

An archipelago within an archipelago: A checklist of liverworts and hornworts of Kepulauan Sunda Kecil (Lesser Sunda Islands), Indonesia and Timor-Leste (East Timor)

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Abstract

The first ever liverwort and hornwort checklist is provided for the Kepulauan Sunda Kecil (Lesser Sunda Islands) of Indonesia and Timor-Leste (East Timor). We report 129 accepted taxa, 12 doubtful taxa and three rejected taxa previously reported for the Lesser Sunda Islands. The list is based on over 130 literature references, including monographs, regional studies, and molecular investigations. It is clear that bryophytes from this region have been overlooked historically, and under collected, compared to seed plants, birds, and other organisms, forming a remarkable gap in the flora of Indonesia. Publications dealing with liverworts of Lesser Sunda Islands are few and scattered. We predict that further fieldwork, in addition to collections unveiled from regional herbaria, will uncover a number of new records that remain to be reported, especially considering that regionally widespread species have been recorded elsewhere.

Keywords

Checklist, hornworts, Indonesia, Kepulauan Nusa Tenggara, Kepulauan Sunda Kecil, Lesser Sunda Islands, liverworts, Timor-Leste (East Timor)

Introduction

The Lesser Sunda Islands (**LSI**), known in Indonesia as Kepulauan Sunda Kecil, are an area covering a longitudinal distance of some 600 kilometres in the southeastern portion of Indonesia, extending between Java in the west and New Guinea in the east (Fig. 1). Lesser Sunda Islands include a multitude of islands, the major ones of which are Flores, Sumba, Sumbawa, and Timor. The region overlaps with two different countries; Indonesia, which includes four different provinces, i.e., Bali, West Nusa Tenggara, East Nusa Tenggara (including Western part of Timor island), and part of Moluccas (van Steenis-Kruseman and van Steenis 1950; Monk et al. 1997; Jepson and Whitaker 2002) and Timor-Leste (East Timor), which includes the eastern part of Timor island (Kusuma 2017). The Lesser Sunda Islands occur as two geologically distinct island chains termed the Inner and Outer Banda Arcs (Audley-Charles 2011). This archipelago also occurs at the heart of the complex crossroads of two continents, Asia and Australia, and two oceans, the Indian and Pacific (Monk et al. 1997). The Lesser Sunda Islands may act as ‘stepping stones’ for animals and plants dispersing between the Greater Sunda Shelf, i.e., the Malay Peninsula, Borneo, Sumatra, Java, and Bali, and the Sahul Shelf, i.e., New Guinea, Australia, and their land-bridge islands (Reilly 2016). Bordered to the west by the Greater Sunda Shelf and to the east by the Sahul Shelf, the Lesser Sunda Islands can be considered oceanic islands in the sense that they have never been connected by land to continental Asia or continental Australo-Papua.

The island chain of LSI comprises 5.2% of endemic species based on families treated in Flora Malesiana (van Welzen et al. 2005). Interestingly, the Indonesian part contains the highest percentages of endemic plants of Indonesia, i.e., 55% (Bappenas 2016). Some important and better-known endemic species in this ecoregion are the Komodo dragon (*Varanus komodoensis*), the largest lizard in the world and the iconic

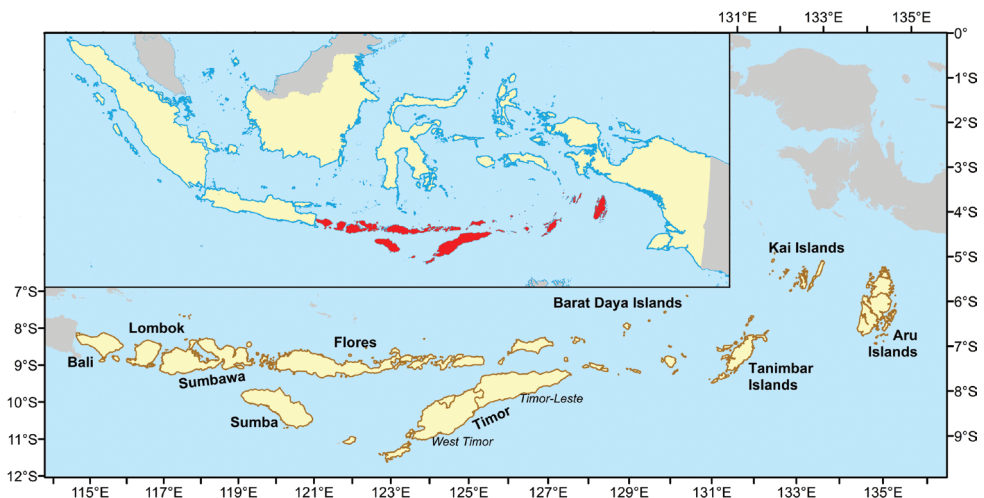


Figure 1. Map of Lesser Sunda Islands with an inset of Indonesia.

tree of East Nusa Tenggara Province, sandalwood tree (*Santalum album* L.), and *Dracaena multiflora* Warb. ex Sarasin (Monk et al. 1997).

The islands of LSI include seven ecoregions in two biomes, Tropical and Subtropical Moist Forests and Tropical and Subtropical Dry Forests (Fig. 2; Terrestrial Ecoregions of the World; Olson et al. 2001). The “Tropical and Subtropical Moist forest” includes two ecoregions on Bali, and two ecoregions on the eastern islands. The Eastern Java-Bali rainforest (<https://www.worldwildlife.org/ecoregions/im0113>) and Eastern Java-Bali Montane Rain Forest (<https://www.worldwildlife.org/ecoregions/im0112>) are situated on the Sunda shelf and both are classified as endangered ecoregions since a lot of forest has been cleared. It forms transitional vegetation types relative to the drier areas of the central islands situated on the Sahul shelf.

The “Tropical and Subtropical Dry forests” consist of three ecoregions from Lombok in the west to Timor and Wetar in the east. All three ecoregions are critically endangered/endangered. The largest of the ecoregions is “Lesser Sunda Deciduous Forests” (<https://www.worldwildlife.org/ecoregions/aa0201>) on Lombok, Sumbawa, Flores and west to Alor including smaller surrounding islands. It consists mainly of semi-evergreen dry forests. With an average annual rainfall of 1,349 mm, this is the driest area but also the most seasonal in Indonesia (Touw 1992). The “Sumba Deciduous Forest” (<https://www.worldwildlife.org/ecoregions/aa0203>) was also dominated by deciduous monsoon forest, but now much of it has been replaced by savanna and grasslands (Monk et al. 1997). The “Timor and Wetar Deciduous Forest” (<https://www.worldwildlife.org/ecoregions/aa0204>) is also largely deforested and replaced by grasslands and savanna.

Further east, two more ecoregions of “Tropical and Subtropical Moist Deciduous Forests” occur. The “Banda Sea Islands Moist Deciduous Forest” (<https://www.worldwildlife.org/ecoregions/aa0102>) includes all islands west of Timor/Wetar, except Aru Island. It includes evergreen rain forest (Kepulauan Kai), semi-evergreen rain forest, moist deciduous forest, and dry deciduous forest (Monk et al. 1997). The forests are still largely intact, but the ecoregion is still classified as vulnerable. The “Vogelkop-Aru Lowland

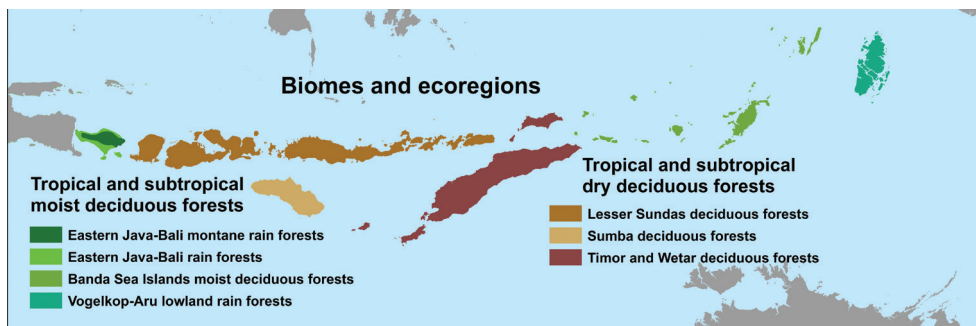


Figure 2. Seven ecoregions in two biomes of Lesser Sunda Islands following the Terrestrial Ecoregions of the World.

Rain Forest” (<https://www.worldwildlife.org/ecoregions/im0128>) is mostly confined to New Guinea but occurs also on Aru. Large parts of the ecoregion are still intact.

Bryophytes, including mosses, liverworts and hornworts, are the second largest group of land plants after flowering plants and are pivotal in our understanding of early land plant evolution (e.g., Ligrone et al. 2012; Zhang et al. 2020). Bryophytes play a significant ecological role including CO₂ exchange (De Lucia et al. 2003), plant succession (Cremer and Mount 1965), production and phytomass (Frahm 1990), nutrient cycling (Coxson 1992) and water retention (Pócs 1980; Gradstein et al. 2001). Retnowati et al. (2019) cited 849 species of liverworts, 28 species of hornworts and 1,884 species of mosses which are scattered in the major islands of Indonesia. As with many regions in the world, it is evident that the bryophyte, especially the liverwort flora, remains very poorly known in comparison to the vascular flora. Gradstein and Culmsee (2010) noted there are few studies from Southeast Asia investigating the diversity and ecology of tropical bryophytes.

It is clear that bryophytes from this region have been overlooked historically, and under-collected, compared to seed plants, birds, and other organisms, forming a remarkable gap in the flora of Indonesia and/or Timor-Leste. Publications dealing with liverworts of LSI also are few and scattered. The first apparent report of liverworts from LSI was by Sande Lacoste (1856) in the mid-19th century. It was not until the late 19th century and early 20th century that further influential works appeared, including those by Schiffner (1898, 1900, 1955), Stephani (1886, 1899, 1907, 1908, 1909, 1911, 1917, 1924), Verdoorn (1930, 1934a, 1934b, 1935, 1937), and others. Among those islands, Bali is the most explored island (Hegewald and van Zanten 1986; Eggers et al. 1998; Schäfer-Verwimp 2006, 2009; Haerida et al. 2010; Alam 2012; Heinrichs et al. 2012; Girmansyah et al. 2013) with 101 species accepted here. Söderström and Séneca (2008) reported only 61 number of liverworts for Lesser Sunda Islands and considered that this low number of species was the effect of the under-explored areas. More recently, little botanical work has been done in the area; the area has occasionally been visited by students and researchers from nearby institutions, but publications are still lacking. This checklist will complement the survey of mosses of Lesser Sunda Islands by Touw (1992) who enumerated 367 species for the area, and complement other checklists of liverworts from Indonesia, including Java (Söderström et al. 2010), Bali (Haerida 2015, 2017) as well as Sumba (Haerida et al. 2020).

We here present the first-ever checklist of liverworts and hornworts for the Lesser Sunda Islands to serve as the baseline information in our study of the liverworts diversity of this archipelago. Furthermore, this checklist can serve to promote and encourage bryological research in the region. The significance of checklists is summarized by Söderström et al. (2008), including outlining the utility of checklists as powerful and important tools, and their applicability to taxonomy, systematics, and conservation.

As with many other regions in the world, given the relatively poor focus on liverworts in LSI historically, we predict that a vast number of new records are yet to

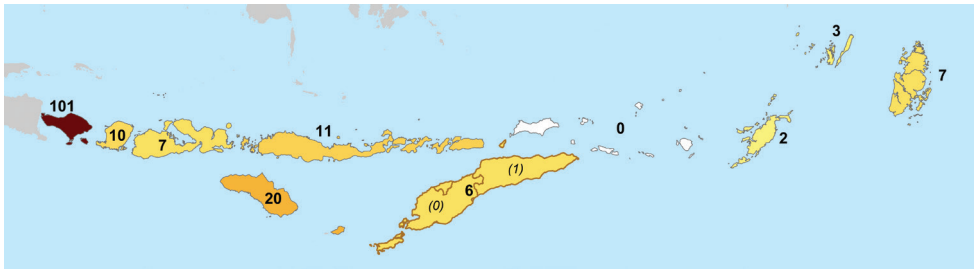


Figure 3. Number of known species from the individual islands. The darker the color, the greater the number of species.

be reported for the area. In this checklist we report 129 taxa, with another 12 taxa questioned and three rejected. The number of known species from individual islands varies from 101 (Bali) to 0 (Barat Daya Islands), but only Bali has more than 20 known species (Fig. 3).

Materials and methods

Nomenclature and taxonomy follows the world checklist of hornworts and liverworts (Söderström et al. 2016) with a few updates from recent taxonomic literature. Sources include over 130 publications found through the work of Early Land Plants Today (**ELPT**) database of liverwort taxonomy and distribution, and with some consultation with taxonomic experts. The checklist follows a similar format of previous liverwort and hornwort checklists by the authors, e.g., Java (Söderström et al. 2010). The checklist distinguishes between records that are based on specimens seen by the author(s) (reference in bold) and second-hand reports, e.g., citations of earlier publications (reference in normal type). All names used for the references are given after the taxon name with spelling variants/errors within quotation marks. Taxa are arranged in alphabetical order. Significantly, each accepted taxon is qualified using a four level ranking system that indicates our level of knowledge about a taxon. The coding convention is outlined in detail by von Konrat et al. (2010). Briefly, ? = Problem with the taxon name; * = Serious doubts about the value of the taxon; ** = Probably a good taxon (default value); *** = Accepted, a good taxon as currently understood.

This checklist covers the Lesser Sunda Islands based on reports from the literature that have been subdivided into 10 geographical units that correspond to geopolitical units. These include from west to east (Fig. 1) Bali, Lombok, Sumbawa, Sumba, Flores, Timor (separated in the Indonesian West Timor and the independent Timor-Leste), Barat Daya Islands, Tanimbar Islands, Kai Islands and Aru Islands.

Types from Lesser Sunda Islands

Recently, there has been some debate whether the type information by Bonner (1962, 1963, 1965), as well as the other volumes of his “Index Hepaticarum”, can be accepted as lectotypes. Renner (2021) argued in favour for the volumes of Bonner (1962, 1963, 1965), including recommendations to improve typification practice, and Engel and Merrill (2019) argued that Bonner’s herbarium designations do not represent lectotypifications. Here we accept the typifications made by Bonner as they pertain to the taxa treated here, but we also provide alternative typifications if ruled against. In the latter cases, we instead “validate” Bonner’s typifications, yet causing no nomenclatural changes whichever view is taken.

It is not always clear if more than one collection exists for a possible type. McNeill (2014) recommends that in such a case a lectotype should be selected from known available material, but with a statement that it may be the only material, in which case a lectotypification would be superfluous. For such cases, we here follow McNeill’s “best practice” advice using the suggested phrase “lectotype here designated, if not a holotype”.

Anastrophyllum integerrimum Steph., Sp. Hepat. (Stephani) 6: 107, 1917 (Stephani 1917). Originally described from “Java (Koorders leg), *Lombock*. (Elbert legit.)”. Lectotype (Bonner 1962): Java, 5000 pd., Koorders s.n. ex hb. Schinz, Zürich, G-00067196 (<http://www.ville-ge.ch/musinfo/bd/cjb/chg/adetail.php?id=118174&lang=en>). Specimen also annotated as “holotype” by J. Váňa in 1974. Note: If Bonner’s typification is rejected, we here designate the specimen as a new lectotype. The species was synonymized with *Gottschia schizopleura* by Grolle (1968).

Chiloscyphus communis Steph., Bull. Herb. Boissier (sér. 2) 7 (10): 839 [=Sp. Hepat. (Stephani) 3: 211], 1907 (Stephani 1907). Originally described from “Java, Sumatra, Celebes, Nova Guinea, Timor, Samoa, Andaman Insulae, Queensland, Assam, Sikkim, Japan, valde communis.”. Lectotype (Bonner 1963): Andamans, Port Blair, VIII.1890, E.H. Man, ex hb. Levier, G-00115054 (<http://www.ville-ge.ch/musinfo/bd/cjb/chg/adetail.php?id=165692&lang=en>). Specimen annotated as isotype by H. Inoue (undated). There are many specimens in G that Stephani may have seen, but apparently only this specimen corresponds to Bonner’s typification. The species was synonymized with *Chiloscyphus bescherellei* (= *Heteroscyphus coalitus*) by Hattori (1966).

Drepanolejeunea moluccensis Herzog, Ann. Bryol. 7: 88, 1934 (Herzog 1934). Originally described from “Molukken: Batjan, G. Sibella (Herb. H. B. Bog. n. 4103, leg. Roepke); Bali: Bratansee (Renner n. 331 ♀ u. ♂)”. Lectotype (here designated): Molukken, Batjan, G. Sibela, 1600–2000 m, W.K.J. Roepke s.n., JE-04002975 (<https://herbarium.univie.ac.at/database/detail.php?ID=120304>). Herzog noted “typus” on the specimen from Batjan while he noted “cotypus” on the specimen from Bali. The Bali material is issued in the exsiccatae “Hepaticae Selectae et Criticae (ed. Fr. Verdoorn) Ser. VIII (1965) 365” as “materia originalis” and should be present in several herbaria.

Fimbraria latifrons Steph., Sp. Hepat. (Stephani) 6: 15, 1917 (Stephani 1917). Originally described from “*Lombock*. (Sunda Archipelagus.) (Elbert legit.)”. Lectotype

(Long 2006: 227): [Indonesia] Lombok, Rindjani-Vulkangebirge, NNO Seite, Andjar Fluss, oberhalb; Monsun Hochwald, 1400–1530 m, humus Sand, 19.5.1909, J. Elbert 1388 (G-15225). Isolectotype: FH). [=G-00113144, <http://www.ville-ge.ch/musinfo/bd/cjb/chg/adetail.php?id=144318&lang=en>]. The species was synonymized with *Reboulia hemisphaerica* by Long (2006).

Frullania longispica Steph., Sp. Hepat. (Stephani) 4: 454, 1911 (Stephani 1911). Originally described from “Insula Timor”. Type (Bonner 1965): Timor, 1100 m, IX 1897, Francis Newton s.n., G. However, there are two specimens in G with those collection data, G barcode 00069224 and 00265585. The former is annotated by Verdoorn in 1928 as “typica, ... species auton. non est!” (<http://www.ville-ge.ch/musinfo/bd/cjb/chg/adetail.php?id=114964&lang=en>), the latter does not have any annotation. Verdoorn never published any typification of *Frullania longispica* but G00069224 is apparently the base for the synonymization with *Frullania squarrosa* in Verdoorn (1930) and is here designated as lectotype.

Lepidozia newtonii Steph., Sp. Hepat. (Stephani) 3: 623, 1909 (Stephani 1909). Originally described from “Insula Timor (Newton)”. Lectotype (here designated, if not holotype): Timor, 1100 m, Sept 1897, Francis Newton, Steph. herb. no. 126, G barcode 00069698 (<http://www.ville-ge.ch/musinfo/bd/cjb/chg/adetail.php?id=135054&lang=en>). There seems to be only one specimen in G that may be designated type, but we have not searched other herbaria and thus do not know if there are any possible type material elsewhere.

Madotheca elbertii Steph., Sp. Hepat. (Stephani) 6: 520, 1924 (Stephani 1924). Originally described from “India orientalis: Lombock (Elbert legit)”. Lectotype (Hattori 1969): Lombock, leg. leg. Dr. Elbert 2016, type of *Madotheca elbertii*, in herb. G (G barcode no. 00043932, <http://www.ville-ge.ch/musinfo/bd/cjb/chg/adetail.php?id=130660&lang=en>). The species was synonymized with *Porella acutifolia* var. *lancifolia* (= var. *acutifolia*) by Hattori (1976).

Mastigobryum sumbavense Steph., Hedwigia 25 (6): 236, 1886 (Stephani 1886). Originally described from “Insula Sumbawa, ad 4000’, Zollinger No. 3400b (Herb. Gottsche)”. Lectotype (Mizutani 1967, ‘type’): Insula Sumbawa, Montis Batu, Alt. 4000 ft., Lante ad arbores, Zollinger 3400b, Steph. herb. no. 10769, G barcode 00066907. If Mizutani’s type specification is rejected we here designate the mentioned specimen as new lectotype (if it is not a holotype).

List of accepted species and infraspecific taxa

Anthocerotophyta

Folioceros

*** *Folioceros fuciformis* (Mont.) D.C.Bharadwaj **BALI: Schiffner 1955** as *Aspiromitus falsinervius*.

Marchantiophyta

Acanthocoleus

- *** *Acanthocoleus javanicus* (Steph.) Kruijt. **BALI: Wilson et al. 2007; Heinrichs et al. 2012; Dong et al. 2013; Haerida 2017.**

Acrolejeunea

- *** *Acrolejeunea aulacophora* (Mont.) Steph. **LESSER SUNDA IS.: BALI: Hegewald and van Zanten 1986; Haerida 2017.**
- *** *Acrolejeunea fertilis* (Reinw., Blume et Nees) Schiffn. **BALI: Gradstein 1975; Wilson et al. 2004; Forrest et al. 2006; Wilson et al. 2007; Heinrichs et al. 2012; Czumay et al. 2013; Dong et al. 2013; Heinrichs et al. 2014a; Heinrichs et al. 2014b; Schäfer-Verwimp et al. 2014; Bechteler et al. 2016a; Bechteler et al. 2016b; Haerida 2017. TANIMBAR ISLANDS: Gradstein 1975. TIMOR: Gradstein 1975.**

Aneura

- *** *Aneura maxima* (Schiffn.) Steph. **BALI: Haerida 2017.**
- *** *Aneura pinguis* (L.) Dumort. **BALI: Haerida et al. 2015; Haerida 2017.**

Asterella

- *** *Asterella blumeana* (Nees) Kachroo **LOMBOK: Long 2006.**
- *** *Asterella vulcanica* (Schiffn.) Kachroo et Bapna **BALI: Haerida et al. 2015; Haerida 2017.**

Bazzania

- *** *Bazzania longicaulis* (Sande Lac.) Schiffn. **SUMBA: Haerida et al. 2020.**
- * ¹ *Bazzania sumbavensis* (Gottsche ex Steph.) Steph. **SUMBAWA: LECTOTYPE of *Mastigobryum sumbavense*, Stephani 1886 as *Mastigobryum sumbavense*, Schiffner 1898; Stephani 1908 as *Mastigobryum sumbavense*, Bonner 1963; Grolle 1966; Mizutani 1967; Tixier 1974; Kamimura 1975; Miller et al. 1983; Miller et al. 1983 as *Mastigobryum sumbavense*, Geissler and Bischler 1985 as *Mastigobryum sumbavense*, Long and Grolle 1990; Sharma and Srivastava 1993; Bapna and Kachroo 2000.**

1 *Bazzania sumbavensis* is possibly conspecific with *Bazzania japonica* (Söderström et al. 2010).

Cheilolejeunea

- ** *Cheilolejeunea ceylanica* (Gottsche) R.M.Schust. et Kachroo **SUMBA: Haerida et al. 2020.**
- *** *Cheilolejeunea trapezia* (Nees) Kachroo et R.M.Schust. **BALI: Haerida 2017. SUMBA: Haerida et al. 2020.**

Chiastocaulon

- *** *Chiastocaulon dendroides* (Nees) Carl. **BALI: So 2001** as *Plagiochila dendroides*.
- *** *Chiastocaulon oppositum* (Reinw., Blume et Nees) S.D.F.Patzak, M.A.M.Renner, Schäf.-Verw. et Heinrichs. **LESSER SUNDA Is.: Pócs et al. 2011** as *Plagiochilion oppositum*. **BALI: Hegewald and van Zanten 1986** as *Plagiochilion oppositum*, **Groth and Heinrichs 2005** as *Plagiochilion oppositum*, Haerida et al. 2015 as *Plagiochilion oppositum*, **Patzak et al. 2016; Renner et al. 2016; Haerida 2017; Renner et al. 2017.** **SUMBAWA: Sande Lacoste 1864** as *Plagiochila opposita*, **Schiffner 1898** as *Plagiochila opposita*, Miller et al. 1983 as *Plagiochilion oppositum*.

Cololejeunea

- *** *Cololejeunea angustiflora* (Steph.) Mizut. **BALI: Haerida 2017.**
- *** *Cololejeunea appressa* (A.Evans) Benedix. **BALI: Haerida 2017.**
- ** *Cololejeunea gottschei* (Steph.) Pandé, K.P.Srivast. et Ahmad **BALI: Haerida 2017.**
- *** *Cololejeunea macounii* (Spruce) A.Evans **BALI: Haerida 2017.**
- *** *Cololejeunea obliqua* (Nees et Mont.) Schiffn. **BALI: Benedix 1953** as *Cololejeunea nymannii*, Tixier 1962 as *Cololejeunea nymannii*, Tixier 1973 as *Cololejeunea nymannii*, Miller et al. 1983 as *Cololejeunea nymannii*.
- *** *Cololejeunea ocelloides* (Horik.) Mizut. **BALI: Tixier 1962** as *Cololejeunea leonidensis* var. *saccata*.
- ** *Cololejeunea subfloccosa* Mizut. **BALI: Haerida 2017.**
- ** *Cololejeunea triapiculata* (Herzog) Tixier **BALI: Haerida 2017.**
- *** *Cololejeunea trichomanis* (Gottsche) Besch. **BALI: Haerida 2017** as *Cololejeunea goebelii*.

Colura

- ** ² *Colura leratii* (Steph.) Steph. **BALI: Eggers et al. 1998; Haerida 2017. FLORES: Jovet-Ast 1967** as *Colura apiculata*, Eggers et al. 1998.

2 *Colura leratii* was omitted in Söderström et al. (2016) as the basionym was erroneously considered invalid.

Diplasiolejeunea

- *** *Diplasiolejeunea cavifolia* Steph. **BALI: Schäfer-Verwimp 2006³; Haerida 2017; Siregar et al. 2020.**

Drepanolejeunea

- *** *Drepanolejeunea levicornua* Steph. **SUMBA: Haerida et al. 2020.**
 ** *Drepanolejeunea moluccensis* Herzog. **BALI: SYNTYPE, Herzog 1934; Verdoorn 1935; Tixier 1979.**
 *** *Drepanolejeunea pentadactyla* (Mont.) Steph. **BALI: Haerida 2017.**

Dumortiera

- *** *Dumortiera hirsuta* (Sw.) Nees **BALI: Haerida et al. 2015; Haerida 2017.**

Fossombronina

- *** *Fossombronina himalayensis* Kashyap. **BALI: Krayesky et al. 2005.**

Frullania

- ** *Frullania apiculata* (Reinw., Blume et Nees) Nees **SUMBA: Haerida et al. 2020.**
 *** *Frullania ericoides* (Nees) Mont. **BALI: Hegewald and van Zanten 1986; Haerida 2017. LOMBOK: Verdoorn 1934b as *Frullania squarrosa*. TIMOR: TYPE of *Frullania longispica*, Stephani 1911 as *Frullania longispica*, Bonner 1965 as *Frullania longispica*.**
 *** *Frullania gaudichaudii* (Nees et Mont.) Nees et Mont. **BALI: Haerida 2015; Haerida 2017.**
 *** *Frullania gracilis* (Reinw., Blume et Nees) Nees **BALI: Haerida 2015; Haerida 2017; Rosyanti et al. 2018.**
 ** *Frullania intermedia* (Reinw., Blume et Nees) Nees subsp. *intermedia*. **ARU ISLANDS: Hattori 1980.**
 *** *Frullania junghuhniana* Gottsche. **BALI: Haerida 2015; Haerida 2017.**
 *** *Frullania meyeniana* Lindenb. **BALI: Haerida 2015; Haerida 2017; Rosyanti et al. 2018.**

3 The collecting data for the report of *Diplasiolejeunea cavifolia* in Schäfer-Verwimp (2006) is “Nord-bali, Distr. Tabanan, Bedugul, Aufstieg im Nebelwald zum Gunung Catur am Bratansee, epiphyll an *Pandanus* sp.; 1260 m, 30. Mai 1995, leg. Schäfer-Verwimp & Verwimp, det. Schäfer-Verwimp (Hb Schäfer-Verwimp No. 16750)” (A. Schäfer-Verwimp in litt. 2021).

- ***⁴ *Frullania moniliata* (Reinw., Blume et Nees) Mont. **BALI: Haerida 2015; Haerida 2017. SUMBA: Haerida et al. 2020. SUMBAWA: Sande Lacoste 1856; Schiffner 1898; Verdoorn 1930 as *Frullania moniliata* subsp. *breviramea*, Hattori 1975 as *Frullania tamarisci* var. *breviramea*.**
- *** *Frullania nodulosa* (Reinw., Blume et Nees) Nees **ARU ISLANDS: Mitten 1885 as *Frullania secundiflora*, Schiffner 1898 as *Frullania secundiflora*. FLORES: Hattori 1975. KAI ISLANDS: Mitten 1885 as *Frullania secundiflora*, Schiffner 1898 as *Frullania secundiflora*, Miller et al. 1983. SUMBA: Verdoorn 1930; Haerida et al. 2020. SUMBAWA⁵: Hattori 1951; Swanson and Miller 1969; Miller et al. 1983. TANIMBAR ISLANDS: Hattori 1980 as *Frullania nodulosa* var. *nodulosa*. TIMOR: Hattori 1980 as *Frullania nodulosa* var. *nodulosa*.**
- *** *Frullania ornithocephala* (Reinw., Blume et Nees) Nees **BALI: Haerida 2015; Haerida 2017. LOMBOK: Verdoorn 1934b.**
- *** *Frullania rio-janeirensis* (Raddi) Ångstr. **BALI: Hegewald and van Zanten 1986; Enroth 1991 as *Frullania africana*, Haerida 2017.**
- *** *Frullania serrata* Gottsche **LOMBOK: Verdoorn 1934b.**
- *** *Frullania ternatensis* Gottsche **BALI: Haerida 2015; Haerida 2017.**
- ** — var. *non-appendiculata* S.Hatt. **BALI: Hegewald and van Zanten 1986.**
- *⁶ *Frullania tricarinata* Sande Lac. **BALI: Hegewald and van Zanten 1986 as *Frullania 'tricarinata'*, Haerida 2017; Winter and Schäfer-Verwimp 2020.**
- *** *Frullania trichodes* Mitt. **KAI ISLANDS: Verdoorn 1937 as *Frullania tenuicaulis*.**

Gottschelia

- *** *Gottschelia schizopleura* (Spruce) Grolle **LESSER SUNDA Is.: Vána and Piippo 1989b; Vána 1991b. LOMBOK: SYNTYPE of *Anastrophyllum integerrimum*, Stephani 1917 as *Anastrophyllum integerrimum*, Bonner 1962 as *Anastrophyllum integerrimum*, Grolle 1968; Miller et al. 1983 as *Anastrophyllum integerrimum*.**

Herbertus

- ** *Herbertus ceylanicus* (Steph.) Abeyw. **FLORES: Juslén 2006.**
- *** *Herbertus dicranus* (Gottsche, Lindenb. et Nees) Trevis. **BALI: Juslén 2006; Vána et al. 2014.**
- ** *Herbertus longispinus* J.B.Jack et Steph. **FLORES: Juslén 2006.**
- ** *Herbertus ramosus* (Steph.) H.A.Mill. **BALI: Hegewald and van Zanten 1986; Haerida 2017.**

⁴ *Frullania moniliata* is a species complex (Vilnet et al. 2014) in sect. *Thyopsiella*.

⁵ We do not know of any first hand report of *Frullania nodulosa* from Sumbawa.

⁶ *Frullania tricarinata* is possibly conspecific with *Frullania hypoleuca* (Söderström et al. 2010).

- *** *Herbertus sendtneri* (Nees) Lindb. **LESSER SUNDA Is.: Juslén 2006** as *Herbertus armitanus*.

Heteroscyphus

- *** *Heteroscyphus argutus* (Reinw., Blume et Nees) Schiffn. **ARU ISLANDS: Mitten 1885** as *Chiloscyphus argutus*, **Schiffner 1898** as *Chiloscyphus argutus*. **BALI: Haerida et al. 2015; Haerida 2017.**
- *** *Heteroscyphus aselliformis* (Reinw., Blume et Nees) Schiffn. **BALI: Haerida 2017. SUMBAWA: Zollinger 1855** as *Chiloscyphus aselliformis*, **Sande Lacoste 1856** as *Chiloscyphus aselliformis*, **Schiffner 1898** as *Chiloscyphus aselliformis*, Schiffner 1900 as *Chiloscyphus aselliformis*, Miller et al. 1983; Piippo 1985; Piippo 1989b; Yamada and Hayashi 2003.
- *** *Heteroscyphus coalitus* (Hook.) Schiffn. **BALI: Hegewald and van Zanten 1986** as *Chiloscyphus coalitus*, Srivastava and Srivastava 2002; Haerida et al. 2015; **Haerida 2017. SUMBA: Haerida et al. 2020. TIMOR: SYNTYPE** of *Chiloscyphus communis*, Stephani 1907 as *Chiloscyphus communis*, Hattori 1951 as *Heteroscyphus communis*, Miller 1968 as *Chiloscyphus communis*, Swanson and Miller 1969 as *Chiloscyphus communis*, Piippo 1993. **TIMOR-LESTE: Piippo 1985; Piippo 1989b.**
- *** *Heteroscyphus splendens* (Lehm. et Lindenb.) Grolle **SUMBA⁷: Miller et al. 1983** as *Heteroscyphus decurrens*. **SUMBAWA: Zollinger 1855** as *Chiloscyphus decurrens*, **Sande Lacoste 1856** as *Chiloscyphus decurrens*, **Schiffner 1898** as *Chiloscyphus decurrens*, Pócs 1971 as *Heteroscyphus decurrens*.

Jackiella

- *** *Jackiella javanica* Schiffn. **BALI: Haerida 2017.**

Lejeunea

- *** *Lejeunea alata* Gottsche **SUMBA: Haerida et al. 2020.**
- *** *Lejeunea apiculata* Sande Lac. **BALI: Haerida 2017.**
- *** *Lejeunea mimula* Hürl. **BALI: Wilson et al. 2004; Gradstein et al. 2006; Wilson et al. 2007; Heinrichs et al. 2012; Czumay et al. 2013; Dong et al. 2013; Heinrichs et al. 2014a; Heinrichs et al. 2014b; Haerida 2017.**

Lepidozia

- * *Lepidozia newtonii* Steph. **TIMOR: TYPE, Stephani 1909.**

⁷ We do not know of any first hand report of *Heteroscyphus splendens* from Sumba. It may be an error for Sumbawa.

Leptolejeunea

- *** *Leptolejeunea elliptica* (Lehm. et Lindenb.) Besch. **SUMBA: Haerida et al. 2020.**
- *** *Leptolejeunea epiphylla* (Mitt.) Steph. **BALI: Haerida 2017.**
- ** *Leptolejeunea foliicola* Steph. **BALI: Eggers et al. 1998; Bechteler et al. 2016c; Haerida 2017; Shu and Zhu 2019.**
- * *Leptolejeunea massartiana* Schiffn. ex Herzog **BALI: Eggers et al. 1998; Haerida 2017.**
- *** *Leptolejeunea subacuta* Steph. ex A.Evans **BALI: Haerida 2017.**

Lopholejeunea

- *** *Lopholejeunea eulopha* (Taylor) Schiffn. **BALI: Zhu and Gradstein 2005; Haerida et al. 2010; Haerida 2017; Siregar et al. 2020.**
- *** *Lopholejeunea horticola* Schiffn. **BALI: Zhu and Gradstein 2005; Haerida et al. 2010; Siregar et al. 2014; Siregar 2015; Pócs and Chantanaorrapint 2016; Haerida 2017.**
- *** *Lopholejeunea nigricans* (Lindenb.) Schiffn. **BALI: Haerida 2017. SUMBA: Haerida et al. 2020.**
- *** *Lopholejeunea recurvata* Mizut. **BALI: Zhu and Gradstein 2005; Haerida et al. 2010; Haerida 2017.**
- *** *Lopholejeunea subfusca* (Nees) Schiffn. **LESSER SUNDA IS.: Pócs et al. 1967. ARU ISLANDS: Mitten 1885 as *Lejeunea subfusca*, Schiffner 1898 as *Lopholejeunea sagrana* var. *subfusca*. BALI: Zhu and Gradstein 2005; Haerida 2009; Haerida et al. 2010; Siregar et al. 2014; Siregar 2015; Haerida 2017; Rosyanti et al. 2018; Siregar et al. 2020.**
- *** *Lopholejeunea zollingeri* (Steph.) Schiffn. **BALI: Haerida 2017.**

Marchantia

- *** *Marchantia acaulis* Steph. **BALI: Haerida et al. 2015; Haerida 2017.**
- *** *Marchantia emarginata* Reinw., Blume et Nees **BALI: Siregar et al. 2013; Haerida et al. 2015; Siregar 2015; Haerida 2017; Ginting and Batubara 2019.**
- *** — subsp. *emarginata*. **BALI: Bischler-Causse 1989; Bischler and Piippo 1991. FLORES: Bischler-Causse 1989; Bischler and Piippo 1991.**
- *** *Marchantia geminata* Reinw., Blume et Nees **BALI: Haerida et al. 2015; Haerida 2017. FLORES: Bischler-Causse 1989.**
- *** *Marchantia treubii* Schiffn. **LESSER SUNDA IS.: Siregar et al. 2013; Siregar 2015. BALI: Haerida 2017. FLORES: Bischler-Causse 1989. LOMBOK: Bischler-Causse 1989. TIMOR: Stephani 1899; Bischler-Causse 1989.**

Metalejeunea

- *** *Metalejeunea cucullata* (Reinw., Blume et Nees) Grolle **BALI: Bechteler et al. 2016b.**

Metzgeria

- *** *Metzgeria ciliata* Raddi **BALI: Haerida 2017.**
- *** *Metzgeria consanguinea* Schiffn. **SUMBA: Haerida et al. 2020.**
- * *Metzgeria foliicola* Schiffn. **FLORES: So 2003b.**
- *** *Metzgeria lindbergii* Schiffn. **BALI: Haerida 2017. FLORES: So 2003b.**

Pallavicinia

- *** *Pallavicinia lyellii* (Hook.) Gray **BALI: Haerida 2017.**

Plagiochila

- *** *Plagiochila bantamensis* (Reinw., Blume et Nees) Mont. **BALI: So 2001.**
- *** *Plagiochila frondescens* (Nees) Lindenb. **BALI: Inoue 1984; Piippo 1989a; Patzak et al. 2016; Renner et al. 2017.**
- *** *Plagiochila javanica* (Sw.) Nees et Mont. **BALI: Inoue 1984; Hegewald and van Zanten 1986; Piippo 1989a; Haerida 2017.**
- *** *Plagiochila junghuhniana* Sande Lac. **BALI: So 2001.**
- *⁸ *Plagiochila kuhliana* Sande Lac. **BALI: Inoue 1984.**
- ** *Plagiochila massalongoana* Schiffn. **BALI: Inoue 1984.**
- *** *Plagiochila obtusa* Lindenb. **BALI: So 2001.**
- *** *Plagiochila parvifolia* Lindenb. **BALI: So 2001.**
- ** *Plagiochila propinqua* Sande Lac. **BALI: Inoue 1984; Inoue 1989; Piippo 1989a; Piippo and Tan 1992; Grolle and So 1999b.**
- *** *Plagiochila renitens* (Nees) Lindenb. **BALI: Inoue 1984; Inoue 1989; Piippo 1989a.**
- *** *Plagiochila salacensis* Gottsche **BALI: Carl 1931 as *Plagiochila jackii*, Hegewald and van Zanten 1986; Grolle and So 1999a; So 2001; Siregar 2015; Haerida 2017; Siregar et al. 2018.**
- *** *Plagiochila sciophila* Nees **BALI: Inoue 1984; Inoue 1989; Piippo 1989a; Enroth 1991; Siregar 2015; Siregar et al. 2018.**
- ** *Plagiochila semidecurrens* (Lehm. et Lindenb.) Lindenb. **BALI: So 2001.**
- ** *Plagiochila spathulifolia* Mitt. **BALI: Inoue 1984; Inoue 1989.**
- *** *Plagiochila teysmannii* Sande Lac. **BALI: Hegewald and van Zanten 1986; So and Grolle 1999; Haerida 2017. SUMBA: Haerida et al. 2020.**

Pleurozia

- *** *Pleurozia gigantea* (F.Weber) Lindb. **FLORES: Thiers 1993.**

⁸ *Plagiochila kuhliana* is possibly conspecific with *Plagiochila sciophila* (Söderström et al. 2010).

Porella

- ** *Porella acutifolia* (Lehm. et Lindenb.) Trevis. **BALI: Hegewald and van Zanten 1986; Haerida 2017. LOMBOK: Miller et al. 1983.**
- ** — var. *acutifolia*. **LOMBOK: LECTOTYPE of *Madotheca elbertii*, Stephani 1924 as *Madotheca elbertii*, Hattori 1969 as *Porella acutifolia* var. *elbertii*.**

Ptychanthus

- *** *Ptychanthus striatus* (Lehm. et Lindenb.) Nees **BALI: Haerida 2017. LOMBOK: Verdoorn 1934a; Miller et al. 1983. SUMBA: Haerida et al. 2020.**

Radula

- ** *Radula acuminata* Steph. **BALI: Haerida 2017.**
- *** *Radula campanigera* Mont. **BALI: Haerida 2017.**
- ** *Radula javanica* Gottsche **BALI: Haerida 2017. SUMBA: Haerida et al. 2020.**
- * *Radula multiflora* Gottsche ex Schiffn. **ARU ISLANDS: Schiffner 1898. BALI: Hegewald and van Zanten 1986; Haerida 2017.**
- * *Radula pinnulata* Mitt. **ARU ISLANDS: Mitten 1885; Schiffner 1898.**
- *** *Radula ventricosa* Steph. **BALI: Haerida 2017.**

Reboulia

- *** *Reboulia hemisphaerica* (L.) Raddi **BALI: Haerida et al. 2015; Haerida 2017. LOMBOK: LECTOTYPE of *Fimbraria latifrons*, Stephani 1917 as '*Fimbriaria*' *latifrons*. Bonner 1965 as '*Fimbriaria*' *latifrons*, Long 2006.**

Riccardia

- ** *Riccardia crenulata* Schiffn. **BALI: Schiffner 1955 as *Riccardia tenuicostata*. SUMBA: Haerida et al. 2020 as *Aneura crenulata*.**

Riccia

- *** *Riccia billardierei* Mont. et Nees **BALI: Jovet-Ast 2000; Jovet-Ast 2003.**
- *** *Riccia cruciata* Kashyap. **BALI: Jovet-Ast 2003.**
- *** *Riccia discolor* Lehm. et Lindenb. **BALI: Jovet-Ast 2003.**
- *** *Riccia junghuhniana* Nees et Lindenb. **BALI: Jovet-Ast 2003; Haerida 2017.**
- *** *Riccia mangalorica* Ahmad ex Jovet-Ast **BALI: Jovet-Ast 2003 as *Riccia mangalorica*.**

Scapania

- *** *Scapania javanica* Gottsche **BALI: Blockeel et al. 2009; Haerida 2017.**

Schiffneriolejeunea

*** *Schiffneriolejeunea tumida* (Nees) Gradst. **BALI: Wilson et al. 2004.**

*** — var. *haskarliana* (Gottsche) Gradst. et Terken. **BALI: Wilson et al. 2007.**

Schistochila

*** *Schistochila aligera* (Nees et Blume) J.B.Jack et Steph. **BALI: So 2003a. FLORES: So 2003a.**

*** *Schistochila blumei* (Nees) Trevis. **BALI: So 2003a.**

Solenostoma

*** *Solenostoma tetragonum* (Lindenb.) R.M.Schust. ex Váňa et D.G.Long **BALI: Váňa 1972, 1973, 1975, 1991a** all as *Jungermannia tetragona*, Miller et al. 1983 as *Jungermannia tetragona*, Váňa and Piippo 1989a as *Jungermannia tetragona*, Bapna and Kachroo 2000 as *Jungermannia tetragona*, Srivastava and Sharma 2000 as *Jungermannia tetragona*, Easa 2003 as *Jungermannia tetragona*.

*** *Solenostoma truncatum* (Nees) R.M.Schust. ex Váňa et D.G.Long **BALI: Váňa and Piippo 1989a** as *Jungermannia truncata*, Váňa 1991a as *Jungermannia truncata*, Bapna and Kachroo 2000 as *Jungermannia truncata*.

Spruceanthus

*** *Spruceanthus polymorphus* (Sande Lac.) Verd. **ARU ISLANDS: Mitten 1885** as *Phragmicoma polymorpha*, **Schiffner 1898** as *Thysananthus polymorphus*. **SUMBA: Haerida et al. 2020.**

*** *Spruceanthus semirepandus* (Nees) Verd. **LOMBOK: Verdoorn 1934a;** Jovet-Ast and Schmid 1958; Kitagawa 1981.

Thysananthus

*** *Thysananthus humilis* (Gottsche) Sukkharak et Gradst. **BALI: Sukkharak and Gradstein 2014** as *Mastigolejeunea humilis*. **SUMBA: Haerida et al. 2020** as *Mastigolejeunea humilis*.

*** *Thysananthus ligulatus* (Lehm. et Lindenb.) Sukkharak et Gradst. **SUMBA: Haerida et al. 2020** as *Mastigolejeunea ligulata*.

*** *Thysananthus spathulistipus* (Reinw., Blume et Nees) Lindenb. **BALI: Wilson et al. 2007; Haerida et al. 2010; Sukkharak 2011; Heinrichs et al. 2012; Czumay et al. 2013; Dong et al. 2013; Heinrichs et al. 2014a; Heinrichs et al. 2014b; Schäfer-Verwimp et al. 2014; Siregar et al. 2014; Siregar 2015; Sukkharak 2015; Bechteler et al. 2016a; Bechteler et al. 2016b; Haerida 2017; Siregar et al. 2017; Siregar et al. 2020. KAI ISLANDS: Verdoorn 1937. SUMBAWA:**

Zollinger 1855; Schiffner 1898; Verdoorn 1934a; Swanson and Miller 1969; Miller et al. 1983; Haerida et al. 2010; Siregar et al. 2014; Siregar 2015; Siregar et al. 2017.

