; pedicels smooth; bulblets ± present .....***A. ekimianum***

### Additional specimens examined

The capital letters and the numbers in bold after species names represent the Grid classification system (Davis, 1965) and the names in bold are the provinces from the Eastern Turkey. The abbreviations and the numbers in brackets at the end of the sentences represent the herbarium names and the accession numbers, respectively.

***Allium asperiflorum***: **A9 Artvin**: Borçka–Artvin arası, Artvin’e 10 km kala, kayalıklar, 200 m, 14 vii 1993, *M. Koyuncu 10539* (AEF 18113). **B6 Sivas**: Divriği–Cürekarası, 3 vi 1983, *H. Başer s.n.* (ESSE 3320). **B7 Erzincan**: İliç, Hassanova village, 900–1100 m, *Çelik s.n.* (AEF 5699). İliç, Hasanova Köyü altındaki Tepeler, 900–1000, 16 vi 1976, *N. Çelik s.n.* (AEF 5699). Erzincan–Refahiye yolu, 35 km, kuruçakıllı yamaçlar, 1900 m, 22 viii 1990, *M. Koyuncu 8808* (AEF 15737). İliç–Refahiye çevresi, Gümüşahar’dan sonar Sunibeli Geçiti, orman açıklıkları, 1700 m, 21 vi 2005, *M. Koyuncu 15098* & *N. Aslan* (AEF 24263). **B7 Tunceli**: Ovacık üzeri, Munzur Dağı, Kepir Gediği, kayalık taşlık arazi, 2400–2750 m, 10 viii 1976, *M. Koyuncu* & *N. Çelik s.n.* (AEF 5683). **C8 Siirt**: Pervari’nin üstü, kalker kayalıklar, stepler, 1600–1700 m, 16 vi 1980, *M. Koyuncu 3260* (AEF 9563). ***Allium sintenisii***: **B6 Kayseri**: Sarız, Yalak, Binboğa Dağı, 2000–2200 m, 1 vii 1992, *M. Koyuncu* & *H. Duman 5175* (AEF 17830). Bakır Dağı–Tufanbeyli arası, Gezbeli Geçidi, 2200 m, 28 vii 2008, *M. Koyuncu 15993* (AEF 25277). **B6 Malatya**: Kuluncak, Kızılyüce Dağı kuzey eteği, çayırılık, 1700 m, 18 vi 1994, *B. Yıldız 11582* (AEF 26253). **B6 Maraş**: Göksun–Binboğa Dağı, 2000–2400 m, 17 vii 1992, *M. Koyuncu 9692*, *H. Duman*, *Z. Aytaç* (AEF 17465). **B7 Malatya/Sivas**: Kangal to Hekimhan, 1300 m, *Stn.* & *Hend. 5390*. **B7 Erzincan**: Spikör Dağı Geçidi, step yamaçlar, 2300 m, 27 viii 2008, *M. Koyuncu 16128* (AEF 25453) **ibid.** 14 vii 2009, *M. Koyuncu 16176* (AEF 25593). ***Allium erzincanicum***: **B7 Erzincan**: Munzur Dağları, Mercan Suyu, kalker kayalıklar, 37 S 550540 D, 4374863 K, 1997 m, 08 vii 2014, *Kandemir 10613* (isotype NGBB).

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# Lectotypifications of six taxa in the Boraginales (Cordiaceae and Heliotropiaceae)

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## Abstract

A large number of specimens used as original material for the description of new species were destroyed in the bombing of the Berlin-Dahlem herbarium, B, in 1943. Six lectotypes are designated here for *Cordia discolor* Cham., *Cordia multispicata* Cham., *Cordia tobagensis* Urb. and its variety *broadwayi* Urb. in the Cordiaceae and for *Tournefortia paniculata* Cham. and *Tournefortia ulei* Vaupel in the Heliotropiaceae.

## Keywords

*Cordia*, Cordiaceae, Heliotropiaceae, lectotype, *Myriopus*, *Tournefortia*, *Varronia*

## Introduction

In the last ten years, several lectotypes have been designated in the Cordiaceae and Heliotropiaceae (Miller in Cafferty and Jarvis 2004; Gottschling and Miller 2006; Miller 2007; Feuillet 2008, 2013; Stapf 2010; Stapf and Silva 2013). In the preparation for the treatment of the Boraginales, or Boraginaceae s.l., for the Flora of the Guianas project, I found more taxa whose names had supposedly lost their type material when the Berlin (B) herbarium was bombed during World War II on the night of 1–2 March 1943 (Hiepko 1987: 251). Besides reading Hiepko (1987), I visited the Berlin collections of Boraginaceae in 1985 and 1987, and corresponded with Paul Hiepko

and more recently with the head of the herbarium and checked the Berlin Virtual Herbarium database online without being able to substantiate the current presence at B of the types of the names lectotypified below. Typification problems in *Cordia* L. (Linnaeus 1753 : 190), *Myriopus* Small (1933: 1131), *Tournefortia* L. (Linnaeus 1753: 140), and *Varronia* P. Browne (1756: 172) are the subject of this paper.

In the citation of types, the word photo refers to a print deposited in herbaria and the word scan refers to a picture posted online, available directly through herbarium sites, or through sites like JSTOR or Europeana.

As far as I could find out, the type material of the names in the Cordiaceae and the Heliotropiaceae treated below have been destroyed at B during World War II. Lectotypes need to be designated according to Art. 9.2. of the International Code of Nomenclature for algae, fungi and plants (McNeill et al. 2012). Six such lectotypes are designated below. All the duplicates conform well to the descriptions and to the photographs of the lost specimens that are held at F and were taken by MacBride. Where the name typified is not the currently accepted name for the species, the accepted name is given beneath the type designation.

## Typifications in the Cordiaceae

### 1. *Cordia discolor* Cham., *Linnaea* 4: 482. 1829.

*Varronia discolor* (Cham.) Borhidi, *Acta Bot. Hung.* 34(3–4): 388. 1988.

**Type.** Brazil. 1814, *F. Sellow s.n.* (B† [F0BN000966, photo!]; lectotype, **here designated**: LE [herb. Chamisso]; isolectotypes: HAL n.v. [HAL0098680, scan!], K! [K000583320, labelled “Ex reliquiis Sellowianis”, scan!], P! [P00634049, scan!]).

**Accepted name.** *Varronia polycephala* Lam.

**Notes.** The name was given by Chamisso in 1829 to a northern South American shrub now recognized as a synonym of *Varronia polycephala* Lam. The material of *C. discolor* used by Chamisso and conserved at B was destroyed during World War II. I have seen the scans of the duplicates cited below as lectotype and isolectotype(s). Chamisso’s herbarium is in the collection of the Leningrad Komarov Institute (LE) in St. Petersburg. Correspondence with Irina Illarionova and Vladimir Dorofeyev (LE) resulted in the photographs of three Sellow specimens for *Cordia discolor* in the LE collections. One has “Hortus Botanicus Imperialis Petri Magni.” printed on top of the sheet and has a label on the bottom that read “Herb. Reg. Berolinense/*Cordia discolor* Cham. et Schl./Brasilia. Sellow legit”. It seems to be part of the general collections of the LE herbarium, but not from Chamisso’s herbarium and the identification is not from Chamisso’s hand. Another one has 2 labels; one on the bottom left reads “Martii Herbar. Florac. Brasil N° 125” and on the bottom right “Herb. Reg. Berolinense. 1845/*Cordia discolor* Cham. et Schl./Brasilia. Sellow legit.”. It was sent to LE after Chamisso’s death. The third one has

one label in the bottom left corner that reads “*Cordia discolor* N.” on top, “Sellow” on the bottom left, and on the bottom right “Bras. tropica” and below “Hb Cham”. It has been seen and annotated by Chamisso. It is the best choice for a lectotype.

A fragment at F labelled *Sellow 47* (GH n.v., fragment [GH00057561, scan!]) might be additional isolectotypes. In the Harvard University Herbaria Index of Specimens, F. Sellow 47 is listed as “Collector F. Sellow” and “Station 47”; the label reads “F. Sellow 472”, number that corresponds to the type of *Stylogyne pauciflora* Mez (Primulaceae). It is likely that in most cases the numbers accompanying Sellow’s collections are not collection numbers.

## 2. *Cordia multispicata* Cham. *Linnaea* 4: 490. 1829.

*Lithocardium multispicatum* (Cham.) Kuntze, *Rev. Gen.* 2: 977. 1891.

**Type.** Brazil. “Eastern Brazil”, *F. Sellow s.n.* [46?] (B† [F0BN000987, photo!]; lectotype **here designated:** US! [US00110697, scan!]; isolectotypes G! [G00177047, scan!], HAL n.v. [HAL0098661, scan!]).

**Accepted name.** *Varronia multispicata* (Cham.) Borhidi, *Acta Bot. Hung.* 34(3–4): 392. 1988.

**Notes:** The type material at B was destroyed during World War II. I am selecting as the lectotype the duplicate preserved at US that I have studied. I have also seen the duplicate at G, but have not carefully studied it.

Correspondence with Irina Illarionova and Vladimir Dorofeyev (LE) resulted in no specimen from the Chamisso herbarium collected by Sellow for *Cordia multispicata* or *Varronia multispicata* in the LE collections.