*** *Thysananthus virens* Ångstr. **BALI: Sukkharak and Gradstein 2014b** as *Mastigolejeunea virens*, Siregar et al. 2020 as *Mastigolejeunea virens*.

Wiesnerella

*** *Wiesnerella denudata* (Mitt.) Steph. **BALI: Haerida 2017.**

Taxa of unclear affinity

A couple of taxa are published from Lesser Sunda Islands as varieties of species synonymized under other names, without transferring or synonymizing the variety. We have not been able to trace any specimen that they may be based on and, thus, not been able to refer them to any valid taxon.

Chiloscyphus

? *Chiloscyphus zollingeri* Gottsche var. *subintegerrimus* Schiffn. **BALI: Schiffner 1955.**

NOTE: *Chiloscyphus zollingeri* Gottsche is now *Heteroscyphus zollingeri* but we are not sure if var. *subintegerrimus* also belongs to that species and is worth recognizing.

Riccardia

? *Riccardia platyclada* Schiffn. var. *leiomitra* Schiffn. **BALI: Schiffner 1955.** NOTE:

Riccardia platyclada Schiffn. is a synonym of *R. graeffei* but it is unclear where var. *leiomitra* from Java belongs (Söderström et al. 2010).

Taxa reported but doubtfully occurring in Lesser Sunda Islands

Marchantiophyta

Bazzania

** *Bazzania ceylanica* (Mitt.) Steph. **LESSER SUNDA IS.: Miller et al. 1983.** NOTE: The report by Miller et al. is unclear and it may be that they meant some of the Greater Sunda Islands. It is widespread in SE Asia, so its presence is not unlikely.

*** *Bazzania erosa* (Reinw., Blume et Nees) Trevis. **LESSER SUNDA IS.: Miller et al. 1983.** NOTE: The report by Miller et al. is unclear and it may be that they meant some of the Greater Sunda Islands. It is widespread in SE Asia so its presence is not unlikely.

*** *Bazzania tridens* (Reinw., Blume et Nees) Trevis. **LESSER SUNDA IS.: Miller et al. 1983. SUMBAWA: Pócs 1971.** NOTE: We are not aware of any first hand report from

Lesser Sunda Islands but it is common in SE Asia so its presence on some of the islands is not unlikely.

Ceratolejeunea

- *** *Ceratolejeunea* cf. *papuliflora* Steph. **SUMBA**: Haerida et al. 2020. NOTE: The species was only reported with doubt. It is otherwise not reported outside Africa, but it occurs on the Western Indian Ocean Islands and may perhaps also occur in SE Asia.

Cololejeunea

- *** *Cololejeunea* cf. *lanciloba* Steph. **BALI**: Haerida 2017. NOTE: The species was only reported with doubt. However, it is widespread in SE Asia and its occurrence in the area is not unlikely.
- ** *Cololejeunea* cf. *serrulata* Steph. **BALI**: Haerida 2017. NOTE: The species was only reported with doubt. It occurs on other Islands in SE Asia so its presence on the Lesser Sunda Islands is not unlikely.

Colura

- *** *Colura ari* (Steph.) Steph. **LESSER SUNDA IS.**: Miller et al. 1983. NOTE: The report by Miller et al. is unclear and it may be that they meant some of the Greater Sunda Islands. It is widespread in SE Asia so its presence is not unlikely.
- ** *Colura imperfecta* Steph. **LESSER SUNDA IS.**: Miller et al. 1983. NOTE: The report by Miller et al. is unclear and it may be that they meant some of the Greater Sunda Islands. It is widespread in SE Asia so its presence is not unlikely.

Conoscyphus

- *** *Conoscyphus trapezioides* (Sande Lac.) Schiffn. **LESSER SUNDA IS.**: Miller et al. 1983 as *Chiloscyphus trapezioides*. NOTE: The report by Miller et al. is unclear and it may be that they meant some of the Greater Sunda Islands. It is widespread in SE Asia so its presence is not unlikely.

Drepanolejeunea

- *** *Drepanolejeunea ternatensis* (Gottsche) Schiffn. **LESSER SUNDA IS.**: Miller et al. 1983. NOTE: The report by Miller et al. is unclear and it may be that they meant some of the Greater Sunda Islands. It is widespread in SE Asia so its presence is not unlikely.

Radula

- *** *Radula complanata* (L.) Dumort. **BALI: Haerida 2017**. NOTE: A mainly boreal species that have its closest known occurrences in Himalaya. The report was

erroneously published without a 'cf' as the identification was only preliminary (I. Haerida).

Targionia

- *** *Targionia hypophylla* L. **BALI:** Haerida 2017. NOTE: The species was only reported with doubt. It is widespread but as the relation to other taxa remains unclear, its distribution is also unclear.

Taxa reported but rejected from Lesser Sunda Islands

Marchantiophyta

Ceratolejeunea

- *** *Ceratolejeunea ceratantha* (Nees et Mont.) Schiffn. **SUMBAWA:** Sande Lacoste 1864 as *Lejeunea ceratantha*, **Schiffner 1898**. NOTE: This is a Neotropical taxon and the old reports from Asia must be rejected.

Frullania

- * *Frullania ludoviciae* Steph. **SUMBAWA:** Miller et al. 1983 (with a '?'). NOTE: Hattori (1986) is rejecting earlier records outside New Caledonia as based on erroneous synonymization of *F. tenuirostris*.

Thysananthus

- *** *Thysananthus auriculatus* (Wilson et Hook.) Sukkharak et Gradst. **BALI:** Wilson et al. 2004 as *Mastigolejeunea auriculata*, **Wilson et al. 2007** as *Mastigolejeunea auriculata*, **Ye and Zhu 2018**. NOTE: Sukkharak and Gradstein (2014) rejects all report of this American-African taxon from SE Asia as *Thysananthus humilis*.

Synonyms

Anastrophyllum integerrimum Steph. = *Gottschelia schizopleura*
Aneura crenulata (Schiffn.) Steph. ≡ *Riccardia crenulata*
Aspiromitus falsinervius (Lindenb. ex Meissner) Steph. = *Folioceros fuciformis*
Chiloscyphus argutus (Reinw., Blume et Nees) Nees ≡ *Heteroscyphus argutus*
Chiloscyphus aselliformis (Reinw., Blume et Nees) Nees ≡ *Heteroscyphus aselliformis*
Chiloscyphus coalitus (Hook.) Nees ≡ *Heteroscyphus coalitus*
Chiloscyphus communis Steph. = *Heteroscyphus coalitus*
Chiloscyphus decurrens (Reinw., Blume et Nees) Nees = *Heteroscyphus splendens*
Chiloscyphus trapezioides Sande Lac. ≡ *Conoscyphus trapezioides*
Cololejeunea goebelii (Gottsche ex Schiffn.) Schiffn. = *Cololejeunea trichomanis*

Cololejeunea leonidens var. *saccata* Benedix = *Cololejeunea ocelloides*
Cololejeunea nymannii (Steph.) Benedix = *Cololejeunea obliqua*
Colura apiculata Steph. = *Colura leratii*
Fimbraria latifrons Steph. = *Reboulia hemisphaerica*
Frullania africana Steph. = *Frullania rio-janeirensis*
Frullania longispica Steph. = *Frullania ericoides*
Frullania moniliata subsp. *breviramea* (Steph.) Verd. = *Frullania moniliata*
Frullania secundiflora Mont. = *Frullania nodulosa*
Frullania squarrosa (Mont.) Nees = *Frullania ericoides*
Frullania tamarisci var. *breviramea* (Steph.) S.Hatt. = *Frullania moniliata*
Frullania tenuicaulis Mitt. = *Frullania trichodes*
Herbertus armitanus (Steph.) H.A.Mill. = *Herbertus sendtneri*
Heteroscyphus communis (Steph.) Schiffn. = *Heteroscyphus coalitus*
Heteroscyphus decurrens (Nees) Schiffn. = *Heteroscyphus splendens*
Jungermannia tetragona Lindenb. \equiv *Solenostoma tetragonum*
Jungermannia truncata Nees \equiv *Solenostoma truncatum*
Lejeunea ceratantha Nees et Mont. \equiv *Ceratolejeunea ceratantha*
Lejeunea subfusca (Nees) Nees et Mont. \equiv *Lopholejeunea subfusca*
Lopholejeunea sagrana var. β *subfusca* (Nees) Schiffn. \equiv *Lopholejeunea subfusca*
Madotheca elbertii Steph. = *Porella acutifolia* var. *acutifolia*
Mastigobryum sumbavense Gottsche ex Steph. \equiv *Bazzania sumbavensis*
Mastigolejeunea auriculata (Wilson et Hook.) Steph. \equiv *Thysananthus auriculatus*
Mastigolejeunea humilis (Gottsche) Schiffn. \equiv *Thysananthus humilis*
Mastigolejeunea ligulata (Lehm. et Lindenb.) Schiffn. \equiv *Thysananthus ligulatus*
Mastigolejeunea virens (Ångstr.) Steph. \equiv *Thysananthus virens*
Phragmicoma polymorpha Sande Lac. \equiv *Spruceanthus polymorphus*
Plagiochila dendroides (Nees) Lindenb. \equiv *Chiastocaulon dendroides*
Plagiochila jackii Schiffn. nom. illeg. = *Plagiochila salacensis*
Plagiochila opposita (Reinw., Blume et Nees) Lindenb. \equiv *Chiastocaulon oppositum*
Plagiochilon oppositum (Reinw., Blume et Nees) S.Hatt. \equiv *Chiastocaulon oppositum*
Porella acutifolia var. *elbertii* (Steph.) S.Hatt. = *Porella acutifolia* var. *acutifolia*
Riccardia tenuicostata Schiffn. nom. illeg. = *Riccardia crenulata*
Riccardia tenuicostata Schiffn. = *Riccardia inconspicua*
Riccia mangalorica Ahmad nom. inval. \equiv *Riccia mangalorica*
Thysananthus polymorphus (Sande Lac.) Schiffn. \equiv *Spruceanthus polymorphus*

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Diversity of leaf anatomy within a single leaflet and between leaflets of four *Butia* (Arecaceae, Arecoideae) species

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Abstract

This paper is an investigation into how the anatomy changes within a leaflet and between the leaflets of a single leaf blade of *Butia*. Four species of *Butia* were studied: *Butia paraguayensis*, *B. eriospatha*, *B. yatay* and *B. odorata*. Changes in the anatomical characters are important because some have been used in keys to help separate the species. Recently, anatomical mid-rib characters were used in a key to separate species of *Butia*. We found that characters, such as abaxially projected or rounded mid-rib fibrous ring or number and arrangement of accessory bundles, do change within a single leaflet or between the leaflets of a single leaf blade. Growing conditions and leaf developmental maturity are also important factors that influence leaflet anatomy and may cause one to be misled in an identification key based on anatomical characters. We re-emphasize the importance of always sampling from the same part of the leaf, to have a broader sampling, be attentive to the environmental condition and health of the plant from which you are sampling and to consider population differences.

Keywords

anatomy, environmental variation, interspecific variation, key

Introduction

Palms (Arecaceae) are an easy family of plants to identify to family and are divided into five subfamilies: Calamoideae, Nypoideae, Coryphoideae, Ceroxyloideae and Arecoideae (Dransfield et al. 2008). Palm leaves come in many different shapes: fan, entire

or pinnate. Fan-like leaves, such as palmate or costapalmate leaves, are identified with the subfamilies Coryphoideae and the Calamoideae, in particular, the Lepidocaryeae tribe. All of the other subfamilies including most of the other Calamoideae have entire or pinnate leaves. One of the genetically most diverse subfamilies is the Arecoideae with 10 tribes, amongst which belong the tribe Cocoseae. Cocoseae are further divided into three subtribes: Attaleinae, Bactridinae and Elaeidinae. The non-spiny Attaleinae is the subtribe to which belongs the well-known coconut (*Cocos*) and also *Butia*, the genus we will be focusing on in this paper.

Leaflet anatomy has been advocated as an alternative method for the identification of palm species. The methodology is simple – choose a middle leaflet and section its centre (or center in American English). Tomlinson (1961) hinted that leaf anatomy might be useful in palm identification. It was used to identify species of *Syagrus* (Glassman 1972; Noblick 2013, 2017; Firmo et al. 2021) and, more recently, species of *Butia* (Sant'Anna-Santos et al. 2015, 2018). Sanin and Galeano (2011) used leaf anatomy to distinguish species of *Ceroxylon* Bonpl. ex DC. and Noraini et al. (2012) to distinguish species of *Johannesteijsmannia* H.E. Moore. Pinedo et al. (2016) wrote a key to the species of *Allagoptera* and Vianna et al. (2017) wrote a key to the species of *Acrocomia* using leaflet anatomy. Finally Guevara et al. (2011) was able to distinguish the three genera of the subtribe Mauritiinae, but unfortunately, was unable to separate the species using leaflet anatomy.

While Glassman (1972) and Noblick (2013, 2017) found plenty of characters in the leaflet margin to distinguish species of *Syagrus*, finding differences in the leaflet margins to distinguish *Butia* species has been challenging, even while *Butia*'s isolateral, nearly mirrored anatomy is one of its most compelling and distinguishing generic characters. Although differences in *Butia* leaflet marginal anatomy have failed to distinguish most species, Sant'Anna-Santos et al. (2015, 2018) discovered that there were important differences found in the mid-ribs, an issue previously stated by Glassman (1972). They used these characters to confirm the dissimilarities between *Butia capitata* (Mart.) Becc. and *Butia odorata* (B.Rodr.) Noblick (Sant'Anna-Santos et al. 2015) and also to construct a key to the various other *Butia* species (Glassman 1972; Sant'Anna-Santos et al. 2018). Recently, the leaflet anatomy was employed in the description of a new species of *Butia*, *Butia buenopolensis* (Sant'Anna-Santos 2021).

After examining leaflet cross-sections of over 100 accessions of *Butia* from the living collections at Montgomery Botanical Center, the first author began to develop some concerns. What if the exact middle leaflet is not selected for study? How quickly does palm leaflet anatomy change depending on which “middle” leaflet is chosen (closer to the base or closer to the leaf apex)? Does the leaflet anatomy change much depending on where the section is made along the leaflet? Does the anatomy change from one side of the leaf blade to the other? Does the leaflet anatomy change from between a more mature and less mature or lesser developed specimen of the same species? Are there differences in the anatomy of the same species from one population to another? These are questions that have not been adequately addressed by those using leaflet anatomy for the purpose of identification and that includes ourselves.

Materials and methods

Plants examined

Fresh material was used to prepare 67 slides from four leaves; one leaf from each of the four *Butia* species. The specimens, sampled in this study, came from the living collections at Montgomery Botanical Center (MBC), Miami, FL. *Butia paraguayensis* (Barb. Rodr.) L.H.Bailey (MBC accession 20020856*C) was grown from seed collected from San Estanislão, Paraguay and was sampled more thoroughly than the others. Figure 1 shows the regions from which our samples were taken for this study and an asterisk indicates those leaf regions that were only sampled in *Butia paraguayensis*. In *B. paraguayensis*, each of eight leaflets was sectioned in five different places: their centre, 5 cm to either side and 10 cm to either side for a total of 40 slides.

After much sectioning, it was reasoned that, if one simply “eye-balls” the middle of a leaf, one is not likely to select a middle leaflet more than 20 cm to either side of the true middle of a leaf, nor section that leaflet by more than 5 cm to either side of its centre. Therefore, only three leaflets were sampled from each of other three *Butia* species, which included *B. yatay* (Mart.) Becc., *B. eriospatha* (Mart. ex Drude) Becc. and *B. odorata* (Barb.Rodr.) Noblick. These three species were chosen, because they all have aboveground stems like *B. paraguayensis* and live, wild collected specimens were readily available at MBC. Most of these species are also widely distributed geographically, allowing us to test for some degree of variation in morphological and anatomical characters. *Butia eriospatha* (92271*E) was grown from seed collected from Paraná, Brazil. *Butia odorata* (20060233*E) was grown from seed collected from Rocha, Uruguay and *Butia yatay* (20040309*C) was grown from seed collected from Batel, Argentina. The leaflets were collected from the middle and 20 cm to either side of the middle. Each of these leaflets was sampled in three places: the centre and 5 cm to either side of it for a total of nine slides for each species and a total of 27 slides.

Anatomical preparation

Several methods for hand sectioning are covered in Noblick (2013, 2017). For this study, the following equipment was used: a hand microtome, a sharp knife, a straight razor, a double-sided razor blade, a small artist's brush, a squirt water bottle, a watch glass, a sharpening stone and a carrot. The hand microtome was purchased from home-science tools.com, Billings, MT, U.S.A. We used a Dovo Straight Razor 3" Full Hollow Ground Carbon Steel Blade for sectioning. Finally, to keep a razor-sharp edge, the Dia-sharp 3 micron 8000 mesh (DMT D8EE 8" Extra Extra Fine Diamond Stone) (DMTsharp.com or Diamond Machining Technology, Marlborough, MA, U.S.A) was found to be an excellent choice. Using it frequently between sectioning maintains the razor sharpness required for making clean, thin sections.

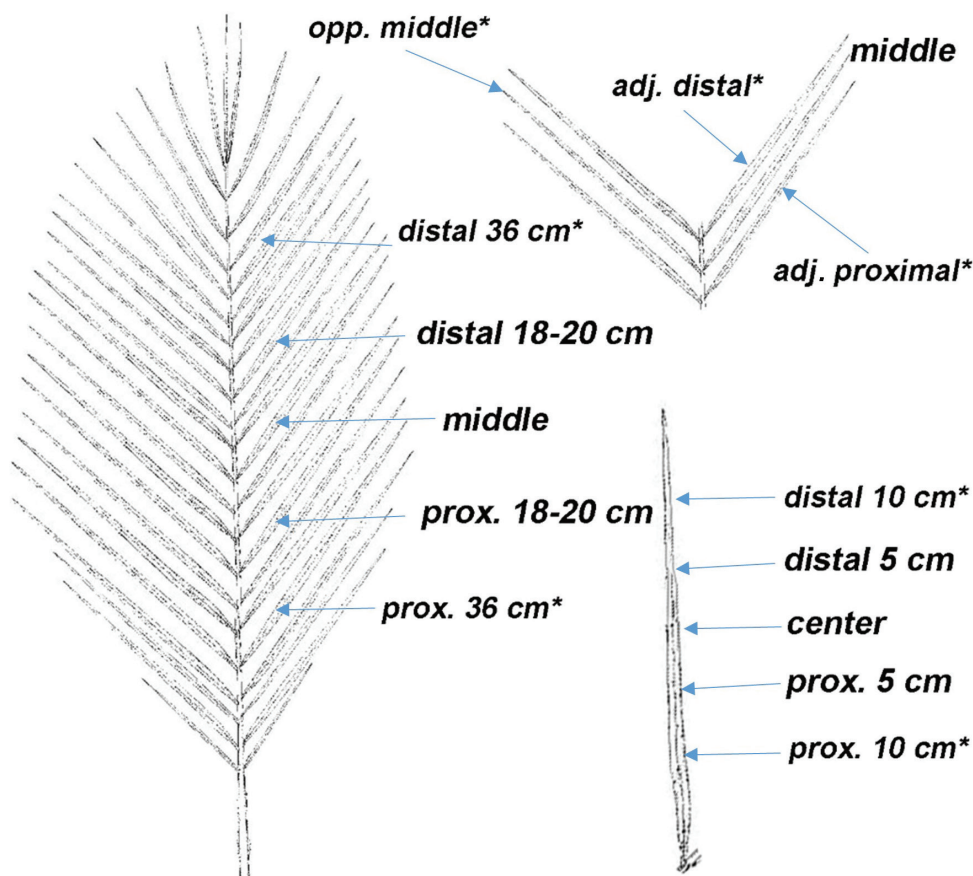


Figure 1. Leaf diagram showing which leaflets of the leaf and which sections of each leaflet that were sampled. * = regions that were only sampled in *Butia paraguayensis*.

Preparing the section

A piece of carrot is cut into a small cube that will fit in the hand microtome as described in Noblick (2017). A deep perpendicular vertical slit is cut in the top of the carrot cube with the double-sided razor blade. The slit in the carrot cube is used to secure the leaflet vertically. If the leaf is stiff and coriaceous, you can mount the specimen with a few mm exposed above the top of the carrot cube with the mid-rib mounted adjacent and parallel to the cube's side (Figure 2). The stiffer, thicker *Butia* leaflets mounted thus allow us to make thinner sections quicker with the straight razor without having to sort through carrot debris. If the specimen is thin and membranaceous, then the specimen must be mounted within the carrot for better support. The carrot cube is then secured in the hand microtome and adjusted down until it is just below the microtome plate. Lubricate the specimen with a drop of water and slide the straight razor across the microtome in a slicing movement, while pressing the side of the blade firmly against the plate. Adjust the microtome up by about a quarter of a turn after each section.

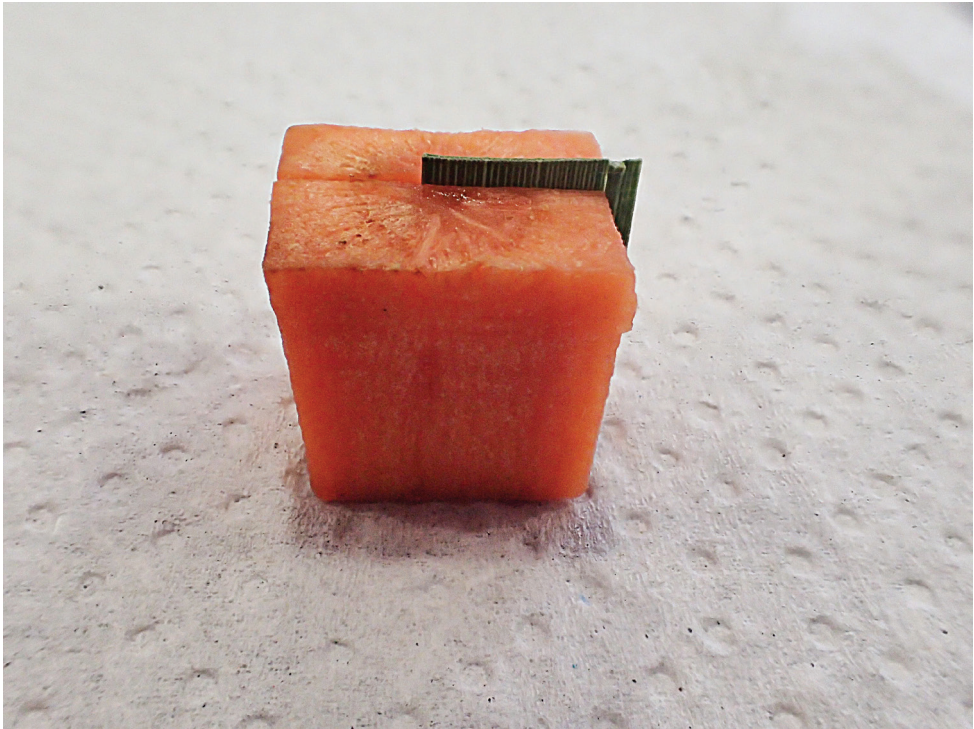


Figure 2. Carrot cube with leaflet sample secured within the carrot slit. Mid-rib of leaflet sample orientated parallel and adjacent to the side of the cube, ready to be placed in the hand-held microtome for sectioning.

Periodically, re-sharpen the blade using the Diamond Stone and water. Keep the specimen lubricated with water. After obtaining one to three sections, tease the sections into the water-filled watch glass using the small artist's brush. Any more than that and you risk cutting the sections you just obtained. Keep sectioning until you obtain four to six good specimens to place on your slide.

Preparing the slide

Glass slides with one side frosted for labelling, glass cover slips, artist's brush, a dropper bottle of 1:1 glycerine and water solution and a dissecting needle are needed for slide preparation. Confirm that the glass slide and glass cover slip are clean before using. Label the frosted portion of the slide and spread a drop or two of the 1:1 glycerine and water solution on to the slide. While looking through the dissecting microscope, select the best sections from the watch glass with the narrow artist's brush and transfer them into the 1:1 glycerine droplet on the slide. After placing a number of the sections on the slide (ca. 4–6), cover the sections with a glass cover slip. Place one edge of the cover slip at the edge of the glycerine droplet on the slide and gently lower it in place over the sections by placing the dissecting needle tip on its side under the other edge of the cov-

er slip. While slowly pulling out the needle as the cover slip lowers into place, most of the air bubbles should exit from under the cover slip on the side of the exiting needle.

For the collection from Tapes, the samples followed the additional protocol proposed by Sant'Anna-Santos et al. (2015) including the softening and double staining with safranin and astra blue (Kraus and Arduin 1997).

Photography

The glass slide is now placed under a 40×–2000× Trinocular Biological Compound Microscope available from Amscope (model T490B) and photographed under the 10× objective (100× magnification). Images were taken with a 5 Mb AmScope digital camera. The images were cleaned of background spots, adjusted for brightness and sharpened, if necessary, using Adobe Photoshop. If the entire mid-rib or leaf margin did not fit into the field of view, adjacent images were photo-merged using the automatic photo-merge capabilities of Adobe Photoshop. A stage micrometer was used to apply a scale to each image.

Characters defined

Characters of the leaflet margin (Figure 3A):

1) Vascular bundles with enlarged sheaths (vbe) – These are a thick sclerenchymous fibre strands with a small portion of vascular tissue. They have been referred to as marginal veins somewhat enlarged (Tomlinson et al. 2011), vascular bundles with exaggerated sheaths (Noblick 2013, 2017) or vascular bundles with reinforced sclerenchymous sheaths (Sant'Anna-Santos et al. 2018). These are found on the edge of the leaflet margin. There are usually two on the leaflet margin with the larger one on the abaxial side. There are also one to three on the adaxial side of the mid-rib and often counted as part of the accessory bundles (ab).

2) Primary vascular bundles (PVB) – Primary vascular bundles are the largest vessels in the leaflet blade and connect to both the adaxial and abaxial hypodermis. They are a slightly swollen in the centre with large open xylem vessels with at least two to four poles of sieve elements and companion cells located abaxially.

3) Secondary vascular bundles (SVB) – Similar to primary vascular bundles but skinnier, also connected to both the adaxial and abaxial hypodermis, larger open xylem vessels are not clearly visible or nearly absent.

4) Tertiary vascular bundles (TVB) – Tertiary vascular bundles are paired vessels with one attached to the adaxial hypodermis and the other attached to the abaxial hypodermis. They are separated by two or more layers of mesophyll cells or chlorenchyma (cells with chlorophyll).

5) Miniveins (mv) – These veins are usually paired and located between the other three kinds of vascular bundles and are unattached to either the adaxial or abaxial surface, “floating” in the mesophyll. Occasionally, the adaxial one is missing. They

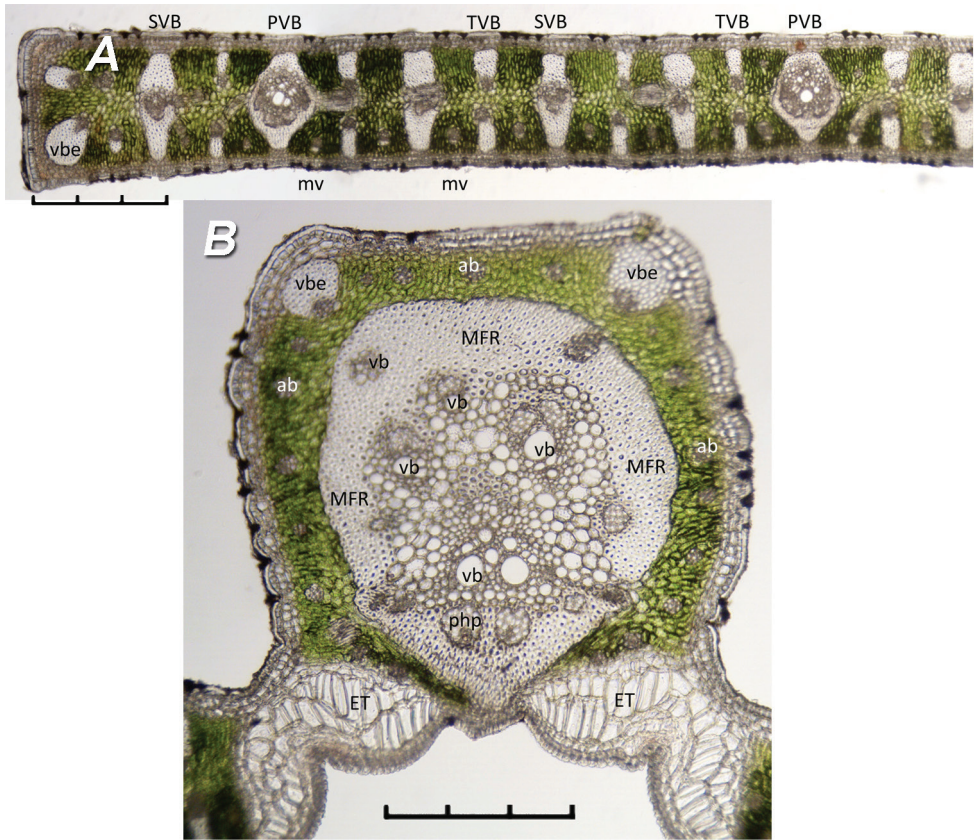


Figure 3. Anatomical characters of leaflet cross-sections **A** *Butia odorata* leaflet margin showing isolateral “mirrored” anatomy **B** *B. yatay* midrib. **ab** = accessory bundle; **ET** = expansion tissue; **MFR** = mid-rib fibrous ring; **mv** = miniveins; **php** = phloem pole; **PVB** = primary vascular bundle; **SVB** = secondary vascular bundle; **TVB** = tertiary vascular bundle; **vb** = vascular bundle or collateral vascular bundle; **vbe** = vascular bundle with enlarged sheath. Not all are labelled. Scale bars: 0.3 mm.

often appear as two grey smudges under the microscope, one near the adaxial surface and one near the abaxial surface. The abaxial one is usually unattached or occasionally attached to the abaxial hypodermis and occasionally may have a few sclerenchymous cells. Miniveins are also the most common veins of the accessory bundles (**ab**) found in the mid-rib.

More characters for the leaflet mid-rib (Figure 3B):

- 1) **Mid-rib fibrous ring (MFR)** – This is a thick to thin sclerenchymous ring surrounding the veins or collateral vascular bundles (**vb**) in the centre of the mid-rib.
- 2) **Collateral vascular bundles (vb)** – These are vascular bundles composed of xylem and phloem that fill the centre of the mid-rib and are surrounded by the MFR.

3) Accessory Bundles (ab) – These are several mv's, miniveins and a few vb's, vascular bundles with enlarged sheaths, which partially or entirely surround the MFR in the mid-rib.

4) Phloem Poles (php) – These are clusters of sieve elements plus companion cells (phloem), either embedded within or adjacent to the abaxial and abaxial portion of the MFR in the mid-rib. They are always associated with xylem to form a vascular bundle (vb).

Results

In the *Butia* leaflet margin (Figure 3A), the vessels are arranged in such a way that the adaxial (upper) and abaxial (lower) surface appear to “mirror” each other and is often referred to as isolateral symmetry. The primary, secondary and tertiary vascular bundles (PVB, SVB, TVB) appear to alternate with each other often in a repeating sequence. Miniveins (mv) are often found alternating with these larger vascular bundles. The leaflet margin itself is reinforced by at least two veins with enlarged fibrous sheaths (vbe). The larger vbe is usually located on the abaxial side of the leaflet. This isolateral anatomical leaflet symmetry is typical for the genus.

In the mid-rib (Figure 3B), there are usually one to three vb's present along the adaxial surface. Rarely are they absent. The centre mid-rib fibrous ring (MFR) is surrounded by several layers of parenchyma or chlorenchyma cells that form a proportionally thicker layer in juvenile leaves than in more mature and larger leaves. There are a number of accessory bundles (ab), mostly miniveins (mv) that are arranged within the chlorenchyma tissues and surround or partially surround the MFR. Most of the accessory bundles are unattached to the mid-rib surfaces, but include one to three vb's, which are attached. The MFR can be thick or thin depending on the age and maturity of the plant or from where the section was sampled. Small vascular bundles (vb) and phloem poles (php) can be found embedded within the MFR itself in older, mature plants, but are usually of a very small size and not easily detected in plants that are in a more juvenile state of development. Within the MFR are one or several vascular bundles (vb), sometimes called collateral bundles, consisting of xylem and phloem and they may or may not be orientated as adaxial and abaxial bundles. The largest vascular bundle is located abaxially in the mid-rib and is orientated with phloem or phloem poles embedded in the abaxial portion of the MFR and with well-developed xylem tissues just above. The other vascular bundles in the MFR are difficult to distinguish or even count, because they are not necessarily orientated as expected.

The proximal cross-sections are located between the centre and the base of the leaflet and the distal sections are located between the centre and the apex of the leaflet. By the same thinking, the proximal leaflets are located between the middle leaflet and the basal leaflet and the distal leaflets are located between the middle leaflet and the apex or leaf tip.

Table 1 summarises observations of variations that occur within the leaf margin of the four *Butia* species (Figures 4–6). We recorded changes between the centre cross-section and the cross-sections of the same leaflet made 5 cm to either side of it. Within that 10 cm length of leaflet margin, the changes observed include: a few of the vascular bundles do not extend between the base and apex of the leaflet as seen in *B. paraguayensis* (Figures 4, 5A). Most of the vascular bundles remain unchanged throughout as in *B. yatay* and *B. odorata* (Figure 6A, B), but in *B. paraguayensis* and *B. eriospatha*, a few change back and forth between primary (PVBs) and secondary vascular bundles (SVBs) (Figures 4, 5A, B). The tip of the margin remains unchanged in *B. eriospatha* and *B. yatay* (Figures 5B, 6A), but goes from adaxially prominent or bent to abaxially prominent towards the distal end (*B. paraguayensis*, Figures 4, 5A) or relatively unbent to abaxially prominent (*B. odorata*, Figure 6B).

Table 2 focuses on the differences found in the mid-rib within a single leaflet. The Table records the changes in the characters of the centre mid-rib section, the sections 5 cm to either side of it in all the species (Figure 7) and the sections 10 cm to either side of it in *B. paraguayensis* (Figure 8A). Mid-rib changes observed from proximal to distal ends of the leaflets are: the MFR becomes thinner; the MFR shape changes from abaxially projected to slightly projected (*B. yatay* and *B. eriospatha*, Figure 7B, C) to round (*B. paraguayensis* and *B. odorata*, Figure 7A, D); the MRF always reaches the hypodermis in *B. paraguayensis* and *B. yatay* (Figure 7A, B) and most of the time in *B. eriospatha* (Figure 7C), but almost never in the distal portion of *B. eriospatha* nor in any portion of *B. odorata* (Figure 7C, D). From the proximal to the distal end, there are fewer abs in the mid-rib and fewer vbs in the MFR in all species.

Table 3 focuses on the differences found in the leaflet mid-rib cross-sections of the middle leaflet and those leaflets 18–20 cm to either side of it in all species (Figure 9) and

Table 1. Changes that occur in the vascular bundles (veins) of the leaflet margins of four different *Butia* species from the proximal to the distal portion of the leaflet. Number of changes from primary vascular bundles (PVB) to secondary vascular bundles (SVB) and from SVB to PVB in that portion of the margin. Number of vascular bundles (VB) that disappear or nearly disappear (Figures 4, 5A, B, 6A, B).

Name (where sectioned)	PVB-SVB	SVB-PVB	VB nearly gone	Margin bent
<i>B. paraguayensis</i> (proximal 10 cm)				abaxially
<i>B. paraguayensis</i> (proximal 5 cm)	1	2	1	adaxially
<i>B. paraguayensis</i> (centre)			1	adaxially
<i>B. paraguayensis</i> (distal 5 cm)	2	2	1	abaxially
<i>B. paraguayensis</i> (distal 10 cm)	1	1	3	none
<i>B. yatay</i> (proximal 5 cm)				none
<i>B. yatay</i> (centre)				none
<i>B. yatay</i> (distal 5 cm)			1	none
<i>B. eriospatha</i> (proximal 5 cm)				none
<i>B. eriospatha</i> (centre)	1	2		none
<i>B. eriospatha</i> (distal 5 cm)				none
<i>B. odorata</i> (proximal 5 cm)				none
<i>B. odorata</i> (centre)				none
<i>B. odorata</i> (distal 5 cm)				abaxially

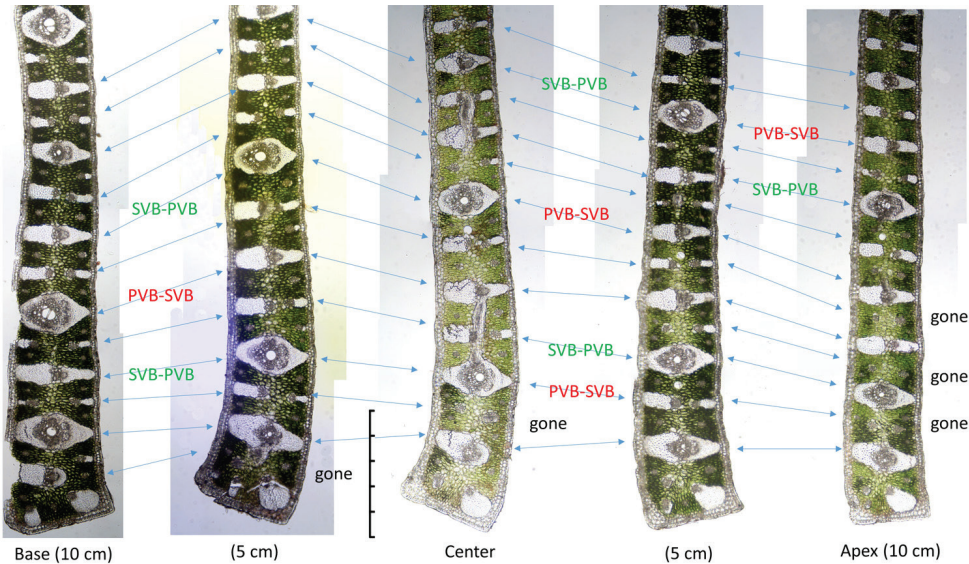


Figure 4. Anatomical changes of the leaflet margins in a 10 cm region to either side of the leaflet centre: *Butia paraguayensis*. **PVB-SVB** = primary vascular bundles transitioning to secondary vascular bundles; **SVB-PVB** = secondary vascular bundles transitioning to primary vascular bundles. **Gone** = vascular bundle has disappeared or nearly ended. Scale bar: 0.5 mm.

Table 2. Anatomical variation of the centre mid-rib cross-section of a middle leaflet, compared to proximal (prox.) and distal sections located 5–10 cm from the centre. ab = accessory vascular bundles, MFR = mid-rib fibrous ring, vb = vascular bundles or collateral vascular bundles, vbe = vascular bundle with enlarged sheath. (Figures 7, 8A).

Name (where sectioned)	MFR thickness (# cell layers)	MFR shape	MRF reaches hypodermis	#vbe	#ab	ab completely surround MFR	#vb in MFR
<i>B. paraguayensis</i> (prox. 10 cm)	9–11	ab-projected	yes	2	22	no	8
<i>B. paraguayensis</i> (prox. 5 cm)	8–9	ab-projected	yes	2	21	no	7
<i>B. paraguayensis</i> (centre)	6–7	slightly ab-projected	yes	2	17	no	5
<i>B. paraguayensis</i> (distal 5 cm)	4–5	round	yes	2	13	no	3–4
<i>B. paraguayensis</i> (distal 10 cm)	3–5	round	yes	2	9	no	3
<i>B. yatay</i> (proximal 5 cm)	6–10	ab-projected	yes	2	24	no	7
<i>B. yatay</i> (centre)	5–10	ab-projected	yes	2	21	no	6
<i>B. yatay</i> (distal 5 cm)	5–8	slightly ab-projected	yes	2	19	no	4
<i>B. eriospatha</i> (proximal 5 cm)	5–8	ab-projected	yes	2	26	no	9–10
<i>B. eriospatha</i> (centre)	4–7	ab-projected	yes	1	25	no	9
<i>B. eriospatha</i> (distal 5 cm)	2–7	slightly ab-projected	no	1	18	no	8
<i>B. odorata</i> (proximal 5 cm)	5–8	ab-projected	no	0	22	yes	8–9
<i>B. odorata</i> (centre)	4–7	round	no	1	21	yes	5–6
<i>B. odorata</i> (distal 5 cm)	2–7	round	no	1	16	yes	5

the leaflets 36 cm to either side of it in *B. paraguayensis* (Figure 8B). We recorded the following trends from the proximal to the distal end of the leaf: in two of the species, the MFR becomes thinner (*B. paraguayensis* and *B. eriospatha*) (Figures 8B, 9A, C); three of the species have MFR shapes that change from abaxially projected to only slightly so (*B. yatay* and *B. odorata*, Figure 9B, D) or to almost round (*B. paraguayensis*,

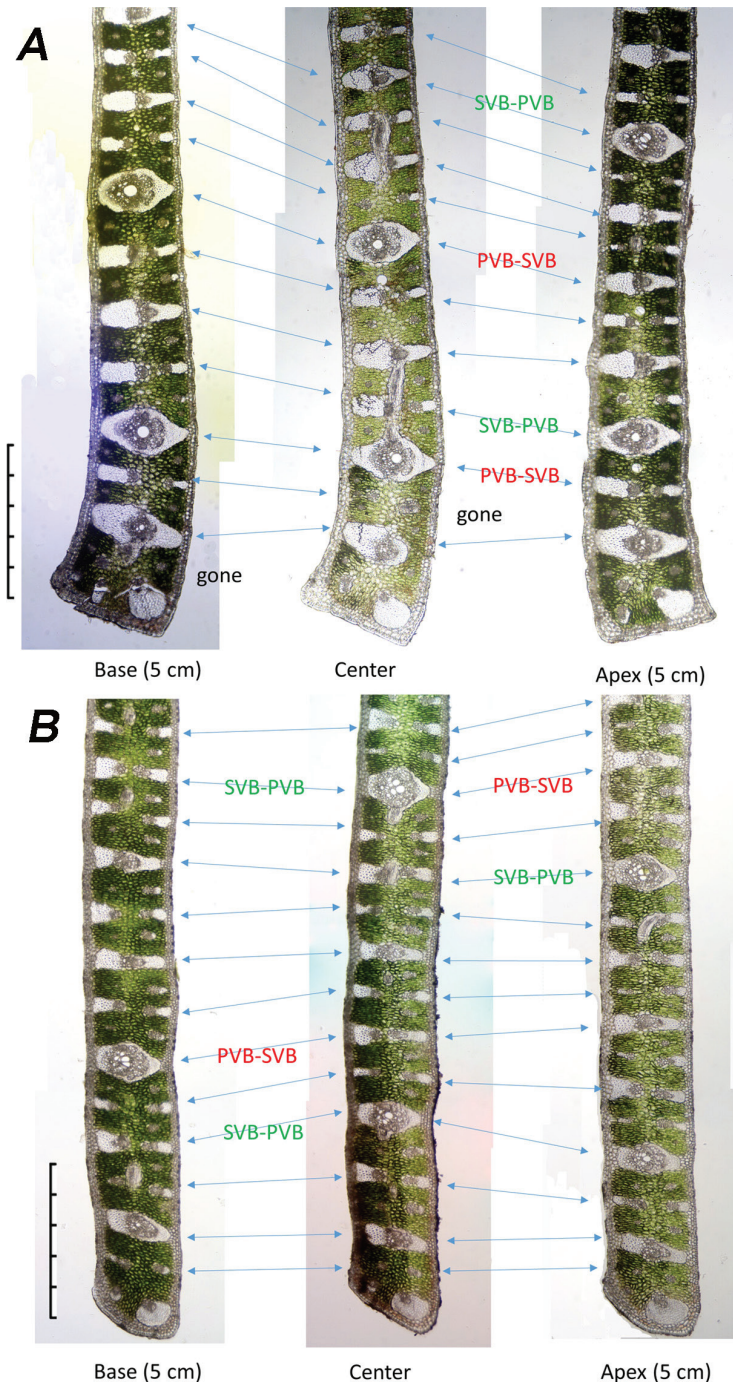


Figure 5. Anatomical changes of the leaflet margins in a 5 cm region near the leaflet centre **A** *Butia paraguayensis* **B** *B. eriopatha*. PVB-SVB = primary vascular bundles transitioning to secondary vascular bundles; SVB-PVB = secondary vascular bundles transitioning to primary vascular bundles. Gone = vascular bundle disappeared or nearly so. Scale bars: 0.5 mm.

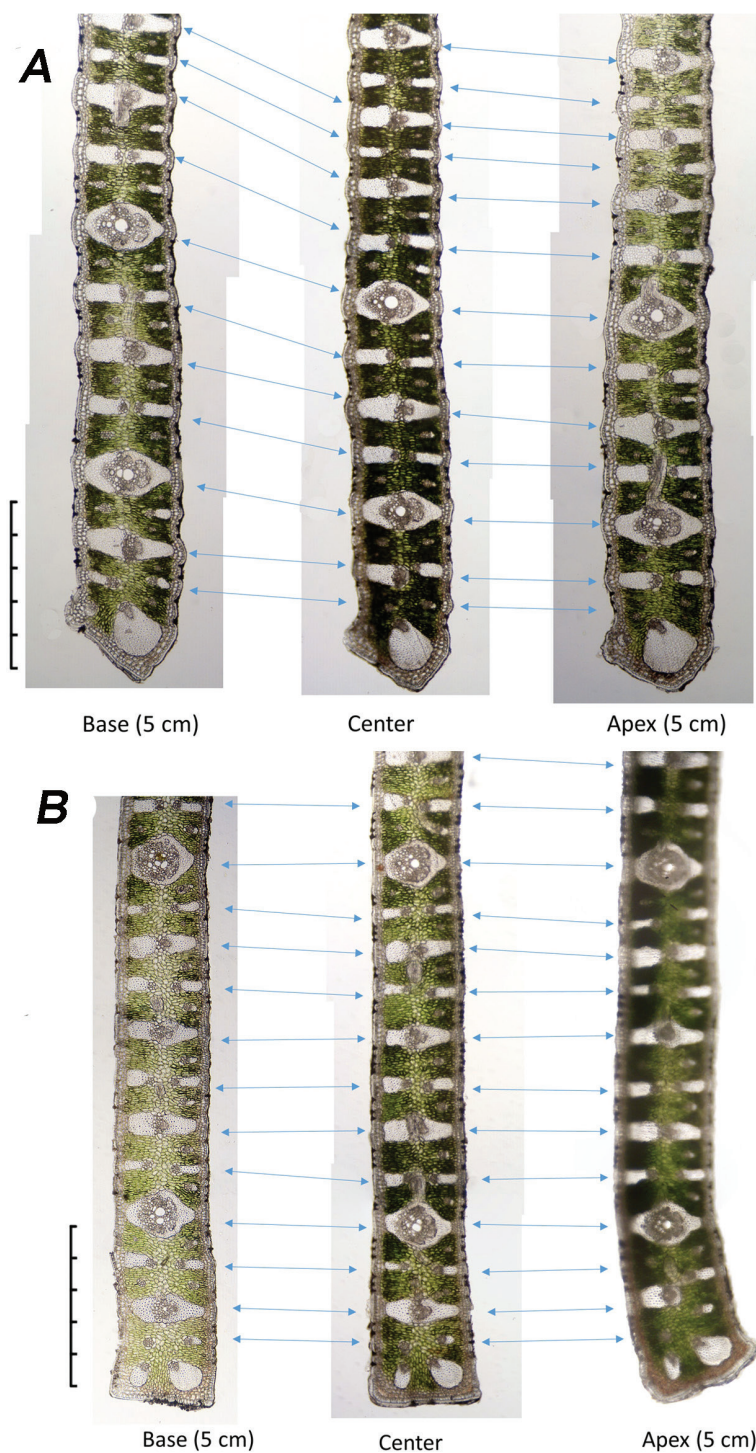


Figure 6. Anatomical changes of the leaflet margins in a 5 cm region to either side of the leaflet centre
A *B. yatay* **B** *B. odorata*. Note no transitional changes in these margins. Scale bars: 0.5 mm.

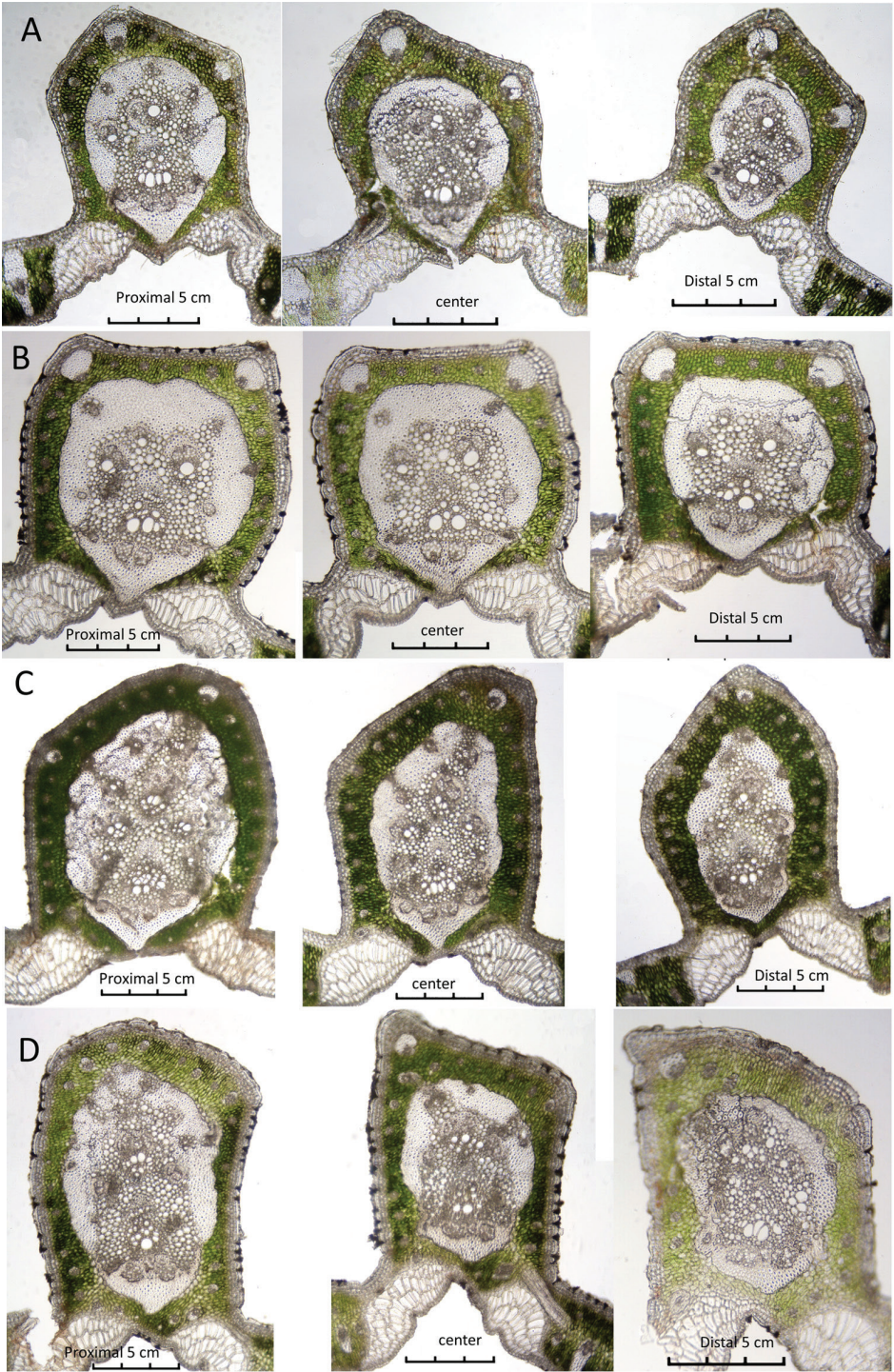


Figure 7. Within leaflet anatomical changes. Centre cross-section and cross-sections 5 cm to either side of it **A** *Butia paraguayensis* **B** *B. yatay* **C** *B. eriospatha* **D** *B. odorata*. Scale bars: 0.3 mm.

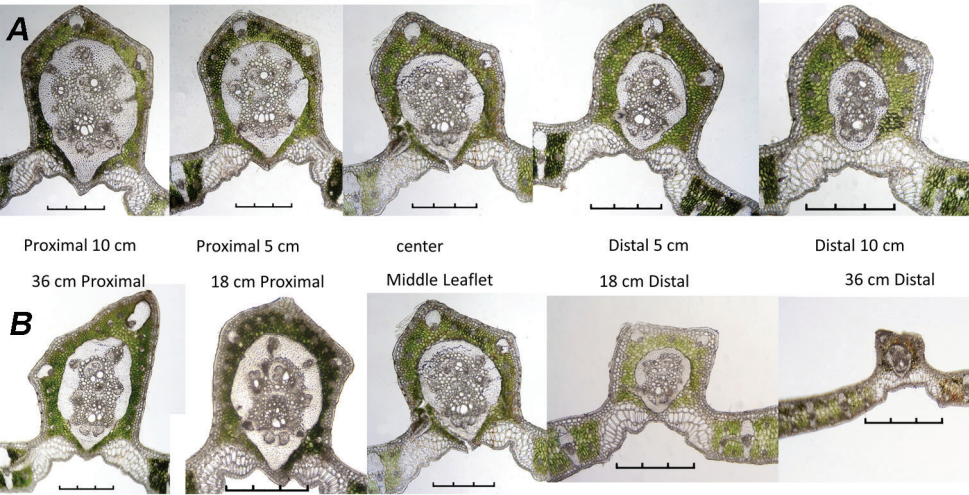


Figure 8. Within and between leaflet comparisons of *Butia paraguayensis* cross-sections **A** centre cross-section and those sections 5 cm and 10 cm to either side of it within the same middle leaflet **B** centre of middle leaflet and centres of the leaflets 18 cm and 36 cm to either side of it. Scale bars: 0.3 mm.

Table 3. Anatomical variation of the centre mid-rib cross-section of a middle leaflet, compared to a proximal (prox.) and a distal leaflets located 18–20 cm from the middle and up to 36 cm from the middle in *B. paraguayensis*. ab = accessory vascular bundles, MFR = mid-rib fibrous ring, vb = vascular bundles or collateral vascular bundles, vbe = vascular bundle with enlarged sheath. (Figures 8B, 9).

Name (where sectioned)	MFR thickness (# cell layers)	MFR shape	MRF reaches hypodermis	#vbe	#ab	ab's completely surround MFR	#vb in MFR
<i>B. paraguayensis</i> (prox. 36 cm)	8–9	ab-projected	yes	2	23	no	7
<i>B. paraguayensis</i> (prox. 18 cm)	8–9	ab-projected	yes	2–3	21	no	6
<i>B. paraguayensis</i> (middle)	6–7	ab-projected	yes	2	17	no	5
<i>B. paraguayensis</i> (distal 18 cm)	3–4	round	yes	2	10	no	3
<i>B. paraguayensis</i> (distal 36 cm)	2–4	round	yes	1	8	no	3
<i>B. yatay</i> (proximal 20 cm)	7–8	ab-projected	yes	2	25	no	7
<i>B. yatay</i> (middle)	5–9	ab-projected	yes	2	21	no	6
<i>B. yatay</i> (distal 20 cm)	6–8	slightly ab-projected	yes	2	16	no	5
<i>B. eriospatha</i> (prox. 20 cm)	3–7	ab-projected	yes	1	21	no	8–9
<i>B. eriospatha</i> (middle)	4–7	ab-projected	yes	1	25	no	9
<i>B. eriospatha</i> (distal 20 cm)	4–5	ab-projected	yes	2	20	no	6
<i>B. odorata</i> (proximal 20 cm)	6–7	ab-projected	no	2	22	yes	8–9
<i>B. odorata</i> (middle)	5–7	slightly ab-projected	no	2	21	yes	5–6
<i>B. odorata</i> (distal 20 cm)	4–5	slightly ab-projected	no	3	16	no	5

Figures 8B, 9A). From the proximal to the distal part of the leaf, all species have a reduced number of abs in the mid-rib. Finally, all usually have a reduced number of collateral vascular bundles, vbs, in their MFR.

Table 4 summarises observations in *Butia paraguayensis* comparing mid-ribs of the centre cross-sections of the middle leaflet, its two adjacent leaflets and the leaflet directly opposite it (Figure 10). We noted the following changes from the proximal to the distal portion of the leaf: the MFR changed from reaching the hypodermis to being separated from the hypodermis by at least one layer of chlorenchyma, from 21

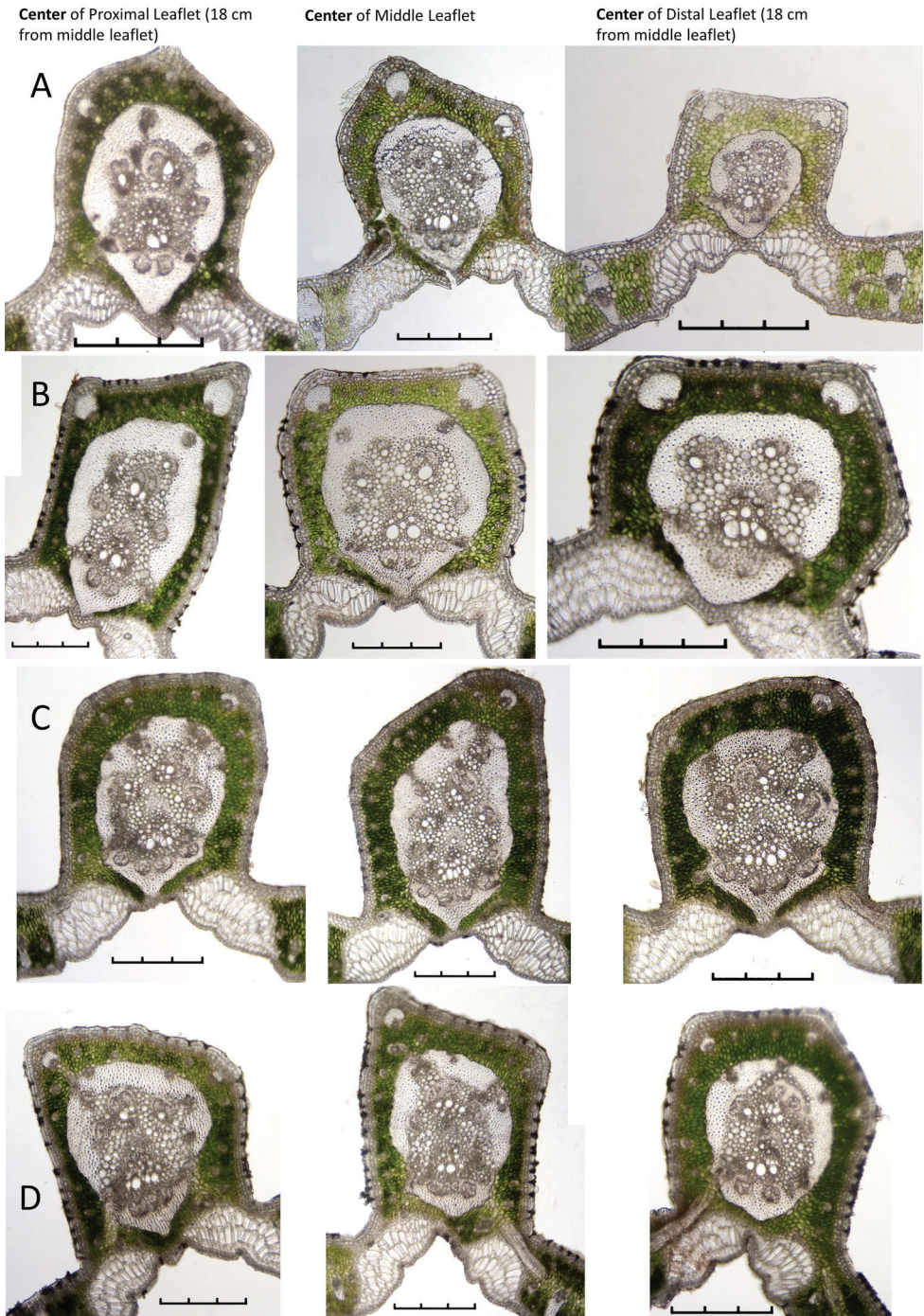


Figure 9. Between leaflet anatomical changes. Centre cross sections of middle leaflet of **A** *Butia paraguayensis* and the leaflets 18 cm to either side of it **B** *B. yatay* and the leaflets 20 cm to either side of it **C** *B. eriospatha* and the leaflets 20 cm to either side of it **D** *B. odorata* and the leaflets 20 cm to either side of it. Scale bars: 0.3 mm.

Table 4. Anatomical variation of the centre mid-rib cross-section of a middle leaflet, compared to centres of the two adjacent (adj.) leaflets on the proximal and distal side and the centre of the opposite (opp.) middle leaflet. ab = accessory vascular bundles, MFR = mid-rib fibrous ring, vb = vascular bundles or collateral vascular bundles, vbe = vascular bundle with enlarged sheath. (Figure 10).

Name (where sectioned)	MFR thickness (# cell layers)	MFR shape	MRF reaches hypodermis	#vbe	#ab	ab's completely surround MFR	#vb in MFR
<i>B. paraguayensis</i> (adj. proximal centre)	5–7	ab-projected	yes	2–3	21	no	6
<i>B. paraguayensis</i> (middle centre)	6–7	ab-projected	yes	2	17	no	5
<i>B. paraguayensis</i> (adj. distal centre)	5–7	round	no	2	15	no	3
<i>B. paraguayensis</i> (opp. middle centre)	4–6	ab-projected	yes	2	15	no	4

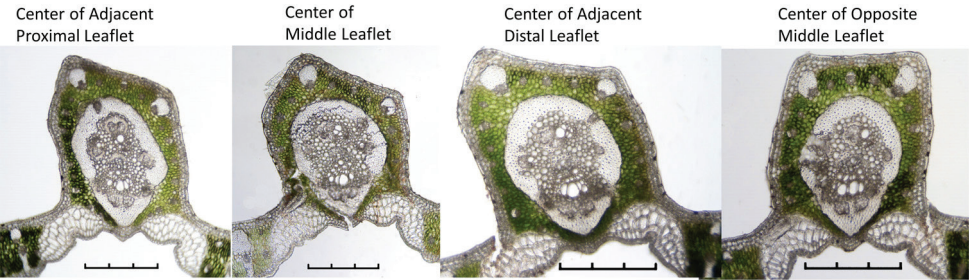


Figure 10. Between leaflet anatomical changes. Centre cross sections of the middle leaflet of *Butia paraguayensis*, its two adjacent leaflets and the leaflet directly opposite it. Scale bars: 0.3 mm.

accessory bundles (ab) to 15 and from six collateral vascular bundles (vb) to four (Figure 10). The middle leaflet on the opposite side has fewer abs (15 vs. 17) and fewer vbs (4 vs. 5) in the MFR than the selected middle leaflet (Figure 10).

Discussion

To our knowledge, there has never been a study that explored the anatomical changes that occur within a single palm leaf or even within a single palm leaflet. Most studies have been focused on the centre of the middle leaflet, which has been found to be very useful. This is certainly true for Glassman (1972), who pointed out that his *Butia* anatomy survey was based mostly on one specimen for each species and largely on material from the middle section of each leaflet. His study did not take into account any variation there may be amongst leaflets of different collections of the same species. Tomlinson (1961) examined and described the leaflet anatomy of 250 species of palms in 137 genera and suggested systematic relationships amongst genera. Tomlinson et al. (2011) expanded the original 1961 paper, presenting information on 183 palm genera of 185 now recognised and suggested relationships, based on anatomy and the use of modern phylogenetic approaches. Horn et al. (2009) took it a step further and mapped lamina anatomy on the phylogenetic tree for the palm family, based on plastid sequence data (Asmussen et al. 2006) in order to understand the evolution of lamina

anatomy. Meerow et al. (2009) showed how leaflet anatomy supported the molecular relationships between *Allagoptera*, *Parajubaea* and *Polyandrococos* (now a synonym of *Allagoptera*). Glassman examined the anatomy of *Syagrus* and its closely-related genera (Glassman 1972, 1987). Noblick (2017) improved on Glassman (1972) by producing a key to identify 25 *Syagrus* species with short, subterranean stems (Noblick 2013) and a key to identify all 65 species and two subspecies of the genus, using only the anatomy of the leaflet margins (Noblick 2017). Noblick's paper (2013) showed how leaflet anatomy could be used to support molecular data (Meerow et al. 2009).

Our study suggests that we need to take a step back and re-examine our previous data to reconfirm and re-evaluate the characters we have been using in our identification keys (Noblick 2013, 2017; Sant'Anna-Santos et al. 2018; Firmo et al. 2021) or in establishing our systematic relationships. As we have seen from this study, leaflet anatomy does vary even between leaflets that are literally adjacent to or directly opposite each other as in *Butia paraguayensis* (Table 4, Figure 10). In the same leaflet, some species of *Butia* showed intraspecific variation in the leaf margin format (Sant'Anna-Santos et al. 2018), demonstrating the importance of studying more than one individual of the same species. By examining adjacent leaflets, Pinedo et al. (2016) discovered that the adaxial and abaxial prominent state of leaflet margins found in *Allagoptera* are simply complementary conditions found between two adjacent leaflet margins. Their work showed the importance of examining adjacent leaflets.

The leaf margins of *Butia* species contain few characters to distinguish species, but the vasculature within each leaflet changes more frequently in some species than in others over a 10 cm length. Changes were observed to take place in *B. paraguayensis* and *B. eriospatha* (Figures 4, 5A, B) with secondary vascular bundles (SVB) becoming primary vascular bundles (PVB) and vice versa, but with no or few changes seen in *B. yatay* and *B. odorata* (Figure 6A, B). Some vessels appear to have disappeared from one section to the other in *B. paraguayensis* (Figures 4, 5A). However, future studies in which refined techniques are employed in sample preparations will allow thin paradermal sections that are essential in understanding the vascular pattern in *Butia*.

Amongst several characters used by Sant'Anna Santos et al. (2018), they used the following in their key: the number of mid-rib collateral bundles (vb), the mid-rib connected or not connected to the hypodermis, the mid-rib fibrous ring (MFR) abaxially projected or not projected and accessory bundles (ab) completely surrounding the MFR or only partially surrounding it to identify *Butia* species. As seen in the Tables, many of these characters do vary, with the number of collateral bundles decreasing in number from the base to the apex, whether that is within the leaflet or between leaflets (see #vb in MFR in Tables 2–4). Whether the MFR is connected to or reaches the hypodermis or not is variable in at least the adjacent distal leaflet of *Butia paraguayensis* (Table 4, Figure 10) or in the distal portion of the leaflet of *Butia eriospatha* (Table 2, Figure 7C). The shape of the MFR changes from abaxially projected and slightly projected to round from the base to the apex, whether that is within a leaflet or between leaflets (see MFR shape in Tables 2–4, Figures 7–10). Accessory bundles (ab) completely surrounding the MFR is one of the main characters used to distinguish

Butia odorata from *Butia capitata* (Sant'Anna-Santos et al. 2015). This was clearly the case for the samples of five specimens from Tapes, RS, Brazil. Of course, accessory bundles cannot completely surround the MFR if they are interrupted by the MFR being connected to the abaxial hypodermis, as in *B. capitata* from Lontra, MG (Sant'Anna-Santos et al. 2015). In our study, the MFR is not connected to the abaxial hypodermis in most specimens of *Butia odorata* from Uruguay, just like the specimens from Tapes, RS, studied by Sant'Anna-Santos et al. (2015). While on close examination the accessory bundles (ab) of some Uruguayan specimens (Figures 7D, 11A, B, D, E) do encircle the MFR (fibrous ring) completely as do those of the more northern populations from Tapes, RS (Figure 11C) (Sant'Anna-Santos et al. 2015), it is not strongly apparent as seen in specimens from Tapes, RS. In fact, in many Uruguayan specimens of *B. odorata*, this is clearly not the case, because while the abs appear to mostly encircle the MFR, they do not completely surround it (Figure 11F–H). So the key will have to be modified to accommodate these population differences. In addition, note that Figure 11A, B are the same 20060233 accession, meaning that both plants were grown from seed collected from the same mother plant. Therefore, it is important to be cognizant of not only population differences when researching anatomical variation, but even intra-plant differences, as previously stated by Sant'Anna-Santos et al (2018) in the leaflet margin of some species of *Butia*. In most cases, the anatomy is consistent. Sant'Anna-Santos et al. (2018) studied both cultivated and native *Butia capitata* and *Butia archeri* specimens and found the same anatomical organisation regarding the leaf anatomy. Although variation does not seem to be a rule for all species, our data show that it is important to investigate different populations of the same species.

Montgomery Botanical Center has several wild collected plants that were grown from seed collected from the same mother. The plants, however, have developed differently due to their unique set of growing conditions, like sun/shade exposure, differences in soil type and available moisture. Certainly, the use of fertilisers may be responsible for favouring the growth of vegetative organs and thus modifying the basic histological patterns. It has been reported that *Butia pubispatha*, under cultivation, showed an accelerated growth, resulting in larger plants than those observed in its natural habitat (Lorenzi et al. 2010). The different growing conditions at MBC resulted in some palms growing more robustly and maturing faster than others. Although it was not an objective of this current study, it is important to note that different growing conditions also result in plants, even from the same mother, having different mid-rib anatomy. Figure 12 shows the images of palms with their corresponding anatomy below. The *B. paraguayensis* labelled specimen M is obviously a larger and more mature specimen than N of the same accession and also the *B. yatay* specimen A is larger and more mature than C. The resulting differences in their anatomy M to N and A to C illustrate the importance of knowing the condition of the palm from which you are sampling, because it does make a difference. Finally, although the anatomical results of plants grown from wild collected seed should not be affected greatly from those collected directly from the wild, the progeny of these may experience changes due to the potential for hybridisation in cultivation.

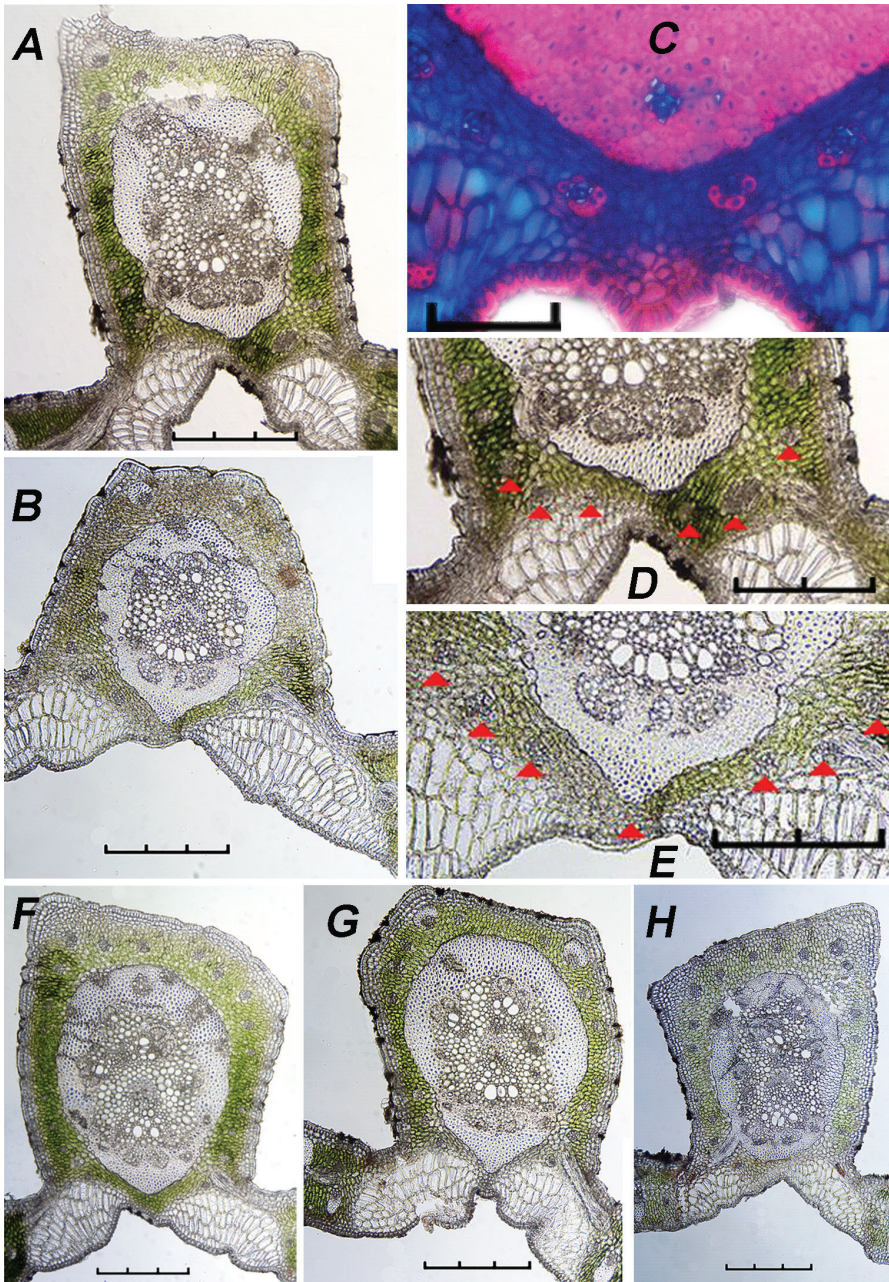


Figure 11. Population and individual differences in *Butia odorata* **A, B, D–H** are from Rocha, Uruguay, **C** is from Tapes, RS, Brazil **A** 20060233***E** **B** 20060233***G** **C** contrasting stains make the abs from the Brazil specimen more visible **D** enlargement of **A** **E** enlargement of **B** **F** 20060234***M** **G** 20060237***C** **H** 20060240***A**. Note that the presence of accessory bundles (ab) surrounding the mid-rib fibrous ring (MFR) is more apparent in the Brazil sample **C** partially due to the staining, but less apparent or absent from the Uruguayan samples. Red arrows pointing out the abs in the Uruguayan samples and abs do not completely surround the MFR in **F–H**. Scale bars: 0.3 mm (**A, B, F–H**), 0.1 mm (**C**), 0.2 mm (**D, E**).

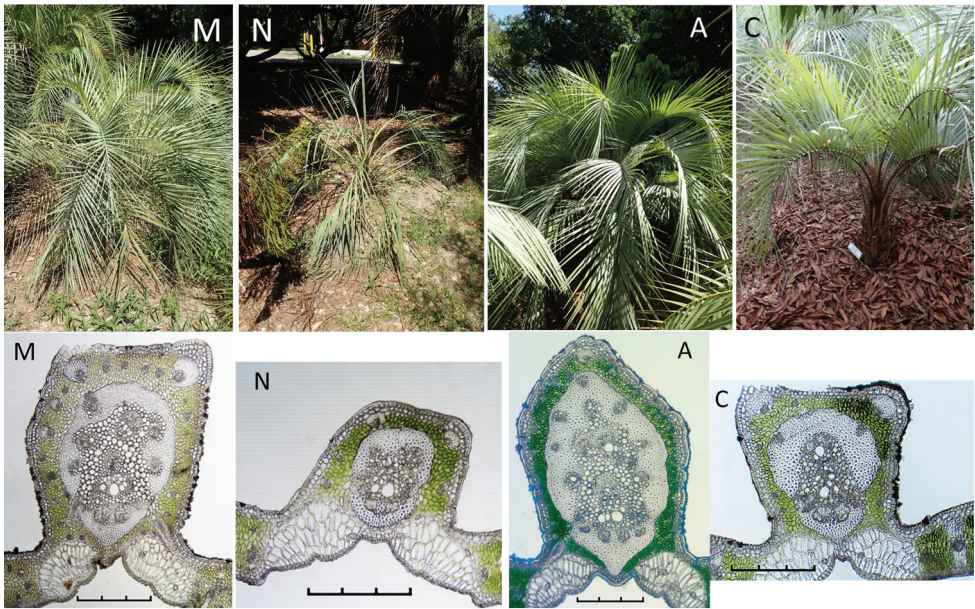


Figure 12. Differences in the centre mid-rib cross-sections within plants of the same species and same accession (seed collected from the same mother plant), but growing under different environmental conditions resulting in a different stage of developmental plant and leaf maturity **M, N** are *Butia paraguayensis* plant accession 20060222*M and 20060222*N **A, C** are *Butia yatay*. plant accession 20040335*A and 20040335*C. Note the differences in the developmental stage of the plant above and its corresponding anatomy below.

Conclusion

This paper has shown the importance of always collecting leaflets as close to the middle of the leaf blade as possible and sectioning that leaflet as close to its centre as possible for consistent and comparable results. It is also important to expect some population differences, differences in plants of different developmental maturity and differences in those growing under distinctly different conditions than those found in their original habitat. Here, we re-emphasise the importance of a broader sampling exercise when studying leaf anatomy due to possible ecological and developmental variations that may occur in some species. The diversity of leaf anatomy, here observed, also led us to suggest that characters previously used should be re-evaluated in further studies, using wild populations and/or cultivated specimens.

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Morphology and molecules support the new monotypic genus *Parainvolucrella* (Rubiaceae) from Asia

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Abstract

Parainvolucrella R.J. Wang, a new monotypic genus for *P. scabra* (Wall. ex Kurz) M.D.Yuan & R.J.Wang, new combination, is segregated from the *Hedyotis-Oldenlandia* complex, based on morphological and molecular evidence. Phylogenetically, the new genus is sister to *Scleromitron*, from which it differs by a combination of morphological characters: herbaceous habit, terminal inflorescence with subtended leaves, heterostylous flowers, indehiscent fruits and pollen with double microreticulate tectum. A key to the genera of the *Hedyotis-Oldenlandia* complex in China is provided for further identification.

Keywords

new combination, palynology, *Parainvolucrella*, *Scleromitron*, taxonomy

Introduction

As one of the largest species groups of the family Rubiaceae, the *Hedyotis-Oldenlandia* complex contains hundreds of species distributed in the tropical and subtropical region worldwide. Due to morphological intermediacy and homoplasy, systematic studies in herbaceous Rubiaceae are very difficult (Gibbons 2020). The generic delimitation within this complex is complicated and controversial (Neupane et al. 2015) and historically disputed. The commonly shared morphological characters, such as four petals and calyx lobes, 2-celled ovaries with numerous ovules on axile placenta and

capsular fruits made some studies treat this complex as one genus, *Hedyotis* L., in a broad sense (Lamarck 1792; Fosberg and Sachet 1991; Dutta and Deb 2004; Chen and Taylor 2011). Whereas, morphological differences in habit, inflorescence position, homo- or heterostylous flowers, dehiscent or indehiscent fruits, as well as the shape and ornamentation of seeds and pollen, provide unquestionable evidence to separate this complex into several small genera (Bremekamp 1952; Terrell et al. 1986; Terrell and Robinson 2003). Recent phylogenetic analyses, based on multiple nuclear and chloroplast DNA markers, revealed that this complex was polyphyletic and supported its subdivision into small genera (Groeninckx et al. 2009; Neupane et al. 2009; Guo et al. 2013; Wikström et al. 2013; Neupane et al. 2015; Gibbons 2020). Then the *Hedyotis* species in China fall into the following genera of *Debia* Neupane & N.Wikstr., *Dime-tia* (Wight & Arn.) Meisn., *Edrastima* Raf., *Hedyotis*, *Involucrella* (Benth. & Hook.f.) Neupane & N.Wikstr., *Leptopetalum* Hook. & Arn., *Oldenlandia* L. and *Scleromitron* (Wight & Arn.) Meisn. (Neupane et al. 2015; Wang 2018).

During our field investigation in Guangxi Zhuang Autonomous Region, we came across the species *Hedyotis scabra* Wall. ex Kurz, not recorded previously in China (Wei 2018), in bamboo forest nearby the Nonggang National Nature Reserve. This species has arbitrarily been treated as *Scleromitron scabrum* (Wall. ex Kurz) Neupane & N.Wikstr. with insufficient morphological and molecular evidence (Neupane et al. 2015). Morphologically, it is similar to *Involucrella coronaria* (Kurz) Neupane & N.Wikstr. for its terminal inflorescence subtended by four involucre leaves. Our subsequent morphological comparison and phylogenetic analysis, based on multiple DNA markers, support that this species represents a new genus.

Materials and methods

Morphological characters of *Hedyotis scabra* were scored from living materials and dried specimens. All vouchers which we collected were deposited at the herbarium of South China Botanical Garden, Chinese Academy of Sciences (IBSC). Pollen and seeds were observed using scanning electron microscopy (JSM-6360LV) under 15.00 kV accelerating voltage. Pollen terminology for description followed Punt et al. (2007).

Methods of DNA extraction and PCRs followed Guo et al. (2011). Sequences of all taxa were downloaded from GenBank for molecular phylogenetic analysis, except for the newly added *Hedyotis hainanensis*, *H. ovata*, and three samples of *Hedyotis scabra* (Table 1). Geneious v.11.0.3 (Kearse et al. 2012) was used for sequence alignment and MrModeltest 2.0 was applied for selecting the best-fit nucleotide substitution model (GTR+G+I) on the basis of the AIC criterion (Nylander 2004). Bayesian Inference (BI) was performed using MrBayes v.3.2.7 (Ronquist et al. 2012), with a calculation of posterior probabilities (PP) to each clade. The bootstrap (BS) values were obtained by IQ-TREE v. 2.0 (Nguyen et al. 2015) for Maximum Likelihood analyses based on the best-fit nucleotide substitution model (GTR+F+R3) selected by ModelFinder (Kalyaanamoorthy et al. 2017).

Table 1. Taxa, vouchers, localities and GenBank accession numbers of ITS, *petD*, *rps16*, *trnH-psbA* and *trnL-F* sequences for phylogenetic analysis.

Taxon	Voucher (herbarium)	ITS	<i>petD</i>	<i>rps16</i>	<i>trnH-psbA</i>	<i>trnL-F</i>
<i>Debia ovatifolia</i> (Cav.) Neupane & N. Wilstr.	China: Xing Guo & Ping Yang 20-1 (IBSC)	JF699940	JF700090	JX111309	JF699795	JX111382
<i>Dentella repens</i> [R. Forst. & G. Forst.	Australia: Anderson 2262 (GB)	AM939440	EU557693	AF333370	/	EU543091
<i>Dimetia ampliflora</i> (Hance) Neupane & N. Wilstr.	China: Ruijiang Wang et al. 1147 (IBSC)	JX111198	JX111086	JX111242	JX111161	JX111317
<i>Dimetia auriculata</i> (L.) R.J. Wang	China: Ruijiang Wang & Yiding Gao 1185 (IBSC)	JF699904	JF700053	JX111298	JF699765	JX111372
<i>Dimetia capitellata</i> (Wall. ex G. Don) Neupane & N. Wilstr. var. <i>capitellata</i>	China: Xianguo Huang et al. GBOW51278 (IBSC)	JX111201	JX111089	JX111250	JX111164	JX111327
<i>Dimetia scandens</i> (Roxb.) R.J. Wang	China: Guo Xing & Ping Yang 10 (IBSC)	JF699949	JF700099	/	JF699804	/
<i>Ednostima trinervia</i> (Retz.) Neupane & N. Wilstr.	Sri Lanka: F. Fagerlind 4338 (S)	HE657769	HE657652	HE649907	/	/
<i>Hedyotis acutangula</i> Champ. ex Benth.	China: Ruijiang Wang HA-02 (IBSC)	JX111197	JX111085	JX111241	JX111160	JX111316
<i>Hedyotis cantoniensis</i> F.C. How ex W.C. Ko	China: Ruijiang Wang et al. 1250 (IBSC)	JF976484	JF700061	JX111247	JF699773	JX111322
<i>Hedyotis caudatifolia</i> Merr. & F.P. Metcalf	China: Ruijiang Wang et al. 1269 (IBSC)	JF699916	JF700065	JX111256	JF699777	JX111329
<i>Hedyotis effusa</i> Hance	China: Ruijiang Wang et al. 1268.1 (IBSC)	JF699933	JF700083	JX111262	JF699790	JX111335
<i>Hedyotis hainanensis</i> (Chun) W.C. Ko	China: Guobing Jiang & Xinxin Zhou 1121 (IBSC)	MZ326000*	MZ403798*	MZ343047*	MZ403808*	MZ403794*
<i>Hedyotis ovata</i> Thunb. ex Maxim.	China: Guobin Jiang et al. 1508 (IBSC)	MZ326003*	MZ403799*	MZ343053*	MZ403807*	MZ403793*
<i>Hedyotis shenbenensis</i> Tao Chen	China: Ruijiang Wang et al. 1262-1 (IBSC)	JF976502	JF700101	JX111276	JF699805	JX111350
<i>Hedyotis uncinella</i> Hook. & Arn.	China: Ruijiang Wang 1217 (IBSC)	JF699963	JF700113	JX111282	JF699814	JX111356
<i>Involucrella cherevensis</i> (Pierre ex Pic.) Neupane & N. Wilstr.	Thailand: Suphantee 799 (ODU)	KP994258	KR005743	KR005803	/	/
<i>Involucrella coronaria</i> (Kurz) Neupane & N. Wilstr.	China: Xing Guo & Ping Yang 22-1 (IBSC)	JX111218	JX111104	JX111270	JX111177	JX111344
<i>Lepiotetulum biflorum</i> (L.) Neupane & N. Wilstr.	Singapore: Ruijiang Wang SIN03 (IBSC)	JX111238	JX111120	JX111302	JX111192	JX111376
<i>Lepiotetulum peritum</i> (Blume) Neupane & N. Wilstr.	China: Ruijiang Wang 1478 (IBSC)	JF699944	JF700094	/	JF699799	/
<i>Oldenlandia capensis</i> L. f. var. <i>capensis</i>	Zambia: Dessin et al. 843 (BR)	AM939496	EU557737	EU543048	/	EU543133
<i>Oldenlandia corymbosa</i> L. var. <i>corymbosa</i>	Singapore: Ruijiang Wang SIN02 (IBSC)	JX111239	JX111121	JX111306	JX111194	JX111380
<i>Oldenlandia duemmeri</i> S. Moore	Uganda: W. H. Lewis 6018 (GH)	HE657744	HE657629	HE649881	/	/
<i>Oldenlandia umbellata</i> L.	Sri Lanka: F. Fagerlind 3320 (S)	HE657674	HE657569	HE649806	/	/
<i>Oldenlandia widdemanni</i> K.Schum.	Kenya: Luke & Luke 8362 (UPS)	AM939525	EU557756	EU543063	/	EU543151
<i>Parainvolucrella scabra</i> (Wall. ex Kurz) M.D. Yuan & R.J. Wang	China: Mingdeng Yuan & Yida Xu YS398.1 (IBSC)	MZ326006*	MZ403801*	MZ343069*	MZ403806*	MZ403796*
<i>Parainvolucrella scabra</i> (Wall. ex Kurz) M.D. Yuan & R.J. Wang	China: Mingdeng Yuan & Yida Xu YS398.2 (IBSC)	MZ326007*	MZ403802*	MZ343070*	MZ403805*	MZ403797*
<i>Parainvolucrella scabra</i> (Wall. ex Kurz) M.D. Yuan & R.J. Wang	China: Mingdeng Yuan & Yida Xu YS399 (IBSC)	MZ326008*	MZ403803*	MZ343071*	MZ403804*	MZ403795*
<i>Parainvolucrella scabra</i> (Wall. ex Kurz) M.D. Yuan & R.J. Wang	Thailand: Neupane 183 (ODU)	KP994264	KR005751	KR005812	/	/
<i>Penodon pentandrus</i> Vatte	Zambia: Dessin et al. 598 (BR)	AM939528	EU557759	EU543066	/	EU543154
<i>Scleromitrium angustifolium</i> (Cham. & Schldt.) Benth.	China: Xing Guo & Ping Yang 12 (IBSC)	JF976506	JF700108	JX111297	JF699810	JX111370
<i>Scleromitrium diffusum</i> (Willd.) R.J. Wang	China: Xing Guo 51 (IBSC)	JF699932	JF700081	JX111308	JF699789	JX111381
<i>Scleromitrium kuanum</i> (R.J. Wang) R.J. Wang	China: Ruijiang Wang et al. 978 (IBSC)	JX111215	JX111101	JX111267	JX111174	JX111341
<i>Scleromitrium pinifolium</i> (Wall. ex G.Don) R.J. Wang	China: Ruijiang Wang 1231 (IBSC)	JX111240	JF700094	JX111311	JX111196	JX111384

Notes: “*” indicates the newly-sequenced fragments, “/” indicates the missing data.

Results

Phylogenetic analysis

The phylogenetic analysis, based on nuclear ITS and four chloroplast DNA regions (*petD*, *rps16*, *trnH-psbA* and *trnL-F*), generated an almost identical tree to that of Neupane et al. (2015). It showed that all the samples of *Hedyotis scabra* cluster into an independent clade which is sister to *Scleromitrium* with robust support (PP = 1, BS = 100, Fig. 1). In addition, the morphological similar species, *Involucrella coronaria*, nested in the *Involucrella* clade (PP = 1, BS = 93, Fig. 1) and is sister to the lineage of (*Debia* clade + (*Leptopetalum* clade + (*Dimetia* clade + (*Scleromitrium* clade + *H. scabra* clade)))) with robust support (PP = 1, BS = 100, Fig. 1).

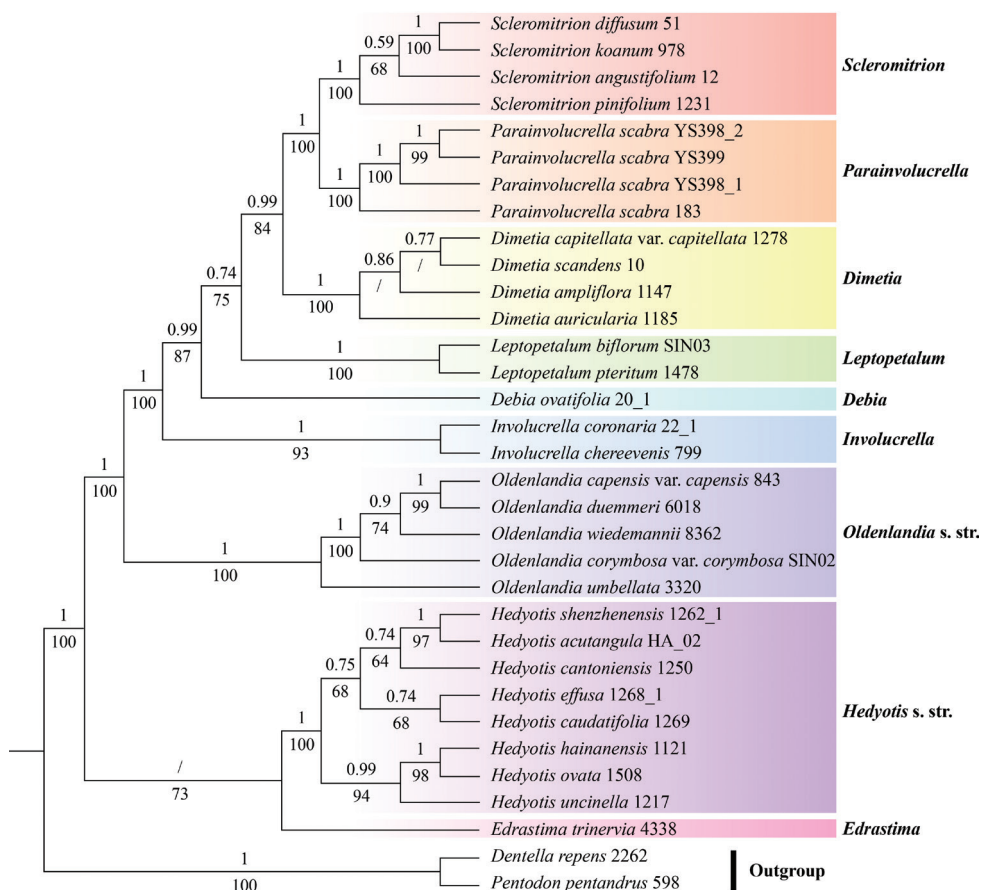


Figure 1. Phylogenetic relationships of the *Hedyotis-Oldenlandia* complex derived from a combined analysis of ITS and plastid *petD*, *rps16*, *trnH-psbA* and *trnL-F*. Bayesian Posterior Probability (PP \geq 0.5) and Bootstrap values (BS \geq 50%) are indicated above and below the branches, respectively.