The collection *F. Sellow 46* has been cited for other groups of plants like ferns, *Asplenium sellowianun* C. Presl ex Hieron. (Meza Torres 2011: 125), Orchidaceae, *Pleurothallis sonderana* H. G. Reichenbach (Harvard University Herbaria, Index of specimens), and *F. Sellow [46]* Solanaceae, *Solanum convolvulus* Sendtn. (Knapp 2013: 143). It is probable that 46 is not a collection number (see above).

## 3. *Cordia tobagensis* Urb., *Repert. Spec. Nov. Regni Veg.* 16: 39. 1919.

*Varronia tobagensis* (Urb.) Borhidi *Acta Bot. Hung.* 34: 393. 1988.

**Type.** Trinidad & Tobago. Tobago, 9 Sep 1912, W.E. Broadway 3072 (holotype B†; lectotype **here designated:** GH n.v. [GH00095082, scan!]) fragment of the B† holotype).

**Accepted name.** *Varronia schomburgkii* (DC.) Borhidi

**Notes.** The type material at B was destroyed during World War II. I am designating as the lectotype the only extant part of the original material known to me.

4. *Cordia tobagensis* Urb. var. *broadwayi* Urb., *Repert. Spec. Nov. Regni Veg.* 16: 40. 1919.

**Type.** Trinidad & Tobago. Tobago, W.E. Broadway 4235 (holotype B†; lectotype **here designated:** GH n.v. [GH00095083, scan!]) fragment of the B† holotype).

**Accepted name.** *Varronia schomburgkii* (DC.) Borhidi

**Notes.** I am designating as the lectotype the only duplicate of the original material known to me. The lectotypes of *Cordia tobagensis* and var. *broadwayi* designated above are mounted on the same sheet at GH, but the two collections are clearly identified and have a different barcode number. At MO, the specimen *W.E. Broadway 4235* from the Grenadines is a member of the Fabaceae, *Alysicarpus* sp. (Tropicos).

## Typifications in the Heliotropiaceae

5. *Tournefortia paniculata* Cham., *Linnaea* 4: 468. 1829.

**Type:** Brazil. “Brazil equinoctial”, *F. Sellow s.n.* (B† [F-1053, photo!]; lectotype **here designated:** G! [G00236172, scan!]).

**Accepted name.** *Myriopus paniculatus* (Cham.) Feuillet, *J. Bot. Res. Inst. Texas* 2(1): 264. 2008.

**Notes.** I designate as the lectotype the only duplicate known to me and that I have examined in 1982 and 1987.

6. *Tournefortia ulei* Vaupel, *Notizbl. Bot. Gart. Berlin–Dahlem* 6: 186. 1914.

**Type.** Bolivia. Río Madeira, Porvenir, Jan 1912, E.H.G. Ule 9711 (B† [F1063, photo!]; lectotype **here designated:** K! [K000583529, scan!]).

**Notes.** I choose as the lectotype the specimen preserved at Kew because I was able to study it 1979 and in the 1990s.

## Acknowledgements

I am indebted to Vladimir Dorofeev (LE), Paul Hiepko (B), and Irina Illarionova (LE) for their help in locating potential type specimens. I want to thank the curators of the herbaria cited who made easy to get loans, or work in the collection in their care, or provided scans of types, the reviewers, and especially Sandy Knapp who helped me with the formatting. I am very grateful to the Department of Botany, Smithsonian Institution, where I was welcomed from 1988 to 2014 and the Botany and Plant Pathology Department, Oregon State University, where I retired and where I do research since the fall of 2014. This is number 214 in the Smithsonian’s Biological Diversity of the Guiana Shield publication series.

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# *Oenanthe incrassans*: An enigmatic species from Turkey and its comparison with *Oenanthe pimpinelloides* (Apiaceae)

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## Abstract

*Oenanthe incrassans* (Apiaceae) was discovered in Istanbul, Turkey. It is related to *Oenanthe pimpinelloides*, but it clearly differs in terms of leaves, inflorescence (ray, bracts, and bracteoles) and fruit features. A taxonomic description, some photographs of the species, geographical distribution and habitat features are given. Additionally, fruit micromorphology, stem, ray and fruit anatomy, and pollen features are studied for the first time and compared to *Oenanthe pimpinelloides*.

## Keywords

Anatomy, micromorphology, pollen, *Oenanthe*, taxonomy, Turkey

## Introduction

*Oenanthe incrassans* Bory & Chaubert (Bory 1832) is one of the synonyms of the *Oe. pimpinelloides* L. (Linneaus 1753) in Flora of Turkey (Hedge and Lammond 1972). Foley and Southam published a study on *Oe. incrassans* and they recognized it as a distinctive plant of the Aegean region (Foley 2007). The species is an element of the East Mediterranean area because of its distribution in Aegean region, but it hasn't been collected from Turkey until recently.

Foley and Southam also discussed *Oenanthe thracica* Griseb. which is the other synonym of *Oe. pimpinelloides* (Hedge & Lammond, 1972). They said that *Oe. thracica* is conspecific with *Oe. pimpinelloides* and its taxonomy is in need of further study. Their result was based on examination of a specimen of *Oe. thracica* recorded as “Turkey (European)–A1(E) Edirne: Kesan, 6 July 1982, Nydegger 17003”. In 2013, Özhatay et al. erroneously reported *Oe. incrassans* as a new record for Flora of Turkey based on this record (Özhatay 2013), and then it was added in the list of Flora of Turkey as a “doubtful species” (Menemen 2012). I have also examined specimen of Nydegger (deposite in E) which Foley and Southam determined as *Oe. thracica*, and in my opinion it is definitely *Oe. pimpinelloides*. This is consistent with an earlier determination of the sheet by Huber-Morath. Menemen (2012) thus recognized nine species (including doubtful species) in Turkey.

Within the scope of revisionary studies on the *Oenanthe* species in Turkey, numerous field trips were held between 2014–2015, on one of which *Oe. incrassans* was discovered in Istanbul. Additionally, W and WU herbarium in Vienna, Austria were visited to investigate specimens of *Oenanthe*. During the investigation, undetermined specimens which were collected by Ernst Vitek from Istanbul were identified as *Oe. incrassans*.

This study aims to present a full description of the species and resolve the delimitation between *Oenanthe incrassans* and *Oe. pimpinelloides* by comparing morphological, anatomical, palynological and micromorphological analyzes and their ecological features.

## Methods

The specimens of *Oenanthe incrassans* and *Oe. pimpinelloides* were collected in different regions of Turkey between 2014–2015 and checked with relevant literature (Hedge and Lammond 1972, Cook 1981, Duman 2000). Herbarium specimens were deposited at GAZI. The specimens were compared with the types and other representative collections present at E, W, WU, GAZI (abbreviations following Thiers 2016). For the anatomic analysis, stem, ray, and fruit parts of the collected specimens were kept in 70% alcohol. Hand-made cross sections were firstly stained in sartur reagent (Çelebioğlu 1949). Detailed anatomic structures of the cross sections were photographed with a stereo microscope attached with a camera (Olympus E330). Relevant resources were made use of during the anatomic evaluation (Mauseth 1988, Dickison 2000).

Pollen acquired from anthers of the herbarium specimens were prepared based on Wodehouse method, stained with basic fuchsin, and analyzed under light microscope (Wodehouse 1935). The pollen samples were placed on aluminium tape, coated with gold by using Polaron SC 502 Sputter Coater device, and microphotographed by Jeol JSM 6490LV model scanning electron microscope (SEM). SEM analysis of mericarp micromorphology was conducted with the same method. The terminology of the pollen and mericarp is based on Moore et al. 1991, Punt et al. (2007), and Doğan Güner et al. (2011).

## Results

*Oenanthe incrassans* Bory & Chaubert, Exp. Sci. Moreé, Bot.:87. 1832.

Figs 1–8, Table 1–2

≡ *Oe. incrassata* Bory & Chaub. in Chaub. & Bory, Nouv. Fl. Pelop.: 19. 1838

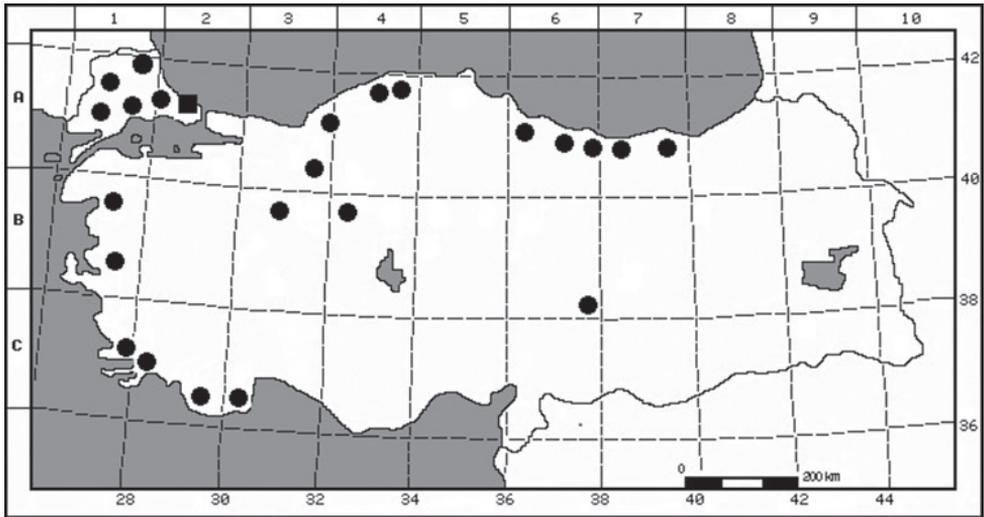
**Lectotypus.** Bory & Chaub., Exp. Sci. Moreé, Bot.: tab. 8. 1835. (designated by Foley 2007!)