Taxonomic treatment

Based on the morphological and palynological differences between *Hedyotis scabra* and *Scleromitron*, as well as the molecular evidence, a new genus is proposed here.

***Parainvolucrella* R.J. Wang, gen. nov.**

urn:lsid:ipni.org:names:77218849-1

拟合叶耳草属 (Nǐ Hé Yè ěr Cǎo Shǔ)

Note. Annual or perennial herbs. Stem decumbent. Inflorescences terminal, congested-cymose, involucreted. Flowers heterostylous; petals 4; ovary 2-loculed, ovules many. Pollen 3-colporate; tectum double microreticulate. Fruits indehiscent. Seeds trigonous; testa reticulate.

Type. *Parainvolucrella scabra* (Wall. ex Kurz) M.D. Yuan & R.J. Wang (*Hedyotis scabra* Wall. ex Kurz)

***Parainvolucrella scabra* (Wall. ex Kurz) M.D. Yuan & R.J. Wang, comb. nov.**

urn:lsid:ipni.org:names: 77218850-1

Figs 2, 3

Basionym: *Hedyotis scabra* Wall. ex Kurz, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 46(2): 133, 136 (1877). Type: MYANMAR. from Martaban down to Upper Tenasserim, Wall. Cat. 880 (holotype: CAL; isotypes: G [G00436284!; G00436285!]; K [K001110148!; K001110149! K000031881!]).

Synonym: *Scleromitron scabrum* (Wall. ex Kurz) Neupane & N.Wikstr., Taxon 64(2): 317 (2015)

Description. Annual or perennial herbs. Stems decumbent, ca. 1 m long, roughly angular, usually rooted at nodes; branches ascending to 30 cm high. Leaves opposite, sessile to petiolate, petiole to 3 mm long; blades 2.0–7.0 × 1.0–3.0 cm, narrowly ovate to ovate, apex acute, base cuneate; leaf scabrid adaxially and along the veins abaxially; mid-rib depressed adaxially and prominent abaxially; secondary veins 5–6 on each side. Stipules ca. 3.0 × 2.0 mm, triangular, fimbriate with tipped colleters, excurved, pubescent abaxially. Inflorescence terminal, (2–)3–8(–12)-flowered, congested-cymose, usually subtended by 4 involucre leaves; peduncle sessile; bracts 2–3 mm long, narrowly ovate, scabrid; bracteoles ca. 1 mm long, truncate to broadly ovate-triangular, fimbriate with tipped colleters, glabrous. Flowers heterostylous, pedicels to 0.8 mm long. Hypanthium ca. 0.8 mm long, obconic, 4 longitudinal projections against the lobes; lobes 4, ca. 1.5 × 0.4 mm long, narrowly triangular to narrowly oblong, scabrid. Corolla white, tube 1.5–2.0 mm long, glabrous abaxially and pubescent adaxially; lobes 4, 2.3–2.8 × 0.7–0.8

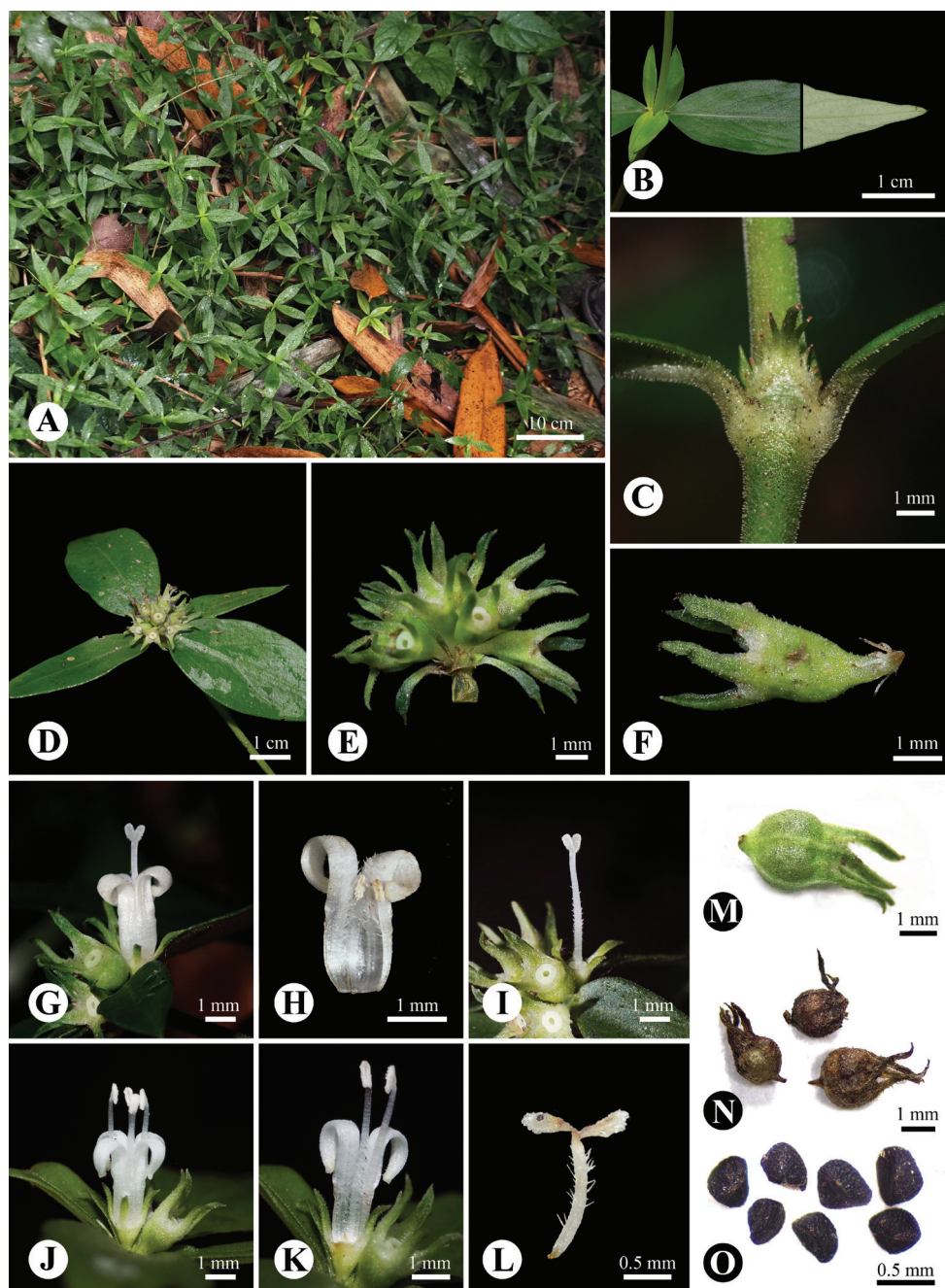


Figure 2. *Parainvolucrella scabra* (Wall. ex Kurz) M.D. Yuan & R.J. Wang **A** habit **B** leaf adaxial (left) and abaxial (right) surface **C** stem and stipule **D** infructescence with four involucre leaves **E** infructescence with bracts **F** calyx with bracteole at base **G–I** longistylous flower **J–L** brevistylous flower **M, N** fruits **O** seeds.

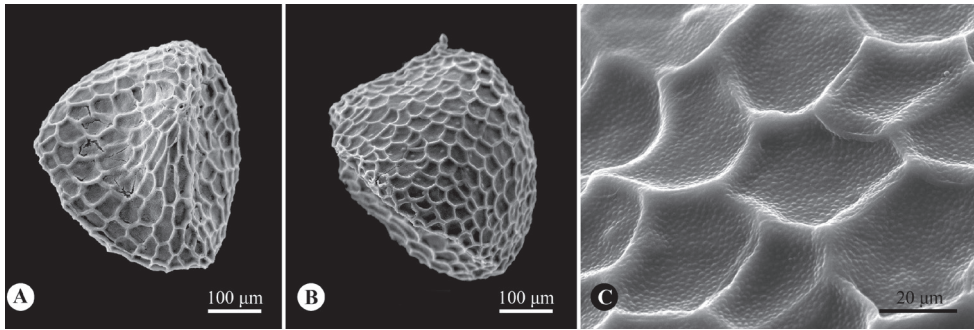


Figure 3. Seed morphology of *Parainvolucrella scabra* **A** ventral side **B** dorsal side **C** testa ornamentation.

mm, oblong. Stamens 4, anthers 0.6–0.7 mm long. Stigma bilobed, 0.5–0.6 mm long, papillate. Longistylous flowers: stamens included, filaments adnate to the base of corolla tube, filaments ca. 2 mm long; styles ca. 4.3 mm long, exserted, included part pubescent, stigma ellipsoid. Brevistylous flowers: stamens included; filaments adnate to the base of corolla tube, filaments ca. 5.6 mm long; styles ca. 2 mm long, exserted, pubescent, stigma clavate. Fruits ca. 2.1 × 2.3 mm, subglobose, with 4 longitudinal projections when young, scabrid, indehiscent. Seeds trigonous, 0.4–0.5 mm, numerous, black; testa reticulate.

Phenology. Flowering from July to September; fruiting from October to December.

Etymology. The generic name *Parainvolucrella* alludes to similarity to *Involucrella coronaria* in possessing terminal inflorescence subtended by four involucre leaves.

Distribution and habitat. Bangladesh, India, Myanmar, Thailand and Vietnam (Fukuoka 1970; Dutta and Deb 2004), and China (new record). Only one subpopulation including about 200 individuals was found in dense bamboo forest and at the edge of the forest nearby the Nonggang National Nature Reserve. The habitat there belongs to a tropical monsoon climate, main associated species are *Dendrocalamus latiflorus* Munro (Poaceae) and *Centotheca lappacea* (L.) Desv. (Poaceae).

Palynology. Monads, isopolar and prolate-spheroidal, with 3-colporate apertures; the tectum is double microreticulate, with a psilate suprareticulum and a microechinate infrareticulum. The pollen size is 22.2 (20.9–23.7) × 20.2 (18.3–21.8) µm with P/E value 1.10 in brevistylous flowers (Fig. 4A–C); and 20.2 (18.5–21.2) × 19.0 (16.6–20.6) µm with P/E value 1.06 in longistylous flowers (Fig. 4D–F).

Additional specimens examined. **CHINA.** Guangxi Zhuang Autonomous Region: Chongzuo City, Longzhou County, Zhubu Town, Nonggang Village, 1 Nov 1978, Nonggang Investigation Team 11263 (IBK!); same locality, 22°29'16"N, 106°56'13"E, elev. 287 m, 29 Oct 2020, Ming-Deng Yuan & Yi-Da Xu YS398, YS399 (IBSC!); same locality, 22°29'22"N, 106°56'11"E, elev. 290 m, 2 Feb 2021, Ming-Deng Yuan YS407 (IBSC!); Zhubu Town, Lenglei Village, 9 Oct 1979, Nonggang Investigation Team 20457 (GXMI!). **INDIA.** India orientalis: in Bengal circa Calcuttam, J.W.Helfer 40 (P03904580). **THAILAND.** Kampeng: A.F.G. Kerr 6161 (SING!); Tak: Ban Musoe, 22 Jul 1973, Gen Murata et al. 16719 (P03904581).

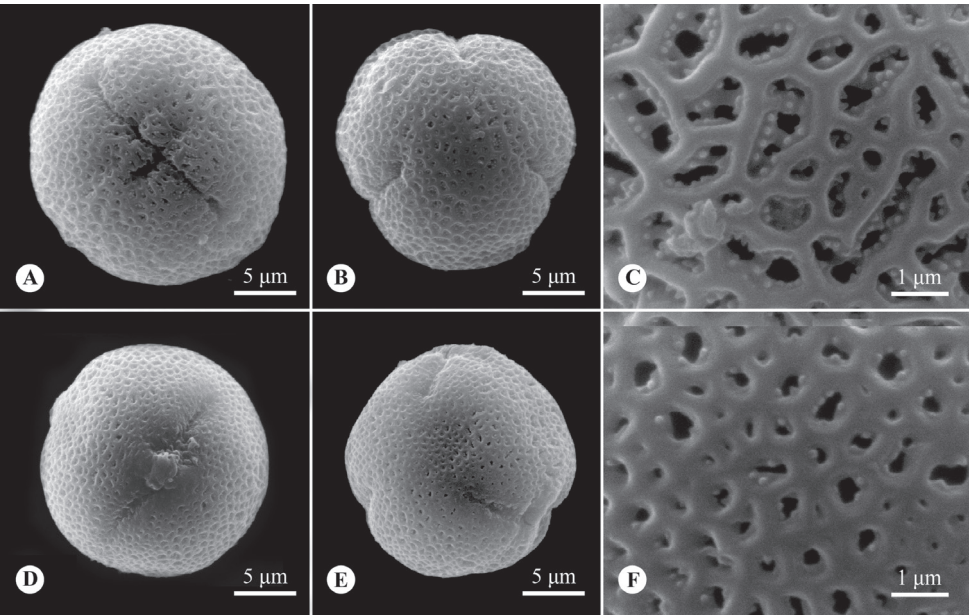


Figure 4. Pollen morphology of *Parainvolucrella scabra* (**A–C** from Mingdeng Yuan & Yida Xu YS398, brevistylous flower **D–F** from Mingdeng Yuan & Yida Xu YS399, longistylous flower) **A, D** equatorial view **B, E** polar view **C, F** double microreticulate ornamentation of mesocolpium.

Key to the genera of the *Hedyotis*-*Oldenlandia* complex in China

- 1 Decumbent or prostrate herbs or climbers2
- Erect or ascending herbs, subshrubs or shrubs.....5
- 2 Herbs; venation triplinerved inconspicuously above base; flowers homostylous.....*Edrastrima*
- Herbs or climbers; pinnated venation; flowers heterostylous3
- 3 Climbers *Dimetia*
- Decumbent or prostrate herbs4
- 4 Stipules triangular, fimbriate with tipped colleters; inflorescence terminal, subtended by four leaves *Parainvolucrella*
- Stipules broadly triangular, apex spinous; inflorescence terminal or axillary, without subtended leaves *Dimetia*
- 5 Shrubs or subshrubs.....*Hedyotis*
- Herbs.....6
- 6 Inflorescence terminal, subtended by two or four leaves7
- Inflorescence terminal or axillary, without subtended leaves8
- 7 Inflorescence large and loose, peduncles and pedicels long *Debia*
- Inflorescence small and congested, peduncles and pedicels subsessile
.....*Involucrella*

8	Fruits winged conspicuously or inconspicuously	<i>Leptopetalum</i>
–	Fruits wingless	9
9	Herbs gracile; growing in limestone area	<i>Involucrella</i>
–	Herbs robust; growing in non-limestone area.....	10
10	Stipules papery, hard, entire or fimbriate; flower homo- or heterostylous; fruits dehisce diplophragmously.....	<i>Hedyotis</i>
–	Stipules membrane, fimbriate; flower homostylous; fruits dehisce loculicidally.....	11
11	Stamens and stigma included in corolla tube	<i>Oldenlandia</i>
–	Stamens and styles exserted from corolla tube	<i>Scleromitron</i>

Discussion

The plant habit, stipule shape, inflorescence position, flower distyly and the dehiscent pattern of the fruits are of diagnostic significance in the different genera of the *Hedyotis*-*Oldenlandia* complex (Dutta and Deb 2004). Several successive field collections observed that the fruits of *Hedyotis scabra* are completely indehiscent, which was obscurely diagnosed by Hooker (1880) and incorrectly described by Dutta and Deb (2004). *Hedyotis scabra* differs from *Scleromitron* by the terminal inflorescences with involucreal leaves (vs. axillary or terminal and axillary in the uppermost leaf axils in *Scleromitron*), the heterostylous flowers (vs. homostylous in *Scleromitron*), pollen grains tectum double microreticulate, with psilate supracreticulum and microechinate infrareticulum (vs. rugulate tectum with microechinate muri in *Scleromitron*) and indehiscent fruits (vs. loculicidally dehiscent in *Scleromitron*). On the other hand, *Parainvolucrella scabra* is similar to *Involucrella coronaria* with respect to their terminal inflorescence subtended by involucreal leaves, heterostylous flowers and indehiscent fruits, but *Parainvolucrella* has decumbent habit (vs. erect or ascending in *Involucrella coronaria*), young fruits with 4 longitudinal projections (vs. smooth surfaces in *Involucrella coronaria*) and trigonous seeds with no pits on the surface (vs. ellipsoidal and 3–5 pitted seeds in *Involucrella coronaria*) (Table 2).

Based on the combined nuclear (ITS, ETS) and plastid (*petD*, *rps16*) data, Neupane et al. (2015) did not provide a well-resolved phylogenetic tree to support the placement of *Hedyotis scabra* as sister to the remainder of *Scleromitron* in the *Hedyotis*-*Oldenlandia* complex, neither did Gibbons (2020). In addition, it seemed that the morphological confliction between the *H. scabra* and *Scleromitron* and the phylogenetic exclusion of *H. scabra* from *Scleromitron* clade were overlooked before making the new combination by Neupane et al. (2015). Our further integrated analysis, based on the morphological incongruence and the robust phylogenetic support (BS = 100, PP = 1), based on nrITS and plastid *petD*, *rps16*, *trnH-psbA* and *trnL-F*, elucidated the taxonomic and phylogenetic confusions and thus the new monotypic genus *Parainvolucrella* is proposed here.

Table 2. Morphological comparison of the *Hedyotis-Oldenlandia* complex distributed in China.

Taxon	Habit	Stipules	Flowers	Fruits	Seeds	Pollen
<i>Debia</i> Neupane & N. Wikstr.	Annual small herbs, erect	Papery, broadly triangular, fimbriate with tipped collectors	Homostylous with exerted stigma and stamens	Compressed globose, loculicidally dehiscent	Conoidal with deeply depressed exotesta, anticlinal boundaries nearly straight or rounded	3-colporate, perforate tectum with psilate muri
<i>Dimetia</i> (Wight & Arn.) Meisn.	Perennial herbs or subshrubs, prostrate, decumbent or climber	Papery, truncate, broadly rounded or broadly triangular, spinous	Heterostylous	Subglobose to ellipsoidal, dehiscent diplophragmously or indehiscent	Dorsiventrally flattened or trigonous, reticulate, anticlinal boundaries nearly straight	3- or 4-colporate, double microreticulate tectum with psilate supareticulum and microechinate infareticulum
<i>Echvastima</i> Raf.	Annual small herbs, decumbent	Membranous, truncate, fimbriate with tipped collectors	Homostylous with exerted stigma and stamens	Subglobose, loculicidally dehiscent	Trigonous to ellipsoidal, reticulate, anticlinal boundaries nearly straight	3-colporate, microreticulate tectum with psilate muri
<i>Hedyotis</i> L.	Perennial herbs to shrubs, erect or ascending	Papery, triangular, entire to fimbriate with tipped collectors	Heterostylous or rarely homostylous with exerted stigma and stamens	Ellipsoidal, dehiscent diplophragmously or rarely indehiscent	Dorsiventrally flattened, reticulate, anticlinal boundaries nearly straight	3- or 4-colporate, double microreticulate tectum with psilate supareticulum and microechinate infareticulum
<i>Involucrella</i> (Hook. f.) Neupane & N. Wikstr.	Annual herbs, erect or ascending	Papery, triangular or truncate, margin fimbriate or acicular spinous with tipped collectors	Heterostylous or rarely homostylous with included stigma and stamens	Hemispherical to ellipsoidal, loculicidally dehiscent or indehiscent	Ellipsoidal, 3–5 pitted, anticlinal boundaries nearly straight or undulate	3- or 4-colporate, double microreticulate tectum with psilate supareticulum and microechinate infareticulum
<i>Oldenlandia</i> L.	Annual small herbs, erect or ascending	Membranous, flabellate or broadly rounded, fimbriate with tipped collectors	Homostylous with included stigma and stamens	Globose to ellipsoidal, loculicidally dehiscent	Trigonous, reticulate, anticlinal boundaries nearly straight	3- or 4-colporate, microreticulate tectum with psilate muri
<i>Parainvolucrella</i> R.J. Wang	Annual or perennial herbs, decumbent	Papery, triangular, fimbriate with tipped collectors	Heterostylous	Subglobose, 4 longitudinal projections when young, indehiscent	Trigonous, reticulate, anticlinal boundaries nearly straight	3-colporate, double microreticulate tectum with psilate supareticulum and microechinate infareticulum
<i>Scleromitron</i> (Wight & Arn.) Meisn.	Annual small herbs, erect or ascending	Membranous, triangular to rounded, fimbriate with tipped collectors	Homostylous with exerted stigma and stamens	Subglobose, loculicidally dehiscent	Trigonous to conoidal, reticulate, anticlinal boundaries nearly straight	3- or 4-colporate, rugulate tectum with microechinate muri
<i>Leptopetalum</i> Hook. & Arn.	Annual small herbs, erect	Papery, triangular or broadly triangular, fimbriate with tipped collectors	Homostylous with included stigma and stamens	Obconical, winged, loculicidally dehiscent	Ellipsoidal with deeply depressed exotesta, anticlinal boundaries undulate	3-colporate, microreticulate tectum with psilate muri

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A new species and a new series of *Elatostema* (Urticaceae) from south-western China

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Abstract

The new series *Elatostema* section *Weddellia* series *Xingyiensia* L.D. Duan & D.H. Yin (Urticaceae) is described. In addition, its new species *Elatostema xingyiense* L.D. Duan & D.H. Yin, endemic to Guizhou Province, is also described and illustrated with photographs. The new series is morphologically similar to series *Melanocarpa* W.T. Wang and series *Sublinearia* W.T. Wang. The new species is most similar to *E. melanocarpum*, *E. sublineare*, *E. obscurinerve*, *E. langicuspe* and *E. youyangense* in morphology, but can be visibly distinguished by a combination of characters, including leaf vein, male inflorescences, female inflorescences and persistent tepals.

Keywords

Elatostema xingyiense, series *Xingyiensia*, taxonomy

Introduction

The genus *Elatostema* J. R. Forster & G. Forster (1775: 53; Urticaceae) is part of the family Urticaceae and includes about 500 species of sub-shrubs and understorey herbs that grow in the deep shade of forests, gorges, stream sides and caves (Wang 2014; L.F. Fu et al. 2019a). More than 290 species occur in China (Wu et al. 2012) and the greatest species richness occurs on limestone karst in Southeast Asia (Lin et al. 2003; Wang 2014; L.F. Fu et al. 2019b). *Elatostema* is distinguished and characterised from other genera of Urticaceae by its inflorescences of determinate capitula with receptacles and involucre (Z.R. Yang et al. 2011).

We found an unknown species from Guizhou Province, south-western China during our field trips in February 2019 and March 2019. This species is morphologically most similar to *Elatostema melanocarpum* W. T. Wang, *Elatostema sublineare* W. T. Wang, *Elatostema obscurinerve* W. T. Wang, *Elatostema langicuspe* W. T. Wang and *Elatostema youyangense* W. T. Wang (Wang 1980, 1984, 2013). It differs distinctly from these known species in several morphological features (Table 1) and is described here as a new species.

The genus *Elatostema* includes four sections, sect. *Pellionioides*, sect. *Weddellia*, sect. *Elatostema* and sect. *Androsyce*. Based on the designations of sections and series by Wang (2014), the new species is a member of section *Weddellia* by having minute staminate receptacles. With the presence of a perennial herbaceous habit and penninerved leaves, the new species has traits consistent with ser. *Crenata*, ser. *Nigrialata*, ser. *Nigribracteata*, ser. *Sublinearia*, ser. *Melanocarpa*, ser. *Stewardiana*, ser. *Bamaensia* and ser. *Involucrata*. However, the male inflorescences are dichotomously branched, inconsistent with any series listed above. Therefore, a new series is described here.

Materials and methods

The species specimen was contrasted with the collections at IBK, PE and KUN. A morphological species concept that was developed as part of previous taxonomic research (Wei et al. 2011) was used. All morphological measurements were performed on dried and fresh specimens. Relevant literature was consulted for the identification of specimens (Wang 1980, 1984, 2013). The morphological characteristics of *Elatostema xingyiense* were determined using a stereomicroscope (Olympus SZX16) integrated camera system (Olympus DP27) and we made the specimen measurements by Olympus cellSens Entry.

Taxonomy

***Elatostema* section *Weddellia* series *Xingyiensia* L.D.Duan & D.H.Yin, ser. nov.**
urn:lsid:ipni.org:names:77218851-1

Diagnosis. Mid-vein impressed, margin revolute, pistillate inflorescence peduncle dichotomously branched. **Typus seriei:** *Elatostema xingyiense* L.D. Duan & D.H. Yin.

Relationship. The staminate capitula of the species is long pedunculata, as such this new series is closely related to ser. *Sublinearia* W.T. Wang (Wang 1980). It also has similarity to ser. *Melanocarpa* W.T. Wang with its achene fawn, ovoid, longitudinally 4(-5)-ribbed and tuberculate (Wang 2013). However, the new series differs from these two series with regards to the following features: leaf mid-vein impressed, the margin revolute (compared to the mid-vein flat and margin flat in ser. *Melanocarpa* and ser. *Sublinearia*); pistillate inflorescence peduncle dichotomously branched (compared to the peduncle not dichotomously branched in ser. *Melanocarpa* and ser. *Sublinearia*) (Table 1).

Table 1. Morphological comparison between *E. xingyiense*, *E. melanocarpum*, *E. sublineare*, *E. obscurinerve*, *E. langicuspe* and *E. youyangense*.

	<i>E. xingyiense</i>	<i>E. melanocarpum</i>	<i>E. sublineare</i>	<i>E. obscurinerve</i>	<i>E. langicuspe</i>	<i>E. youyangense</i>
Leaf Veins	Mid-vein impressed, margin revolute	Mid-vein flat, margin flat	Mid-vein flat, margin flat	Mid-vein flat, margin flat	Mid-vein flat, margin flat	Mid-vein flat, margin flat
Male inflorescences	Peduncles 4–20 mm long, dichotomously branched, receptacles cochleariform to oblong, ca. 2–3 mm long, ca. 1–2 mm wide	Unknown	Peduncles 6–10 mm long, single, receptacles inconspicuous	Peduncles 3.5–9.0 mm long, single, receptacles inconspicuous	Peduncles 15–23 mm long, single, receptacles inconspicuous	Peduncles 15–23 mm long, single, receptacles tiny
Female inflorescences	Peduncles 1.0–1.5 mm long, receptacle papilionaceous or elliptic, bipartite, margin indehiscent or lobed, 1.5–6.5 mm long, 1.5–5.4 mm wide, bracts numerous, linear-lanceolate, abaxially puberulent, margin ciliate	Peduncles 1.0–1.5 mm long, receptacle conspicuous or inconspicuous, elliptic, 6 mm long, 3 mm wide, bracts ca. 10, triangular or narrow-triangular, 1.5 mm long, 0.7–3.0 mm wide, ciliolate, abaxially strigulose	Peduncles 1.0–3.5 mm long, receptacle sub-rectangular, 5–7 mm long, indehiscent or bisected. Bracts 50 or more, triangular or narrow-triangular, 0.8–1.2 mm long, densely ciliate.	Peduncles 0.7 mm long, receptacle sub-rectangular, ca. 1.5 mm long and broad. Bracts ca. 17, 2-seriate, broad-ovoid to ovoid, 0.6–1.2 mm long, female flower sessile, ovary ellipsoidal.	Inflorescence sessile. Receptacle sub-orbicular, 1 mm in diam. Bracts 6, narrow-ovoid, 2.5 mm long	Peduncles short and robust, receptacle small. Bracts 8, broad-ovoid, 0.2–0.4 mm long. Bracts missing, ovary subglobose, 0.15 mm long.
Achenes	Sessile, ovoid, ca. 0.35–0.40 mm long, longitudinally 4(–5)-ribbed and tuberculate	Pedice short, narrow-ovoid, 1.0–1.5 mm long, densely tuberculate, so metimes with numerous short lines.	Pedice short, elliptic-ovate, 0.6–0.8 mm long, longitudinally 8-ribbed	Unknown	Unknown	Unknown
Tepals	Absent	Ca. 1 mm long	Absent	Absent	Absent	Absent

***Elatostema xingyiense* L.D. Duan & D.H. Yin, sp. nov.**

urn:lsid:ipni.org:names:77218852-1

Fig. 1

Type. CHINA Guizhou: Xingyi City, Maling River Canyon Scenic Area, adarces and walls in the valley floor of middle mountains, 25°09'58.00"N, 104°57'20.07"E, 1110 m alt., 8 February 2019, *Lin-Dong Duan & Zhen Lu*, 6118 (**holotype**: HUSY!, **isotype** HNNU!, PE!, HUSY!).

Relationship. This new species is closely related and similar to *Elatostema melanocarpum* (Wang 2013), *Elatostema sublineare* (Wang 1980), *Elatostema obscurinerve* (Wang 1980), *Elatostema langicuspe* (Wang 2013) and *Elatostema youyangense* (Wang 1984). This new species is visibly distinguished by a combination of characters: leaf mid-vein impressed, leaf margin revolute (mid-vein flat, margin flat in the other five species); pistillate inflorescence peduncle dichotomously branched (not branched in the other five species) (Table 1).

Description. Herbs perennial. Young stems ca. 16–30 cm tall, glabrous, purple, simple, with 3–4 leaves. Leaves sub-sessile, glabrous; blades thin-papery, adaxi-

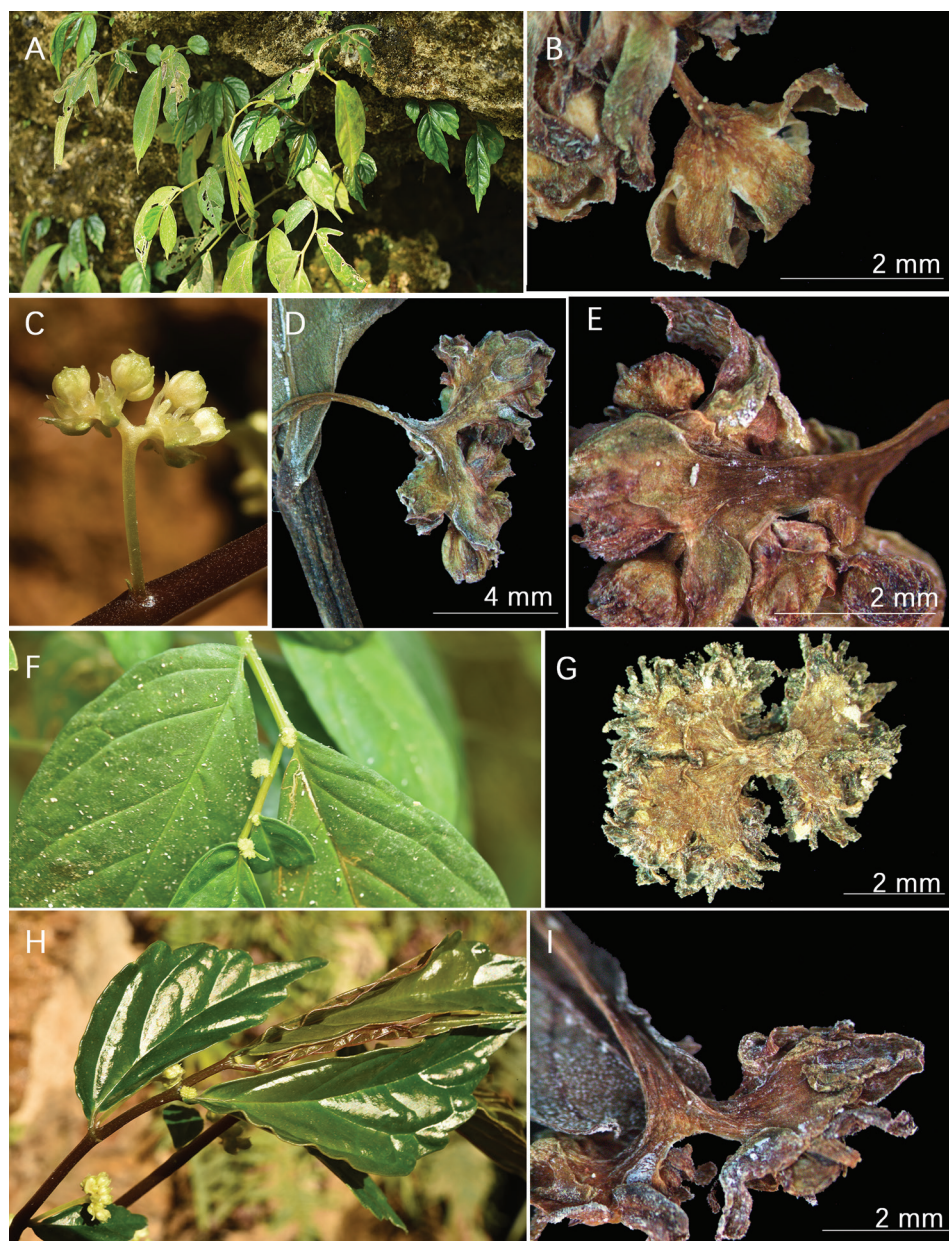


Figure 1. *Elatostema xingyiense* L.D. Duan & D.H.Yin **A** habit **B** male flower **C** male inflorescence in fresh specimen **D** male inflorescence **E** male inflorescence and secondary peduncle **F** female inflorescence in fresh specimen **G** female inflorescence **H** blades in fresh specimen **I** bract longitudinally 3-ribbed. Photos: Lin-Dong Duan and Dan-Hong Yin.

ally green, abaxially purple, obliquely long elliptic, lanceolate-elliptic or ovate-elliptic, 4.0–12.5 cm long, 1.2–3.7 cm wide; apex caudate-acuminate (acumens entire); base sub-orbicular to broad-cuneate at broad side and cuneate at narrow side; margins

below mid-leaf entire, above mid-leaf crenate, revolute; venation pinnate, with 3–5 pairs of lateral nerves; cystoliths conspicuous, dense, bacilliform, 0.08–0.16 mm long; stipules subulate, 1.0–1.5 mm long. Mature stems ca. 25–45 cm tall, glabrous, simple or sometimes branched, with female inflorescences near apex with 3–5 leaves. Leaves sub-sessile or shortly petiole, 0.2–4.0 mm long, glabrous; blades papery, obliquely long elliptic, obliquely elliptic to obovate-elliptic, 15–16 cm long, 2.5–6.0 cm wide, apex caudate-acuminate, base broadly cuneate at broad side and cuneate at narrow side; margin below mid-leaf entire, above mid-leaf crenate, margin notably revolute; both surfaces glabrous; venation pinnate, with 4–7 pairs of lateral nerves, adaxially mid-vein impressed, lateral vein impressed near mid-vein, abaxially mid-vein and lateral vein notably ridged, cystoliths conspicuous the same as caulicles. Monoecious, male inflorescence axillary on young stems, female inflorescence axillary on mature stems. Staminate capitula singly axillary, peduncles round, glabrous, 4–20 mm long, apex dichotomously branched, branches 0.5–2.0 mm long, nearly glabrous, capitulum above each secondary peduncle, 3.6–4.8 mm long, 3.6–4.0 mm wide, receptacle cochleariform to oblong, ca. 2–3 mm long, ca. 1–2 mm wide and receptacle 1(–2)-lobed when oblong, glabrous, unilateral bract 3–5 (3 when receptacle is cochleariform, 5 when receptacle is oblong), oval to narrow triangular, 2.0–2.5 mm long, 0.6–2.3 mm wide; apical bract abaxial surface longitudinally 1(–3)-ribbed, ca. 1–2 mm long, abaxial surface nearly glabrous; lateral bract longitudinally 1-ribbed, ca. 1 mm long, abaxial surface nearly glabrous or puberulent, bracteoles few, membranous, semi-hyaline, white, lanceolate; abaxially puberulent with cystolith, margin ciliate, ca. 3 mm long. Staminate flowers peduncles glabrous, 3 mm long; tepals 5, oval, 3 mm long, base connate, glabrous, apex corniculate on 2–3 tepals; stamens 5. Pistillate capitula singly axillary, papilionaceous to quadrangular, 2–8 mm long, 2.0–6.5 mm wide; peduncles 1.0–1.5 mm long, flowers numerous, receptacle papilionaceous or elliptic, bipartite, margin indehiscent or lobed, 1.5–6.5 mm long, 1.5–5.4 mm wide, bracts numerous, linear-lanceolate, black, abaxially puberulent, margin ciliate; bracteoles numerous, linear-lanceolate, black, 1.0–2.6 mm long, abaxially puberulent, margin ciliate. Pistillate flowers sessile, tepals absent, ovary ovoid, stigma penicillate. Achenes brownish, ovoid, ca. 0.35–0.40 mm long, longitudinally 4(–5)-ribbed, tuberculate.

Phenology. During our field trips, plants were observed in full bloom and without fruits on 10 February 2019, then flowers and fruits on 9 April 2019. The flowering in February to April, fruiting in March to May can be expected.

Habitat. The new species grows on limestone in the valley floor of middle mountains, Maling River Canyon Scenic Area, Xingyi City, Guizhou Province, south-western China.

Distribution. *Elatostema xingyiense* is only known from one locality in Maling River Canyon Scenic Area, Xingyi City, Guizhou Province, south-western China.

Etymology. The new species was named after its type locality, Xingyi City, Guizhou Province, China.

Vernacular name. 兴义楼梯草(Xīng yì lóu tī cǎo) is Chinese Pinyin for *Elatostema xingyiense*, the first two characters are the place name of Xingyi City, the last three characters are the Chinese name for *Elatostema*.

Conservation status. *Elatostema xingyiense* is only known from one collection with about 1000 individuals in Maling River Canyon Scenic Area, Xingyi City, Guizhou Province, south-western China (ca. 74 km²). This species is under threat because of its fragmented habitat and there is tourism in the type location, Maling River Canyon Scenic Area. It is only in one small area of less than 100 km² and has threats from anthropogenic factors. We suggest that *E. xingyiense* should be considered as “Endangered” (EN) according to the IUCN Red List Categories and Criteria (IUCN 2019).

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Cyphostemma calcarium, a new species of Vitaceae from the Ankarana Special Reserve, Madagascar

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Abstract

Cyphostemma calcarium Rabarij & L.M.Lu, **sp. nov.**, is herein described as a new species found on limestone outcrops in northern Madagascar. Its diagnostic morphological characteristics were compared to the species occurring in the Ankarana Special Reserve. We present detailed descriptions, illustrations, distribution map, and a preliminary conservation assessment of the species. An identification key to all known species of *Cyphostemma* from the Ankarana Special Reserve is also provided.

Keywords

Ankarana, *Cyphostemma*, *Cyphostemma calcarium*, Madagascar, Vitaceae

Introduction

The genus *Cyphostemma* (Planch.) Alston contains ca. 200 species, representing the second largest genus following *Cissus* within the grape family, Vitaceae (Wen et al. 2018; Rabarijaona et al. 2020). Species of *Cyphostemma* are distributed mainly in Africa with a few species occurring in southern India, Thailand and southwest China (Dang et al. 2017; Wen et al. 2018). The genus is distinguished by several unique morphological characters: floral buds constricted at the middle, a floral disc of 4-large free glands, conspicuous stipules, and seeds with extra layers of endotestal sclereids covering the ventral infolds in cross-section (Wen 2007; Chen and Manchester 2007, 2011).

In Madagascar, *Cyphostemma* consists of ca. 25 species and displays substantial morphological diversity (Baker 1887; Descouings 1967; The Madagascar Catalogue Project 2019). Species are found in a diversity of habitats, including rainforests, savannas, dry thickets, dunes, and seasonal arid habitats such as the vegetation on limestones or an area within the reserve referred to as “Tsingy”. Several of the species of Vitaceae from Madagascar exhibit features that are very unusual in the family, such as succulent shrubs or trees, rather than lianas, and the lack of leaf-opposed tendrils (Hearn et al. 2018). Northern Madagascar possesses the highest species diversity for Vitaceae across the island, with ca. 68% at the family level and ca. 56% for *Cyphostemma* (The Madagascar Catalogue Project 2019).

Since *Cyphostemma* species were reported to exhibit distinct morphotypes during their vegetative and flowering stages, we conducted an in-depth morphological investigation of all 25 described *Cyphostemma* species from Madagascar. Of the eight species of *Cyphostemma* in the Ankarana Special Reserve (Fig. 1), *Cyphostemma ankaranense* Desc., *C. caeruleans* Desc., *C. rutilans* Desc., and the newly described species in this paper, all lack tendrils. However, the new species can be distinguished from the other three species based on several traits such as habit, stipule shape and size, leaf architecture, flower color, style length, and fruit shape (Table 1). We herein describe and illustrate this new species, assess its conservation status, and provide an identification key to all the species found in the Ankarana Special Reserve.

Materials and methods

The morphological description is based on measurements of dried specimens, supplemented by photos of mature living plants collected from the field. Herbarium specimens and digital images of the most closely-related species to the new described species were examined from the following herbaria: K, P, PE, and TAN. Protologues of type specimens were gathered from Descouings (1967) and JSTOR Global Plants (<http://plants.jstor.org>). Flowers, fruits, and seeds were dissected after briefly soaking in hot water. Images of floral parts and seeds were captured using a stereomicroscope (Leica DVM6 camera, Wetzlar, Germany). Terminologies describing seed morphology followed Chen and Manchester (2011).

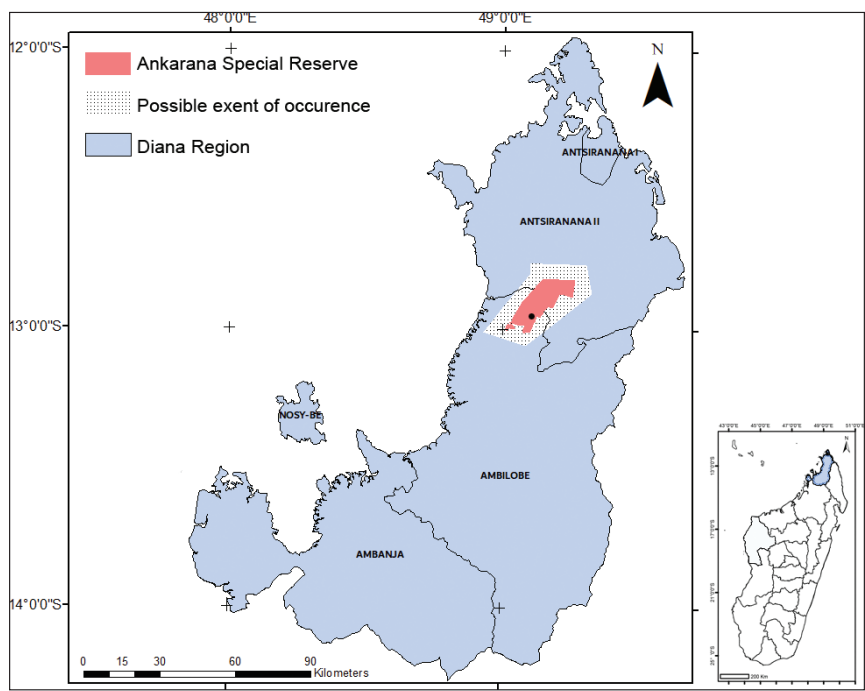


Figure 1. Distribution map of *Cyphostemma calcarium* sp. nov. with the black dot showing the locality of the type specimens. Map on the right shows the position of Ankarana Special Reserve in Madagascar.

Table 1. Morphological comparison of four shrubby tendril-less species of *Cyphostemma* in the Ankarana Special Reserve, Madagascar.

Taxon	Habit	Stipule	Branch and leaf	Leaf architecture	Flower colour	Style length (mm)	Fruit
<i>C. ankaranense</i> Desc.	suberect or prostrate	ovate to widely triangular, 12–25 × 6–10 mm	glabrous	bi-ternate to bi-pinnate	reddish	± 0.7	ellipsoid; 5–7 × 4–5.5 mm
<i>C. caeruleans</i> Desc.	prostrate	± falcate, 10–15 × 2.5–3.5 mm	glabrous	bi-pinnate	yellowish	± 1.5	globose or subglobose; 6.5–9 mm in diameter
<i>C. rutilans</i> Desc.	erect	triangular; up to ca. 5 × 3 mm	glabrous	3-foliolate	reddish	± 1.5	ellipsoid; 6–8 × 5–6 mm
<i>C. calcarium</i> Rabarij & L.M.Lu	erect	triangular to ± falcate; 4–5 × 1.5–2.5 mm	pubescent	3-foliolate, central leaflet often dropped	reddish	± 2.5	ellipsoid; 9–12 × 5–7 mm

Taxonomic treatment

Cyphostemma calcarium Rabarij & L.M.Lu, sp. nov.

urn:lsid:ipni.org:names:77218853-1

Figs 2, 3

Diagnosis. *Cyphostemma calcarium* is most closely comparable to *C. rutilans* Desc. in morphology. It differs from the latter in having distinct pubescent branches (vs.

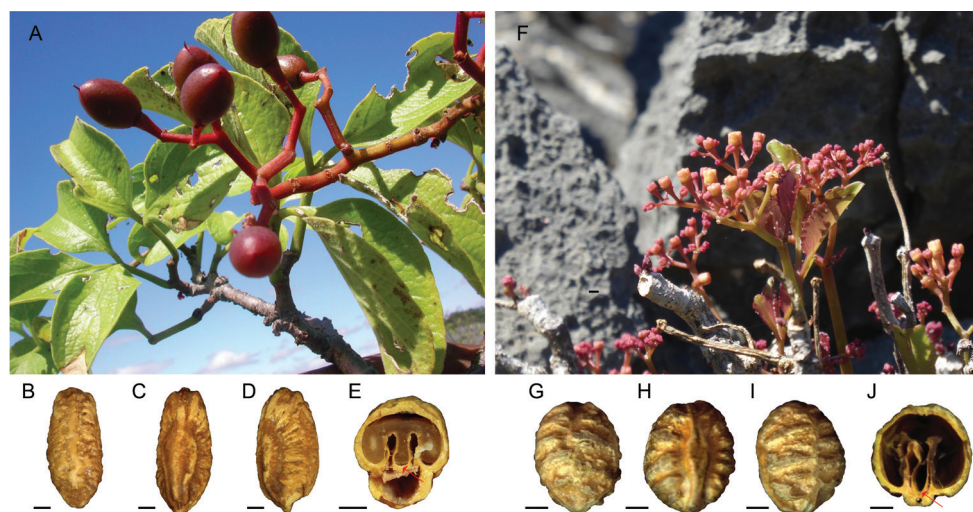


Figure 2. Comparison of two shrubby *Cyphostemma* species with 3-foliolate leaves in the Ankarana Special Reserve **A–E** *Cyphostemma calcarium* sp. nov. **A** branches showing puberulent leaves and infructescence **B–E** seed morphology from Rakotovoao C. et al. 6376 (Dorsal, ventral, lateral, and cross-section presented from left to right) **F–J** *Cyphostemma rutilans* Desc. **F** branches with glabrous leaves and inflorescence **G–J** seed morphology from Bardot-Vaucoulon M. 817 (Dorsal, ventral, lateral, and cross-section presented from left to right). Photos by Rakotovoao Charles, Missouri Botanical Garden (**A**); Billiet Frieda, Meise Botanic Garden (**F**). The red arrow indicates an extra layer of endotestal sclereids covering the ventral infolds. Scale bars: 1 mm

branches entirely glabrous in *C. rutilans*); leaves minutely puberulous and shiny on the adaxial surface, abaxial surface densely whitish pubescent to velvety particularly on the veins (vs. leaves entirely glabrous and shiny on both sides in *C. rutilans*); and leaflets broadly oblong or elliptic, base cuneate (vs. leaflets narrowly ovate, base subcordate in *C. rutilans*). Seeds of *C. calcarium* are ellipsoid in outline, $7\text{--}7.5 \times 3\text{--}3.5$ mm, surface rugose to \pm muricate (vs. seeds globose, 5–6.5 mm in diameter, surface strongly rugose in *C. rutilans*).

Type. MADAGASCAR. Antsiranana: Diana, Ankarana Special Reserve, Tsingy Rary, $12^{\circ}56'24.00''\text{S}$, $49^{\circ}07'04''\text{E}$, 97 m, 16 May 2013, Rakotovoao C. et al. 6376 (holotype: TAN!).

Description. Succulent erect shrub, up to 2 m tall. Old stems swollen, succulent; bark smooth, lenticellate; branches brown to reddish, shortly pubescent. Tendrils absent. Stipules triangular to \pm falcate, $4\text{--}5 \times 1.5\text{--}2.5$ mm, soon caducous. Leaves 3-foliolate, central leaflet often drooping, somewhat thick and fleshy when fresh, becoming coriaceous when dry, usually folded upwards along the midrib; leaflets $3\text{--}5 \times 1.5\text{--}2.5$ cm, broadly oblong or elliptic, base cuneate, rounded to obtuse at the apex, margin shallowly denticulate; minutely puberulous and shiny on the adaxial surface, abaxial surface densely whitish pubescent to velvety particularly on the veins; venation closely reticulate, prominent. Petioles 1.5–2.5 cm long. Petiolules equal, up to 1 cm long. Inflorescence a compound dichasium, terminal, ca. 7.5 cm long, very shortly

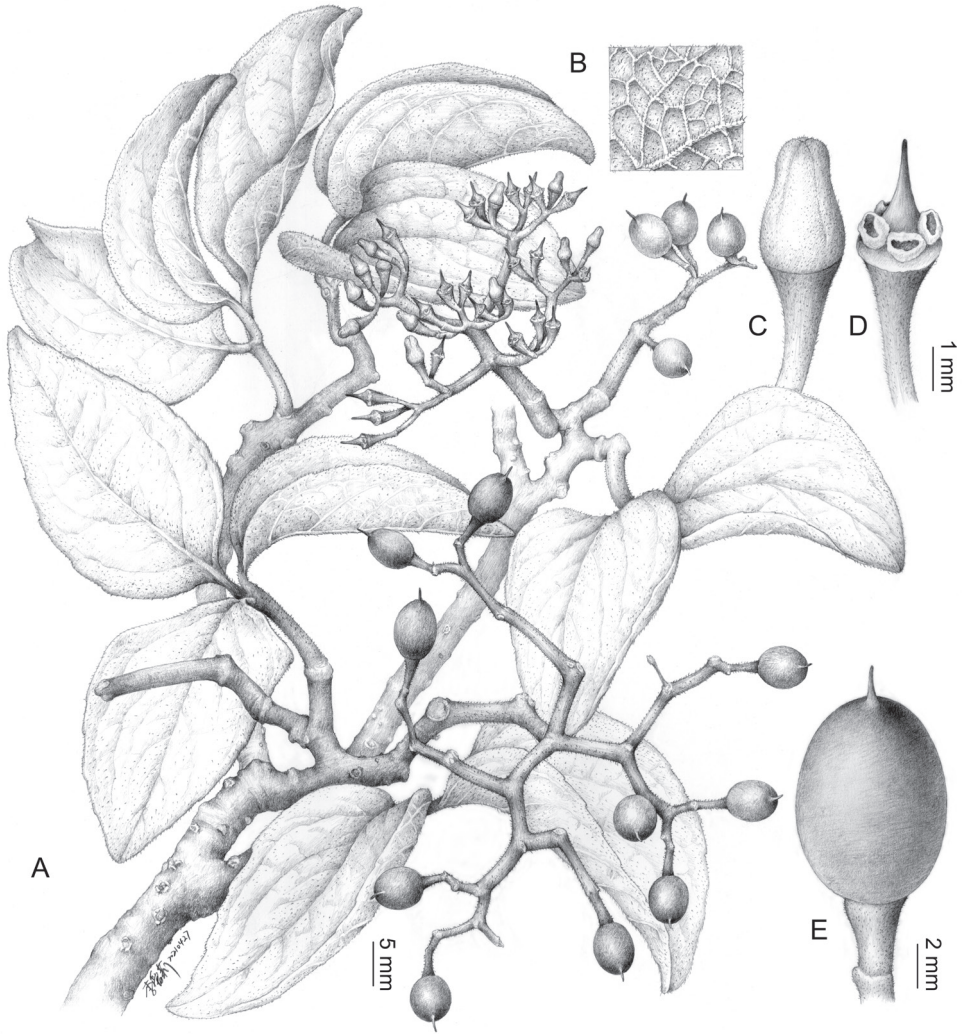


Figure 3. *Cyphostemma calcarium* sp. nov. **A** branches showing the inflorescence and infructescence and the bark with distinct lenticels **B** trichomes on the abaxial leaflet surface **C** flower bud constricted at the middle **D** flower with petals and stamens removed to show the floral disc of 4-large free glands **E** fruit with a persistent stigma (Illustration by Ai-Li Li; based on Rakotovo C. *et al.* 6376, TAN).

pubescent; bracts inconspicuous; pedicels 2–4 mm. Floral buds ± 2.5 mm long, minutely puberulous or glabrescent; sepals ± 0.5 mm long; petals reddish; stamens 4, filaments cylindrical, ca. 2.2 mm long, anthers ca. 0.8 mm long; ovary glabrous, styles ± 2.5 mm long. Fruits ellipsoid, 9–12 \times 5–7 mm, glabrous. Seeds broadly ellipsoid, 7–7.5 \times 3–3.5 mm, rugose; base rostrate; beak conspicuous; apex revolute; rugae apex shallowly conspicuous on both surfaces; chalaza linear, sinuate, up to 6 mm long (ca. 6/7 of seed length); ventral ridge raised, elongate but widened in the middle, extending up to 6/7 of seed length; endosperm m-shaped in cross-section.

Phenology. Flowering and fruiting around May.

Etymology. The epithet of the species refers to the habitats on limestone outcrops.

Distribution and habitat. It grows on limestone outcrops in northern Madagascar at an altitude of 90–300 m. (Fig. 1)

Provisional conservation assessment. The new species is endemic to Madagascar with distribution restricted to its type locality. It is assessed here as Critically Endangered (CR) according to the IUCN Categories and Criteria (IUCN 2019). Even though the species occurs within a protected area, succulent plants are still highly sought after by collectors for their horticultural values. Seeds of *Cyphostemma calcarium* should therefore be collected, banked, and propagated to ensure its long-term conservation.

Taxonomic notes. This species is described from materials collected by *Rakotavao C. et al.* in 2013. It was initially identified as *Cissus pileata* Desc., but it clearly belongs to *Cyphostemma* in having constricted flower buds and floral disks with four free glands. These characters, together with its M-shaped endosperm as viewed in cross sections of the seeds and the presence of extra layers of endotestal sclereids covering the ventral infolds in cross-section, clearly distinguish the new species from *Cissus* L. A summary of some diagnostic characters that differentiate this new species from other shrubby species of *Cyphostemma* in Ankarana Special Reserve is provided in Table 1.

Key to the species of *Cyphostemma* in Ankarana Special Reserve, Madagascar

- 1a Shrubby succulent plants; tendrils absent.....2
- 1b Climbers to woody vines, sometimes tree-like; tendrils usually present5
- 2a Stems erect or suberect; leaves usually 3-foliolate; flowers reddish3
- 2b Stems rather prostrate; leaves pinnately arranged; flowers green to yellowish....4
- 3a Young stems, branches, and petioles glabrous; leaves entirely glabrous and shiny on both sides; leaflets narrowly ovate, base subcordate..... ***C. rutilans***
- 3b Young stems, branches, and petioles puberulent; leaves minutely puberulous and shiny on the adaxial surface, abaxial surface densely whitish pubescent to velvety particularly on the veins; leaflets elliptic, base cuneate....***C. calcarium***
- 4a Leaflets narrowly oblong-elliptic, overall with a reddish tone; stipules ovate to widely triangular, 12–25 × 6–10 mm; flowers pale green; fruits ovoid or elongate–ellipsoid, apiculate.....***C. ankaranense***
- 4b Leaflets rhomboid, ovate or suborbicular, rather green; stipules ± falcate, lanceolate-acuminate, 10–15 × 2.5–3.5 mm; flowers yellowish; fruits globose or subglobose, not apiculate ***C. caerulans***
- 5a Leaves digitately arranged, 3–5-foliolate..... ***C. glanduloso-pilosum***
- 5b Leaves pinnately arranged6
- 6a Trunk sub-spherical, 0.50–0.70 m diameter; bark flaking, corky to reticulately fissured; inflorescences and flowers reddish***C. pachypus***
- 6b Trunk tree-like, up to 5 m tall or even taller; bark smooth, peeling, papery; inflorescences and flowers green to yellowish.....7

- 7a Leaflets 1-pinnate, densely pubescent; petioles 4–6 cm long; inflorescences 6–10 cm, usually shorter, densely pubescent; fruits subglobose, 12–13 mm in diameter ***C. macrocarpum***
- 7b Leaflets 2-pinnate, glabrous; petioles 6–12 cm long; inflorescences 8–15 cm long, glabrous above, with scattered white-pubescent at the base of the nerves beneath, somewhat-like domatia; fruits ellipsoid, 10–12 × 6–7 mm....
..... ***C. greveanum***

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Nomenclatural revision of *Delphinium* subg. *Consolida* (DC.) Huth (Ranunculaceae)

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Abstract

Recent molecular phylogenetic studies have indicated that *Aconitella* is embedded in *Consolida*, which in turn is embedded in *Delphinium*. We choose not to split the genus *Delphinium* (c. 300 species), as it is horticulturally and pharmaceutically important, by conserving a broad *Delphinium* by transferring the names from *Consolida* and *Aconitella* to *Delphinium* s.lat., and more precisely in the resurrected *D.* subg. *Consolida*. Including 58 species of *Aconitella* and *Consolida* within *Delphinium* causes fewer nomenclatural overall changes than do alternative schemes because most of the species of *Aconitella* and *Consolida* were once named under the name *Delphinium*. We present here the list of synonyms for the species once named under *Consolida* or *Aconitella* and gather the information relative to the types of these names. Two new combinations are provided, and 21 lectotypes are designated here.

Keywords

Aconitella, larkspur, Old World flora, paraphyly, Ranunculales

Introduction

Different taxonomic systems based on morphological characters have led authors to treat *Consolida* J.F.Gray (including *Aconitella* Spach) (Fig. 1) and *Delphinium* L. (Ranunculaceae) as two different genera (Linnaeus 1753; Soó 1922; Davis 1965; Munz 1967a, b; Greuter and Long 1989; Chater 1993; Tamura 1993), or to consider *Consolida* as included in *Delphinium* (Candolle 1824; Boissier 1867; Huth 1895; Chowdhuri et al. 1958).

Based on a molecular phylogenetic study with a broad taxonomic sampling, Jabbour and Renner (2011) first found that *Consolida* and *Aconitella* were embedded in *Delphinium*. More precisely, *Aconitella* was nested within *Consolida*, which in turn was nested within *Delphinium*. More recent analyses confirmed this result (Jabbour and Renner 2012a; Wang et al. 2013; Xiang et al. 2017) but do not support the different subgroups (the “Untergruppen or Tribus”) previously described in *Consolida* (Huth 1895). Thus, the overemphasis on distinctive characters (see Pfeil and Crisp 2005) in *Consolida* and *Aconitella* led to recognizing a paraphyletic *Delphinium*.

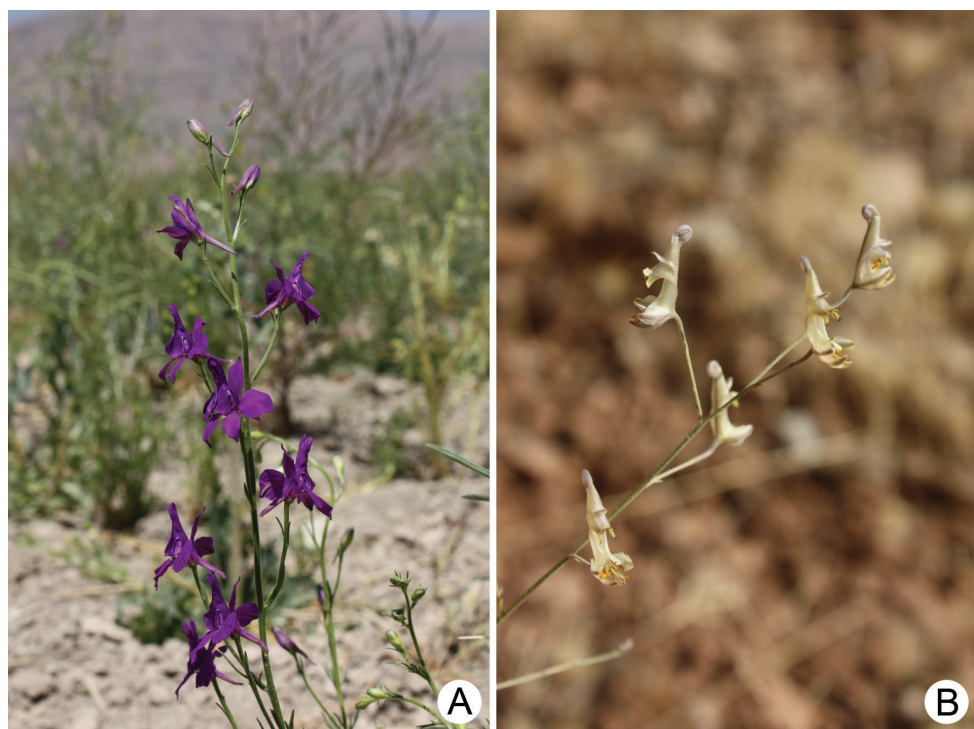


Figure 1. Inflorescences of *Delphinium* subg. *Consolida* **A** *Delphinium hispanicum* Costa **B** *D. anthoroides* Boiss. Photos: Shahin Zarre (Iran, 2011).

As a consequence of these results, the last author previously decided (Christenhusz et al. 2018: 73) not to split the large genus *Delphinium* (c. 300 species), as it is horticulturally and pharmaceutically important (Tamura 1993), by conserving a broad *Delphinium* (see Kadereit et al. 2016) by transferring under *Delphinium* the eight species names (out of 58) of *Consolida*, all published after 1965, that were never transferred. The new combinations were: *D. arenarium* (Carlström) Jabbour, *D. coelesyriacum* (Mouterde) Jabbour, *D. kandaharicum* (Iranshahr) Jabbour, *D. lineolatum* (Hub.-Mor. & C.Simon) Jabbour, *D. lorestanicum* (Iranshahr) Jabbour, *D. samium* (P.H.Davis) Jabbour, *D. staminosum* (P.H.Davis & Sorger) Jabbour, and *D. stapfianum* (P.H.Davis & Sorger) Jabbour.

As flower morphological characters support a clade including *Consolida* and *Aconitella* (Jabbour and Renner 2012b), we treat *Consolida* as a subgenus of *Delphinium* in this article. We re-introduce here *Delphinium* subg. *Consolida* (DC.) Huth and list its 58 species with information relative to their typification.

Methods

We analysed the original material cited in the protologue of each taxon and compiled the relevant synonyms. Except for rare cases, the infraspecific taxa of *Consolida* are not mentioned as taking taxonomic decisions at this taxonomic level is beyond the scope of this work.

Herbarium specimens and images of specimens from the herbaria ATHU, B, BASBG, BC, BEI, BH, BM, BP, BR, C, E, FI, FR, G, GB, GH, GOET, GZU, H, HAL, HBG, HUJ, ISL, JE, K, L, LD, LE, LI, LY, MJSD, MA, MEL, MO, NY, O, OXF, P, PAD, PH, S, TARI, UC, UPS, US, W, WAG, WRSL, and WU were examined. We studied all the available digitized specimens of the relevant collections. The following online resources were consulted: Geneva Herbaria Catalogue, JSTOR Global Plants, Kew Herbarium Catalogue, Naturalis BioPortal, Paris virtual herbarium of vascular plants, RBGE Herbarium Catalogue, Sweden's Virtual Herbarium, the University and Jepson Herbaria, the Virtual Herbaria JACQ, and the Virtual herbarium Berolinense.

Based on the methodology of typification followed by Al-Shehbaz and Barriera (2019), we provide notes about the typification, especially if a lectotype is designated here for the first time or if earlier lectotypifications were incomplete or erroneous. In some cases and some relatively recently described species, the holotype was not found in the mentioned herbarium. When we consider that further investigations are necessary, we have decided not to designate a lectotype. Accepted names are in bold italics and listed alphabetically. The reference of cited specimens (herbarium code, and when available, the barcode) are provided. The herbarium codes follow Thiers (2018). Specimens marked '!' were examined in the scope of this paper. Note that JE, WU, and W barcodes have temporary barcodes and are susceptible to change in the future (Jochen Müller, Dieter Reich, and Christian Bräuchler, curators, pers. comm.).

Results

Delphinium subg. *Consolida* consists of 58 species. Two new combinations are made, and 21 lectotypes (including three second-step lectotypifications) are designated herein.

Typification and nomenclature

***Delphinium* subg. *Consolida* (DC.) Huth, Bot. Jahrb. 20: 337. 1895.**

- ≡ *Consolida* S.F.Gray, Nat. Arr. Brit. Pl. 2: 711. 1821.
- ≡ *Delphinium* sect. *Consolida* DC., Reg. Veg. Syst. Nat. 1: 341. 1817.
- ≡ *Ceratosanthus* Schur, Enum. Pl. Transsilv. 30. 1866. Type: *Delphinium consolida* L.
- = *Delphinium* subg. *Aconitella* (Spach) Iranshahr, Fl. Iranica 171: 92. 1992.
- ≡ *Aconitella* Spach in Hist. Nat. Veg. 7: 358. 1839.
- ≡ *Consolida* sect. *Aconitella* (Spach) Tamura in Acta Phytotax. Geobot. 41: 101. 1990.
Type: *Delphinium aconiti* L.
- = *Aconitopsis* Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 125. 1940. Type: not designated.

1. *Delphinium aconiti* L., Mant. Pl.: 77. 1767 [basionym].

- ≡ *Consolida aconiti* (L.) Lindley in J. Roy. Hort. Soc. 6: 55. 1851.
- ≡ *Aconitella aconiti* (L.) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969.
- ≡ *Aconitopsis aconiti* (L.) Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 125. 1940, non
Aconitella delphinioides Spach in Hist. Nat. Veg. 7: 359. 1839.
- ≡ *Aconitum monogynum* Forssk., Fl. Aegypt.-Arab. 27. 1775. Type: Turkey. “in Dardanella”, leg. P. Forsskål (holotype not found).

Notes. The description of *D. aconiti* is based on a Forsskål’s gathering made “in Dardanella”. At LINN, no Forsskål’s material was found for this taxon, whereas two gatherings, *Forsskål* 913 (C10001572) and *Forsskål* 914 (C10001573), are deposited at C, in the Vahl herbarium, and are likely to correspond to the type material. The typification of the Forsskål collection is complex and needs a careful examination of the letters sent by Forsskål to Linnaeus. Note that *Forsskål* 914 was a priori used for the tab XIII (Vahl 1790).

2. *Delphinium ajacis* L., Sp. Pl.: 531. 1753 [basionym].

- ≡ *Consolida ajacis* (L.) Schur in Verh. Mitth. Siebenbürg. Vereins Naturwiss. Hermannstadt 4: 47. 1853.
- ≡ *Ceratosanthus ajacis* (L.) Schur in Enum. Pl. Transsilv. 30. 1866. Type: Herb. Burser VII(1): 83 (lectotype, designated by Molero and Blanché 1984, pg. 217: UPS image!).

- = *Delphinium gayanum* Wilmott in J. Bot. 62: 26. 1924.
- ≡ *Consolida gayana* (Wilmott) Láinz, in Anales Inst. Forest. Invest. 1967: 6. 1967.
- *Consolida ambigua* auct. non *Delphinium ambiguum* L.

Notes. *Consolida ambigua* auct. (non *D. ambiguum* L.) is a misapplied name of *D. ajacis* in most floras, such as "Flora Europaea" (Chater 1993) and "Flora of Turkey and the East Aegean Islands" (Davis 1965). For details, see Janchen (1965: 34).

3. *Delphinium anthoroideum* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 369. 1841 [basionym], non sensu Boiss., Fl. Or. 1: 85. 1867.

- ≡ *Consolida anthoroidea* (Boiss.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 62. 1909.
- ≡ *Aconitella anthoroidea* (Boiss.) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969.
- ≡ *Aconitopsis anthoroidea* Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 125. 1940.
Type: "Syria", s.d., leg. P. M. R. Aucher-Eloy 65 (lectotype, designated by Chowdhuri et al. 1958, pg. 412: G-BOIS [G00788330 image!, 2 sheets]; isolectotypes: E [E00438703 image! =photo of G00788330], G [G00390151 image!], K [K000692355 image!], P [P00195789!, P00195790!].
- = *Delphinium acutilobum* Turrill in Bull. Misc. Inform. Kew 1929: 223. 1929. Type: Azerbaïdjan. "near Tabriz. Yam.", 21 Aug. 1927, leg. B. Gilliat-Smith 2086 (holotype: K [K000692358 image!]).

Notes. The misinterpretation of *D. anthoroideum* by Boissier in "Flora Orientalis" (1867) is clarified by Chowdhuri et al. (1958). Among the isolectotypes of *D. anthoroideum*, only G00390151 and P00195789 bear the date "1837".

4. *Delphinium arenarium* (A. Carlström) Jabbour in Global Fl. 4(1): 73. 2018.

- ≡ *Consolida arenaria* A. Carlström in Willdenowia 14: 16. 1984 [basionym]. Type: Greece. South Aegean: "Rodos. 2 km E of Archipolis, Stegena beach", 13 May 1982, leg. A. Carlström 5808 (holotype: LD [LD1023446 image!]).

Notes. No duplicate of the type collection was found.

5. *Delphinium armeniacum* Huth in Bot. Jahrb. Syst. 20: 380. 1895 [basionym].

- ≡ *Consolida armeniaca* (Huth) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 62. 1909. Type: Turkey. Erzincan: "Sipikordagh", 30 Jul. 1890, leg. P. E. E. Sintenis

3177 (lectotype, designated here: WU [WU 109667 image!]; isolectotypes: BR [BR0000005295548 image!], G [G00390154 image!], GZU [GZU000278000 image!], JE [JE00018622 image!, JE00018623 image!], K [K000692372 image!, K000692373 image!], LD [LD1742274 image!], LE [LE01053086 image!], P [P00195865!] (Fig. 2A), PH [PH00010711 image!], WRS� [destroyed during the WWII]).

Notes. Chowdhuri et al. (1958) indicated the holotype at W, but we were unable to find it. No duplicate from the above herbaria was annotated by Huth, and we choose to designate WU 109667 as the lectotype for now.

6. *Delphinium aucheri* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 362. 1841 [basionym].

≡ *Delphinium persicum* Boiss. var. *aucheri* (Boiss.) Boiss., Fl. Orient. 1: 77. 1867.

≡ *Consolida aucheri* (Boiss.) Iranshahr in Fl. Iranica 171: 103. 1992. Type. «Persia australis», s.d., leg. P. M. R. Aucher-Eloy 4030 (holotype: P [P00198500!]; isotypes: G [G00390155 image!], P [P00198911!]).

Notes. No specimen was found in Boissier's herbarium. Boissier's annotation on P00198500 indicates that the species description is based on that sheet, which is the holotype.

7. *Delphinium axilliflorum* DC., Syst. Nat. 1: 341. 1817 [basionym].

≡ *Consolida axilliflora* (DC.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4: 62. 1909. Type: «Syrie», s.d., leg. J. J. Labillardière s.n. (holotype: FI [FI056536 image!]).

Notes. No duplicate of the type collection was found.

8. *Delphinium baluchistanicum* (Qureschi & Chaudhri) Jabbour & Du Pasquier, comb. nov.

urn:lsid:ipni.org:names:77218867-1

≡ *Consolida baluchistanica* Qureschi & Chaudhri, Pakistan Syst. 2: 11. 1978 [basionym]. Type: Pakistan. Baluchistan: «Water supply station», 23 Apr. 1977, leg. H. Mansoor & A. Maqsood 394 (holotype: ISL).

Notes. When asking for an image of the holotype, the curator of ISL provided us only with an image of the specimen *Mansoor & Maqsood 395* (collected 23.04.1977), whereas the protologue indicates *Mansoor & Maqsood 394*. We could not decide whether: 1) #394 (the holotype) could not be found; or 2) #395 is the holotype, and



Figure 2. Three lectotypes (and one isolecotype) selected among the 21 lectotypes designated in this article **A** isolecotype of *Delphinium armeniacum* Huth (P00195865; <http://coldb.mnhn.fr/catalognumber/mnhn/p/p00195865>) **B** lectotype of *D. deserti* Boiss. (P00197319; <http://coldb.mnhn.fr/catalognumber/mnhn/p/p00197319>) **C** lectotype of *Delphinium sclerocladum* Boiss. var. *rigidum* (Frey & Sint.) Hossain & P.H.Davis (P00195794; <http://coldb.mnhn.fr/catalognumber/mnhn/p/p00195794>) **D** lectotype of *D. tomentosum* Boiss. (P00201127; <http://coldb.mnhn.fr/catalognumber/mnhn/p/p00201127>). All four specimens are kept at P Herbarium.

the #394 citation in the protologue is a mistake. However, #395 seems to have been used for the drawing on plate XI in *Pakistan Syst.* 2. (1978).

9. *Delphinium barbatum* Bunge in Arb. Naturf. Ver. Riga 1: 126. 1847 [basionym].

≡ *Consolida barbata* (Bunge) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 62. 1909.

≡ *Aconitella barbata* (Bunge) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969.

≡ *Aconitopsis barbata* (Bunge) Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 127. 1940.

Type: Kazakhstan. “jugi Karatau, ad superiorem Sarafschan”, 10 Sep. 1841, leg. A. Lehmann 38 (lectotype, designated here: P [P00197235!]; isolectotypes: LE [LE00050813 image!, LE00050814 image!]).

Notes. Iranshahr (1992) indicated that the holotype is kept at P, whereas Munz (1967a) indicated that it is kept at LE, but without having seen it. We found a duplicate at P and two at LE. None of them seem to have been annotated by Bunge. The P00197235 sheet bears three specimens and two handwritten labels. These two labels are in Latin, probably from Lehmann’s hand, and correspond to the locality indicated in the protologue. They are almost identical (the left one carries “*Delphinium* sp?” and “10 Sept.”, and the right one bears the collection year 1841 and no identification). Both labels were stuck on Bunge’s printed handwritten labels “*Reliquiae Lehmannianae*. Herb. Al. de Bunge.”, and the right one is itself stuck to another label (“*Rel. Lehm. N°38.*”) written by a different hand, probably a curator of P. At LE, the labels bear the exact mention of the locality as in the protologue (in German) on a preprinted label “*Alexandri Lahmann/ Reliquiae botanicae. Al. Bunge.*” and one of both bears the full date.

10. *Delphinium brevicorne* Vis., Fl. Dalmat. 3: 90. 1850 [basionym].

≡ *Consolida brevicornis* (Vis.) Soó in Österr. Bot. Z. 71: 245. 1922. Type. Croatia. Split-Dalmatia: “In agris circa Gelsa ins. Lesina/ as. Stalio”, s.d., Stalio s.n. (holotype: PAD [image!]).

Notes. No duplicate of the type collection was found.

11. *Delphinium camptocarpum* Ledeb., Fl. Ross. 1: 58. 1841 [basionym].

≡ *Consolida camptocarpa* (Ledeb.) Nevski in Komarov, V. L., Fl. URSS 7: 106. 1937.

Type: Irak. “Turcomania”, s.d., leg. G. S. Karelin, s.n. (Lectotype (first step

designated by Nevski in Komarov, V. L., Fl. URSS 7: 106. 1937; second-step designated here): LE [LE00050875 image!]; isolectotypes: LE [LE00050877 image!, LE00050981 image!, LE00050986 image!].

Delphinium camptocarpum Ledeb. var. *camptocarpum*

≡ *Delphinium campocarpum* Ledeb. var. *leiocarpum* Ledeb., Fl. Ross. 1: 58. 1841.

Notes. When describing *Delphinium camptocarpum*, Ledebour quoted Karelin's gathering "ad latus orientale maris caspii" and described two varieties (*D. camptocarpum* var. *dasycarpum* and *D. camptocarpum* var. *leiocarpum*) according to the presence or not of indumentum on the follicle, but without citing any material. Several of Karelin's gatherings of *D. camptocarpum* were found at LE. Four of them belong to Ledebour's herbarium (two can be attributed to *D. camptocarpum* var. *leiocarpum*, but it is unclear for the other two) and can be regarded as type collection. We synonymise *D. camptocarpum* var. *leiocarpum* under the autonym.

Nevski's indication (1937) that the type is housed at LE can be considered a first-step lectotypification, and we designate here the specimen LE00050875 as the second-step lectotype.

12. *Delphinium coelesyriacum* (Mouterde) Jabbour in Global Fl. 4(1): 73. 2018.

≡ *Consolida coelesyriaca* Mouterde, Nouv. Fl. Liban Syrie 2: 23. 1970 [basionym].

= *Delphinium oliganthum* auct. non Boiss.

= *Consolida oligantha* auct. non Boiss. Type: Syria. «entre Hama et Palmyre, Tell Bouada», 18 May 1857, leg. C. I. Blanche 2832 (holotype: G-BOIS [G00788352 image!]; isotype: BEI?).

Notes. We did not find the duplicate at BEI, as could be expected from Mouterde's quotation (1970).

13. *Delphinium consolida* L. Sp. Pl.: 530. 1753 [basionym].

≡ *Consolida regalis* S.F.Gray, Nat. Arr. Brit. Pl. 2: 711. 1821.

≡ *Ceratosanthus consolida* (L.) Schur in Enum. Pl. Transsylv. 30. 1866.

≡ *Consolida arvensis* Opiz in Seznam 32. 1852. Type: Described from Britain. Herb. Linn. No. 694.1 (lectotype, designated by Jonsell and Jarvis 1994, pg. 161: LINN [LINN-HL694-1 image!]).

= *Delphinium segetum* Lam. Fl. Franç. 3: 325. 1778. [nom. illeg.]

– *Consolida regalis* S.F.Gray subsp. *consolida* (L.) Gajic in Josifovic, Fl. SR Srbije 1: 230. 1970. [nom. inval].

≡ *Consolida regalis* S.F.Gray subsp. *arvensis* (Opiz) Soó, in Österr. Bot. Z. 71: 242. 1922.

≡ *Delphinium consolida* L. subsp. *arvense* (Opiz) Graebner & Graebner fil., in Asch. & Graebn., Syn. Mitteleur. Fl. 5: 671. 1929. Type: not designated.

Notes. The genus *Consolida* published by Opiz (1852) is a valid but illegitimate name (Holub and Pouzar 1967).

Three subspecies are usually accepted under *Delphinium consolida*:

13.1. *Delphinium consolida* L. subsp. *consolida*

13.2. *Delphinium consolida* L. subsp. *paniculatum* (Host) Busch in Kuznetzow, Fl. Cauc. Crit. 3: 44. 1902.

≡ *Delphinium paniculatum* Host, Fl. Austriaca 2: 65. 1831.

≡ *Consolida paniculata* (Host) Schur. in Verh. Mitth. Siebenbürg. Vereins Naturwiss. Hermannstadt 4: 47. 1853.

≡ *Consolida regalis* S.F.Gray subsp. *paniculata* (Host) Soó in Österr. Bot. Z. 71: 243. 1922.

≡ *Ceratosanthus paniculata* (Host) Schur in Enum. Pl. Transsilv. 30. 1866. Type: Montenegro. “near Cattaro”, Tomasini s.n. (not found).

13.3. *Delphinium consolida* L. subsp. *divaricatum* (Ledeb.) A.Nyár.

≡ *Delphinium divaricatum* Ledeb. in Eichw., Pl. Nov.: 16. 1831.

≡ *Consolida divaricata* (Ledeb.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 27, 62. 1909.

≡ *Consolida regalis* S.F.Gray subsp. *divaricata* (Ledeb.) Munz in J. Arnold Arbor. 48: 179. 1967.

≡ *Consolida regalis* S.F.Gray subsp. *paniculata* (Host) Soó var. *divaricata* (Ledeb.) P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 26: 174. 1965.

≡ *Ceratosanthus divaricata* (Ledeb.) Schur in Enum. Pl. Transsilv. 30. 1866. Type: Russia. “In insulis ad ostium Wolgae amnis sitis, etiam ad fluvium Torrain”, Henning s.n. (holotype: LE [not seen]).

14. *Delphinium cornutum* Hossain & P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 22: 424. 1958 [basionym].

≡ *Consolida cornuta* (Hossain & P.H.Davis) P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 26: 174. 1965. Type: “Armenia”, s.d., leg. Calvert & Zohrab s.n. (holotype: E [not found]).

Notes. Despite the efforts of the curator at E, the holotype was not found.

15. *Delphinium cruciatum* Hossain & P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 22: 422. 1958 [basionym].

- ≡ *Consolida cruciata* (Hossain & P.H.Davis) P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 26: 174. 1965. Type: Turkey. Adana: “Bozanti”, 1896, leg. W. Siehe 362 (holotype: E [E00438700 image!]; isotypes: B [B 10 0264874 image!], E [E00438699 image!], GH [GH00038199 image!], K [K000692438 image!], P [P00195910!]).

Notes. The specimen E00438700 is explicitly designated as the holotype in the protologue, whereas the indication of collection locality and date is only found on B 10 0264874 and GH00038199.

16. *Delphinium deserti-syriaci* Zohary in Palestine J. Bot. Jerusalem Ser., 2: 155. 1941 [basionym].

- ≡ *Consolida deserti-syriaci* (Zohary) Munz in J. Arnold Arbor. 48: 187. 1967a.
 ≡ *Aconitella deserti-syriaci* (Zohary) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969. Type: Syria. “Azra to Damascus”, 16 May 1931, leg. M. Zohary s.n. (holotype: HUJ image!, fragments only).

Notes. The type was partially destroyed during the war (most likely WWII) in Israel (Munz 1967a).

17. *Delphinium flavum* DC., Syst. Nat. 1: 346. 1817 [basionym].

- ≡ *Consolida flava* (DC.) Schrödinger in Ann. K. K. Naturhist. Hofmus. 27: 43. 1913. Type: “de Bagdad à Kermancha”, s.d., leg. G. A. Olivier & J. G. Bruguère s.n. (lectotype, designated here: P [P00197330!]; isolectotypes: G-DC [G00200080 image!], P [P00197331!]).

Delphinium flavum DC. var. *flavum*

= *Delphinium flavum* DC. var. *velutinum* DC., Syst. Nat. 1: 346. 1817.

= *Delphinium deserti* Boiss., Fl. Orient. 1: 83. 1867.

- ≡ *Consolida deserti* (Boiss.) Munz in J. Arnold Arbor. 48: 51. 1967a. Type: «Désert de Suez à Gaza», Jul. 1832, leg. N. Bové 131 (lectotype, designated here: P [P00197319!] (Fig. 2B); isolectotypes: G [G00440765 image!, G00440766 image!], K [K000076088 image!, K000076089 image!], P [P00197320!]).

Notes. In the protologue of *D. flavum*, Candolle (1817) described two varieties (var. *velutinum* and var. *glabrum*) based on the pubescence and the bracteole position on the pedicel. We synonymize here *D. flavum* var. *velutinum* with the autonym. Candolle indicates that he saw the specimen in Olivier’s herbarium (now at P), whereas we found at G-DC a duplicate received in 1822. At P, we found two sheets of the Olivier and

Bruguère's gathering. It is not sure whether Candolle annotated these sheets. The specimen P00197330 bears the label “dans les lieux incultes steriles de Bagdad a Kermancha” and a mixture of both varieties (the specimen in the bottom right corner corresponds to *D. flavum* var. *glabrum*). We designate as lectotype the six other specimens on this sheet.

A single and fragmentary specimen of *D. deserti*, labelled “*D. deserti*” by Boissier, was found in G-BOIS (G00788308) and probably came from a P duplicate. We designate as lectotype of *D. deserti* the specimen P00197319, the only one bearing a priori an annotation from Boissier.

18. *Delphinium glandulosum* Boiss. & Huet in Boiss., Diagn. Pl. Orient., Ser. 2, 5: 11. 1856 [basionym].

≡ *Consolida glandulosa* (Boiss. & Huet) Bornm. in Repert. Spec. Nov. Regni Veg. Beih. 89: 13. 1936. Type: Turkey. Erzurum: “in cultis Meimansour”, Aug. 1853, leg. Huet du Pavillon, A. s.n. (holotype: G-BOIS [G00788286 image!, 3 sheets]; isotypes: BM [BM000553908 image!], G [G00390160 image!, G00390161 image!], GOET [GOET009744 image!], JE [JE00018629 image!, JE00018630 image!, JE00018631 image!, JE00018632 image!], K [K000075573 image!], LE [LE00012145 image!], MO [MO-203061 image!], O [O-V2130694 image!, O-V2130695 image!], P [P00197358!, P00197359! probable], S [S07-14845 image!], UC [UC1055003 image!], WAG [WAG0004719 image!]).

Notes. The description was based on the specimen in G-BOIS, a folder containing three sheets. Only this specimen was annotated by Boissier, which is, therefore, the holotype.

19. *Delphinium gombaultii* J.Thiébaud in Bull. Soc. Bot. France 81: 114. 1934 [basionym].

≡ *Consolida gombaultii* (J.Thiébaud) Munz in J. Arnold Arbor. 48: 175. 1967a. Type: Syria. As-Suwayda: “Djebel Druze”, 21 May 1932, leg. R. Gombault s.n. (holotype: MJSD [MJSD028148 image!]; isotypes: P [P00197360!, P00197361!]).

Notes. Thiébaud (1934) based the species description on the duplicate in his herbarium, which is housed at MJSD. The duplicates at P bear the collection number 1717, which is not indicated on the MJSD specimen.

20. *Delphinium halophilum* Huth in Bot. Jahrb. Syst. 20: 487. 1895 [basionym].

≡ *Consolida halophila* (Huth) Munz in J. Arnold Arbor. 48: 189. 1967a. Type: Iran. “Persia borealis. Gussediche”, 1882, leg. T. Pichler s.n. (holotype: G [G00390261 image!]; isotypes: K [K000692367 image!, K000692368 image!]).

Notes. Huth (1895) based his species description solely on the unicate in the Barbey herbarium (now G).

21. *Delphinium hellesponticum* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 366. 1841 [basionym].

- ≡ *Consolida hellespontica* (Boiss.) Chater in Feddes Repert. Spec. Nov. Regni Veg. 69: 55. 1964. Type: Turkey. “ad Hellespontum”, Aug. 1836, leg. P. M. R. Aucher-Eloy 67 (holotype: G-BOIS [G00788295 image!, 2 sheets]; isotypes: G [G00440745 image!], K [K000075580 image!], P [P00197463!, P00201125!]).
- = *Delphinium macedonicum* Halácsy & Charrel in Charrel, Géogr. Bot. Salonique: 8. 1892.
- ≡ *Consolida macedonica* (Halácsy & Charrel) Soó in Österr. Bot. Z. 71: 245. 1922.
- ≡ *Delphinium hellesponticum* subsp. *macedonicum* (Halácsy & Charrel) Hossain & P.H.Davis in Notes Roy. Bot. Gard. Edinb. 22: 419. 1958.
- ≡ *Consolida hellespontica* subsp. *macedonica* (Halácsy & Charrel) Chater in Feddes Repert. Spec. Nov. Regni Veg. 69: 55. 1964. Type: Greece. Thessaloniki: “Kiel tépé [probably Profitis Ilias, SE of Chortiatis fide Strid, 2002]”, s.d., A.-u.-R. Nadji s.n. (holotype: WU [WU033827 image!], isotype: P [P02500001!, P02840902!])
- = *Delphinium paphlagonicum* Huth in Bull. Herb. Boissier 1: 328. 1893.
- ≡ *Delphinium olopetalum* Boiss. var. *paphlagonicum* (Huth) Huth, in Engler, Bot. Jahrb. 20: 381. 1895. Type: Turkey. Kastamonu: “Paphlagonia: Wilajet Kastambuli, Tossia”, 7 Aug. 1892, leg. P. E. E. Sintenis 4547 (lectotype, designated here: LD [LD1742402 image!], isolectotypes: B [B 10 0295663 image!, B 10 0264875 image!], BH image!, GZU [GZU000279189 image!], HAL [HAL0062300 image!], HBG [HBG508807 image!], P [P00197464!, P00198840!], US [US00103588 image!]).
- = *Delphinium hellesponticum* subsp. *aintabense* Hossain & P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 22: 420. 1958. Type: Turkey. “Aintab [Gaziantep]”, Jun. 1889, leg. G. E. Post, s.n. (holotype: BM [BM013718242 image!]).
- = *Delphinium campylopodium* Stapf in Denkschr. Acad. Wiss. Wien, Math. Naturw. Kl. 51: 358. 1886.
- ≡ *Delphinium hellesponticum* Boiss. subsp. *campylopodon* (Stapf) Hossain & P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 22: 419. 1958. Type: “Owadjik”, 1 Aug. 1882, leg. F. Luschan s.n. (lectotype, designated by Chowdhuri et al. 1958, pg. 419): WU [WU0072944 image!]).

Notes. Boissier based the species description of *Delphinium hellesponticum* on the G-BOIS specimens, which is a folder containing two sheets. Only the K duplicate bears a date (“Aug. 1836”). Among the duplicates of *Delphinium macedonicum*, only P02840902 bears a date (27 avril 1892) and the collection number 37. Huth based his description of *Delphinium paphlagonicum* on the *Sintenis 4547* specimen in his herbarium. The duplicates found in the different herbaria bear different dates, and only LD1742402 (with the date “7 Aug. 1892”), belonging to the Sintenis herbarium, was annotated by Huth, and we treat it as a lectotype. All isotypes indicate herein bear that date.

22. *Delphinium hispanicum* Costa in Anales Soc. Esp. Hist. Nat. 2: 27. 1873 [basionym].

- ≡ *Consolida hispanica* (Costa) Greuter & Burdet in Willdenowia 19: 43. 1989.
- ≡ *Consolida orientalis* (Gay) Schrödinger subsp. *hispanica* (Willk.) P.W.Ball & Heywood in Feddes Repert. Spec. Nov. Regni Veg. 66: 151. 1962. Type: Spain. «Linares más arriba de la región de la vid.», 1864, leg. Vivas s.n. (lectotype, designated by Blanché and Simón 2000, pg. 304): BC image!, specimen on the left side).
- = *Delphinium orientale* Gay in Actes Soc. Linn. Bordeaux 11: 182. 1840 [nom. illeg.]
- ≡ *Consolida orientalis* (Gay) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 27, 62. 1909. Type: not designated.
- = *Delphinium bithynicum* Griseb. in Spic. Fl. Rumel. 1: 320. 1843 [basionym]. Type: Turkey. “Bolu”, s.d., leg. F. Pestalozza s.n. (holotype: GOET [GOET009749 image!]).

Notes. *Delphinium orientale* Gay was misapplied instead of *D. hispanicum* in most Floras e.g. “Flora Orientalis” (Boissier 1867), “Flore de l’Afrique du Nord” (Maire 1952), “Flora of Syria, Palestine and Sinai” (Post 1932), “Flora of Turkey and the East Aegean Islands” (Davis 1965). See Greuter and Raus (1989) for a discussion of the nomenclature.

23. *Delphinium hohenackeri* Boiss., Fl. Orient. 1: 85. 1867 [basionym].

- ≡ *Consolida hohenackeri* (Boiss.) Grossh., Fl. Kavkaza 2: 101. 1930.
- ≡ *Aconitella hohenackeri* (Boiss.) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969.
- ≡ *Aconitopsis hohenackeri* (Boiss.) Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 127. 1940. Type: Turkey. Bayburt: “Baibout Mt. du Tchorok coteaux arides”, 12 Jul. 1862, leg. E. Bourgeau 21 (lectotype (first step designated by Chowdhuri et al. 1958, pg. 415; second-step designated here): G-BOIS [G00788345 image!]; isolectotypes: E [E00438706 image!], JE [JE00018599 image!], LY [LY0042520 image!], P [P04023369!, P00195762!, P00195791!, P00195763!, P00195764!], UC [UC1055009 image!]).