**Specimens examined. GREECE. Crete:** Listr. Malevyzi, in paludosis fluviorum Gazanos et Almyros prope Gazi, 25 June 1942, KH. Rechinger fil. 14050 (W!); Sphakia: Sumpfiger Badem bei Frankokasteli, 13 April 1904, I.Dörfler, (WU!); **Corfu:** Ipsos to Ag. Markos, 16 July 1972, sides of moist fields, Davis 54531 (E); in einem Sumphe unterhalb des königlichen Schlosse Monrepos, 9 May–4 June 1996, Baenitz s.n. (E!); Ex regione collina Insula Corcyra, June 1877, Ball s.n. (E!); **Ep. Milopotamas:** b. Murdzana am N-Fuss der Kulukunas-Berge, 18 April 1962, W. Greuter 4170 (W!); **Cephalonia (Argostolion):** Chelmata-Kompothekrata region, 15 April 1967, E. Stamatiadou 207 (W!); **Kissamos:** lieux humides, 2 May–2 July 1884, Reverchon 247 (as *Oe. callosa*) (E!); **Thasos:** Limenas, 19 May 1891, Sintenis & Bornmüller 451 (W!);

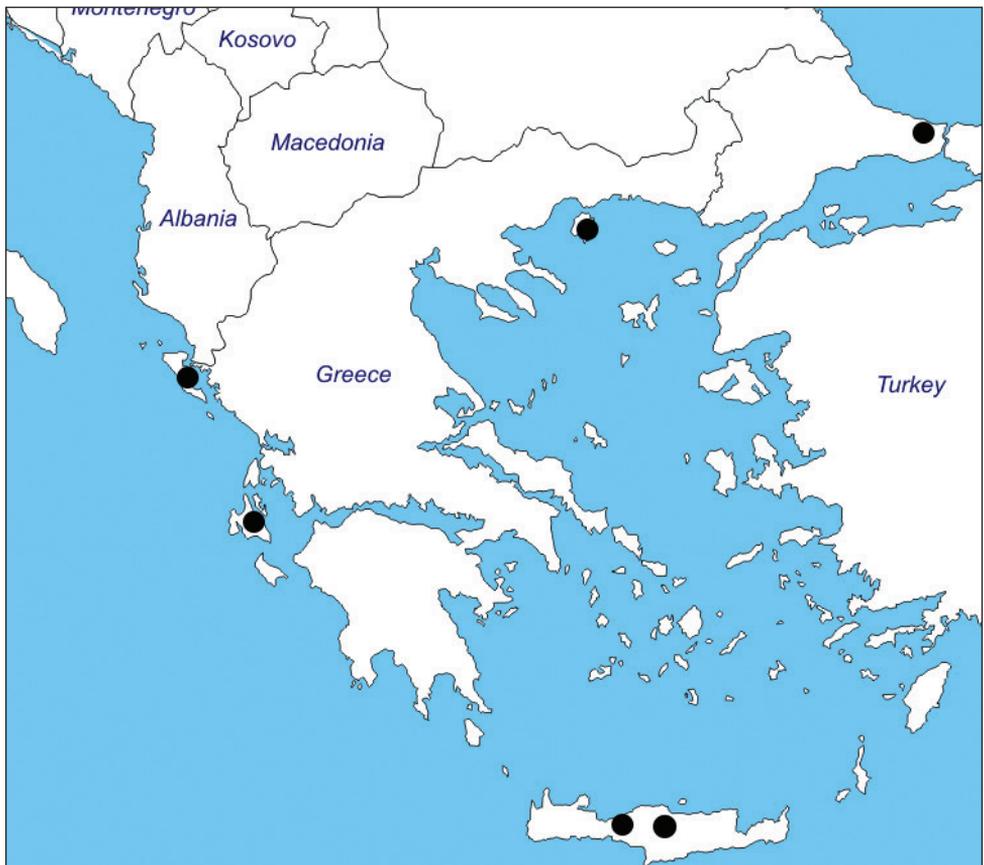
**TURKEY. Istanbul:** c. 35 km NW von Istanbul, bei Durusu, am Ufer des Durusu-Sees, 20 m s.m., 41°17'43"E/ 28°35'40"N, 16 May 2000, E. Vitek 2000–28



**Figure 1.** General view of inflorescens of **a–b** *Oenanthe incrassans* **c–d** *Oe. pimpinelloides*.



**Figure 2.** Distribution map of the *Oenanthe incrassans* (■) and *Oe. pimpinelloides* (●).



**Figure 3.** Distribution of the *Oenanthe incrassans* (●) in Greece and Turkey.

(W!); Terkos to Karaburun, 20–50 m, marshy lakeside, 30 May 2014, ED. Güner 2009 (GAZI); *ibid.* 15 June 2015, ED. Güner 2098 (GAZI).

Perennial, 50–70 cm tall, herb, glabrous, with ovoid or oblong tubers far from stem base. Stem erect, sparsely branched above, hollow, deeply striate (furrowed). Basal and lower stem leaves 2–pinnate, ovate to lanceolate in outline, up to 15 cm with petiole; ultimate segments with pinnatifid lobes, ovate, 9–15 × 8–14 mm; petiole shorter than leaf lamina, broader at leaf base. Upper stem leaves 2–pinnate, ovate-triangular in outline; ultimate segments 2–2.5 cm long and 2–5 mm broad, elliptic. Umbels with 7–12 rays of subequal length (1.5–2 cm), rays becoming hardly thickened and elongating in fruit; involucre bracts 0–1, linear, up to 6 × 1 mm. Umbellets almost flat, with unequal, thickened pedicels in fruit, many flowered, about 1.5 cm diam., pedicel of surrounding flowers longer than inner ones. Bracteoles 10–12, linear, ca. 3 × 1 mm. Petals radiating, creamy white, the outer flowers are female, petals cordate, deeply emerginate in tip, inner petal surface papillate. Styles shorter than fruit, fruit oblong, 3.5–4 × 2–2.5 mm.

**Distribution, habitat and ecology.** *Oenanthe incrassans* is distributed in Greece and Turkey (Figs 2–3). The species is distributed around Istanbul (Arnavutköy, Durusu–Terkos region), Turkey. The flowering time is April, fruiting time is June. It grows on lake sides at 20–50 m altitude.

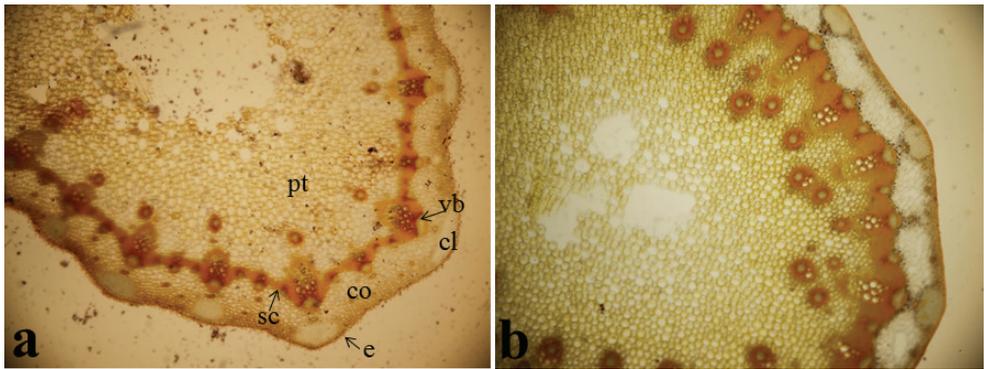
**Morphology.** *Oenanthe incrassans* is close to *Oe. pimpinelloides*, but it clearly differs in leaves, inflorescences and features of fruit. Their differences are given in Table 1.

**Anatomy.** *Stem anatomy:* The shape of stem cross section is triangular or ovoid in outline in *Oenanthe incrassans*; whereas it is circular in *Oe. pimpinelloides*. Parenchymatic cells of cortex 4–5-seriate in *Oe. incrassans*; but it is 2–4-seriate in *Oe. pimpinelloides*. Sclerenchyma tissue cells are 4–5-seriate between two peripheral vascular bundles in *Oe. incrassans*; while they are 10–12-seriate in *Oe. pimpinelloides*. 1–2 small central bundles are placed below peripheral bundles in *Oe. incrassans*; but 1–3 central bundles are placed below peripheral bundles in *Oe. pimpinelloides* (Fig. 4a–b).

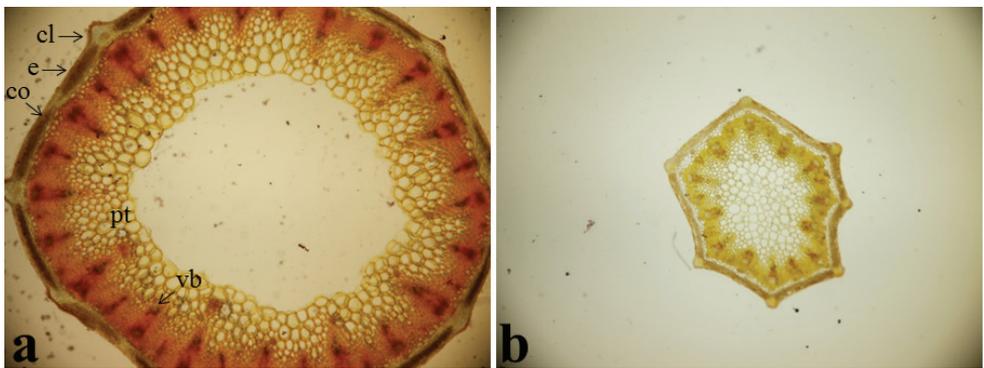
**Ray anatomy.** Rays are hardly thickened and the shape of cross section is 8–10-ridged and circular in outline in *Oenanthe incrassans*; but they are slightly thickened

**Table 1.** Comparison of the morphological characters of *Oenanthe incrassans* and *Oe. pimpinelloides*.

	<i>Oenanthe incrassans</i>	<i>Oe. pimpinelloides</i>
Ultimate segments of basal and lower stem leaves	Pinnatifid, ovate, 9–15 × 8–14 mm	Pinnatifid or pinnatifid, ovate–triangular, 8–10 × 5–8 mm
Ultimate segments of upper stem leaves	Elliptic, 20–25 × 2–5 mm	Linear or narrowly elliptic, 30–35 × 0.4–1.5 mm
Rays and pedicels	Strongly thickened	Thickened
Bracts	0–1	0–3
Bracteoles	10–12, ca 3 × 1 mm	12–14, 1.5–2 × 0.5 mm
Sepals	0.4–0.9 mm in fruit	0.2–0.4 mm in fruit
Styles	Shorter than fruit	± Equal fruit body
Fruit	3.5–4 × 2–2.5 mm	2.5–3 × 1–1.5 mm



**Figure 4.** Cross sections of stem (10 × 5), **a** *Oe. incrassans* **b** *Oe. pimpinelloides*, (cl: collenchyma, co: cortex, e: epidermis, pt: pith, sc: sclerenchyma, vb: vascular bundle).

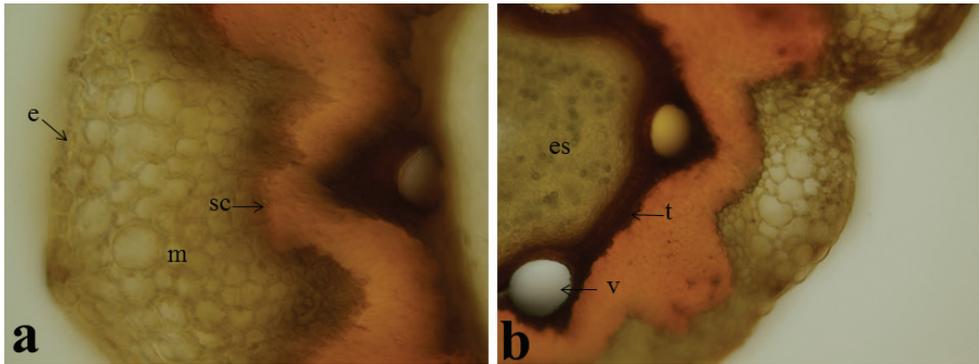


**Figure 5.** Cross sections of ray (10 × 5), **a** *Oe. incrassans* **b** *Oe. pimpinelloides*, (cl: collenchyma, co: cortex, e: epidermis, pt: pith, sc: sclerenchyma, vb: vascular bundle).

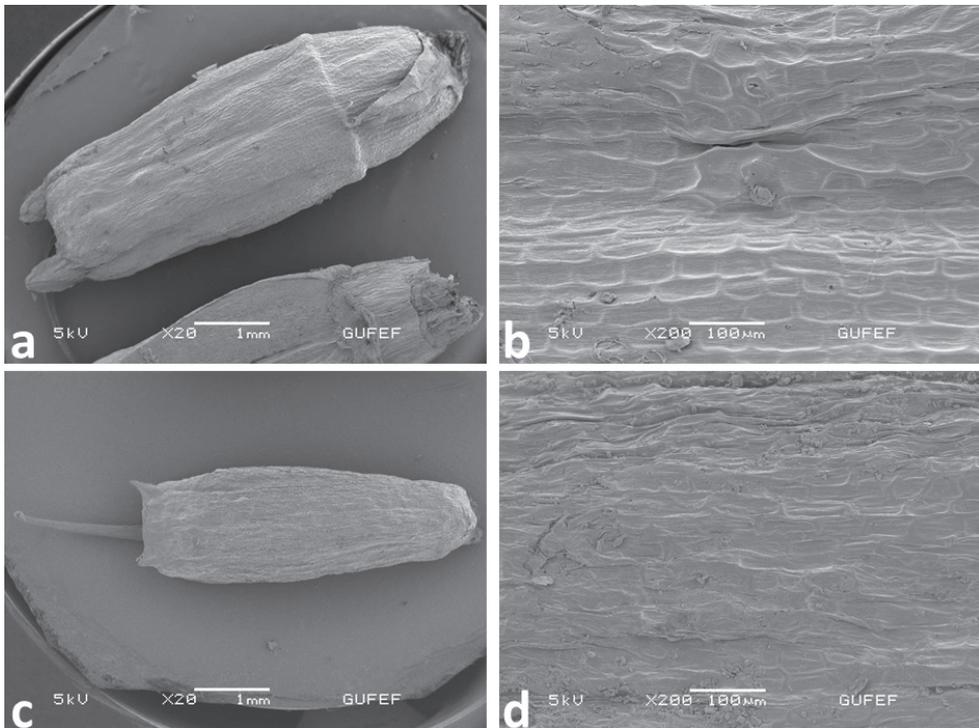
and 7-ridged ovoid or oblong in outline in *Oe. pimpinelloides*. There are 8–9-seriate collenchyma cells in *Oe. incrassans*; but 5–6 seriate in *Oe. pimpinelloides*. Pith cells are 3–4-seriate and disappear towards the center in *Oe. incrassans*; but they are present at the center in *Oe. pimpinelloides* (Fig. 5a–b).

**Fruit anatomy.** Size and shapes of mericarps show morphological differences between the two species. The cross section shape of mericarps is semi-circular in outline and 4-ridged at the dorsal surface in *Oenanthe incrassans*. However, it is triangular in outline and only faintly 4-ridged in *Oe. pimpinelloides*. Mesocarp tissue consists of two types of cells; parenchymatic-slightly thickened cells and lignified sclerenchyma cells around vascular bundles. There are 9–10-seriate parenchymatic cells in *Oe. incrassans*, but there are 4–5-seriate parenchymatic cells in *Oe. pimpinelloides* (Fig. 6a–b).

**Mericaip micromorphology.** *Oenanthe incrassans* and *Oe. pimpinelloides* show fruit characteristics of the genus *Oenanthe*. The fruit micromorphology of *Oe. incrassans* differs from *Oe. pimpinelloides* by 3.5–4 × 2–2.5 mm sized mericarps (not 2.5–3



**Figure 6.** Cross sections of mericarp (10 × 20), **a** *Oe. incrassans* **b** *Oe. pimpinelloides*, (e: epidermis, es: endosperm, m: mesocarp, sc: sclerenchyma, t: testa, v: vittae).

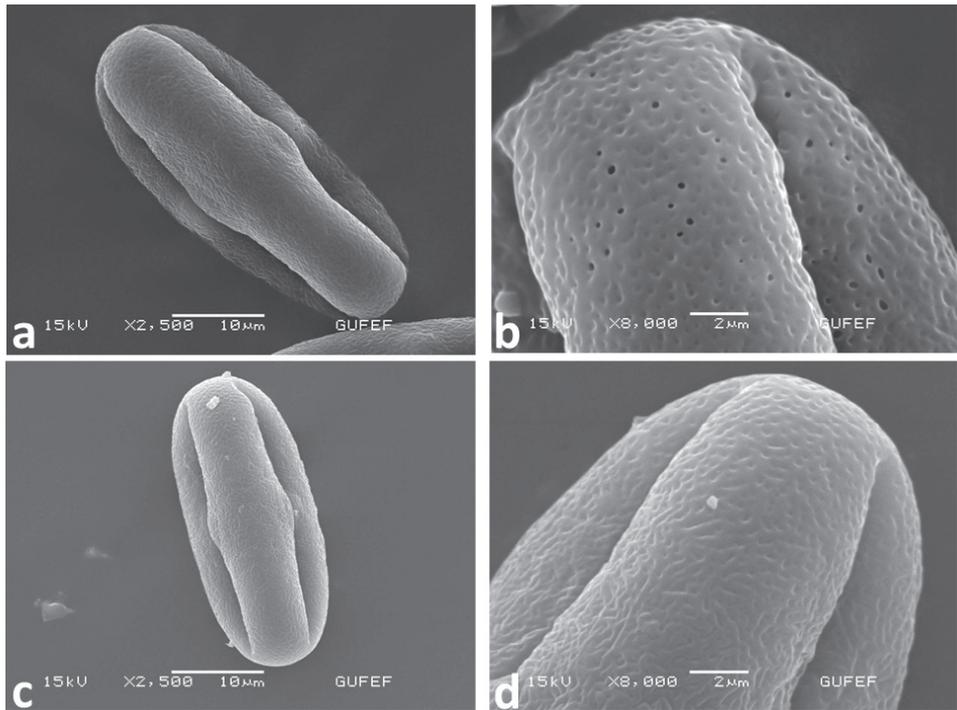


**Figure 7.** Mericarp microphotography **a–b** *Oenanthe incrassans* (EDG 2098) **c–d** *Oe. pimpinelloides* (EDG 2076).