Notes. The designation by Chowdhuri et al. (1958) of *Bourgeau 7* at K as the lectotype is corrected herein as a second-step typification from K (where no Bourgeau’s gathering of *D. hohenackeri* was found) to G-BOIS. However, the only Bourgeau’s gathering of *D. hohenackeri* at G-BOIS bears the collection number 21. In contrast, *Bourgeau 7* is found at E, JE, LY, P, and UC (*sub D. anthoroideum*), usually on printed Bourgeau’s collection labels.

24. *Delphinium incanum* E.D.Clarke, Travel 2(1): 451. 1812 [basionym].

- ≡ *Consolida incana* (E.D.Clarke) Munz in J. Arnold Arbor. 48: 181. 1967a. Type: Israel: "Migdal", 13 Jun. 1942, leg. P. H. Davis 4819 (neotype, designated by Munz 1967a, pg. 181: BM [BM013718647 image!]; isoneotype: E [E00438698 image!]).
- = *Delphinium exsertum* DC., Syst. Nat. 1: 345. 1817 [basionym]. Type: sine loco, Labillardière, J. J. (holotype: FI [FI058566 image!; isotype: FI [FI058565 image!]).
- = *Delphinium rigidum* DC., Syst. Nat. 1: 344. 1817.
- ≡ *Consolida rigida* (DC.) Bornm. in Beih. Bot. Bot. Centralbl., Abt. 2. 31: 181. 1914. Type: "Syria", s.d., leg. J. J. Labillardière s.n. (holotype: G [G00390153 image!]).

Notes. Munz (1967a) designated an isoneotype for *D. incanum* at K, which was not found. At FI, the specimen FI058564 could correspond to a duplicate of the type material of *D. rigidum*.

25. *Delphinium intricatum* Pau in Trab. Mus. Cienc. Nat. Ser. Bot. 14: 12. 1918 [basionym].

- ≡ *Consolida teheranica* (Boiss.) Rech. f. var. *intricata* (Pau) Parsa, Fl. Iran 2: 326. 1986.
- ≡ *Aconitella intricata* (Pau) C.Blanché & J.Molero in Bot. J. Linn. Soc. 113: 127. 1993. Type: Iran. «Kouh-Cherri (Alto Karum)», 23 Jul. 1899, leg. M. de la Escalera s.n. (lectotype, designated by Blanché and Molero 1993, pg. 127: MA [MA39257 image!]).

Notes. No duplicate of the type collection was found in the different herbaria consulted.

26. *Delphinium kabulianum* Akhtar in Bull. Misc. Inform. Kew 1938: 86. 1938 [basionym].

- ≡ *Consolida kabuliana* (Akhtar) Iranshahr in Fl. Iranica 171: 102. 1992.
- ≡ *Consolida stocksiana* (Boiss.) Nevski var. *kabuliana* (Akhtar) Tamura in Kitamura, Fl. Afghan. 124. 1960. Type: Afghanistan. "near Kabul", 23 Aug. 1937, leg. S. A. Akhtar (holotype: K [K000692442 image!]).

Notes. No duplicate of the type collection was found in the different herbaria consulted.

27. *Delphinium kandaharicum* (Iranshahr) Jabbour in Global Fl. 4(1): 73. 2018.

- ≡ *Consolida kandaharica* Iranshahr in Pl. Syst. Evol. 155: 56. 1987 [basionym]. Type: Afghanistan. Kandahar: “versus lacum artificiale / Arghandab Reservoir”, 22–23 May 1967, leg. K. H. Rechinger 34869 (holotype: W [W1984-0011834 image!]).

Notes. No duplicate of the type collection was found in the different herbaria consulted.

28. *Delphinium leptocarpum* (Nevski) Nevski in Fl. URSS 7: 110. 1937

- ≡ *Consolida leptocarpa* Nevski in Acta Inst. Bot. Acad. Sci. URSS 4: 296. 1937 [basionym]. Type: «Ak-Davan», 21 Jun. 1931, S. A. Nevski 364 (holotype: LE [LE00050815 image!]; isotype: K [K000692381 image!]).

Notes. Although Nevski annotated both duplicates at LE and K, the latter is clearly labelled “Dupla”, and we considered LE00050815 as the holotype.

29. *Delphinium linarioides* Boiss. in Ann. Sci. Nat. Bot. ser. 2, 16: 368. 1841 [basionym].

- ≡ *Consolida linarioides* (Boiss.) Munz in J. Arnold Arbor. 48: 191. 1967a. Type: Iran. “Ispahan”, s.d., leg. P. M. R. Aucher-Eloy 4029 (lectotype, designated here: G-BOIS [G00788305 image!]; isolectotypes: G [G00440762 image!], K [K000692379 image!], P [P00198677!, P00198678!]).

Notes. Boissier’s annotation is found on P00198677 and G00788305, indicating Boissier based the species description on these duplicates. Therefore, the lectotypification is justified.

30. *Delphinium lineolatum* (Huber-Morath & C.Simon) Jabbour in Global Fl. 4(1): 73. 2018.

- ≡ *Consolida lineolata* Huber-Morath & C.Simon in Bauhinia 6: 285. 1978 [basionym]. Type: Turkey. Ermenek: “41 km sw Mur”, 13 Jul. 1976, leg. M. Nydegger 11138 (holotype: BASBG [BASBG-00000081 image!]; isotype: G [G00440764 image!, 3 sheets], GOET [GOET009747 image!]).

Notes. The protologue and G00440764 indicate erroneously that the collection number is 1138 when it is 11138.

31. *Delphinium lorestanicum* (Iranshahr) Jabbour in Global Fl. 4(1): 73. 2018.

- ≡ *Consolida lorestanica* Iranshahr in Pl. Syst. Evol. 155: 55. 1987 [basionym]. Type: Iran. Lorestan: “10–20 km on road from Aligodarz to Shoulabad”, 2 July 1977, leg. Runemark & Lazari 26530 (holotype: TARI image!).

Notes. No duplicate of the type collection was found in the different herbaria consulted.

32. *Delphinium mauritanicum* Cosson in Bull. Soc. Bot. France 27: 68. 1880 [basionym].

- ≡ *Consolida mauritanica* (Cosson) Munz in J. Arnold Arbor. 48: 48. 1967b. Type: Algeria. Oran: “Champs incultes à Lalla-Maghrnia”, 24 May 1856, leg. E. Bourgeau s.n. (lectotype, designated here: P [P02336111!]; isolectotypes: K [K001394825 image!], P [P02379147!]).

Notes. In his protologue, Cosson quotes several syntypes. Munz (1967b) designated the gathering *Bourgeau* at P as type. We found two duplicates at P, of which only P02336111 bears an annotation from Cosson.

33. *Delphinium oliverianum* DC., Syst. Nat. 1: 341. 1817 [basionym].

- ≡ *Consolida oliveriana* (DC.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 62. 1909. Type: Irak. «de Bagdad à Kermachan», s.d., leg. G. A. Olivier & J. G. Bruguère s.n. (holotype: P [P00198747!]).

Notes. No specimen was found at G. Candolle (1817) based on the species description on the unicate in Olivier’s herbarium, which is housed at P.

34. *Delphinium olopetalum* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 364. 1841 [basionym], non sensu Hayek in Repert. Spec. Nov. Regni Veg. Beih. 30(1): 313. 1924.

- ≡ *Consolida armeniaca* (Huth) Schrödinger var. *olopetala* (Boiss.) Parsa, Fl. Iran. 2: 316. 1986. Type: “Perse ?”, 1837, leg. P. M. R. Aucher-Eloy, s.n. (holotype: P [P00198568!]).

Notes. No specimen was found in Boissier’s herbarium. Boissier’s annotation on P00198568 indicates that the species description is based on this unicate (“exemplar unicum”), which is the holotype. Boissier (1841) indicated that the collection was mixed with *D. tomentosum*, which is no longer the case.

35. *Delphinium paradoxum* Bunge in Arbeiten Naturf. Vereins Riga 1: 124. 1847 [basionym].

- ≡ *Consolida paradoxa* (Bunge) Nevski in Komarov, V. L., Fl. URSS 7: 113. 1937.
- ≡ *Consolida rugulosa* (Boiss.) Schrödinger f. *paradoxa* (Bunge) Iranshahr in Fl. Iranica 171: 105. 1992. Type: Iran. “Djan-Darja”, 3 May 1842, leg. A. Lehman 36 (lectotype, designated here: P00198841, isoelectotypes: BM [BM000946072 image! =photo of LE], GH [GH00038197 image!], H [H1506244 image!], K [K000692370 image!], LE).

Notes. When describing new species, Bunge usually annotated the specimens cited with “mihi” or “m.” behind the species name. Unfortunately, we did not find any annotation from Bunge on the different duplicates. P00198841 bears ten individuals and three different preprinted Lehmann’s collection labels, all corresponding to collection number 36. One of them is from Lehmann’s hand with the locality (in Latin) and the date indicated in the protologue. No date is indicated on the other duplicates. LE (photo seen at BM) bears a label with the locality translation in German. After an investigation by the curator, the LE specimen was not found.

36. *Delphinium persicum* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 362. 1841 [basionym].

- ≡ *Consolida persica* (Boiss.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 17. 1909. Type: Iran. “Persia Circa Amadan”, 1837, leg. P. M. R. Aucher-Eloy 78 (holotype: G-BOIS [G00150139 image!]; isotypes: G [G00192123 image!, G00192122 image!]; K [K000692364 image!]; P [P00198487!, P00198912!]).

Notes. Boissier based the species description on the duplicate in G-BOIS. The date “1837” is only indicated on the isotypes housed at G and P.

37. *Delphinium phrygium* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 363. 1841 [basionym].

- ≡ *Delphinium ajacis* L. var. *phrygium* Fin. & Gagnep. in Bull. Soc. Bot. France 51: 467. 1904.
- ≡ *Consolida phrygia* (Boiss.) Soó in Österr. Bot. Z. 71: 245. 1922.
- ≡ *Consolida orientalis* (Gay) Schrödinger subsp. *phrygia* (Boiss.) Chater in Feddes Rept. Spec. Nov. Regni Veg. 68: 193. 1963. Type: Turkey. “in Phrygia”, 1831, leg. P. M. R. Aucher-Eloy 71 (holotype: P [P00198754!]; isotype: G-BOIS [G00789467 image! fragments only]).

Notes. Duplicate found in G-BOIS correspond to fragments taken from P00198754, which bears an original collection label, and was examined and annotated by Boissier for the species description.

37.1. *Delphinium phrygium* Boiss. subsp. *phrygium***37.2. *Delphinium phrygium* Boiss. subsp. *thessalonicum* (Soó) Jabbour & Du Pasquier, comb. nov.**

urn:lsid:ipni.org:names:77218868-1

- ≡ *Consolida orientalis* (Gay) Schrödinger var. *thessalonica* Soó in Österr. Bot. Z. 71: 239. 1922 [basionym].
- ≡ *Consolida phrygia* (Boiss.) Soó subsp. *thessalonica* (Soó) P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 26: 174. 1965. Type: Greece. Thessalia: “Kalampaka”, 4 Jun. 1896, leg. P. E. E. Sintenis 579 (holotype: not found; isotypes: E [E00346595 image!], LD [LD1742978 image!], P [P02500761!, P02574100!, P02819490!, P02819491!]).

Notes. Describing the subspecies, Soó indicated two herbaria (the herbarium of the National Museum of Hungary and Borbás’ herbarium), which are at BP now. However, after an investigation by the curators, no type specimen was found. None of the isotypes cited herein are annotated by Soó. More investigation is needed to argue that the BP specimens are lost before designating any lectotype.

38. *Delphinium pubescens* DC. in Lam. & DC., Fl. Franç., Ed. 3 5: 641. 1815 [basionym].

- ≡ *Consolida pubescens* (DC.) Soó in Österr. Bot. Z. 71: 241. 1922.
- ≡ *Delphinium consolida* L. subsp. *pubescens* (DC.) Nyman Consp. Fl. Eur. 21. 1878. Type: France. Occitanie: «lieux cultivés près Fontfroide», 12 Jun. 1807, A. P. Candolle s.n. (lectotype, designated here: G00131934 image!).
- = *Delphinium loscosii* Costa in Anales Soc. Esp. Hist. Nat. 2: 26. 1873.
- ≡ *Delphinium pubescens* DC. subsp. *loscosii* (Costa) Graeber & Graeber fil., in Asch. & Graebn., Syn. Mitteleur. Fl., 5(2): 676. 1929.
- ≡ *Delphinium consolida* L. var. *loscosii* (Costa) Pau, in Not. Bot. Fl. Españ. 4: 12. 1891.
- ≡ *Consolida loscosii* (Costa) Holub., in Novit. Bot. Delect. Seminum Horti Bot. Univ. Carol. Prag, 1960: 4. 1960.
- ≡ *Consolida pubescens* (DC.) Soó subsp. *loscosii* (Costa) Soó, in Österr. Bot. Z. 71: 241. 1922.
- ≡ *Consolida pubescens* (DC.) Soó var. *loscosii* (Costa) P.W.Ball & Heywood, in Feddes Repert. Spec. Nov. Regni Veg. 66: 151. 1962. Type: Spain. “in Aragonia australis pratis arvisque quoque in Catalaunia”, s.d., leg. A. C. Costa s.n. (lectotype, designated by Blanché and Simon 2000, pg. 307: BC [BC-975765 image!]).

Notes. Candolle did not mention any specimen in his protologue when he described *D. pubescens*. Although some original material of the “Flore Française” can be at MPU or P (Staffeu 1967), where Candolle worked before moving to Geneva, we found a

Candolle's gathering dated 1807 at G in the prodromus herbarium, that we designate as the lectotype.

39. *Delphinium pusillum* Labill., Icon. Pl. Syr. 4: 5. 1812 [basionym].

- ≡ *Consolida pusilla* (Labill.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 62. 1909. Type: Syria. “Djebel Cher”, s.d., leg. J. J. Labillardière s.n. (holotype: FI [FI005591 image!]).
- = *Delphinium pygmaeum* Poiret in Lam., Encycl. Suppl. 2: 458. 1812.
- ≡ *Consolida pygmaea* (Poiret) Schrödinger in Ann. K. K. Naturhist. Hofmus. 27: 43. 1913. Type: “Syrie”, s.d., leg. J. J. H. Labillardière s.n. (holotype: FI [FI005590 image!]; isotype: P [P04023292!]).
- = *Delphinium oliganthum* Boiss. Fl. Orient. 1: 80. 1867.
- ≡ *Consolida oligantha* (Boiss.) Schrödinger in Ann. K. K. Naturhist. Hofmus. 27: 43. 1913.
- ≡ *Consolida tomentosa* (Boiss.) Schröd. subsp. *oligantha* (Boiss.) P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 26: 175. 1965. Type: Syria. “In agris apris: p. Assy. p Aintab”, 27 Jun. 1865, leg. H. C. Haussknecht s.n. (lectotype (first step designated by Chowdhuri et al. 1958, pg. 417, second-step designated here): G [G00788351a image!, not G00788351]; isotypes: G [G00390259 image!, specimen in the middle only], K [K000075574 image!, two specimens annotated as “3”], P [P00198731!, P00550831!, P00198733!, P00198737!]).

Notes. The holotype of *D. pusillum* bears a handwritten protologue by Labillardière. Munz (1967a) indicated that he saw an isotype of *D. pusillum* at K (obviously K000692380), but it is not clear whether this specimen belongs to the type collection or not.

As explained by Chowdhuri et al. (1958), when dealing with *D. oliganthum*, the Haussknecht's gathering housed at G and K is a mixed collection of *D. hellespoticum* and *D. oliganthum*. In the Boissier herbarium, the folder of *D. oliganthum* contains two sheets, one with *D. hellespoticum* (G00788351), which bears the original label, and the other one with *D. oliganthum* (G00788351a), both annotated in 1956 by M. Hossain, one of the co-authors with P. K. Chowdhuri and P. H. Davis. At G, K and P duplicates also contain both species. We complete the first step of lectotypification by Chowdhuri et al. (1958), who indicated G and K simultaneously in designating the specimen on the sheet G00788351a at G-BOIS as the second-step lectotype.

40. *Delphinium raveyi* Boiss., Diagn. Pl. Orient. 1: 66. 1843 [basionym].

- ≡ *Consolida raveyi* (Boiss.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 62. 1909. Type: Turkey. Aydin: “in arvis Cariae ad Geyra”, Jun. 1842, leg. P. E. Boissier s.n. (lectotype, designated here: G-BOIS [G00330114 image!, 5 sheets]; isolecto-

types: BM [BM000553909 image!], G [G00390157 image!, 2 sheets, G00390156 image!], GOET [GOET009748 image!], JE [JE00018604 image!, JE00018605 image!, JE00018606 image!], K [K000692363 image!, K000692382 image!], MEL [MEL2409727 image!], NY [NY00353414 image!, NY00353415 image!], P [P00344101!, P00198977!, P00198978!, P00198979!], S [S07-15317 image!], US [US00409759 image!]).

Notes. Boissier annotated P00198978 and, therefore, we designate as lectotype the duplicate, including five sheets, in his herbarium.

41. *Delphinium rugulosum* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 361. 1841 [basionym].

- ≡ *Delphinium camptocarpum* Fisch. & C.A.Meyer var. *rugulosum* (Boiss.) Bunge in Arb. Naturf. Ver. Riga 1: 126. 1848.
- ≡ *Consolida rugulosa* (Boiss.) Schrödinger in Ann. K. K. Naturhist. Hofmus. 27: 43. 1913. Type: Iran.”ad lacum Ourmiah”, s.d., leg. P. M. R. Aucher-Eloy 4028 (holotype: G-BOIS [G00150138 image!]; isotypes: BM [BM000570952 image!], G [G00192124 image!], K [K000692365 image!, K000692366 image!], P [P00198502!, P00198503!, P00198504!, P00198505!]).

Notes. Boissier based the species description on the unicate at G-BOIS.

42. *Delphinium saccatum* Huth in Bull. Herb. Boissier 1: 328. 1893 [basionym].

- ≡ *Consolida saccata* (Huth) P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 26: 173. 1965.
- ≡ *Aconitella saccata* (Huth) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969.
- ≡ *Aconitopsis saccata* (Huth) Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 127. 1939. Type: Turkey. “Mardin: Rischemil, in lapidosis”, 28 Jun. 1888, leg. P. E. E. Sintenis 1186 (lectotype, designated here: LD [LD1016965 image!]; isolectotypes: BR [BR0000005295852 image!], E [E00438701 image!], G [G00440763 image!], JE [JE00018615 image!, JE00018616 image!, JE00018617 image!, JE00018618 image!], K [K000692359 image!, K000692360 image!], LD [LD1017157 image!], MO [MO-2196034], P [P00198522!, P00198523!, P00198524!], PH [PH00010734 image!], S [S07-15323 image!]).

Notes. Huth (1893) saw the *Sintenis 1186* specimen at B (but destroyed during WWII) and in his personal herbarium. Among the duplicates, we found specimens annotated by Huth at K (K000692359) and LD (LD1016965). Therefore, their lectotypification was needed.

43. *Delphinium samium* (P.H.Davis) Jabbour in Global Fl. 4(1): 73. 2018.

- ≡ *Consolida samia* P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 26: 172. 1965 [basionym]. Type: Greece, North Aegean. “Samos. SW-slope of Mt. Kerki”, 26 May 1963, leg. H. Runemark & S. E. Snogerup 19592 (holotype: LD [LD1023318 image!]; isotype: E [E00202626 image!]). Davis (1965) indicated that the holotype was kept at LD.

44. *Delphinium schlagintweitii* Huth in Bull. Herb. Boiss. 1: 329. 1893 [basionym].

- ≡ *Consolida schlagintweitii* (Huth) Munz in J. Arnold Arbor. 48: 191. 1967a. Type: Pakistan. Gilgit-Baltistan: “Bálti. Environs of Skárdo”, 6 Aug.–4 Sep. 1856, leg. A. Schlagintweit 821 (holotype: G [G00390260 image!]; isotypes: B [destroyed], BM [BM000553907 image!], MEL [MEL2407606 image!], US [US00409758 image!]).

Notes. Huth based his description solely on the duplicate in the Barbey herbarium (now G).

45. *Delphinium sclerocladum* Boiss., Diagn. Pl. Orient. 8: 8. 1849 [basionym].

Delphinium anthoroideum Boiss. var. *sclerocladum* (Boiss.) Boiss. Fl. Orient. 1: 85. 1867.

- ≡ *Consolida scleroclada* (Boiss.) Schrödinger in Ann. K. K. Naturhist. Hofmus. 27: 44. 1913.

- ≡ *Aconitella scleroclada* (Boiss.) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969.

- ≡ *Aconitopsis scleroclada* (Boiss.) Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 127. 1940.

Type: Syria. Latakia: “montagnes de Latakieh”, May-Jul. 1846, leg. P. E. Boissier s.n. (lectotype, designated here: G-BOIS [G00788332 image!, 3 sheets]; isolectotypes: E [E00438707 image! =photo of G-DC], G-DC, P [P00195757!, P00195758!]).

Notes. Boissier annotated P00195758. Therefore the lectotypification is justified. The G-DC specimen (observed only on the photo at E) bears the date “Jun 1846”. A specimen at JE (JE00018613) could probably be part of the type material.

45.1. *Delphinium sclerocladum* Boiss. var. *sclerocladum*

45.2. *Delphinium sclerocladum* Boiss. var. *rigidum* (Freyn & Sint.) Hossain & P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 22: 414. 1958.

- ≡ *Delphinium anthoroideum* Boiss. var. *rigidum* Freyn & Sint. in Österr. Bot. Z. 41: 363. 1891 [basionym].

- ≡ *Consolida scleroclada* (Boiss.) Schrödinger var. *rigida* (Freyn & Sint.) P.H.Davis, Fl. Turkey 1: 123. 1965.
- ≡ *Consolida euphratica* Schrödinger in Ann. K. K. Naturhist. Hofmus. 27: 43. 1913. Type: Turkey. “Chama ad Euphratem. Ichlik prope Tuzla”, 15 Jul. 1890, leg. P. E. Sintenis 2969 (lectotype, designated here: P [P00195794!] (Fig. 2C); isolectotype: LD [LD1011461 image!]).

Notes. Contrary to the quotation of Hossain and Davis in their protologue, the type specimen was found neither at W nor at WU (probably destroyed during WWII). At JE, the specimen *Sintenis 2969* (JE00018614) does not correspond to type material since it bears the mention “Erzinghan: in declivibus ad Euphratem prop. Sürek” with the date 17 Jul. 1890. In 1913, Schrödinger recombined the varietal rank “*rigidum*” by renaming it as *Consolida euphratica*. He quoted as synonym *D. anthoroideum* var. *rigidum* Freyn & Sint. In order to resolve both names simultaneously, we designate the specimen “*Sintenis 2969*” at P as lectotype of *D. anthoroideum* var. *rigidum* Freyn & Sint. and *C. euphratica* Schrödinger.

46. *Delphinium songoricum* (Kar. & Kir.) Nevski, in Komarov, V. L., Fl. URSS 7: 109. 1937.

- ≡ *Delphinium camptocarpum* Fisch. & C.A.Mey. var. *songoricum* Kar. & Kir. in Bull. Soc. Nat. Mosc. 15:136. 1842 [basonym].
- ≡ *Consolida songorica* (Kar. & Kir.) Nevski in Komarov, V. L., Fl. URSS 7: 109. 1937. Type: Russia. “In arenosis Songoriae ad fl. Lepsa”, 1841, leg. G. S. Karelin & I. P. Kirilow 1165 (holotype: LE, not found; isotypes: BM [BM000946032 image!], H [H1252673 image!], K [K001394824 image!], NY [NY00353417 image!], P [P00197046!, P00197047!]).

Notes. The holotype should be at LE (indicated by Nevski 1937), although we did not find it.

47. *Delphinium staminosum* (P.H.Davis & Sorger) Jabbour in Global Fl. 4(1): 73. 2018.

- ≡ *Consolida staminosa* P.H.Davis & Sorger in Notes Roy. Bot. Gard. Edinburgh 40: 89. 1982 [basonym]. Type: Turkey. Niğde: “Çaykavak pass”, 19 Jul. 1979, leg. Hübl, Meusel & Valant 7-19-13 (holotype: E [not found]; isotype: LI [LI02796901 image!]).

Notes. Despite investigations by the curators, the specimen at E was not found, and contrary to what Davis and Sorger indicated in their protologue, duplicates were found neither at WU nor at W.

48. *Delphinium stapfianum* (P.H.Davis & Sorger) Jabbour in Global Fl. 4(1): 73. 2018.

- ≡ *Consolida stapfiana* P.H.Davis & Sorger in Notes Roy. Bot. Gard. Edinburgh 40: 89. 1982 [basionym]. Type: Turkey. Antalya: “20 km SW of Korkuteli, 1200 m, field margins”, 12 Jul. 1968, leg. F. Sorger 68-27-11 (holotype: E, not found; isotype: LI [LI02796918 image!]).

Notes. Despite investigations by the curators, the specimen at E was not found.

49. *Delphinium stenocarpum* Hossain & P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 22: 413. 1958 [basionym].

- ≡ *Consolida stenocarpa* (Hossain & P.H.Davis) P. H. Davis in Notes Roy. Bot. Gard. Edinburgh 26: 173. 1965.
- ≡ *Aconitella stenocarpa* (Hossain & P.H.Davis) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969. Type: Turkey. Konya: “between Ağabeyli and Körkuyu”, 8 Sep. 1949, leg. P. H. Davis 16638 (holotype: E [E00438702 image!]; isotypes: K [K000692450 image!, K000692449 image!]).

Notes. Hossain and Davis formally designated the holotype of *Delphinium stenocarpum* at E, where we found E00438702 annotated by themselves.

50. *Delphinium stocksianum* Boiss., Diagn. Pl. Orient., Ser. 2, 1: 12. 1853 [basionym].

- ≡ *Consolida stocksiana* Nevski in Komarov, V. L., Fl. URSS 7: 111. 1937. Type: Pakistan. “Baluchistan”, 1851, leg. J. E. Stocks 979 (holotype: G-BOIS [G00789496 image!, 3 sheets]; isotypes: K [K000075584 image!, K000075586 image!, K000075587 image!]).

Notes. The holotype is a folder of three sheets.

51. *Delphinium sulphureum* Boiss. & Hausskn. in Boiss., Fl. Orient. 1: 81. 1867 [basionym].

- ≡ *Consolida sulphurea* (Boiss. & Hausskn.) P.H.Davis in Notes Roy. Bot. Gard. Edinburgh 26: 175. 1965. Type: Turkey. Maraş: “Montes azia/ Marasch”, 1865, leg. H. C. Haussknecht s.n. (holotype: G-BOIS [G00788353 image!, 2 sheets]; isotype: P [P00201052!]).

Notes. In the protologue, Boissier quoted an unnumbered Haussknecht’s collection with the following indication “in graminosis montium Syriae borealis prope Marasch alt. 4000”.

Davis (1965) indicated as “types” a specimen housed at K. However, Boissier did not examine this specimen and based his description solely on specimens in his herbarium, where we found a collection folder containing two sheets. One bears a printed label of Haussknecht’s collection with his handwritten additions of locality “In apris v. Karabigukle et pr. Marasch”, and the date “Aug. 65”. The other one bears three of Boissier’s handwritten labels, one of which bears the mention of the locality “Montes azia/ Marasch” and the date “1865”.

At JE, K, and P, we found Haussknecht’s duplicates (JE00018589, K000692378, and P00201052) with a label handwritten by himself bearing the locality “Uffoschikle” (or “Uffoschakli”) with the date 11 July 1865. A duplicate at JE bears, in addition, the number 970. All these specimens correspond to syntypes.

52. *Delphinium teheranicum* Boiss., Fl. Orient. 1: 85. 1867 [basionym].

≡ *Consolida teheranica* (Boiss.) Rech. f. in Ann. Nat. Mus. Wien 51: 376. 1940.

≡ *Aconitella teheranica* (Boiss.) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969.

≡ *Aconitopsis teheranica* (Boiss.) Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 127 1940.

Type: Iran. “Teheran”, leg. C. G. T. Kotschy, s.n. (lectotype, designated here: G-BOIS [G00788331 image!]).

Notes. In the protologue, Boissier (1867) based the species description on the specimen *Kotschy 884* housed at W (“in herb. Mus. Vindob!”). Iranshahr (1992) indicated to have seen this specimen at G. However, after investigation, the specimen *Kotschy 884* was found neither at W, nor at WU, nor G. In G-BOIS, we found a Kotschy’s gathering of *D. teheranicum* with a fragmentary specimen (probably a part of the specimen cited in the protologue) and a label written by Boissier. We designate this specimen as the lectotype.

53. *Delphinium tenuissimum* Sm., Fl. Graec. Prodr. 1: 370. 1809 [basionym].

≡ *Consolida tenuissima* (Sm.) Soó in Österr. Bot. Z. 71: 241. 1922. Type: Greece.

Stereia Ellas: “Mt Hymethus”, s.d., leg. J. Sibthorp s.n. (holotype: OXF [Sib-1234 image!], isotype: BM [BM000613696 image!]).

Notes. Sibthorp’s herbarium is housed at OXF, where we found a duplicate bearing the locality annotation “Mt Hymethus”.

54. *Delphinium thirkeanum* Boiss., Fl. Orient. 1: 84. 1867 [basionym].

≡ *Consolida thirkeana* (Boiss.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 62. 1909.

≡ *Aconitella thirkeana* (Boiss.) Soják in Folia Geobot. Phytotax. Bohem. 4: 448. 1969.

≡ *Aconitopsis thirkeana* (Boiss.) Kem.-Nath. in Trudy Tbilissk. Bot. Inst. 7: 125. 1940. Type: Turkey. “Amasia et Tokat”, s.d., F. Wiedemann s.n. (lectotype, designated here: G-BOIS [G00788335 image!], isolectotype: E [E00438704 image! =photo of G-BOIS]).

Notes. In his protologue, Boissier (1867) cited two gatherings: “in Bithynia, Thirke” and “circa Amasia et Tokat Anatoliae, Wiedem.”. Wiedemann’s gathering at G-BOIS is here chosen as lectotype. Munz (1967a) indicated that he saw a duplicate of this gathering at GH and K. However, the duplicate at GH could not be found by the curator. It is unclear whether the Wiedemann’s gathering at K of *D. thirkeanum* (K000075588), which is apparently a duplicate from a specimen at LE, belongs to the type material. Moreover, Huth (1895) quotes a specimen at LE, which was not observed.

55. *Delphinium tomentosum* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 365. 1841 [basionym].

≡ *Consolida tomentosa* (Boiss.) Schrödinger in Abh. K. K. Zool.-Bot. Ges. Wien 4(5): 62. 1909. Type: Syria. “Persia”, 1836, P. M. R. Aucher-Eloy 77 (lectotype, designated here: P [P00201127!] (Fig. 2D)).

Notes. In his protologue, Boissier cited two gatherings of Aucher-Eloy: “N.76. Alep” and “77. Persia”. Chowdhuri et al. (1958. 22: 418) erred in designating as lectotype the gathering *Aucher 75* “Syria!” that Boissier (1841) indicated under *Delphinium virgatum* Poir. (in fact, *Aucher 75* corresponds to *D. peregrinum* L.). No sheet of *Aucher 76* bears any annotation from Boissier, whereas P00201127 (*Aucher 77*) is annotated. We designate this latter specimen as the lectotype. No duplicate was found.

56. *Delphinium trigonelloides* Boiss. in Ann. Sci. Nat. Bot. Ser. 2, 16: 366. 1841 [basionym].

≡ *Consolida trigonelloides* (Boiss.) Munz in J. Arnold Arbor. 48: 190. 1967a. Type: Iran. “Pers. australi”, s.d., leg. P. M. R. Aucher-Eloy 4033 (holotype: G-BOIS [G00788304 image!]; isotypes: BM [BM000570953 image!], G [G00440760 image!, G00440761 image!], K [K000692375 image!], P[P00201193!, P00201194!]).

Notes. Boissier based his species description on the duplicate of his herbarium.

57. *Delphinium tuntasianum* Halácsy in Magyar Bot. Lapok 11: 117. 1912 [basionym].

≡ *Consolida tuntasiana* (Halácsy) Soó in Österr. Bot. Z. 71: 239. 1922. Type: Greece. Sterea Ellas: “in regione abietina m. Gerania Megarae”, 23–28 Jun. 1910, B. Tun-

tas 1245 (lectotype, designated here: WU [WU 01067863 image!, specimen on the bottom left corner]).

Notes. Halácsy based his description of *D. tuntasianum* on the specimen *Tuntas 1245* from the “Plantae exsiccatae Florae Hellenicae” collection. Three *Tuntas* specimens of *D. tuntasianum*, each one including several plant individuals, were found at WU: *Tuntas 1245*, *Tuntas 800*, and *Tuntas s.n.* Examination of *Tuntas 1245* shows two different dates: “23–28 Jun. 1910” (printed) and “10/23 Mai 1911” (handwritten), this later date being the same as the gathering “s.n.”. Therefore, the gathering “1245” is probably a combination of two different collections. We designate it as a lectotype despite the uncertainty regarding its collection date.

58. *Delphinium uechtritzianum* Huth in Bot. Jahrb. Syst. 20: 378. 1895 [basionym].

≡ *Consolida uechtritziana* (Huth) Soó in Österr. Bot. Z. 71: 236. 1922. Type: Albania. “In arvis ad Zojz”, 1889, leg. A. Baldacci s.n. (lectotype, designated here: G [G00414314 image!, 2 sheets]).

Notes. In his protologue, Huth quotes two syntypes (*Pančić 1881* seen in three different herbaria, and *Baldacci 1889* seen in the Barbey herbarium, now G). At G, there is a folder with two sheets of the second gathering that we designate here as lectotype.

Discussion and conclusions

According to the nomenclatural revision presented here, *Delphinium* subg. *Consolida* consists of 58 species. This work will facilitate a taxonomic study aimed at revising the circumscription of sections within *D.* subg. *Consolida*. Infrasubgeneric relationships were tackled and discussed in Jabbour and Renner (2011). Moreover, a thorough taxonomic study of the species-rich subgenera *Delphinastrum* (DC.) Peterm. and *Oligophyllon* Dimitrova is now timely, as they are the last subgenera in *Delphinium* that still require revision.

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Three new endemic species of *Lepanthes* (Orchidaceae, Pleurothallidinae) from the highlands of Ecuador

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Abstract

Three new species of *Lepanthes* from Ecuador are described and illustrated. These additions to the Ecuadorean flora were recorded in evergreen montane forest and páramo as part of three different research projects conducted during the last five years (2016–2021). *Lepanthes orolojaensis* was discovered in the southwest of El Oro province and is similar to *L. jimburae*, differing mainly in the much smaller plants, inflorescences and floral parts. *Lepanthes microprosartima* from the western slopes of Pichincha volcano in northern Ecuador resembles *L. obandoi* but differs in the coloration of the leaves, the inflorescence that are shorter than the leaves and the smaller floral appendix. *Lepanthes caranqui*, found in eastern Pichincha and Imbabura, is most similar to *L. pachychila* but differs from it in its much larger plants and different shape of the petals and the floral appendix. Preliminary assessments of the conservation status of the three taxonomic novelties are provided, using the IUCN Red List Categories and Criteria.

Keywords

El Oro, endemism, evergreen montane forest, Imbabura, *Lepanthes caranqui*, *Lepanthes microprosartima*, *Lepanthes orolojaensis*, páramo, Pichincha

Introduction

Pleurothallidinae Lindl., with over 12,000 names published and around 5,100 currently accepted species, is the largest orchid subtribe worldwide (Karremans 2016). *Lepanthes* Sw. is one of the most diverse genera of the subtribe, and the estimated number range between 1,100 and 1,200 species (Larsen et al. 2018; Baquero et al. 2019; Bogarín et al. 2020), accounting for more than 20% of the species (Karremans 2016). *Lepanthes* is restricted to the Neotropics, ranging from the Antilles and southern Mexico through the Andes south to Bolivia, with a few species known from Brazil (Luer and Thoele 2012; Larsen 2014). The largest number of species is concentrated in the Andes of Colombia, Ecuador and Peru (Damian and Larsen 2017; Bogarín et al. 2020), but an important number of species is also distributed in Costa Rica, Panama (Salazar and Soto-Arenas 1996; Bogarín et al. 2020). In Ecuador, this genus includes about 350 species, of which 240 are considered endemic to the country (Dodson and Luer 2011; Baquero et al. 2019). Nevertheless, their richness is far from being fully inventoried, as new species are continuously being discovered and described as the country's forests continue to be explored (Thoele and Hirtz 2015; Baquero 2018; Baquero et al. 2018; Tobar et al. 2018; Zambrano and Solano 2019).

Three new species: *Lepanthes microprosartima* Tobar & M.J.Gavil., *Lepanthes caranqui* Tobar & Monteros and *Lepanthes orolojaensis* Tobar & M.F.Lopez are described and illustrated here. These additions belong to the subgenus *Lepanthes*, sect. *Lepanthes*, which contains more than 243 spp. in Ecuador, and thus by far the largest in the genus (Luer and Thoele 2012); *Lepanthes* subsections *Lepanthes* and *Breves* it subdivided into series, based largely on the morphology of the genus in Ecuador. An extensive examination of the genus beyond the borders of Ecuador demonstrated that these series were untenable, therefore (Luer 1993; Luer 1996; Luer 2010), we place the three species into subsection *Lepanthes* without further division.

These novelties were discovered and collected as part of three different research projects conducted during the last five years (2016–2021), including “The Ecology of Plant and Hummingbird Interactions Project (EPHI),” carried out in the western slopes of Pichincha province; “El Oro Biodiversity Project,” conducted in southwestern Ecuador; and the “Floristic Inventory of La Carboneria forest remnant,” in eastern Imbabura and Pichincha provinces. The discovery of these new species demonstrates the importance of continuing the botanical exploration of a mega-diverse and incompletely inventoried country such as Ecuador.

Materials and methods

Plants were photographed in situ and subsequently pressed and dried, and deposited at QCA and QCNE (acronyms according to Thiers 2018 continuously updated). Photographs were taken using a Nikon D100 digital camera equipped with a 105 mm macro lens (Nikon). Morphological observations and measurements were made from live and

alcohol-preserved material. The samples were compared with *Lepanthes* species previously recorded in Ecuador, including the herbarium collections at QCNE and QCA, as well as in published descriptions and illustrations of the genus from South America, Mexico, and southern Central America.

We assess the extinction risk of the three species following the IUCN (2012) Red List Categories and Criteria. We consider observations, collection sites and individual counts marked during field visits. Species extent of occurrence (EOO) and area of occupancy (AOO) were calculated using GeoCAT (Bachman et al. 2011; <http://geocat.kew.org/>) with the default 2 km² grid. Based on all available information, we preliminarily evaluate the risk of extinction of each species separately through all the Categories and Criteria.

Taxonomic treatment

Lepanthes orolojaensis Tobar & M.F.Lopez, sp. nov.

urn:lsid:ipni.org:names:77218876-1

Figs 1, 2, 3a

Diagnosis. This species is similar to *Lepanthes jimburae* Luer & Hirtz, but can be distinguished by the smaller plants that are less than 3 cm tall (vs. up to 4 cm tall); the shorter inflorescence that is less than 4 cm long (vs. inflorescence up to 10 cm long), the shorter dorsal sepal with a shorter sepaline tail (6.0 mm vs. 9.0 mm long), the apical lobe of the petals ovate and lower lobe triangular-oblong (vs. petals with subequal, obliquely triangular, acute lobes).

Type. ECUADOR. El Oro, Zaruma, Salvias, near Cerro de Arcos, -3.06963333°N, -79.478944°W, 3500 m, 28 Aug 2015, Tobar, Gálvez & Obando 1648 (**holotype**: QCNE; **isotype**: QCA).

Epiphytic, caespitose herbs up to 3 cm tall. Roots flexuous, cylindrical 0.7 mm in diameter. Rhizome inconspicuous. Ramicaul arcuate to pendulous, 0.9–1.9 × 0.1–0.3 cm long, with 3–4 internodes, covered entirely by light brown minutely puberulent lepanthiform sheaths with a minutely pubescent, acuminate ostium. Leaves dark-green suffused with purple, arcuate 1.0–1.3 × 0.4–0.6 cm, coriaceous, elliptic, subacute to obtuse, tridentate at the apex, base cuneate, contracted into a petiole 2–4 mm long. Inflorescence racemose, one per stem, longer than the leaf, 2.0–3.5 cm long, flexuous, producing 3–16 widely spaced, successively opening flowers; peduncle filiform, 1–3 mm long, surrounded at the base by a bract 1.5 mm long. Floral bracts sub-distichous, infundibuliform, longapiculate. Ovary 1.5 mm long, obpyramidal, slightly arcuate, irregularly keeled. Flowers ca. 12 × 4 mm; dorsal sepal red with a yellow margin, lateral sepals yellow suffused with red around the middle vein; petals with the upper lobe red and the lower one yellow, lip reddish with yellow tips, column reddish, with white and red anther. Dorsal sepal glabrous, slightly concave, ovate, ending in a decurved cauda, 3-veined, 6.0 × 2.7 mm including the cauda. Lateral sepals glabrous, with minutely denticulate margins, connate on their basal one-third,

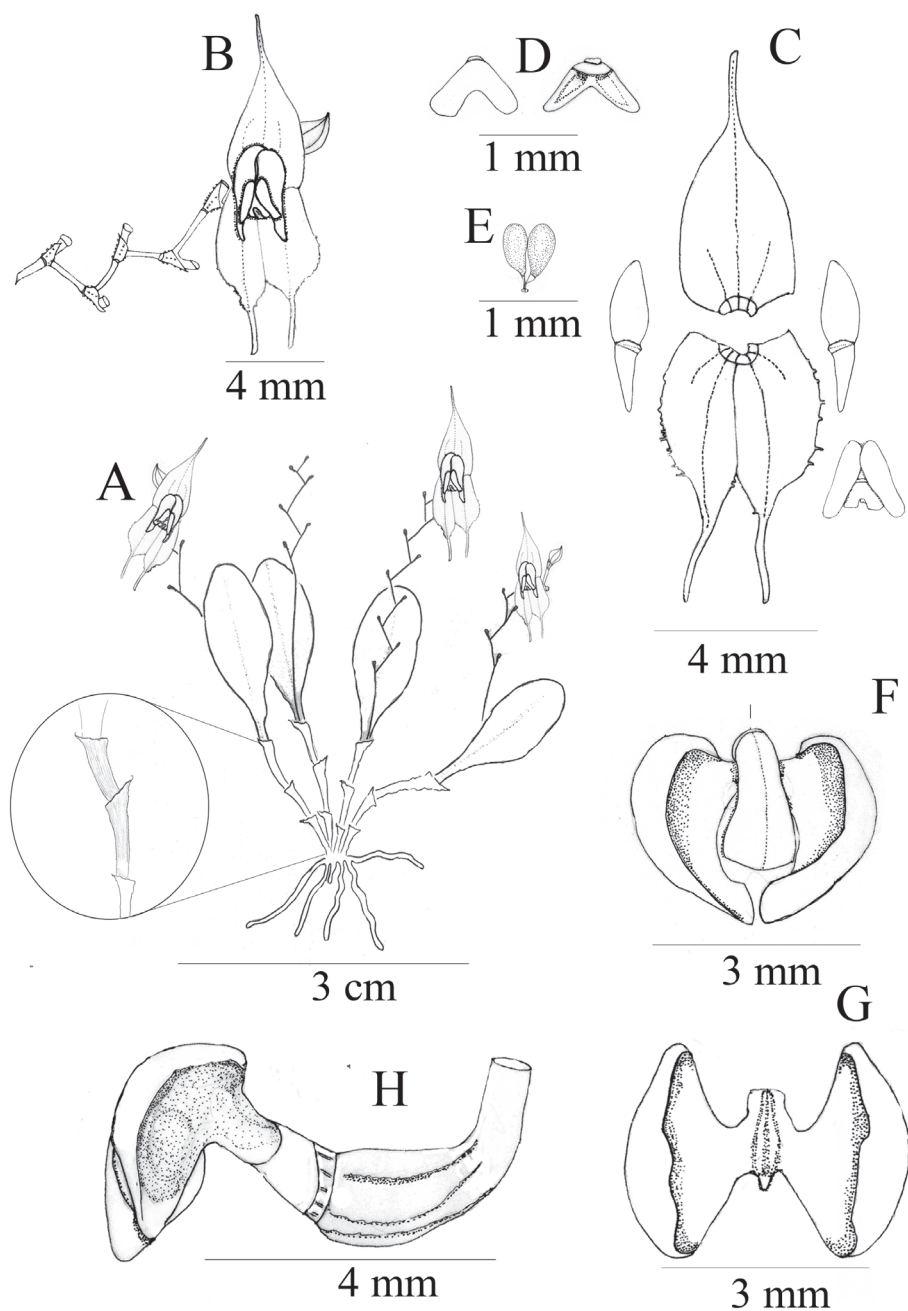


Figure 1. *Lepanthes orolojaensis* **A** habit **B** flower **C** dissected sepal and petals **D** anther dorsal and ventral view **E** pollinarium **F** dorsal view of the spread-out lip with dorsal view of the column **G** dorsal view of the spread-out lip without the column **H** lateral view of the ovary, lip and column. Drawn by F. Tobar & S. Tobar from the plant that served as type (Tobar et al 1648).