× 1–1.5 mm); sepals 0.4–0.9 mm in fruit (not 0.2–0.4 mm); styles shorter than fruit body (not ± equal fruit body); pedicel width ± equal fruit body width (not narrower). While lateral ridges of mericarp are 0.7–0.9 mm width in *Oe. incrassans*, it is 0.5–0.6 mm width in *Oe. pimpinelloides*. Stylopodium is conical and embedded along calyx line in both species (Fig. 7).

**Table 2.** Detailed comparison table of pollen features of *Oenanthe incrassans* and *Oe. pimpinelloides*.

	<i>Oenanthe incrassans</i> (EDG 2009)	<i>Oenanthe pimpinelloides</i> (EDG 2028)
Symmetry	Radial, isopolar	Radial, isopolar
Pollen shape (P/E)	Perprolate (P/E= 2.09)	Prolate (P/E= 1.89)
Equatorial outline	Elliptic	Elliptic
Ornamentation	Rugulate (equatorial area), perforate (polar area)	Rugulate(equatorial area), perforate (polar area)
Exine sculpturing	Subtectate	Subtectate
Polar Axis (P) (min-max)	43.2±0.41 mm (37 mm–47mm)	31.2±0.43 mm (26 mm–36 mm)
E1 = Equatorial Axis (wide side of polen) (min-max)	21.0±0.27 mm (15 mm–22.5 mm)	14.8±0.22 mm (12 mm–17 mm)
E0 = Equatorial Axis (center of pollen) (min-max)	20.6±0.26 mm (15.5 mm–22 mm)	16.5±0.24 mm (13 mm–19 mm)
E2 = Equatorial Axis (narrow side of polen) (min-max)	20.6±0.26 mm (15.5 mm–22 mm)	16.5±0.24 mm (13 mm–19 mm)
Clg = Colpus length (min-max)	33.9±0.44 mm (27 mm–36 mm)	24.3±0.41 mm (20 mm–29 mm)
Clt = Colpus width (min-max)	2.1±0.04 mm (1.5 mm–2.5 mm)	1.9±0.04 mm (1.5mm–2.5 mm)
Plg = Pore length (min-max)	5.3±0.12 mm (3 mm–6 mm)	4.9±0.10 mm (4 mm–6 mm)
Plt = Pore width (min-max)	5.0±0.07 mm (3 mm–6 mm)	4.9±0.12 mm (4 mm–7 mm)
Int-e = Intine equatorial (min-max)	1.1±0.01mm (1 mm–1.25 mm)	0.9±0.02 mm (0.75 mm–1 mm)
Int -p = Intine polar (min-max)	1.0±0.01 mm (1 mm–1.25 mm)	0.7±0.03 mm (0.50 mm–1 mm)
Ex-e = Exine equatorial (min-max)	1.1±0.02 mm (1 mm–1.25 mm)	0.9±0.02 mm (0.75 mm–1mm )
Ex-p = Exine polar (min-max)	1.0±0.01 mm (0.75 mm–1.25 mm)	0.7±0.03 mm (0.50mm–1mm)

**Figure 8.** Ornamentation and aperture of pollen by SEM: **a–b** *Oenanthe incrassans* (EDG 2009) **c–d** *Oe. pimpinelloides* (EDG 2043).

**Pollen morphology.** The pollen grains characters of *Oenanthe incrassans* and *Oe. pimpinelloides* are given in the Table 2 for the first time. Umbelliferae is a stenopalyinous family (Erdtman 1952). Cerceau- Larrival (1962) divided the pollen of Umbelliferae into 5 types based on P/E ratio: subrhomboidal (type 1, P/E: 1–1.5), sub-circular (type 2, P/E: 1–1.5), oval (type 3, P/E: 1.5–2), subrectangular (type 4, P/E: 2), and equatorially constricted (type 5, P/E: over 2). In the present study, pollen of *Oe. incrassans* is equatorially constricted (type 5, P/E: over 2) and *Oe. pimpinelloides* is oval (type 3, P/E: 1.5–2). According to Erdtman (1943), *Oe. incrassans* pollen grains are perprolate (P/E > 2), *Oe. pimpinelloides* pollen grains are prolate (P/E: 1.33–2.00). Table 2 shows that pollen size of two species are significantly different. Mature pollen grains of *Oe. incrassans* are longer than *Oe. pimpinelloides* (Table 1) (Fig. 8).

## Discussion

There are many studies about anatomical features of genera of Apiaceae (Liu 2003, Ashena 2014, Akalin Urusak 2013, Yilmaz 2013, Lyskov 2015) because the fruit morphology and anatomy are distinctive characters which frequently clarify the similarities and differences between species. Also a lot of research shows that pollen features of the members of Apiaceae help to distinguish at species (Hebda 1985, Doğan Güner 2011, Yilmaz 2013).

*Oenanthe pimpinelloides* shows wide distribution in the World and also in Turkey. The species has been recorded Aegean, Mediterranean, Thrace and Black Sea region in Turkey but not the East Anatolian region (Figure 2). Investigation of the collected specimens show that the plant has variable leaf characters. *Oe. pimpinelloides* not only prefers wetlands or marshy areas, but is also found on dry slopes or under the shade of trees. It has longer stems and leaves in wetlands than in dry habitats, but its inflorescence and fruit features remain unchanged throughout its range. On the other hand, *Oe. incrassans* only occurs in wet areas and it shows similar morphology all localities. Foley and Southam mentioned that morphological characteristics of *Oe. incrassans* were retained even in cultivation in England (Foley and Southam 2007). *Oe. incrassans* is placed in synonymy of *Oe. pimpinelloides* in Hedge and Lammond (1972) because these authors thought some characters such as the thick peduncle and rays of *Oe. incrassans* only reflected local variation of *Oe. pimpinelloides*. After collecting *Oe. incrassans* and a lot of specimens of *Oe. pimpinelloides* from different localities, and observing the differences outlined above (Table 1), we agree with treatment of Foley and Southam 2007 and recognize them as distinct species. Therefore, there are nine species *Oenanthe* species in Turkey.

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## Appendix

**Selected Specimens Examined.** *Oenanthe pimpinelloides*: **TURKEY. Edirne:** Keşan, Murat Köy Dam Lake, road sides, steppe, 90 m, 19 June 2014, 40°45'5.8"N / 26°45'5.6"E, ED. Güner 2047 & B. Bani (GAZI); **Kırklareli:** Demirköy, clearings forest, 628 m, 18 June 2014, 41°49'27.7"N / 41°46'35.3"E, ED. Güner 2043; ibid 03 August 2014 ED. Güner 2076 & B. Bani (GAZI); **Canakkale:** Biga –Kemer, 90 m, 19 June 2014, 40°24'43.3"N / 27°4'6.9"E, ED. Güner 2049 (GAZI); **Bolu:** Abant-Bolu, Akçaalan village, wet meadows, 918 m, 17 June 2014, 40°39'36.2"N/31°25'01.6"E, ED. Güner 2036 & B. Bani (GAZI); **Ordu:** Fatsa, clearings forest, level, 23 July 2014, ED. Güner 2073 (GAZI); **Rize:** Arşin - Rize, 22 m, 29 June 2014, 40°57'30.5"N / 39°57'11.2"E, ED. Güner 2063 (GAZI); **Muğla:** Çandır, meadows, 5–10 m, 1 June 2014, 36°49'46.0"N / 28°37'54.7"E, ED. Güner 2017 & B. Bani (GAZI).



# The rediscovery of the Great Winterberg endemic *Lotononis harveyi* B.–E.van Wyk after 147 years, and notes on the poorly known Amathole endemic *Macowania revoluta* Oliv. (southern Great Escarpment, South Africa)

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## Abstract

South Africa's 800 km-long southern Great Escarpment hosts numerous endemic plant species only known from their type specimens or from very few records. This is a legacy of a 100–150 year lag between the pioneer work of 19<sup>th</sup> century botanists and repeat fieldwork in the 21<sup>st</sup> century. As a result, population and ecological data are lacking for many local endemic species. Here we report on the rediscovery of *Lotononis harveyi* B.–E.van Wyk 147 years after its original description, and provide the first detailed ecological notes on the poorly known shrub *Macowania revoluta* Oliv. Both species are locally endemic to the Great Winterberg–Amatholes (Eastern Cape Province). With only six known individuals, *L. harveyi* is recommended the conservation status of Critically Endangered, with fire (and potentially grazing) being the main population constraints. *Macowania revoluta* is locally abundant, and it is surprising that it has been so poorly collected in recent decades. It occupies an important local niche as a keystone montane wetland species, and its narrow distribution range – combined with pressure from woody alien invasive species – suggests that its conservation status should be Rare. The research further highlights the need for continued biodiversity field research along South Africa's poorly explored Great Escarpment.

## Keywords

*Lotononis harveyi*, *Macowania revoluta*, Great Winterberg, Amatholes, endemic, rediscovery, fieldwork, Red Data status, Great Escarpment, South Africa, Eastern Cape

## Introduction

The ‘Cape Midlands Escarpment’ (comprising the Sneeuberg, Great Winterberg–Amatholes (GWA) and Stormberg, mostly in the Eastern Cape Province, South Africa) has been part of a southern Great Escarpment biodiversity research focus since 2005 (Clark 2010, Clark et al. 2009, 2014). Despite the numerous rediscoveries and species new to science (Goldblatt and Manning 2007, Nordenstam et al. 2009, Stirton et al. 2012, Boatwright and Manning 2013, Rourke et al. 2014, Clark et al. 2015), several endemic plant species only known from their type specimens have remained elusive, and the ecology of several others is still very poorly known. For instance, Clark et al. (2014) indicate that eight (23%) of the c.36 plant species endemic to the GWA are still only known from their type specimens.

Here we provide detailed notes on two of these poorly-known GWA endemics: *Lotononis harveyi* B.–E.van Wyk, rediscovered 147 years after its description in *Flora Capensis*, and first-time population and ecological data for *Macowania revoluta* Oliv., last reliably collected some 40 years ago.

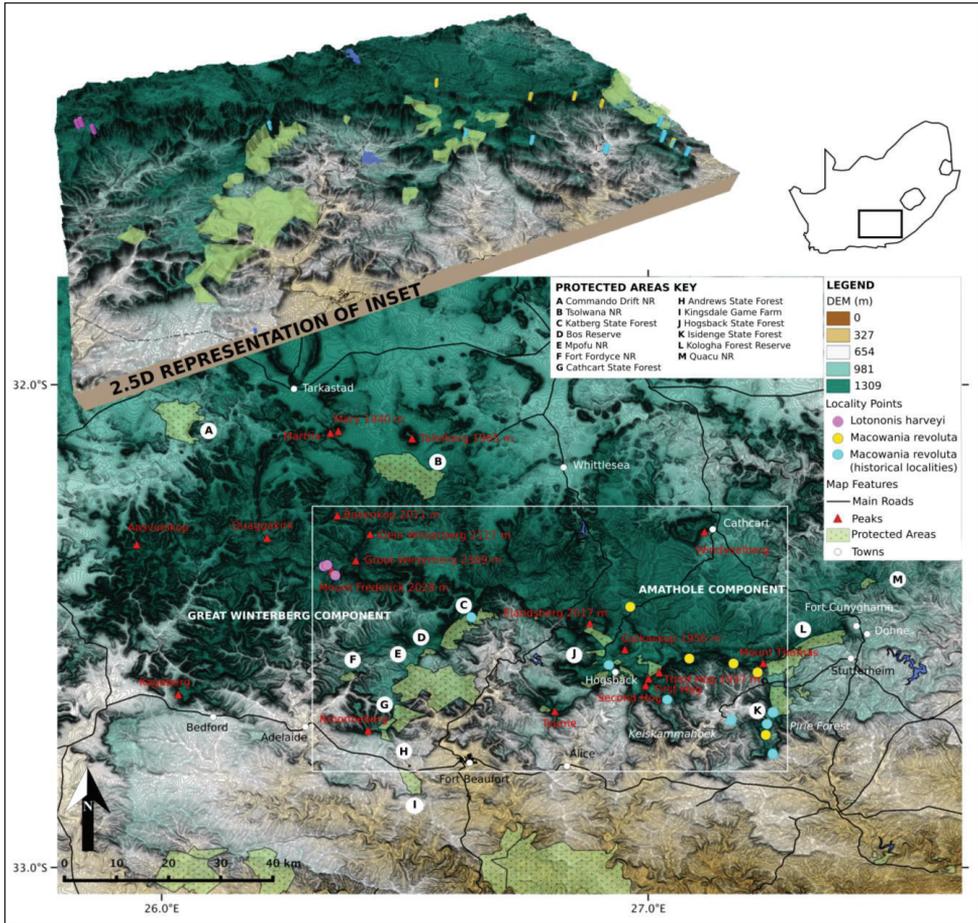
## Systematic

### *Lotononis harveyi* B.–E.van Wyk (Fabaceae)

Fig. 1; Plate 1

**Remarks.** Described by William Harvey in *Flora Capensis* as *Buchenroedera spicata* Harv. in 1862 (Harvey and Sonder 1862), this species was collected (without date) by Mrs Elizabeth Mary Barber sometime in the 1800s on the ‘Winterberg’. Three vouchers of this original material exist: one in the Bolus Herbarium (BOL), under her own initials; one in Kew (K) under F.W. Barber, her husband’s initials; and one in Trinity College Dublin Herbarium (TCD), also under her own initials. At the time of Van Wyk’s (1991) ‘*Synopsis of the genus Lotononis*’, this species was still only known from the type material. This remained the case when Clark et al. (2014) published their overview of plant diversity and endemism in the GWA.

Extensive fieldwork by VRC in the Great Winterberg in January 2009 for his PhD resulted in the first recollection of this species since its publication in *Flora Capensis*, although this was not realised at the time. The specimen (Clark VR, Pienaar C, Daniels R 316; GRA, NBG) was given the tentative identification *L. cf. viminea* (E.Mey.) B.–E.van Wyk until re-examination in 2014 suggested that it was in fact *L. harveyi*. A follow-up expedition to find more plants was undertaken on the 6<sup>th</sup> November 2014,



**Figure 1.** Localities of *Lotononis harveyi* B.-E.van Wyk and *Macowania revoluta* Oliv. in the Great Winterberg–Amatholes, Eastern Cape, South Africa. Cartography by J. Bentley.

based on the 2009 specimen having been in fruit in January 2009, as it was thought the plants might flower in November–December.

The 2009 site (hereafter Locality 1) was relocated without difficulty, and the search extended southwards down the 19<sup>th</sup> century wagon trail to the trigonometric beacon and eastwards to the edge of Paradise Kloof (part of the Fenella Falls gorge complex), covering approximately one square kilometre. Despite exploring the area carefully (in the plateau grassland and along the edge of the ravine, as well as in the fynbos and grassland on the steep slopes of the ravine) only six individual plants were found (three in flower, three not).

**Key characters confirming rediscovery.** The 2009 specimen was assigned to *L. harveyi* on the basis of the elongated racemes (therefore not *L. trichodes* (E.Mey.) B.-E. van Wyk, another local Great Winterberg endemic); the white flowers with densely hairy petals (based on the label information and a few remaining petals on the specimen, as the plant was mostly in pod); the long calyx lobes, hirsute leaves, and long

stipules (which match Van Wyk's 1991 figure 89 very well). The identification was confirmed by the November 2014 plants, especially by the white, hairy petals.

**Population assessment.** The plants at the three localities are described separately:

In 2009, two plants were found and collected at Locality 1, recorded as ca. 50 cm tall and with white flowers. This site occupies two square meters and is located on the two meter-wide 'middle man' between the 19<sup>th</sup> century wagon trail over the Great Winterberg and the current Finella Falls farm access road. In November 2014, at the same site, three plants were found. One was 45–50 cm tall, branched and in full flower. The other two were 15 cm and 5 cm tall respectively, both damaged on their main axes (probably being the two specimens collected in 2009, one lodged in the Selmar Schonland Herbarium, GRA, and a duplicate to the Compton Herbarium, NBG) but shooting side branches; neither were flowering. Locality 2, situated on the western lip of Paradise Kloof, comprised one plant 15 cm tall, in flower. Locality 3, only a little further back from Locality 2, contained two plants: one 30 cm tall, in flower, the other 20 cm tall, not in flower.

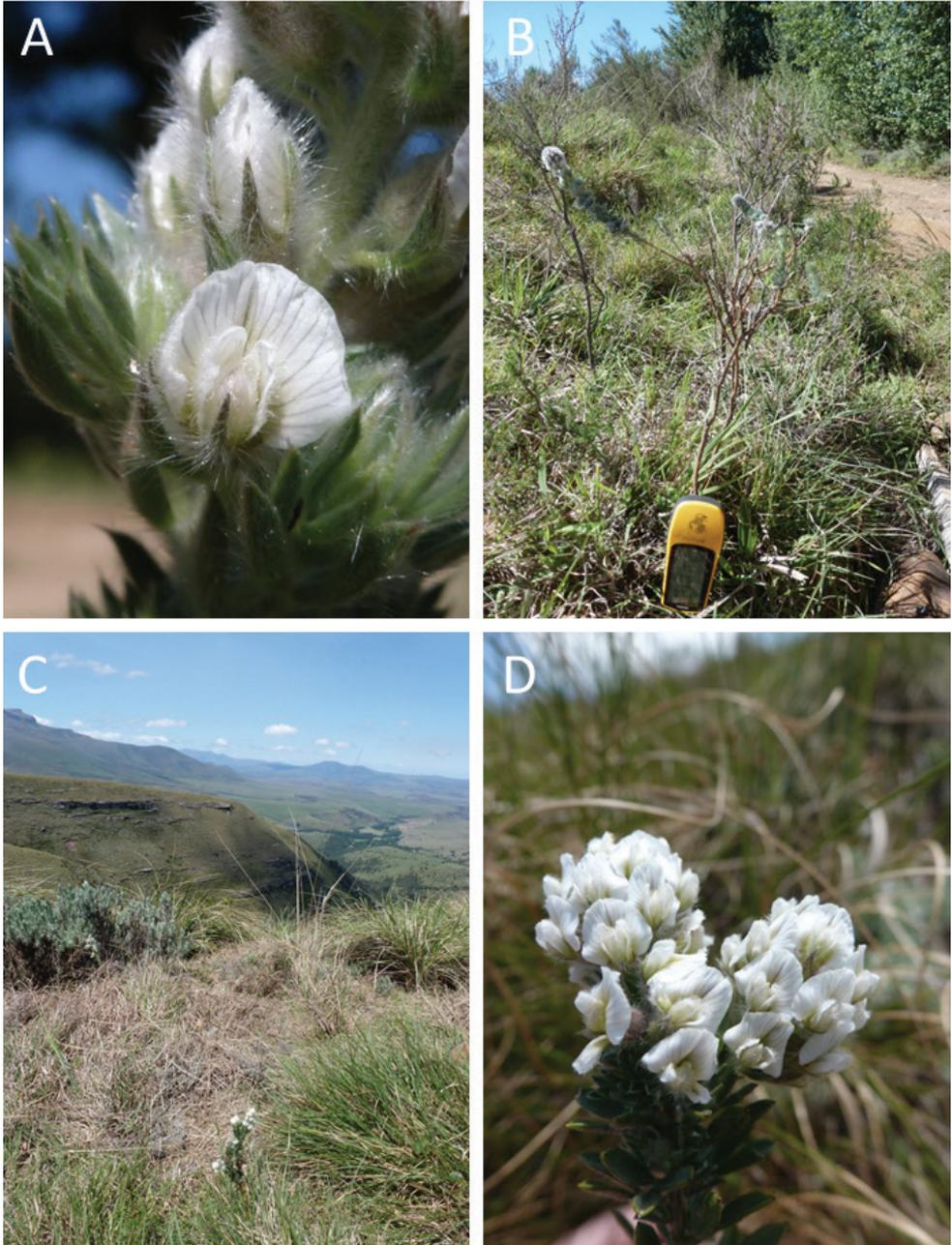
**Habit and ecology.** Van Wyk (1991) indicated that the habit of *L. harveyi* was not known. From the recent collections it can now be stated that it is an erect to spreading woody shrublet 20–50 cm tall, comparing well with Mrs Barber's notes on her TCD voucher: '*about a foot and a half high – slender with very few branches – perennial*'. As was postulated by Van Wyk (1991), it is indeed distinct from the prostrate habit of *L. trichodes*. Mrs Barber notes on her TCD voucher '*blossoms in autumn*', and as we found the species in full bloom in November, *L. harveyi* perhaps flowers in sync with the bimodal rainfall regime dominant in this area, i.e. early and late summer (Mucina and Rutherford 2006).