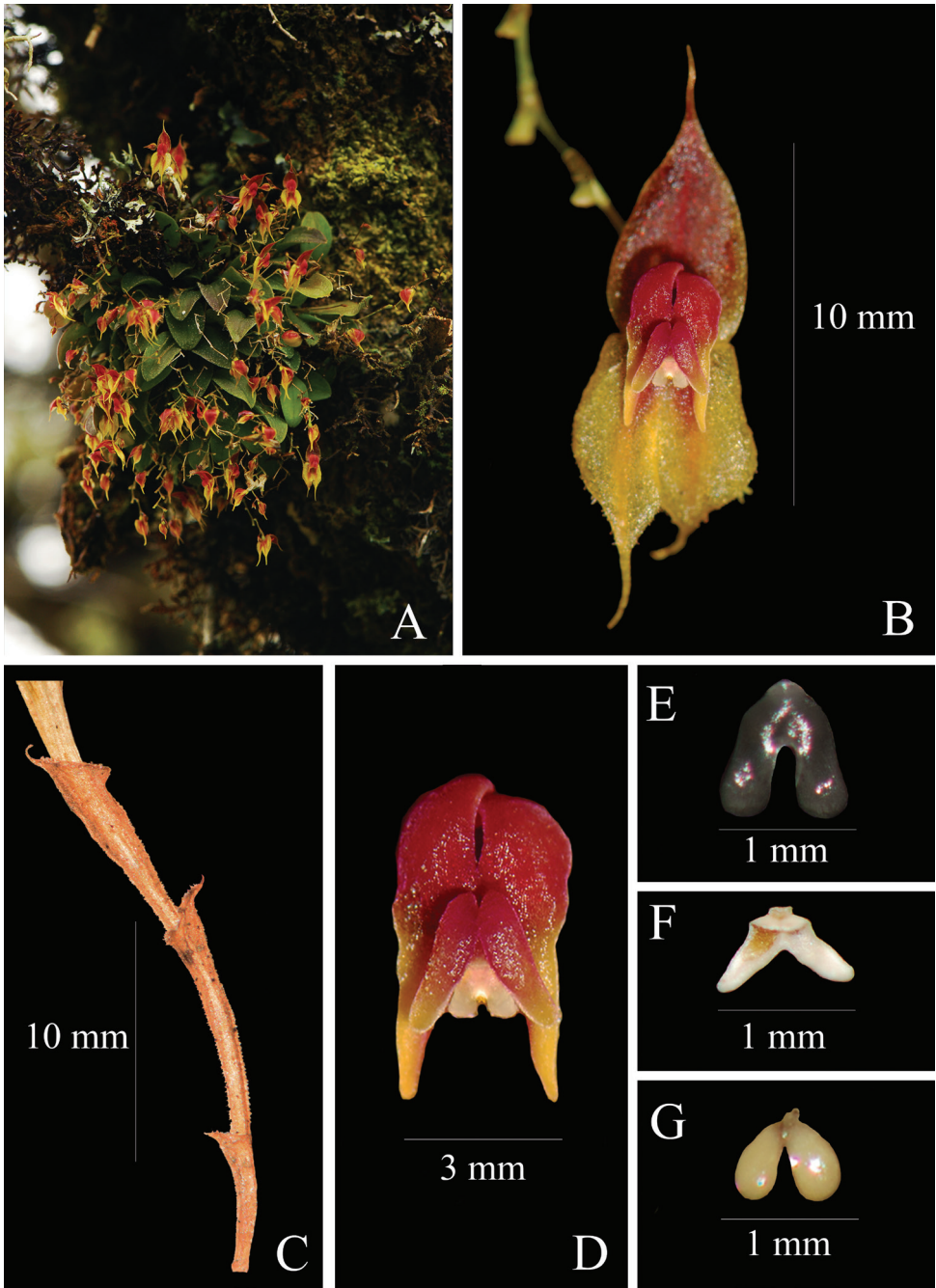


Figure 2. *Lepanthes orolojaensis* **A** plant growing in its natural habitat **B** front view of the flower **C** detail of the lepanthiform sheath **D** detail of lip and petals **E** anther dorsal view **F** anther ventral view **G** polinarium. Photograph by F. Tobar from the plant that served as type (Tobar *et al.* 1648).

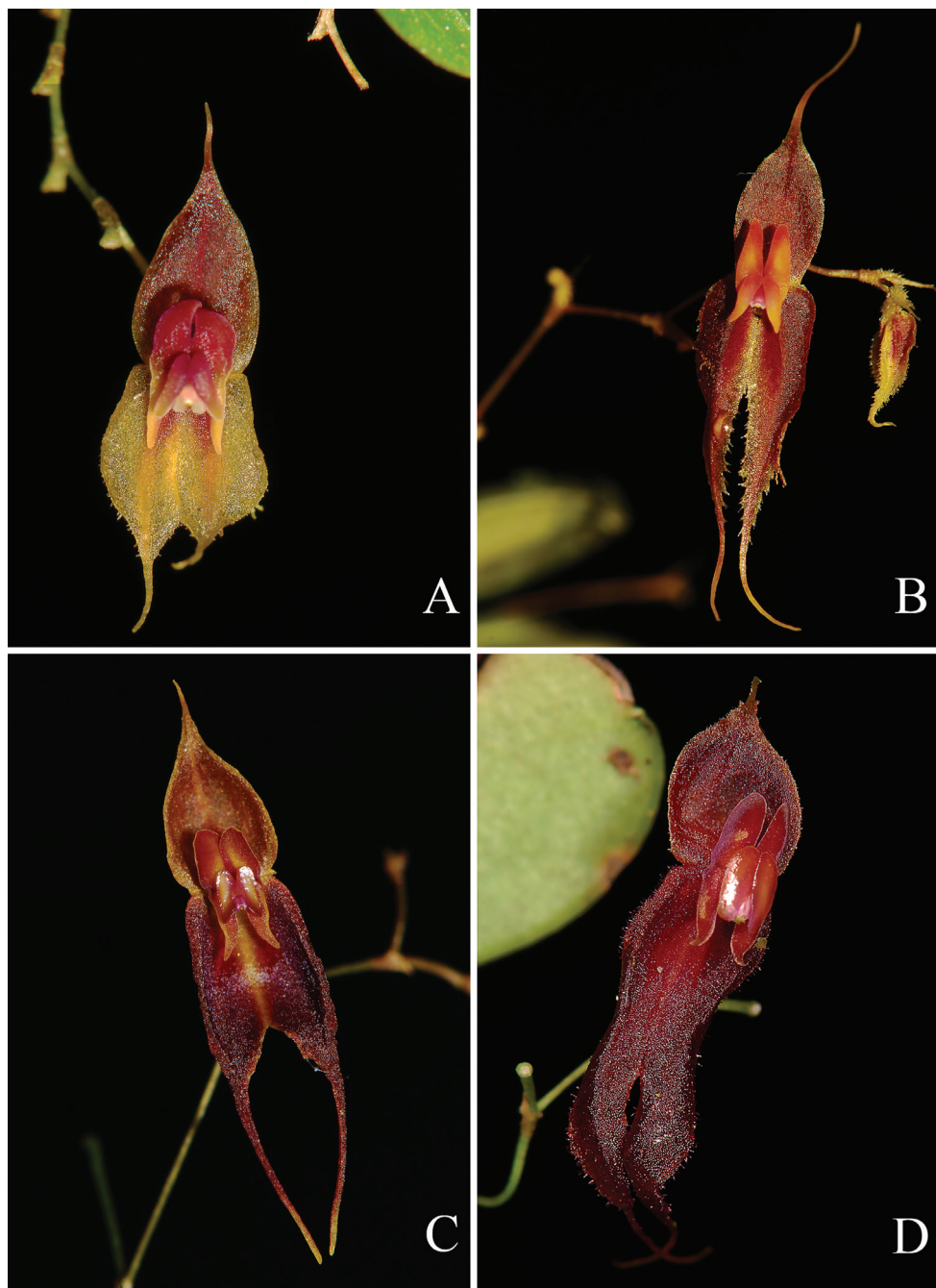


Figure 3. Comparison with the most similar species to *Lepanthes orolojaensis* Tobar & M.F.Lopez
A *Lepanthes orolojaensis* **B** *Lepanthes jimburae* **C** *Lepanthes corkyae* **D** *Lepanthes schizix*. Photographs by F. Tobar.

ovate, caudate, 2-veined, 5.0×2.0 mm. Petals, bilobate, microscopically pubescent; apical lobe ovate, rounded, lower lobe triangular-oblong, acute, ca. 3.5×0.9 mm. Lip bi-laminate, blades ovate, convex, subacute at the base and rounded at the apex, microscopically pubescent, covering most of the column, ca. 1.8×0.7 mm; the base of the lip fused to the ventral part of the column, the connectives shortly cuneate, the sinus narrowly oblong with very small, triangular, microscopically pubescent appendix. Column claviform, arcuate, markedly broaden above the middle, truncate at the apex, ca. 1.6×0.8 mm. Pollinarium with two ovoid pollinia, with a round, drop-like viscidium. Anther dorsal, deltate. Stigma ventral, horseshoe-shaped. Rostellum minute, apiculate. Capsule globose, 4×3 mm.

Distribution and habitat. *Lepanthes orolojaensis* is known from a single locality on the border between El Oro and Loja provinces (Fig. 4). The species was collected in a small patch of scrubs, growing on *Berberis lutea* Ruiz & Pav. (Fig. 5), which is a representative species of the evergreen forest formation (BsSn01) according to Ministerio del Ambiente del Ecuador (2013). This type of vegetation is found in sites protected from the wind and desiccation, such as glacial valleys, ravines or under large blocks of rock, which allow them to maintain a higher humidity than the surrounding vegetation and favors the presence of some epiphytes (Sierra et al. 1999).

Phenology. The species was collected in bloom in August and had inflorescences in different stages of development, which suggests that the flowering period may be much broader.

Etymology. The specific epithet refers to the provinces of El Oro and Loja, since this species was discovered at their border.

Preliminary conservation status. *Lepanthes orolojaensis*, is known only from the type location, and only two mature individuals were observed. After its discovery in 2015, two additional visits were conducted to explore surrounding areas but it was not possible to find more plants. However, it was evident that the original habitat is under strong pressure due to cattle ranching, the collection of remaining shrubs as firewood and a rapid transformation and fragmentation of the surrounding landscape due to fires and exotic species plantations such as *Pinus radiata* D. Don (Penafiel et al. 2018). Therefore, its small population size, area of occupancy of four km², as well as its habitat restriction and degradation of its unique location allow us to apply criteria B of the IUCN (2012) Red List. The species is preliminarily assessed as Critically Endangered (CR) B2a+b(ii,iii,v) given that it is known from a single location where its area of occupancy, habitat quality, and number of mature individuals are probably declining.

Discussion. Morphologically, the most similar species is *Lepanthes jimburae* (Fig. 3b) from the southeastern slopes of the Ecuadorian Andes. From that species, *L. orolojaensis* differs in the smaller plants, the dorsal sepal attenuate into a shorter decurved cauda, the lateral sepals with minutely denticulate margins and petals with the upper lobe ovate, with rounded apex and lower lobe triangular-oblong. The new species is also similar to *L. corkyae* (Fig. 3c) and *L. schizix* (Fig. 3d), both occurring on the west-

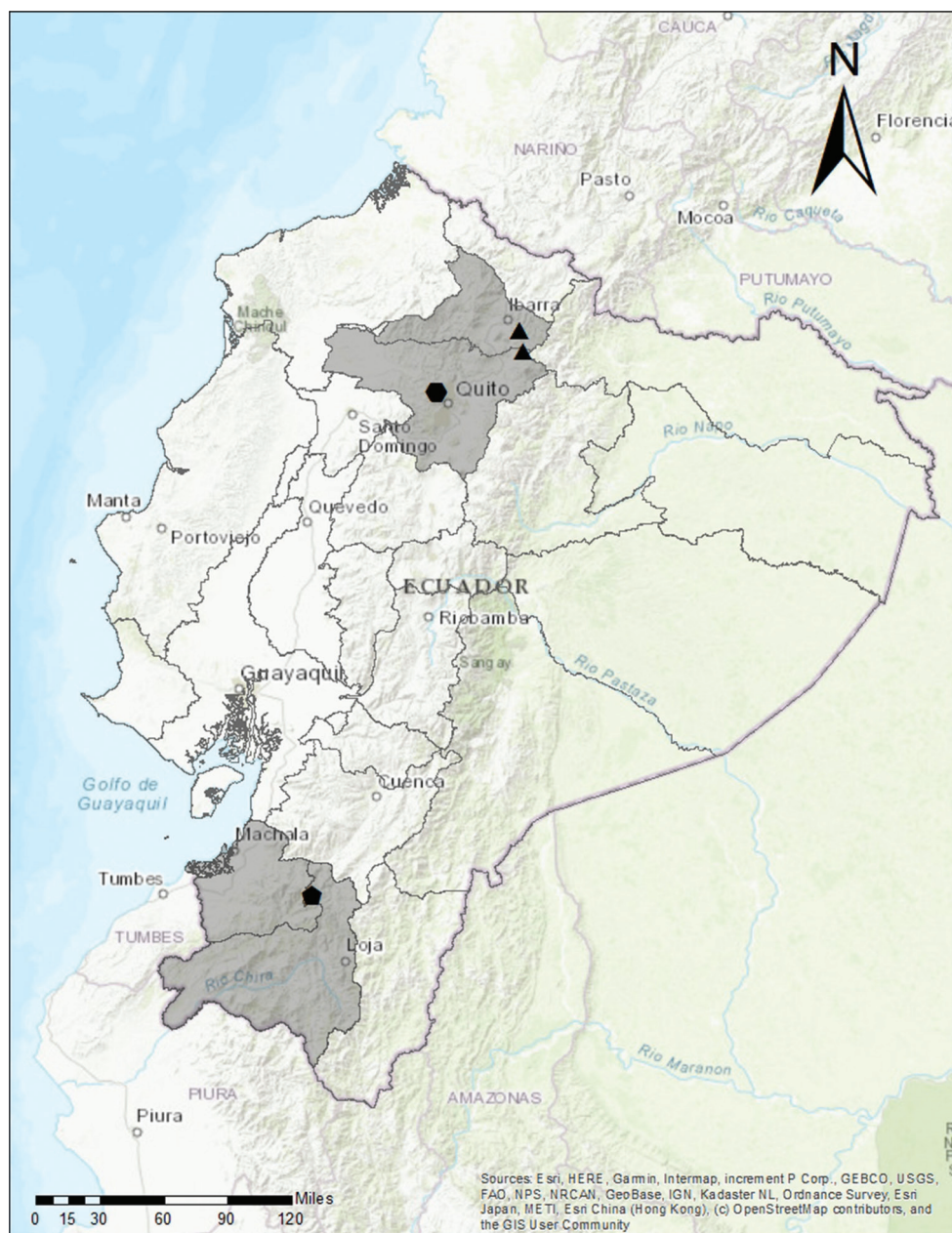


Figure 4. Geographical distribution of the three new species of *Lepanthes micropsartima* Tobar & M.J.Gavil. (black hexagon, three collections), *Lepanthes caranqui* Tobar & Monteros (black triangle, two collections) and *Lepanthes orolojaensis* Tobar & M.F.Lopez (black pentagon, one collection).

ern slopes of the northern Ecuador and from which it differs in the red to reddish with yellow dorsal sepals, yellow lateral sepals suffused with red around the mid-vein (vs. orange to red brown sepals in *L. corkyae* and purple flower in *L. schizix*), lateral sepals in

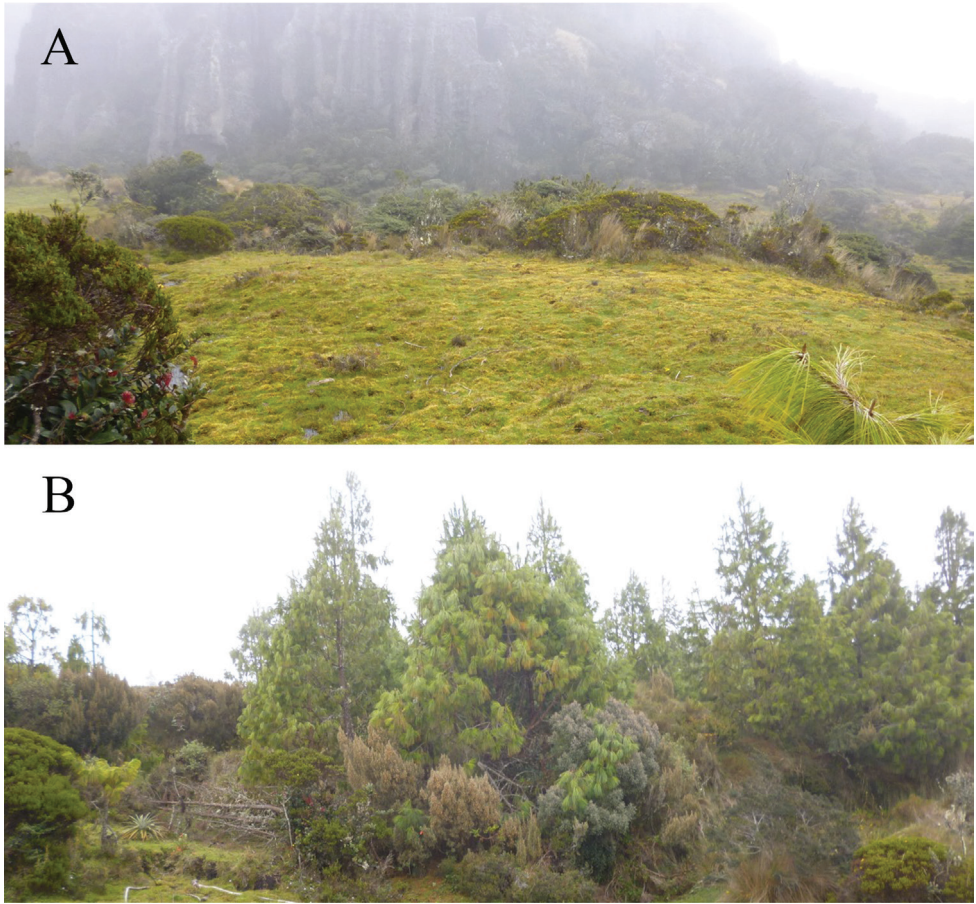


Figure 5. Landscape near to Cerro de Arcos, where *Lepanthes orolojaensis* was collected, in El Oro Province **A** natural vegetation remnants **B** areas where *Pinus* have been planted.

L. orolojaensis are minutely denticulate in the margin, are not denticulate in *L. corkyae* and minutely ciliate in *L. schizix*. In Both *L. corkyae* and *L. schizix* the lip blade are glabrous (vs. microscopically pubescent *L. orolojaensis*) and, lip blades are oblong in *L. corkyae* and *L. orolojaensis* and lunate in *L. schizix*.

2. *Lepanthes microprosartima* Tobar & M.J.Gavil., sp. nov.

urn:lsid:ipni.org:names:77218877-1

Figs 6, 7, 8a

Diagnosis. Similar in habit to *Lepanthes obandoi* Tobar & M.F. López, but distinguished by the inflorescence shorter than the leaf (vs. Inflorescence longer than) and petals with unequal triangular lobes (vs. lobes lanceolate-oblong, subequal). *Lepanthes mirador* Luer & Hirtz is also similar, differing from it in the superposed,

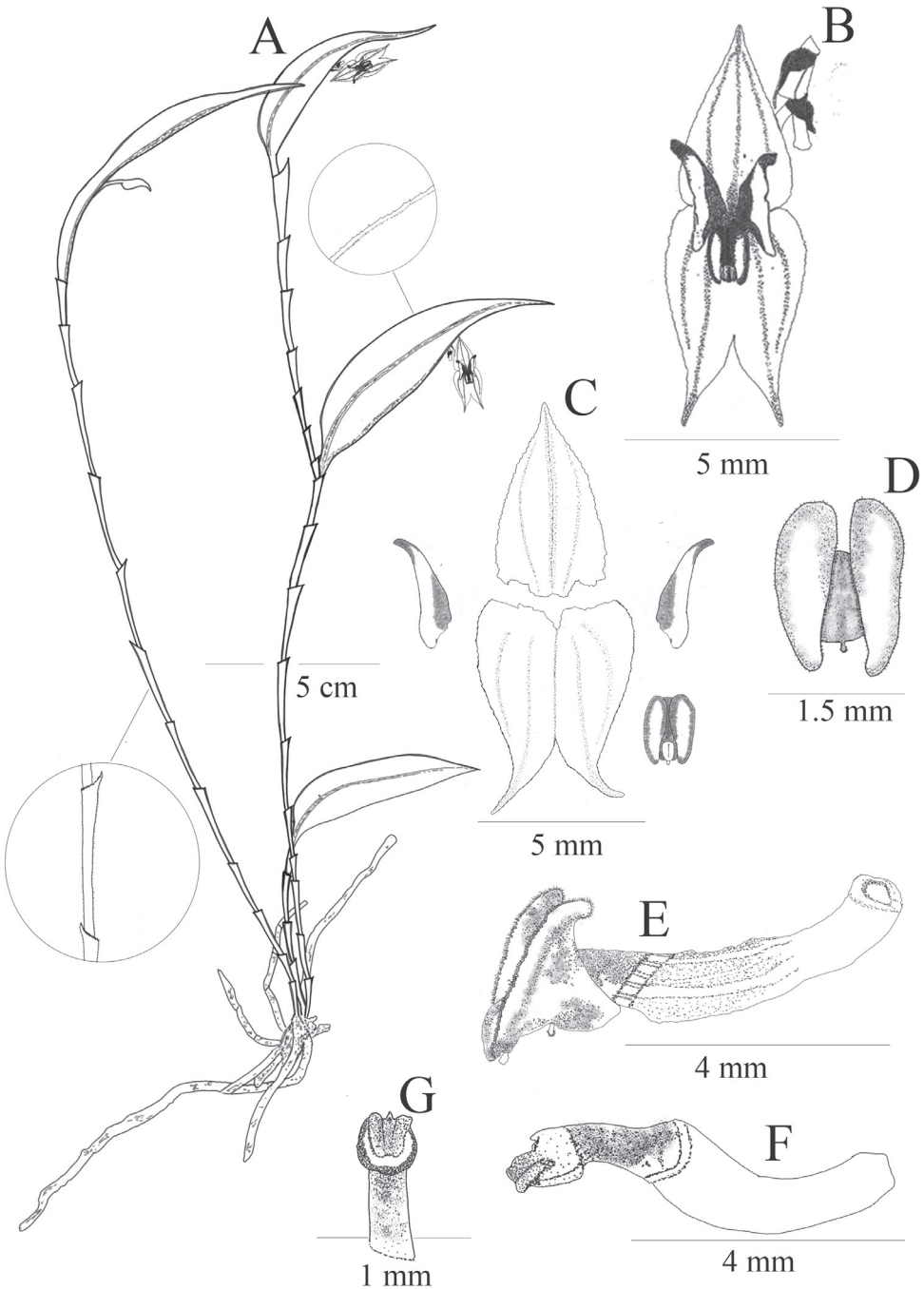


Figure 6. *Lepanthes microprosartima* **A** habit **B** flower **C** dissected sepal and petals **D** dorsal view of the spread-out lip whitout the column **E** lateral view of the ovary, and lip **F** lateral view of the ovary and column **G** ventral view of the column showing the horse-shaped stigma Drawn by M. Gavilanes from the plant that served as type (Tobar et al. 3357).

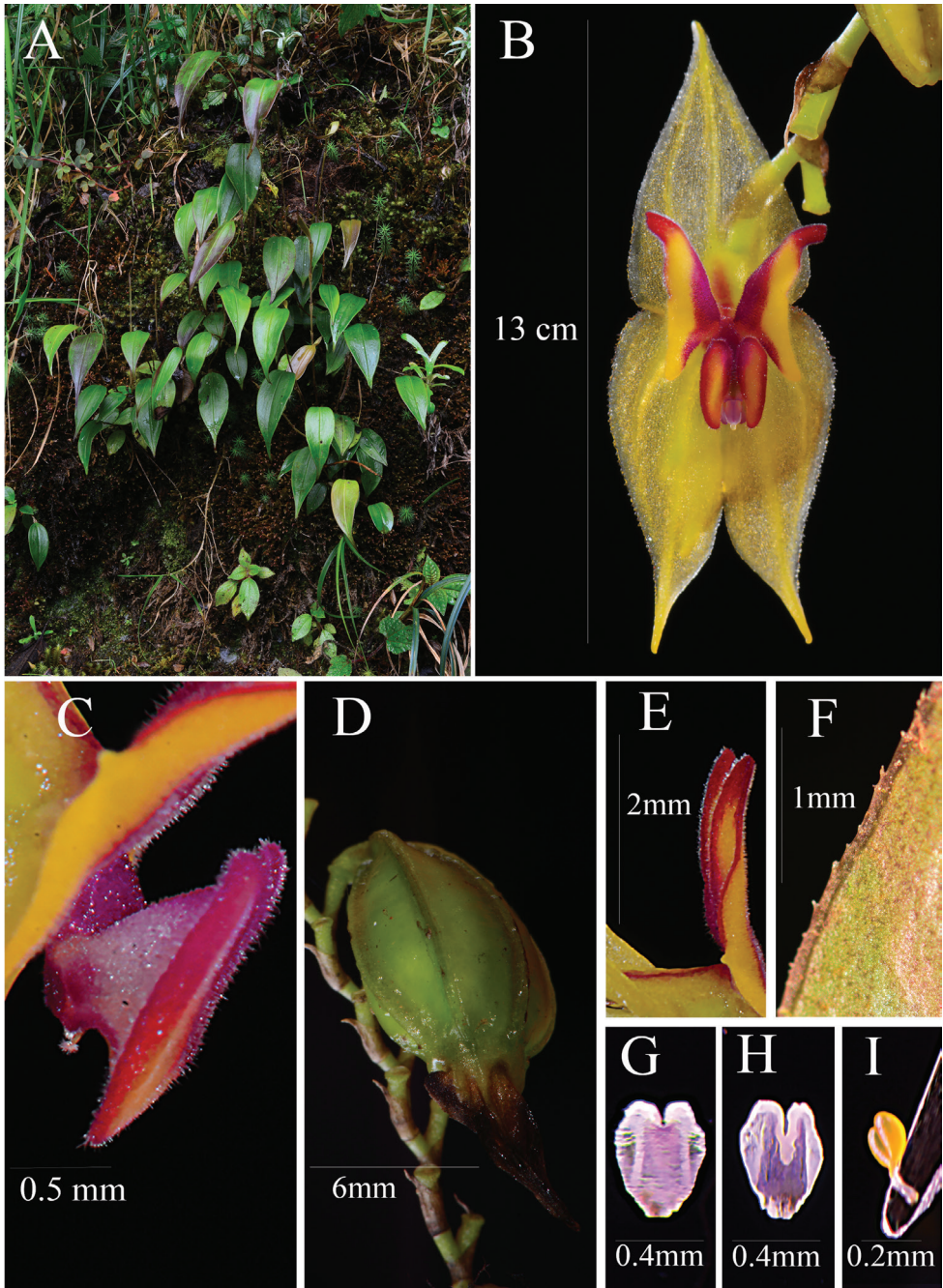


Figure 7. *Lepanthes microprosartima* **A** plant growing in its natural habitat **B** front view of the flower **C** lateral view of the lip showing the apêndice **D** detail of the fruit **E** lateral view of the petal showing the revolute apex **F** detail of the leaf margin, minutely denticulate **G** anther dorsal view **H** anther ventral view **I** polinarium. Photograph by Francisco Tobar from the plant that served as type (*Tobar et al.* 3357).

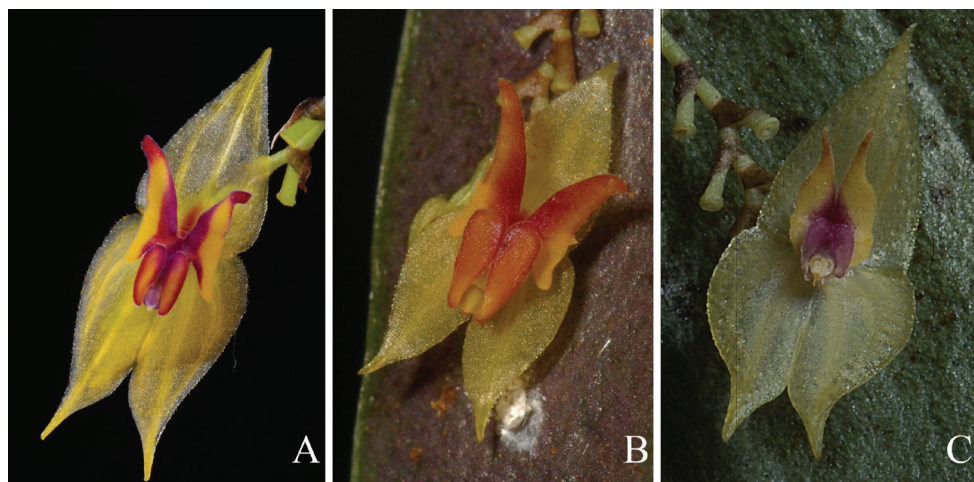


Figure 8. Comparison with the most similar species to *Lepanthes microprosartima* Tobar & M.J.Gavil. **A** *Lepanthes microprosartima* **B** *Lepanthes mirador* **C** *Lepanthes tungurahuae*. Photographs **A**, **B** by F. Tobar and **C** A. Hirtz.

arcuate secondary stems (vs. secondary stems erect, not superposed), leaf light green on the underside (vs. dark purple underside), and the tiny, oblong-lanceolate appendix (vs. appendix oblong with bilobed apex).

Type. ECUADOR. Pichincha, Nono, Yanacocha Reserve, masked trogon path, 0.122416°N, -78.590283°W, 3530 m, 25 Nov 2018, *Tobar & Angulo 3357* (**holotype**: QCA-spirit; **isotypes**: QCNE, HPUCESI-spirit).

Terrestrial, caespitose, prolific herbs up to 40 cm in height. Roots flexuous, cylindrical, pink with yellow apex. Ramicauls arcuate, new stems arise from the apex of the old ones superposed, 4.1–25.0 × 0.2–0.3 cm long, with 4–16 internodes, covered completely by lepanthiform sheaths, these light brown, 0.3–2.9 cm long, the ostium microscopically muricate, acuminate. Leaves arcuate, 7.5–9.4 × 1.1–2.2 cm, blades oblong-ovate, light to dark green, minutely serrate along the margin, long-acuminate apically, base cuneate, contracted into a petiole 4–7 mm long. Inflorescence one per stem, shorter than the leaf, 2.5–6 cm long, borne on the underside of the leaf, racemose; peduncle filiform, 2 mm long, ca. 0.5 mm in diameter, surrounded by a basal bract. Floral bracts 2 mm long, papiraceous, obliquely infundibuliform, glabrous and long-apiculate. Ovary 3.2 mm long, obpyramidal, with irregular keels. Flowers ca. 4.5 × 13 mm; sepals entirely yellow, petals yellow with edges slightly suffused with red or pink; lip yellow with the base and edges of the blades red or pink; column pink or purple and anther purple with two yellow spots at the base. Sepals with minutely denticulate margins, dorsal sepal 6 × 4.5 mm, broadly ovate-triangular, minutely denticulate, shortly acuminate, 3-veined; lateral sepals 7 × 2.4 mm long, connate to their middle, obliquely ovate with divergent acute-acuminate apex, 2-veined. Petals ca. 3 × 1.4 mm long, 1-veined, minutely pubescent, transversely bilobed, the upper lobe narrowly triangular with revolute margins, the lower lobe smaller, broadly triangular,

obtuse. Lip bi-laminate, the blades minutely pubescent, ovate, rounded, close to each other in their proximal part and divergent at the apex, ca. 1.4×1.2 mm; connective short, deeply cuneate, the base of the lip connate with the base of the column, sinuous, obtuse; appendix tiny, oblong-lanceolate, pubescent at the apex. Column slightly arcuate, slightly broadened apically, somewhat compressed dorsoventrally, ca. 1.2×0.8 mm; clinandrium covering the lower half of the anther. Anther dorsal, stigma ventral, horseshoe-shaped. Rostellum minutely triangular, yellow. Capsule ovoid 6-ribbed ca. 4×6 mm, with persistent perianth. Capsule ellipsoid, 6-ribbed.

Other specimens examined. *Paratypes* ECUADOR. Pichincha, Nono, Reserva Verdecocha, Verdecocha: Transecto de Aves y Conservación en Reserva Verdecocha, $-0.118420^{\circ}\text{N}$, $-78.597470^{\circ}\text{W}$, 3400 m, 06 Feb 2018, *Tobar, Santander & Hipo 3130* (QCA); Nono, Yanacocha Reserve, sendero hacia la Reserva Verdecocha 500 metros al suroeste de los bebederos de colibríes, 0.118420°N , $-78.597470^{\circ}\text{W}$, 3810 m, 07 May 2018, *Tobar 3359* (QCA).

Distribution and habitat. This species is endemic to the Yanacocha and Verdecocha reserves on the western slopes of Volcán Pichincha (Fig. 4), where it is found growing from 3200 to 3800 m in evergreen montane forest (BsAn03) according to Ministerio del Ambiente del Ecuador (2013). *Lepanthes microprosartima* grows terrestrially on the edges of the trails of both reserves and shares the habitat with other species such as *L. mucronata* Lindl., *L. bibalbis* Luer & Sijm and *L. dunstervilleorum* Foldats, as well as *Stelis laevigata* (Lindl.) Pridgeon & M.W.Chase, *Stelis pusilla* Kunth, *Masdevallia laevis* Lindl. and *Platystele stonyx* Luer. Unlike other terrestrial species of *Lepanthes* that grow on roadside embankments with greater availability of light, this species can also thrive within the forest in dense shade.

Phenology. The species was collected in flower in November, February and May, which suggests that flowering occurs throughout the rainy season, from October to the end of May.

Etymology. From the Greek μικρό, small and προσάρτημα, appendix, in reference to the tiny appendix of this species.

Preliminary conservation status. Only three collecting sites have been found during three years of monitoring at two locations: Yanacocha and Verdecocha reserves (Fig. 9), and around 40 mature individuals are known, which suggests that it is a rare species. This orchid is mainly terrestrial, and has not been found growing in other trails of the reserve or in nearby areas, the extent of occurrence calculate for the specie is $< 100 \text{ km}^2$ and area of occupancy is 8 km^2 , Based on the available information, this species is preliminarily assessed as Critically Endangered (CR) B1a+2a given that the known population are restricted to a small area in the western slopes of Pichincha Volcano, representing one location (sensu IUCN 2012), and the number of known mature individuals is fewer than 250.

Discussion. The closest species are *Lepanthes mirador* (Fig. 8a) from north-east Ecuador and Central Cordillera of Colombia, and *L. tungurahuae* Luer & Hirtz (Fig. 8c) from central Ecuador, but is easily distinguished from both by the overlapping secondary stems. *Lepanthes microprosartima* also differs from *L. mirador* in the light green



Figure 9. Natural habitat of *Lepanthes microprosartima* in the western slopes of Pichincha volcano **A** Yanacocha reserve **B** Verdecocha reserve.

leaves and oblong-lanceolate appendix (vs. leaves dark purple in the abaxial surface and appendix oblong, with a bilobed apical segment). From *L. tungurahuae* the new species is distinguished by the oblong leaves (vs. ovate elliptical), the petal lobes revolute, marked with red at the edges (vs. not revolute and marked with red at the base) and the blades of the labellum ovate (vs. blades narrowing oblong-ovate). In habit it also resembles *L. obandoi* from the north east of Ecuador, but the new species has an inflorescence shorter than the leaf (vs. longer than the leaf.), and the petals have triangular, unequal lobes (vs. lobes subequal, lanceolate-oblong).

3. *Lepanthes caranqui* Tobar & Monteros, sp. nov.

urn:lsid:ipni.org:names:77218878-1

Figs 10, 11, 12a

Diagnosis. Similar to *Lepanthes pachychila* Luer & Hirtz, differing in the taller plants up to 40 cm long (vs. less than 20 cm tall), the petals with narrowly triangular-oblong lobes (vs. lobes triangular), the lip with the blades thin, ovate-oblong, the base rounded and apically acute (vs. lip blade thick, broadly ovate with basal and apically rounded

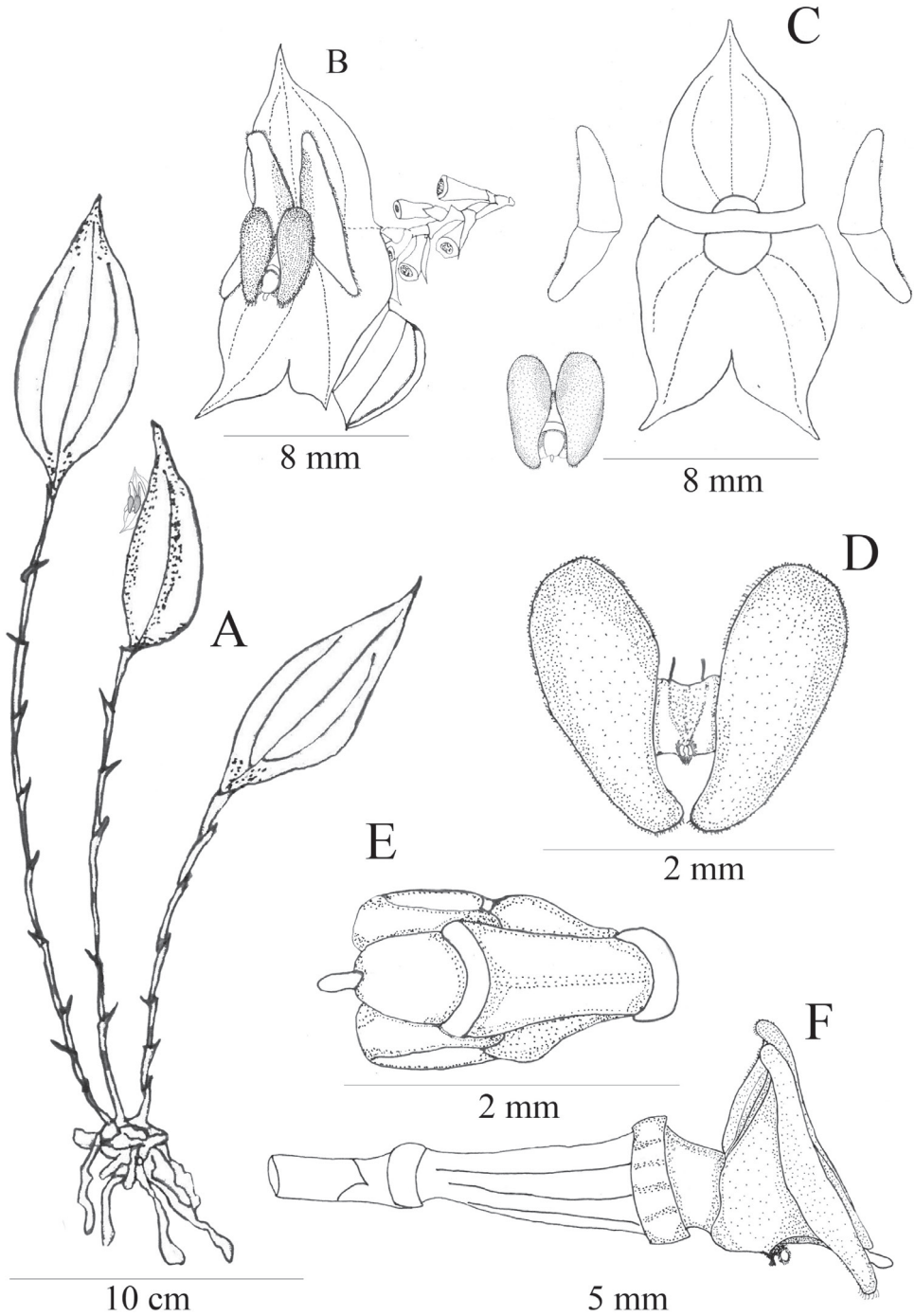


Figure 10. *Lepanthes caranqui* **A** habit **B** flower **C** dissected sepal and petals **D** dorsal view of the spread-out lip without the column **E** dorsal view of the column **F** lateral view of the ovary, and lip. Drawn by F. Tobar from the plant that served as type (Tobar *et al.* 3348).

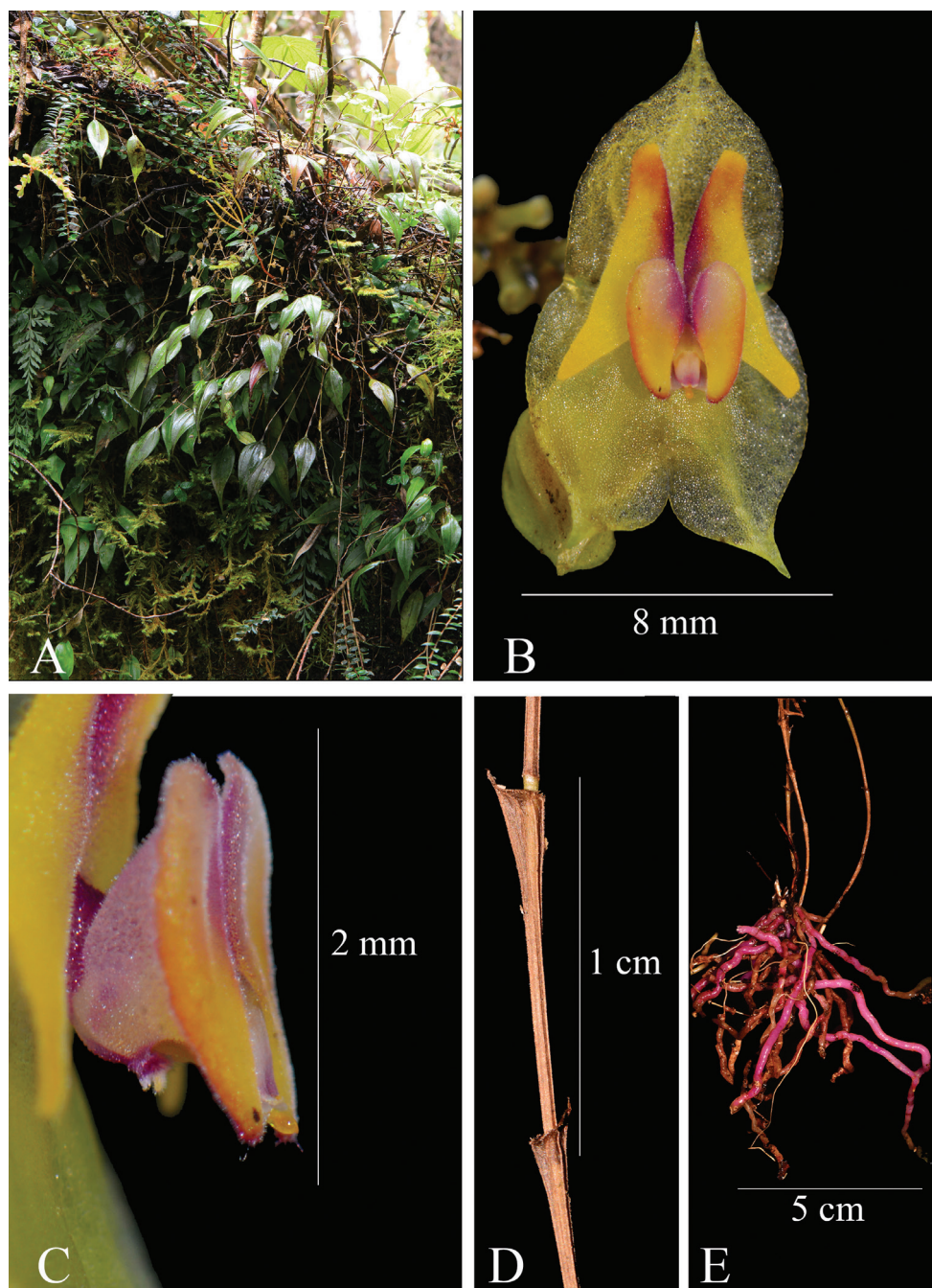


Figure 11. *Lepanthes caranqui* **A** plant growing in its natural habitat **B** front view of the flower **C** lateral view of the lip showing the apêndice **D** detail of the lepanthiform sheath **E** roots detail. Photograph by F. Tobar from the plant that served as type (Tobar *et al.* 3348).

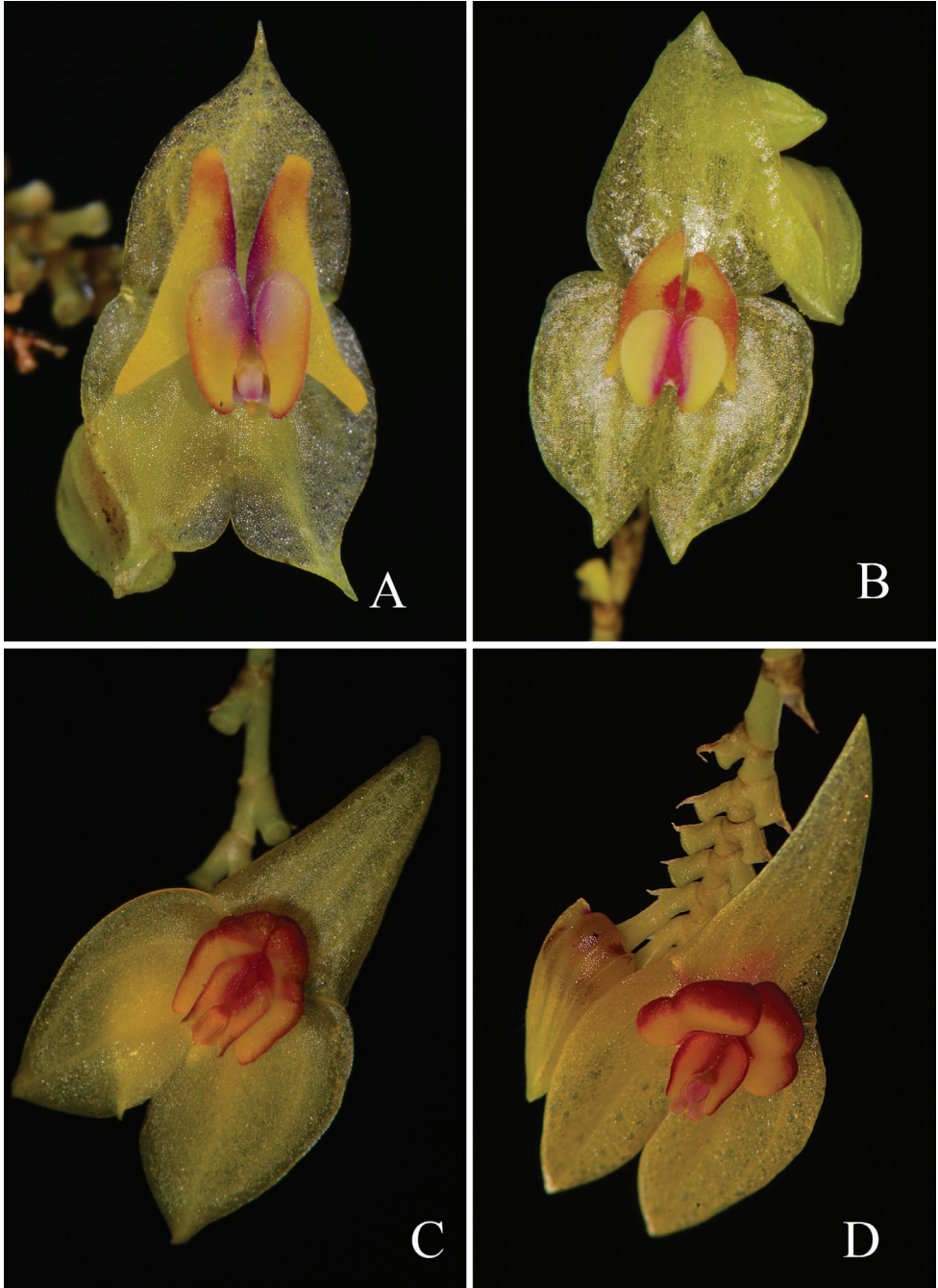


Figure 12. Comparison with the most similar species to *Lepanthes caranqui* Tobar & Monteros **A** *Lepanthes caranqui* **B** *Lepanthes pachychila* **C** *Lepanthes chrysina* **D** *Lepanthes ballatrix*. Photographs by F. Tobar.

ends) and appendix triangular in dorsal view, with two protuberances on the top and a minute tuft of hairs at the base (vs. minutely bilobulate appendix).