If the two smaller plants recorded in November 2014 at Locality 1 are indeed the survivors of the two 2009 vouchers, their limited growth since then suggests that the species grows extremely slowly, and this may partly account for its apparent rarity. In contrast, it is surprising that there is no obvious evidence of recruitment despite the floribund inflorescences.

**Habitat.** Generally speaking, *L. harveyi* occurs in Amathole Montane Grassland (Mucina and Rutherford 2006). The habitat conditions at each locality are discussed separately to identify common ecological factors which may account for this species' apparent rarity.

Locality 1 consists of a very small area of moribund *Themeda triandra* Forssk. grassland. Other species present in this area are *Cliffortia* sp. (50–60 cm tall), *Luzula africana* Drège ex Steud. and *Fingerhuthia sesleriiformis* Nees. The remainder of the road reserve comprises the invasive tree *Populus × canescens* (Aiton) Sm.. The soil is deep and clayey. No plants were evident in the grassland on either side of the road reserve: these grasslands comprise well-gazed *Themeda triandra* grassland studded with tall *Festuca costata* Nees tussocks. The gradients are gentle, soils deep and rich, there is limited rockiness, and the grass is probably burnt on a regular basis to limit the spread of the unpalatable *Festuca costata*.

Locality 2 comprised (prior to burning) *Tenaxia disticha* (Nees) N.P.Barker & H.P.Linder (= *Merxmuellera disticha* (Nees) Conert)–*Themeda triandra*–*Festuca costata* grassland with the fynbos elements *Erica leucopelta* Tausch, *Searsia rosmarinifolia* (Vahl)



**Plate I.** The first ever photographs of the Great Winterberg–Amatholes endemic *Lotononis harveyi* B.–E. van Wyk **A** flower detail (*Clark VR, Bentley L 9*) **B** habit (*Clark VR, Bentley L 9*; the Garmin GPS indicates scale) **C** montane grassland habitat, with *L. harveyi* in the middle foreground (*Clark VR, Bentley L 11*) **D** complete and open inflorescences (*Clark VR, Bentley L 12*). Photographs by V.R. Clark.

F.A. Barkley, and shrubs/trailers such as *Rubus ludwigii* Eckl. & Zeyh. subsp. *ludwigii* and *R. rigidus* Sm.. The edge of the plateau comprises rocky sandstone outcrops favoured by the fynbos elements, while away from this the soil is a deeper, loamy clay.

Locality 3 comprises moribund *Tenaxia disticha*–*Themeda triandra*–*Festuca costata* veld with scattered *Arrowsmithia styphelioides* DC. dwarf shrublets and *Helichrysum splendidum* (Thunb.) Less.. Fire has evidently been absent for some time.

Mrs Barber's TCD voucher notes that her specimens grew 'amongst the rocks and long grass' and in 'good soil'. This – together with the six plants all being found in fire-exclusion areas or moribund grassland – suggests that the species is susceptible to fire and possibly grazing pressure. There is no currently no indication on whether this species is a resprouter or a reseeder, and research into the autecology of this species is warranted.

**Conservation status and threats.** *Lotononis harveyi* is currently listed as Data Deficient (Victor and Dold 2005). Based on our observations we suggest that it be considered 'Critically Endangered' until more surveys in the general area are carried out. Currently virtually nothing about its biology is known, and accordingly no concrete conservation recommendations can be made. Possible general threats are the over-use of fire (a fire management history of the relevant farms can probably be obtained to indicate fire frequency), although fire has been a natural part of the ecology of these mountains well prior to the discovery of this species.

The general area is vulnerable to invasion by *Rosa rubiginosa* L. (a fast-emerging invader, with several seen in Localities 1 & 3) and *Pinus patula* Schtdl. & Cham. (Locality 2), while Locality 1 is in danger of being overrun by *Populus × canescens*. The targeting of mountain environments for wind farms in South Africa is another concern, with potentially detrimental impacts on localised endemics such as *L. harveyi*.

**Areas for further exploration.** A more exhaustive search along the rugged, extensive rocky rims of the Fenella Gorge area and perhaps on the (still unexplored) slopes of Mount Frederick and Besterskop (the promontory below the main Great Winterberg peak) and the scarp slopes below The Ruitjies might produce more plants. In fact, much of this area has still to be explored botanically, particularly from Mount Frederick–Besterskop eastwards along the scarp below The Ruitjies. The relevant localities/properties are summarised as follows (taken from 1:50 000 sheet 3226AD Spring Valley): Finella Falls 1 (parts of this farm were well surveyed in 2009, but there are extensive rocky areas not yet explored); the scarp margins on the Bosch River Spruit 26; Petraea 2 (being the south-western slopes of Mount Frederick and Besterskop); Oribi Fountains 3 (also being the south-eastern slopes of Mount Frederick and Besterskop, as well as the south-facing scarp of The Ruitjies); and those portions of Emerald Hill 26 and adjacent farms that comprise the 'Groenberg'.

**Collections and localities.** South Africa, Eastern Cape Province, 3226AD, Farm Emerald Hill 26, Great Winterberg (Adelaide): grassland in road reserve on farm track towards Fenella Falls. 32°22'34"S, 26°20'28"E, 1616 m, 23 January 2009. *Clark VR, Pienaar C, Daniels R 316* (GRA, NBG) (=Locality 1).

—Eastern Cape Province, 3226AD, Farm Emerald Hill 26, Great Winterberg (Adelaide): grassland in road reserve on farm track towards Fenella Falls. 32°22'25"S,

26°20'24"E, 1649 m, 6 November 2014. *Clark VR, Bentley L 9* (=Locality 1; the same population as above, but the 2009 GPS and altitude were a generic reading taken for plant collections along the entire road, and are not as accurate as these provided here. Only photographs were taken of these plants).

—Eastern Cape Province, 3226AD, Farm Bosch River Spruit 26, Great Winterberg (Adelaide): plateau grassland. 32°23'42"S, 26°21'04"E, 1616 m, 6 November 2014. *Clark VR, Bentley L 11* (GRA) (=Locality 2; only this plant was collected as a voucher specimen, as the landowner indicated that this area was to be burnt the following day).

—Eastern Cape Province, 3226AD, Farm Emerald Hill 26, Great Winterberg (Adelaide): moribund grassland on the plateau. 32°23'42"S, 26°21'04"E, 1619 m, 6 November 2014. *Clark VR, Bentley L 12* (=Locality 3; only photographs were taken of these plants).

### ***Macowania revoluta* Oliv. (Asteraceae)**

Fig. 1; Plate 2

**Remarks.** *Macowania revoluta*, the type species of *Macowania*, was first collected by Peter MacOwan in the eastern part of the Amatholes sometime prior to 1870 and described by Daniel Oliver in *Icones Plantarum* (Hooker 1867–1871). This almost exclusively southern African genus was later revised by Smith (1927). Relatively few collections of *M. revoluta* exist (most specimens being repeat collections by a few historical collectors, see below). Raimondo (2008) indicates that this species had not been re-collected since before 1949, although herbarium investigations by JB indicate that there is one collection from 1976 (albeit with virtually no other data).

The first concrete records of this species' continued existence was a collection in July 2010 by JB and Nicola Bergh (Compton Herbarium) in the vicinity of Keiskammahoek (Locality 1 – the closest record to the type locality), followed by a second specimen in October 2010 by APD near the Madonna & Child Waterfall in Hogsback (Locality 2). Following this, in December 2014, the species was found by VRC to be abundant in the central Amathole mountains along the Amatola Hiking Trail (Localities 3–5). In March 2015 another plant was recorded by VZ from Isidenge State Forest on the road to Evelyn Hut (one of the overnight huts on the Amatola Hiking Trail; Locality 6).

**Key characters confirming rediscovery.** The plant is typically an erect, candelabra-like shrub 50 cm to three metres tall, but often lax and weedy when small. The leaves are distinctly linear, dark green, sticky glandular and sweetly aromatic with strongly revolute margins (hence its specific name) and a raised abaxial midrib. Both disc and ray florets are yellow, with the ray floret petals rounded upwards. The involucre is bell-shaped with distinctly long bracts; the margins are strikingly dark-brown.

Another species endemic to the GWA, *Arrowsmithia styphelioides* – earlier believed by Hilliard and Burtt (1985) to be closely affiliated to *Macowania* – has since been



**Plate 2.** The poorly known Great Winterberg–Amatholes endemic *Macowania revoluta* Oliv. **A** a capitulum showing the distinctive dark involucre bract margins (*Bentley J 1*) **B** shrubby, candelabra growth-habit (above Wolf River Main Forest along the Amathole Hiking Trail, specimen not collected) **C** detail of flowering stem (*Bentley J 1*) **D** young plant showing ruderal tendencies (*Clark VR 451*). Photographs by C. McKune (**A**), V.R. Clark (**B, D**) and N. Bergh (**C**).

found by recent phylogenetic analysis to be nested within *Macowania*, as sister to *M. revoluta* (Bentley et al. 2014; the taxonomic revision is currently in progress). *Arrow-smithia styphelioides* differs in its sharply acuminate, ovate leaves, absence of the raised abaxial midrib, as well as in several features of the reproductive organs. Otherwise, no

other *Macowania* species are currently known from the GWA (Clark et al. 2014), with the next closest known population of another species (*M. pulvinaris* N.E.Br.) being on the Andriesberg, 115 km to the north.

**Population assessment.** At Locality 1, *M. revoluta* was found to be locally abundant, with plants in excess of one meter in height and forming the dominant species. Only one plant was noted at Locality 2, growing on the edges of a derelict *Pinus patula* plantation and *Acacia mearnsii* De Wild. invasions. Locality 3 contained about 20 plants, 0.5–1 m tall, with two in flower and many others in seed. Locality 4 comprised a large colony (ca. 50 m × 100 m in extent) with *M. revoluta* (1–3 m tall) forming the dominant species; many were in flower. Locality 5 consisted of a dense but small colony (1–3 m tall) covering ca. 50 m × 10 m; also with many in flower. Only one plant was located at Locality 6, and was not in flower.

**Habitat and ecology.** Based on the information on the type material, Clark et al. (2014) suggested that this species should be looked for along forest edge and in adjacent grassland. This was a good deduction, as the plants form dense colonies on wet scarp slopes, on cliff-tops, on the margins of indigenous forests, and on the edges of pine plantations and alien thickets. *Macowania revoluta* generally prefers wet areas, and can form the dominant component of mountain fynbos in suitable habitat, co-occurring with various Cyperaceae, *Erica* species, *Pelargonium cordifolium* (Cav.) Curtis, *Psoralea glabra* E.Mey., *Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum*, *Rubus rigidus* and *Widdringtonia nodiflora* (L.) Powrie.

**Conservation status and threats.** *Macowania revoluta* is currently listed as Data Deficient (Raimondo 2008), but is obviously much more common than previously thought. Despite the species' local abundance, its ruderal tendencies, and being somewhat tolerant of less dense alien vegetation, it is (mostly) known from one quarter degree grid on a small mountain range that is under severe pressure from woody alien invasive species (notably *Acacia dealbata* Link, *A. mearnsii*, *A. melanoxylon* R.Br. and *Pinus patula*). Furthermore, the potential impacts of climate change on this (and other local montane endemics) is currently unknown. Also, its response to fire (and autecology in general) is unknown and requires investigation. Accordingly we recommend the status 'Rare'.

**Recommended areas for further exploration.** *Macowania revoluta* potentially occurs anywhere along the wet southern scarp of the Amathole Mountains, between Katberg Pass and Stutterheim. So far it has not been recorded on the adjacent Great Winterberg.

**Historical collections and localities (a selection of these is mapped in Figure 1).** South Africa, Eastern Cape Province, 3227CA & 3227CD, Amathole Mountains (King Williams Town): rocky summit of Pirie Mountain, Buffelsrivier, Kaffraria (label detail differs among the duplicates). October 1887 (this date on the GRA specimen is a bit of an enigma, as it post-dates the species description). *Macowan P 2013* (BOL, E, GH, GRA, K, NYBG, P, PRE; type specimens).

—Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): summit of Pirie mountains, Kaffraria. 1200 m (4000'), October 1884. *Leighton (J?) 225* (GRA, NBG, PRE).

- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): summit of Mount Pirie. May 1887. *Tyson W 2935* (PRE).
- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): Perie (=Pirie), Kaffraria. August 1892. *Sim TR s.n.* (BOL).
- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): Pirie. 1200 m (4000'), September 1892. *Sim TR 3283* (NU).
- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): Summit of Perie (=Pirie). 900 m (3000'), November 1893. *Flanagan HG 2144* (GRA, BOL).
- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): Summit of Perie (=Pirie) mountains. 11<sup>th</sup> September 1901. *Galpin EE 5930* (PRE).
- Eastern Cape Province, 3226DB, Amathole Mountains (Victoria East): Hogsback, common in scrub. January 1920. *Ratray G 304* (GRA).
- Eastern Cape Province, 3227CA, Amathole Mountains (Keiskammahoek): Wolf River Plateau, forest margins in scrub. 29<sup>th</sup> October 1921. *Stayner FJ 28* (GRA, PRE).
- Eastern Cape Province, 3226DB, Amathole Mountains (Cathcart): Hogsback. September 1925. *Pole Evans IB 1748* (PRE).
- Eastern Cape Province, 3226DB, Amathole Mountains (Stockenstrom): hillside above forest at Hogsback. 28<sup>th</sup> October 1946. *Esterhuysen E 13,249* (BOL).
- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): Wolf Ridge, Hogsback. 1200 m (4000'), 10<sup>th</sup> September 1947. *Storoy R 3119* (GRA, PRE).
- Eastern Cape Province, 3227CA, Amathole Mountains (Keiskammahoek): Wolf River Forest. 18<sup>th</sup> September 1947. *Dyer RA 104* (GRA).
- Eastern Cape Province, 3227CA, Amathole Mountains (Keiskammahoek): Gwili-Gwili Mountain, old military road to Evelyn Valley. 25<sup>th</sup> April 1949. *Storoy R 3797* (PRE).
- Eastern Cape Province, 3227CA, Amathole Mountains (Keiskammahoek): No details. 1976. *Gibbs Russell s.n.* (NU).
- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): summit of Mount Pirie. No date. *Macowan P 9053* (PRE).
- Eastern Cape Province, 3226BC, Katberg (Fort Beaufort): no details. No date. *Macowan P s.n.* (PRE).
- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): Pirie. November, no year. *Sim TR 1029* (PRE).
- Eastern Cape Province, 3227CA, Amathole Mountains (King Williams Town): Pirie. No date. *Sim TR 3130* (NU).

**Recent collections and localities.** South Africa, Eastern Cape Province, 3227CA, Amathole Mountains (Stutterheim): between isiDengi Forest Station and Evelyn Valley Forestry Station. 32°43'32"S, 27°14'30"E, 1208 m, 27<sup>th</sup> July 2010. *Bentley J 1 & 5* (NBG) (=Localities 1).

- Eastern Cape Province, 3226DB, Amathole Mountains (Cathcart): above Madonna & Child Waterfall, Hogsback, 32°36'27"S, 26°57'47"E, 1106 m, 7<sup>th</sup> October 2010. *Dold T 15,010* (GRA) (=Localities 2).

- Eastern Cape Province, 3227CA, Amathole Mountains (Stutterheim): about one kilometre from Dontsa Hut on the Amatola Hiking Trail (Day 2 from Maden Dam side): in an earth road drain on the edge of a pine plantation next to a forestry road. 32°35'46"S, 27°13'29"E, 948 m, 3<sup>rd</sup> December 2014. *Clark VR 450* (GRA) (=Localities 3).
- Eastern Cape Province, 3227CA, Amathole Mountains (Stutterheim): about five kilometres from Dontsa Hut towards Cata Hut on the Amatola Hiking Trail (Day 3 from Maden Dam side): montane fynbos and streams banks. 32°34'40"S, 27°10'31"E, 1371 m, 4<sup>th</sup> December 2014. *Clark VR 451* (GRA) (=Localities 4).
- Eastern Cape Province, 3227CA, Amathole Mountains (Stutterheim): along the Amatola Hiking Trail towards Zingcuka Hut (Day 5 from Maden Dam side): along a cliff top above Wolf River Main Forest. 32°34'03"S, 27°05'04"E, 1259 m, 6<sup>th</sup> December 2014 (=Localities 5; only photographs were taken, by VRC).
- Eastern Cape Province, 3227CA, Amathole Mountains (Stutterheim): from Isidenge State Forest on the road to Evelyn Hut. 32°43'29"S, 27°14'37"E, 1198 m, 15<sup>th</sup> April 2015. (=Localities 6; only photographs were taken, by VZ).

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