Type. ECUADOR. Pichincha, Cayambe, Olmedo, El Chalpar, 5 km northwest of the San Marcos Lagoon, 3500 m, 00.15211°N, -78.00220°W, 20 Jul 2019, *Tobar, Jaramillo, Correa & Monteros 3348* (**holotype** QCA, spirit; **isotypes** QCNE, HPUSECI).

Terrestrial, caespitose, prolific herbs up to 40 cm in height. Roots flexuous, cylindrical, deep pink. Ramicauls arcuate or pendulous, with 6–12 internodes, 4–22 × 0.2–0.8 cm long, covered completely by lepanthiform sheaths, these light brown, papillose, 0.5–2.5 cm long, the ostium microscopically muricate, acuminate. Leaves arcuate, slightly concave, 3.5–9.0 × 0.8–2.4 cm, blades ovate to oblong, light to dark green, long-attenuate, tridenticulate apically, base cuneate, contracted into a petiole 1–3 mm long. Inflorescence 1.0–5.6 cm long, shorter than the leaves, racemose, densely flowered, one or six per stem, producing one or two successively opening flowers; peduncle filiform, 1.0–1.5 mm long, surrounded by a basal bract. Floral bracts 2 mm long, distichous, glabrous, apiculate. Ovary 3 mm long, obpyramidal, with 6 irregular keels. Flowers ca. 13 × 8 mm; sepals minutely denticulate, entirely light yellow; petals pubescent, yellow with proximal part of the upper lobe red to brown, lip minutely pubescent white with yellow, with the base and edges of the blades purple or brown, column pink and yellow, anther white with purple apex. Dorsal sepal 7.0 × 5.0 mm, broadly ovate, shortly acuminate, 3-veined. Lateral sepals 2-veined, 6.0 × 4.0 mm, connate at least on their proximal two-thirds, obliquely ovate with divergent, shortly acuminate apices. Petals 1-veined, ca. 4.5 × 1.5 mm, transversely bilobed, lobes subequal, narrowly triangular-oblong, rounded. Lip with blades ovate-oblong, microscopically pubescent, close to each other in their proximal part and divergent at their apices, not covering the column, base of the blades rounded, apical part acute, incurved, ciliate, ca. 2.0 × 1.6 mm; connective broadly cuneate, minutely pubescent, its body connate with the base of the column, sinus obtuse, with a small, rounded, pubescent appendix, which has two protuberances on the top and a minute tuft of hairs. Column claviform, straight, ca. 2.0 × 0.8 mm; clinandrium covering only the lower half of the anther. Anther dorsal, stigma ventral. Rostellum more or less oblong with the apex rounded, yellow. Capsule not seen.

Other specimens examined. *Paratypes* ECUADOR. Imbabura, Ibarra, El Sagrario, forest near La Carbonería, 3732 m, 0.310255°N, -78.066891°W, 15 May 2017, *Tobar, Monge & Obando 2498* (HPUCEI, spirit).

Distribution and ecology. This species was collected in the buffer zone of the Cayambe-Coca National Park on the eastern Imbabura and Pichincha provinces (Fig. 4). The population from Imbabura (Fig. 13) grows in páramo (AsSn01) according to Ministerio del Ambiente del Ecuador (2013) as small groups or isolated individuals that grow on roadside embankments along with other members of Pleurothallidinae like *Draconanthes aberrans* (Schltr.) Luer, *Stelis pusilla*, *S. lamellata* Lindl., *Pleurothallis bivalvis* Lindl. and *P. apopsis* Luer. The specimens collected in Pichincha grew in evergreen montane forest (BsAn01)(Fig. 13) according to Ministerio del Ambiente del Ecuador (2013), and unlike the Imbabura population, the

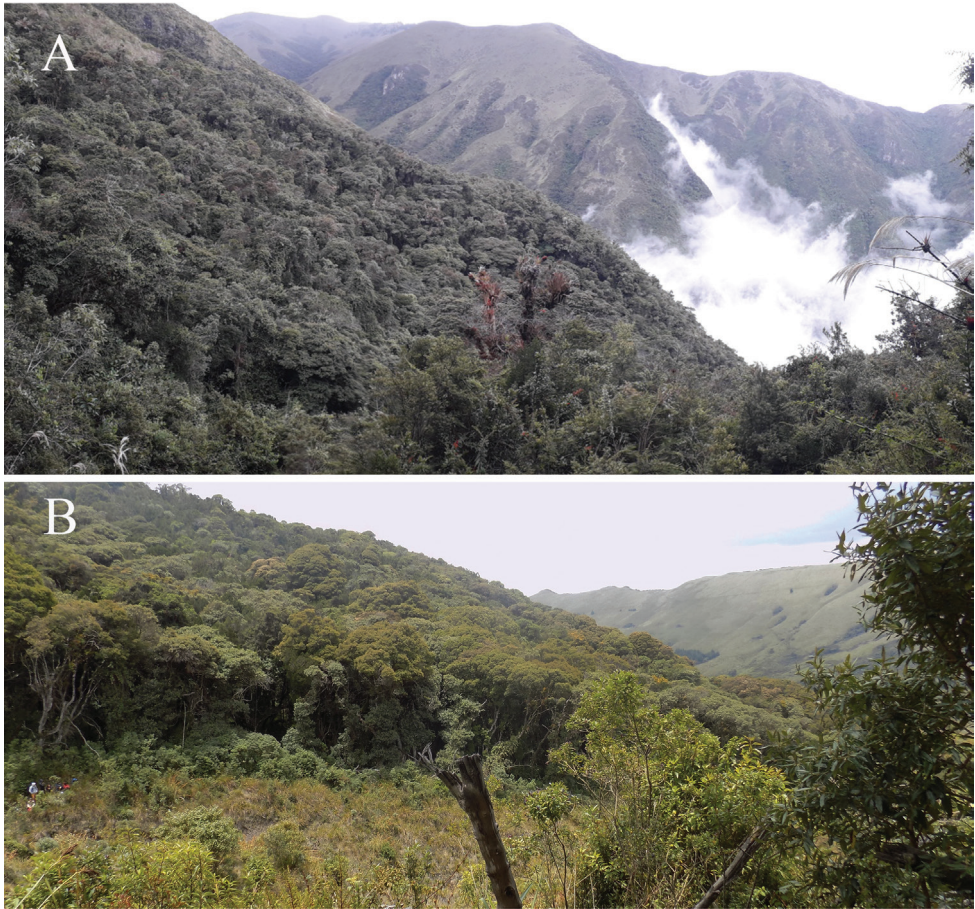


Figure 13. Natural habitat of *Lepanthes caranqui* **A** Paramo of La Carboneria in east of Imbabura province **B** El Chalpar Area east of Pichincha province. Photographs by F. Tobar and M. Monteros.

plants grow epiphytically at the base of the trunks or on the lower branches of the trees, where they also share their habitat with *Stelis pusilla*, *S. lamellata*, *Pleurothallis bivalvis* and *P. apopsis*.

Phenology. The species has been found in flowers and with fruits at different stages of maturity from May to July, suggesting that reproduction takes place all year round.

Etymology. The specific epithet honors the Caranqui culture that historically occupied the same areas where this species is distributed.

Preliminary conservation status. *Lepanthes caranqui* is known from two localities within an extent of occurrence of 575 km². It inhabits both paramo and montane forest where it is more abundant, forming small colonies on tree trunks. Its habitat is not considered to be under pressure since it is located in the buffer zone of a protected area but a potential threat would be the advance of the agricultural frontier. However, it has been observed that this orchid can adapt to moderately

disturbed areas and is able to colonize different types of vegetation. Considering the abundant number of mature individuals observed in the field we estimate an approximate number of 500 mature individual and giving that its area of occupancy, habitat quality and the number of mature individuals are not declining we suggest the Least Concern (LC) category following the IUCN (2012) Red List Categories and Criteria.

Discussion. *Lepanthes caranqui* is morphologically most similar to *L. pachychila* (Fig. 12b) from the southwest of Ecuador, it differs in having taller plants, petals narrowly triangular-oblong, the lip blade thick, broadly ovate with rounded ends, appendix triangular in the dorsal view, with two protuberances on the top and a minute tuft of hairs at the base. The new species also resembles *L. ballatrix* (Fig. 12c) which is widespread in Ecuador and Colombia and *L. chrycina* (Fig. 12d) endemic from the southwest of Ecuador. Both species have a triangular, acute dorsal sepal (vs. broadly-ovate, narrowly acuminate). The petal lobes in *L. ballatrix* are suborbicular to broadly elliptical, and in *L. chrycina* the upper lobe is oblong, obtuse and the lower obliquely triangular (vs. petals equal, narrowly triangular-oblong in *L. caranqui*), the lip blades is glabrous in *L. chrycina* and minutely pubescent in *L. ballatrix* and *L. caranqui*, and are oblong lunate in *L. ballatrix* and ovate-oblong in *L. chrycina* and *L. caranqui*. The appendix in *L. caranqui* is triangular pubescent with two protuberances on the top, and in *L. ballatrix* is triangular, minutely pubescent, thickened at the end, with a pair of minute finger like process.

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Agapetes heana, a new species of *A. ser. Longifiles* (Ericaceae) from Yunnan, China

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Abstract

Agapetes heana Y. H. Tong & J. D. Ya (Ericaceae), a new species from Lüchun Xian, Yunnan Province, China is described and illustrated. This new species is assigned to *Agapetes* sect. *Agapetes* ser. *Longifiles* Airy Shaw. It is closest to *A. inopinata* Airy Shaw and *A. oblonga* Craib, but differs in having bead-like tubers, leaf blade with a wholly serrulate margin, subulate and much longer calyx lobes, much larger corollas that are carmine, green at the apex and maroon on angles, and longer stamens without spurs on the back.

Keywords

China-Vietnam border, epiphytic, Huanglian Shan, morphology

Introduction

A general introduction to *Agapetes* D. Don ex G. Don, focusing on the species in China was given in previous papers published by the first author and is not repeated here (Tong 2016; Tong et al. 2019). With 17 species and two varieties of *Agapetes* in-

cluding the recently published *A. yingjiangensis* Y. H. Tong, B. M. Wang & N. H. Xia, Yunnan Province, after Tibet, harbors the second most species of this genus in China (Huang and Fang 1991; Fang and Stevens 2005; Tong 2014). During one recent field trip to Huanglian Shan National Nature Reserve, Yunnan Province, China, an unknown *Agapetes* species was discovered. The combination of its ovate to ovate-lanceolate leaf blades, inflorescence with glandular hairs and elongated filaments immediately reminded us of two other similar species from the same province, viz. *A. oblonga* Craib and *A. inopinata* Airy Shaw. However, the latter two species have very differently colored corollas. After examining the specimens of similar species and referring to the related literature (Hiep 2003; Kress et al. 2003; Fang and Stevens 2005; Banik and Sanjappa 2014; Watthana 2015), we concluded that this unknown species is a new one to science, which is described and illustrated below.

Materials and methods

Specimens were collected from Huanglian Shan National Nature Reserve, Yunnan Province, China during two field expeditions in March and April 2021, respectively. All descriptions were based on dried specimens, which were deposited at the herbaria of Kunming Institute of Botany, Chinese Academy of Sciences (KUN) and South China Botanical Garden, Chinese Academy of Sciences (IBSC).

Taxonomic treatment

Agapetes heana Y. H. Tong & J. D. Ya, sp. nov.

urn:lsid:ipni.org:names:77218883-1

Figures 1, 2

Type. CHINA. Yunnan Province: Lüchun Xian, Huanglian Shan National Nature Reserve, elev. 1803 m, 4 March 2021 (fl.), J. H. He 210304 (**holotype** KUN).

Diagnosis. *Agapetes heana* is similar to *A. inopinata* Airy Shaw and *A. oblonga* Craib in the leaf blade shape, the glandular hairy inflorescence and the filaments that are longer than thecae, but can be distinguished from the latter two by its bead-like tubers (vs. spindle-shaped), leaf blade with a wholly serrulate margin (vs. entire, or inconspicuously serrate beyond middle, or sparsely denticulate at apex), subulate (vs. triangular) and much longer (7–8 mm vs. ca. 1 mm and 1.5–2.0 mm, respectively) calyx lobes, much larger (ca. 3.5 cm vs. ca. 0.8 cm and 1.3–1.9 cm, respectively) corollas that are carmine, green at the apex and maroon on angles (vs. red, crimson or carmine), and longer (ca. 3.6 cm vs. ca. 0.7 cm and 1.0–1.5 cm, respectively) stamens that are without spurs on the back (vs. with 2 obvious short spurs) (Table 1).

Description. Evergreen shrub, epiphytic on trees. Tuber globose, 1–3 cm in diam, bead-like. Stems and branches slender, obliquely spreading. Twigs greyish brown,

Table 1. A morphological comparison among *Agapetes heana*, *A. inopinata* and *A. oblonga*.

Characters	<i>A. heana</i>	<i>A. inopinata</i>	<i>A. oblonga</i>
Tubers	Bead-like	Spindle-shaped	Spindle-shaped
Leaf blade margin	Serrulate	Entire	Entire or inconspicuously serrate beyond middle, or sparsely denticulate at apex
Inflorescence	Shortly racemose, 2–3-flowered	Racemose, 4–6-flowered	Fasciculate, 1–4-flowered
Calyx lobes	Subulate, 7–8 mm long	Triangular, ca. 1 mm long	Triangular, 1.5–2.0 mm long
Corolla color	Carmine, green at the apex and maroon on angles	Red	Crimson or carmine
Corolla length	Ca. 3.5 cm	Ca. 0.8 cm	1.3–1.9 cm
Corolla lobes	Narrowly triangular, 6–7 mm long	Triangular, ca. 1 mm long	Triangular, ca. 1.5 mm long
Stamen length	Ca. 3.6 cm	Ca. 0.7 cm	1.0–1.5 cm
Spurs on the back of anthers	Absent	Present	Present

terete, 2–3 mm in diam., densely glandular-setose and pubescent, glabrescent when old. Leaves sub-distichously scattered; petiole 2–3 mm long, pubescent adaxially, glandular-setose and pubescent abaxially; leaf blades thinly leathery or firmly papery, ovate to ovate-lanceolate, 4.5–7.0 × 1.5–2.6 cm, adaxially glabrous except the pubescent midvein, abaxially sparsely glandular-setose, more so on midvein, trichomes deciduous when old, midveins conspicuously raised above, slightly raised below, secondary veins 6–11 pairs, with veinlets conspicuous on both sides, base rounded to slightly cordate, without basal glands, margin slightly revolute when dry, each side with 20–24 serrula, each serrula with a glandular seta at the tip, setae deciduous, apex caudate-acuminate. Inflorescences shortly racemose, 2–3-flowered, 0.3–1.0 cm long, pseudoterminal, densely glandular-setose and pubescent; bracts unknown; pedicels 9–10 mm long, densely glandular-setose and pubescent, slightly expanded upwards; bracteoles 2, basal, ovate, ca. 1 mm long, brown, deciduous. Calyx tube green, 3.0–3.5 mm long, densely glandular-setose and pubescent, trichomes slightly denser and longer than those on pedicels; limb 1.1–1.2 cm long, densely glandular-setose and pubescent, lobes tinged with carmine, subulate, 7–8 × 1.5–2.0 mm, densely glandular-setose and pubescent outside, pubescent inside, apex acute. Corolla carmine, green at the apex and maroon on angles, tubular, slightly 5-angled, ca. 3.5 × 0.7–0.9 cm, sparsely glandular-setose and pubescent along the upper half of angles outside, glabrous inside; lobes green, spreading, narrowly triangular, 6–7 mm long, glandular-setose and pubescent on midvein outside, nearly glabrous inside. Stamens 10, ca. 3.6 cm long; filaments flat, ca. 2.5 cm long, glabrous; anthers ca. 1.45 cm long, thecae adnate to each other, ca. 4.5 mm long, tubules ca. 1 cm long, without spurs on the back. Style slender, 3.8–4.0 cm long; stigma truncate; ovary 10-pseudoloculed, each locule with several ovules; disk glabrous. Young fruit green, subglobose, densely glandular-setose and pubescent, with erect persistent calyx lobes at apex.

Etymology. The species epithet is named in honor of Ms. Jiang-Hai He, a local staff in Huanglian Shan National Nature Reserve, who has worked there for almost 30 years and made a big contribution to the knowledge of biodiversity of this nature reserve, and is also the discoverer of this new species.

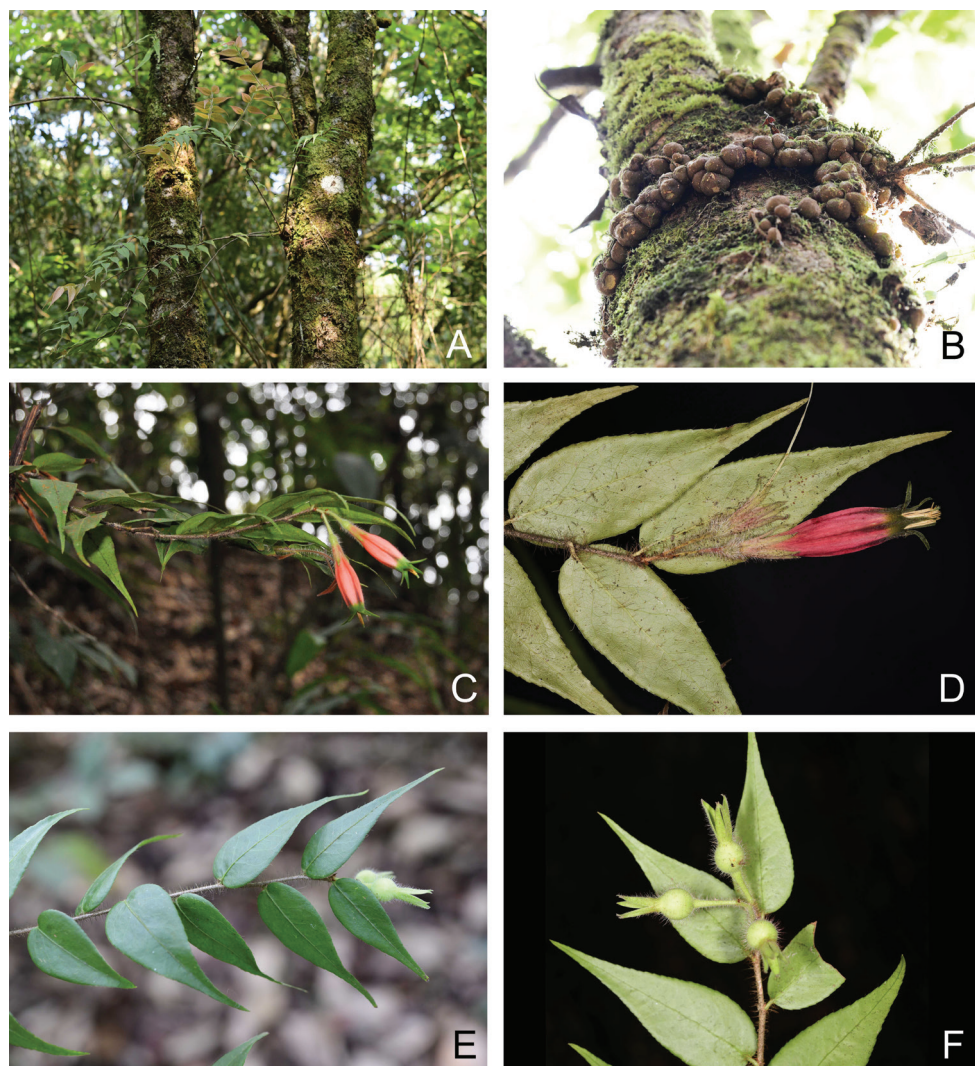


Figure 1. *Agapetes beana* **A** habit **B** tubers **C** flowering branch **D** inflorescence **E** fruiting branch **F** fructescence with young fruits (**C**, **D** from J. H. He 210304, **A**, **B**, **E**, **F** from J. D. Ya et al. 21CS20738). All photographs by J. D. Ya except **C** by J. H. He.

Vernacular name. 疆海树萝卜 (Chinese pinyin: Jiāng hǎi shù luó bo).

Distribution and habitat. This species is currently known only from the type locality, i.e. Huanglian Shan National Nature Reserve, Yunnan, China. Since this locality is very close to the border of China and Vietnam and the habitat is similar and continuous, this species is probably also distributed in Vietnam. It grows on the trunks of trees like *Schima wallichii* (DC.) Korth. or *Lithocarpus* sp. under broadleaved forests at an elevation of ca. 1800 m.

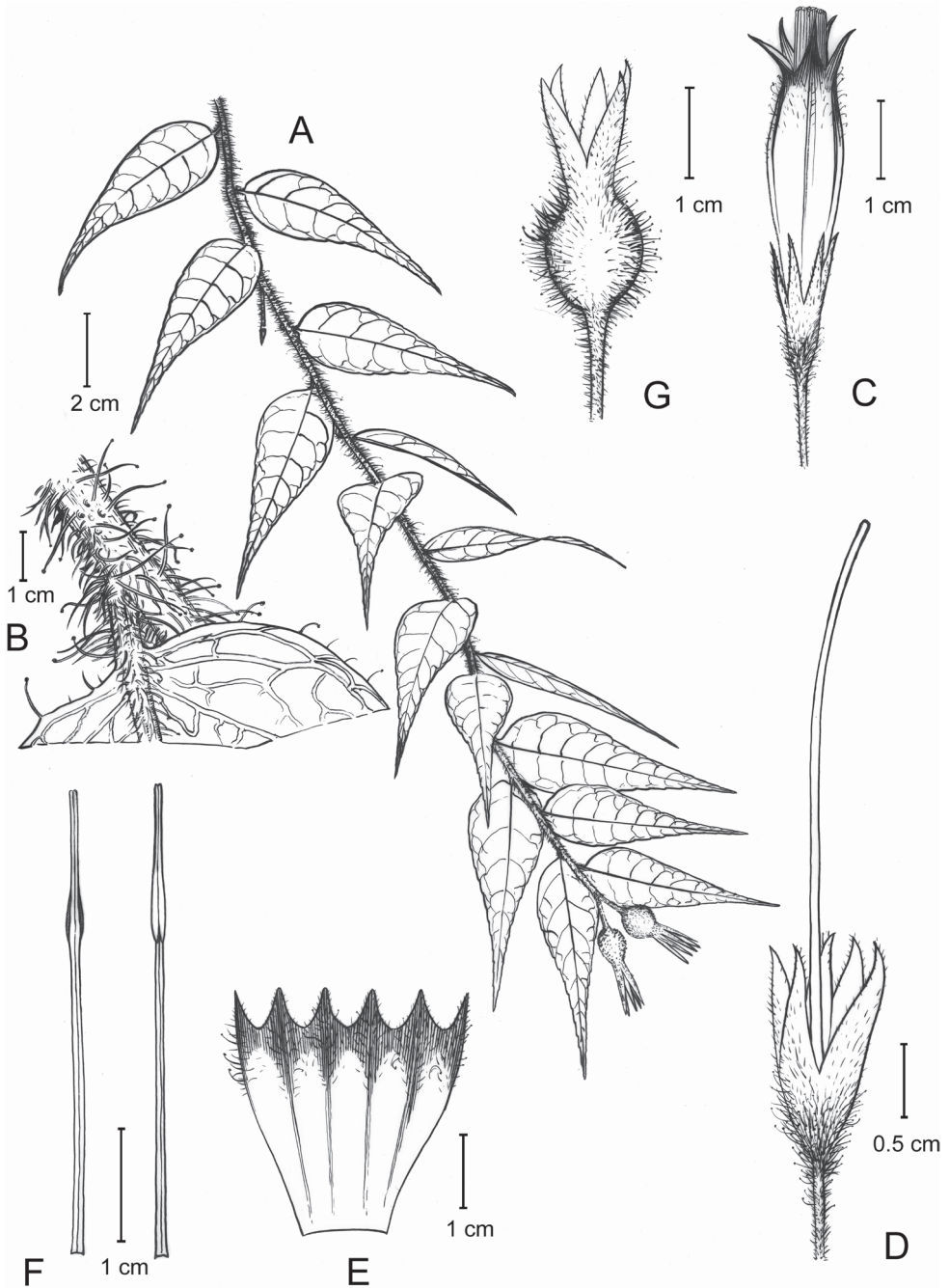


Figure 2. *Agapetes heana* **A** fruiting branch **B** trichomes on branch and petiole **C** flower **D** calyx and style **E** opened corolla, abaxial view **F** stamens, abaxial (left) and adaxial (right) view **G** young fruit (**A, G** from J. D. Ya et al. 21CS20738, **B–F** from J. H. He 210304). Drawn by Mr. D. H. Cui.

Conservation status. *Agapetes heana* seems to be very rare in the type locality, since only a population of fewer than 10 individuals has been found for now, but the threat risk seems to be low because it is not economically valuable and the conservation condition of the reserve is good. Because no population assessment of this species in the field of China or adjacent area of Vietnam has been made, it is best classified as ‘Data Deficient’ (DD) (IUCN Standards and Petitions Committee 2019).

Additional specimens examined. (*paratypes*) The same locality as holotype, 8 April 2021 (young fruits), *J. D. Ya et al.* 21CS20738 (KUN, IBSC).

Discussion

According to Airy Shaw’s infrageneric system, *A. heana* fits well with the circumscription of *Agapetes* sect. *Agapetes* ser. *Longifiles* Airy Shaw due to its slender stems, flowers arranged into a short raceme, and elongated filaments (longer than anthers) (Airy Shaw 1935, 1959), except that its anthers are not spurred, while almost all the species of that series own spurred anthers. Both spurred and unspurred anthers occur in other series, such as ser. *Agapetes* and ser. *Pteryganthae* (Airy Shaw 1935, 1948, 1959; Huang 1991). Thus, this character appears to have evolved more than once in this genus. Besides this new species, there are another two species of *Agapetes* distributed in the same mountain (Huanglian Shan), viz. *A. lobbii* C. B. Clarke (*S. K. Wu et al.* 652, PE!, KUN0230909!) and *A. rubrobracteata* R. C. Fang & S. H. Huang (*S. K. Wu et al.* 253, PE!). However, these two species are distantly related to our new species due to their very different vegetative and productive characters, such as habits, leaf blade shapes, indumentum on branches and inflorescences, various floral characters, and so on.

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Taxonomic notes on Cyperaceae of Nepal: new records of a genus, six species and other noteworthy species

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Abstract

This paper reports on the presence of one generic and six specific new records of Cyperaceous species for the flora of Nepal. Amongst the new discoveries are the genus *Machaerina*, alongside species: *Eleocharis ochrostachys*, *Fimbristylis acuminata*, *F. ferruginea*, *F. nutans*, *F. thomsonii* and *Scleria rugosa*. The taxonomy and distribution of *Actinoscirpus grossus*, *Fimbristylis salbundia* and *Fuirena umbellata* in Nepal are clarified through notes on nomenclature, description, distribution, specimen examination, identification keys and photographs.

Keywords

Actinoscirpus grossus, *Eleocharis ochrostachys*, *Fimbristylis*, Flora of Nepal, *Machaerina rubiginosa*, *Scleria rugosa*, Tarai, wetland

Introduction

The sedge family, Cyperaceae, consisting of 95 genera and > 5600 species (Larridon et al. 2021) are predominantly perennial or annual herbs and are cosmopolitan in distribution (Goetghebeur 1998; Dai et al. 2010). Cyperaceae often have rhizomes and are distinguished by florets arranged in a spikelet, with a mostly triangular culm

(stem). The ovary is superior and unilocular, producing an achene fruit, from anemophilous or entomophilous pollination (Goetghebeur 1998; Dai et al. 2010; Laridon et al. 2021).

In Nepal, Cyperaceae have a distribution range from tropical Tarai to alpine Himalaya (Rajbhandari and Rai 2017; Shrestha et al. 2018). So far, 213 species in 17 genera have been reported in Nepal (Rajbhandari and Rai 2017; Shrestha et al. 2018). However, literary research has indicated this is an incomplete record, as the South and South-East Asian genus *Machaerina* Vahl and some species in *Eleocharis* R.Br., *Fimbristylis* Vahl and *Scleria* P.J.Bergius remain absent from published works (Koyama 1978; Press et al. 2000; Rajbhandari and Baral 2010; Rajbhandari and Rai 2017; Shrestha et al. 2018). Furthermore, the occurrence of *Actinoscirpus grossus* (L.f.) Goeth. & D.A.Simpson var. *grossus*, *Fimbristylis salbundia* (Nees) Kunth and *Fuirena umbellata* Rottb. in Nepal is yet to be clarified (Clarke 1907; Halder and Dey 2016; Rajbhandari and Rai 2017).

Compared to other families, collections of Cyperaceae in Nepal are rather lacking. Plant exploration in Nepal is typically focused around mid-hills and high Himalayas; while the Tarai (lowlands) are mostly ignored (Rajbhandari 2016). To fill this gap, a series of field surveys was organised in both lowland and the valleys of mid-hills in Nepal from July 2019 to February 2021. Identification of the collected specimens revealed several new records for the flora of Nepal, including one genus and six species. The taxonomic status and distribution of *Actinoscirpus grossus*, *Fimbristylis salbundia* and *Fuirena umbellata* were also clarified.

Methods

Specimen collection and identification

Plant explorations were made in Tarai and valleys of mid-hills representing Western, Central and Eastern Nepal between July 2019 and February 2021. Wetlands around these regions were frequently visited and fruiting samples were collected. Fruiting individuals were collected, pressed, dried, mounted and deposited at the National Herbarium and Plant Laboratories (**KATH**) and Tribhuvan University Central Herbarium (**TUCH**). Field images of the living plant were captured with a Nikon D810 camera with lens attachment AF-S Micro Nikkor 105 mm.

The specimens were identified with reference to literature (Kern 1974; Rao and Verma 1982; Noltie 1994; Dai et al. 2010; Dey and Prasanna 2015; Simpson 2019) and comparing them to the specimens in various herbaria. KATH and TUCH were visited and utilised to examine the dried samples, while the digital images were accessed through online databases of BM, E, K and TI (acronyms following Thiers 2021 onwards). The culm, leaf and achene morphologies were observed under a zoom stereomicroscope ZSM-111.

Results

Taxonomic treatment

Actinoscirpus (Ohwi) R.W.Haines & Lye, *Bot. Not.* 124: 481. 1971.

Actinoscirpus grossus (L.f.) Goetgh. & D.A.Simpson, *Kew Bull.* 46(1): 171. 1991.

Scirpus grossus L.f., *Suppl. Pl.* 104. 1782.

Schoenoplectus grossus (L.f.) Palla, *Allg. Bot. Z. Syst.* 3. 1911.

Type. INDIA, collector unknown s.n. [lectotype, designated by Goetghebeur and Simpson 1991, pg. 171: LINN (Herb no. 71/32 image!)].

Description. Perennial herbs, stolon bearing. Culm up to 2 m high, acutely 3-angled, smooth or scabrid. Leaves linear, 8–19 mm wide, margin entire to scabrid. Involucral bracts leaf-like exceeding inflorescence to 60 cm. Inflorescence in terminal anthela bearing many spikelets. Spikelets ovoid-ellipsoid, 2–4 × 2–3 mm. Glumes broadly ovate or elliptic to oblong, brownish, 2–3 × 1.5–2.5 mm, membranous, abaxially pubescent, margin ciliate, apex apiculate or mucronate, single-veined. Perianth bristles 6, retrorsely scabrous or plumose, slightly shorter to slightly longer than achene. Stamens 3, longer than achene. Anthers 1.5 mm. Style 1 mm long. Stigmas 3, 1 mm long. Achene 3-sided, obovoid, 1.5 × 1–1.3 mm, brownish, smooth.

Key to the varieties

- 1a Culm angle smooth, glumes apiculate, perianth bristles retrorsely scabrous..... **var. *grossus***
- 1b Culm angle scabrid, glumes mucronate, perianth bristles plumose..... **var. *kysoor***

Actinoscirpus grossus var. *grossus*

Actinoscirpus grossus var. *kysoor* auct. non (Roxb.) Noltie, in *Handb. Fl. Pl. Nepal* 1: 206. 2017, (R.R. Kaffle 7, (TUCH))

Description. Culm angle entire. Glumes apiculate. Perianth bristles retrorsely scabrous. (Fig. 1A–C).

Nepali name. Gudh, Gulgulia

Distribution. Nepal, India, Bhutan, China, Myanmar, Bangladesh, Sri Lanka, Pakistan, Laos, Vietnam, Malaysia, Thailand, Indonesia, Philippines, New Guinea and Australia.

Ecology. Grows in paddy field and lake banks; 600–630 m elev.

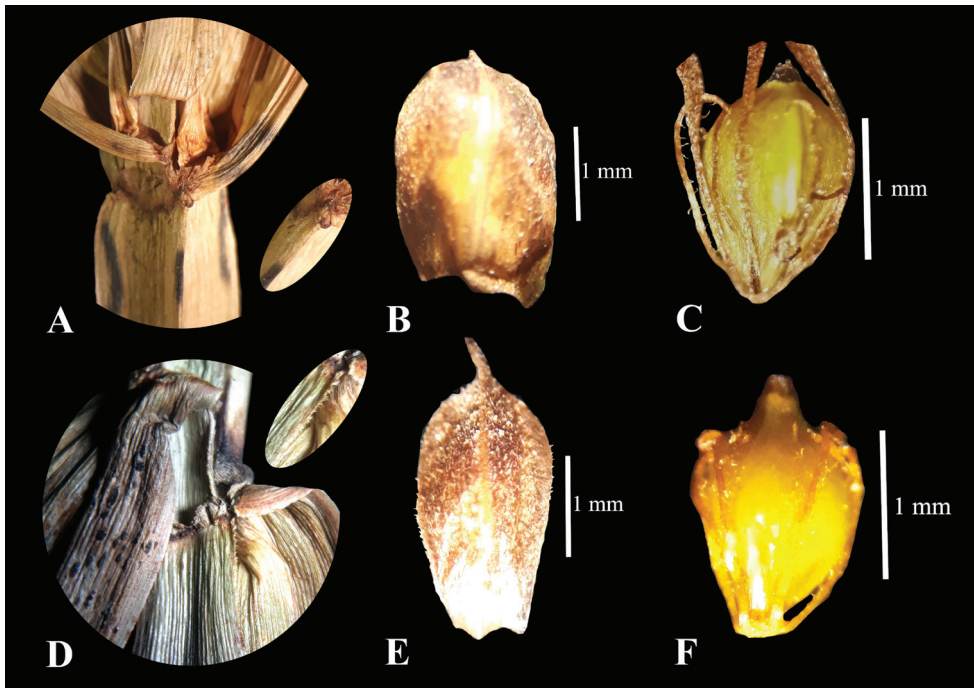


Figure 1. *Actinoscirpus grossus* var. *grossus* **A** culm **B** glume **C** achene; *A. grossus* var. *kysoor* **D** culm **E** glume **F** achene.

Phenology. Flowering in July–September; fruiting in October–December.

Specimens examined. **Nepal, Kaski:** Pokhara Valley, Rupa Lake, 28°9'54.31"N, 84°7'24.48"E, 630 m elev., 17 Sep 2019, *P. Bhandari & V. Adhikari* KAS07 (KATH); **Kaski:** Pokhara Valley, Rupa Lake, 600 m elev. 15 Apr 1999, *R.R. Kafle* 7 (TUCH); **Nawalparasi:** 05 Aug 2007, *S. Dahal* 20074 (KATH).

Actinoscirpus grossus var. *kysoor* (Roxb.) Noltie, *Edinburgh J. Bot.* 51(2): 173. 1994.

Scirpus kysoor Roxb., *Fl. Ind.* 1: 235. 1820.

Scirpus grossus var. *kysoor* (Roxb.) Clarke, *Fl. Brit. India* 6: 660. 1894.

Scirpus grossus f. *kysoor* (Roxb.) Beetle, *Amer. J. Bot.* 33(8): 661. 1946.

Schoenoplectus grossus auct. non (L.f.) Palla, in *Enum. Pl. Nepal* 1: 118. 1978.

Type. Roxburgh Icones No. 2017 [(lectotype, designated by Noltie 1994, pg. 173: K, n.v.), (epitype, designated by Noltie 1994, pg. 173: E (E00386664 image!))].

Description. Culm angle scabrous towards the apex. Glume with a distinct 0.5 mm, recurved mucro. Perianth bristles plumose. (Fig. 1D–F).

Distribution. Nepal, India and Bhutan.

Ecology. Grows in paddy fields; 71 m elev.

Phenology. Flowering in August–September; fruiting in October–December.

Specimen examined. **Nepal, Jhapa:** Kachankawal Rural Municipality (RM), Baniyani, 26°26'15.94"N, 88°3'1.28"E, 71 m elev., 04 Dec 2020, *S. Chaudhary 20120410* (KATH, TUCH).

Note. The first author visited: Rupa Lake and other wetlands of Pokhara Valley, Central Nepal and Jhapa District, East Nepal; observing multiple specimens. Samples deposited at KATH (Central Nepal, *S. Dahal 20074*) and TUCH (Central Nepal, *R.R. Kafle 7*) were examined. Upon close inspection of the culm, glume and achene characters, the Central Nepal populations exactly match *Actinoscirpus grossus* var. *grossus*, while the East Nepal populations matched with that of *Actinoscirpus grossus* var. *kysoor*. Therefore, it can be concluded that the two varieties of *Actinoscirpus grossus* occur in Nepal.

***Eleocharis* R.Br., Prodr. Fl. Nov. Holland. 224. 1810.**

***Eleocharis ochrostachys* Steud., Syn. Pl. Glumac. 2(7): 80. 1855.**

Scirpus ochrostachys (Steud.) Kuntze, Revis. Gen. Pl. 2: 758. 1891.

Type. INDONESIA, Java, 17 August 1842, *H. Zollinger 291* [holotype: P (P00329735 image!)]].

Description. Plant 30–110 cm tall, stoloniferous, tufted. Sheaths 2, tubular, purplish-red to pale green or hyaline, 4–12 cm, mouth obliquely truncate, apex acute. Culm round, sometimes obscurely 3-angled, lacking septa. Spikelet cylindrical to ovoid, 0.7–3.2 cm with many spirally arranged glumes; lowermost glume empty. Glume ovate, leathery, 3.5–4.5 × 2–3.5 mm, margin hyaline, apex obtuse. Persistent style base flattened, up to half the width of achene. Stigmas 2 or 3. Stamens 3, as long as perianth bristles; anther 2 mm. Perianth bristles 6 to 8, almost twice or more than twice the length of achene, retrorsely scabrous. Achene biconvex, obovoid, 1.5–2 × 1.2–1.5 mm, yellowish-brownish, shiny, surface longitudinally striate with more than 25 rows of transversely linear-oblong epidermal cells, apex with an annular thickening, forming a small neck. (Fig. 2A).

Distribution. Nepal (new record), India, China, Myanmar, Bangladesh, Sri Lanka, Malaysia, Thailand, Indonesia, Philippines, Vietnam and New Guinea.

Ecology. Grows in marshy areas, floating islands, lake edges and waterlogged fields; 70–762 m elev.

Phenology. Flowering in August–September; fruiting in October–December.

Specimens examined. **Nepal, Kaski:** Pokhara valley, Begnas Lake, 690 m elev., 17 September 2019, *P. Bhandari & V. Adhikari KAS14* (KATH); **Kaski:** Pokhara Valley, Gunde Lake, 28°11'30.29"N, 84°2'21.58"E, 762 m elev., 09 Dec 2020, *P. Bhandari & V. Thapa 20120912* (KATH); **Kaski:** Pokhara Valley, Neureni Lake, 28°11'30.37"N, 84°2'52.30"E, 749 m elev., 30 Dec 2020, *P. Bhandari & N.L. Bhandari 20123002* (KATH); **Jhapa:** Kachankawal RM, Aambari Road, Thulo Kechana, 26°25'36.56"N, 87°59'15.75"E, 70 m elev., 05 Feb 2021, *P. Bhandari, A. Neupane & S. Chaudhary 21020505* (KATH).

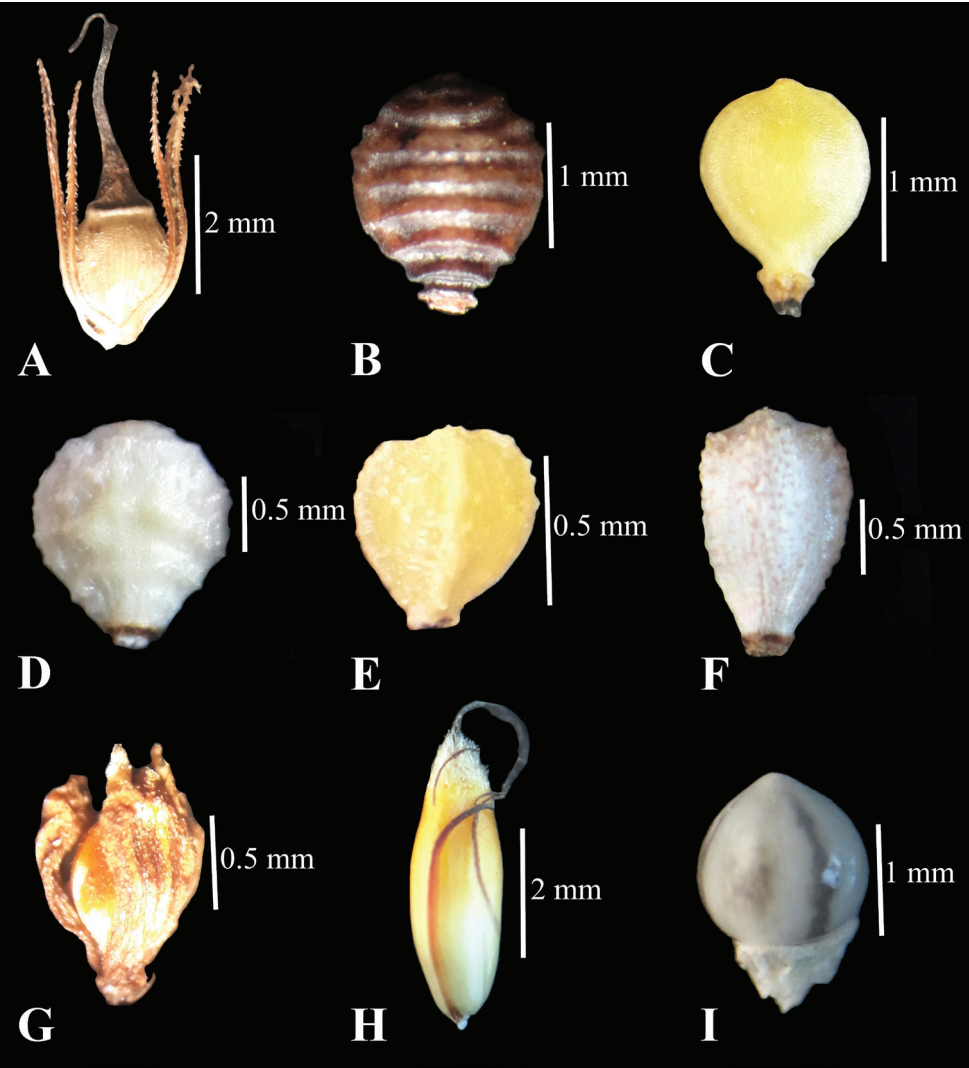


Figure 2. Achene **A** *Eleocharis ochrostachys* **B** *Fimbristylis acuminata* **C** *F. ferruginea* **D** *F. nutans* **E** *F. salbundia* **F** *F. thomsonii* **G** *Fuirena umbellata* **H** *Machaerina rubiginosa* **I** *Scleria rugosa*.

Keys to the species of *Eleocharis* in Nepal

- 1a Spikelet usually cylindrical or narrowly ellipsoid as wide as culms2
- 1b Spikelet ovoid to narrowly ovoid, rarely cylindrical usually wider than culm4
- 2a Culms with transverse septa, spikelet with basal two glumes empty, achene smooth..... *E. dulcis*
- 2b Culms without transverse septa, spikelet with only basal-most glume empty, achene surface cancellate or reticulate.....3

- 3a Culms terete, sometimes weakly 3-angled; achene apex lacking constriction.....*E. ochrostachys*
- 3b Culms sharply 3-angled, achene apex with a distinct constriction....*E. acutangula*
- 4a Persistent style base scarcely differentiated from achene apex and seemingly a continuation of it.....5
- 4b Persistent style base differentiated from achene apex by a constriction or articulation at the junction with it.....6
- 5a Plant annual, achene winged or angled, reticulate to deeply pitted-reticulate with isodiametric epidermal cells.....*E. retroflexa*
- 5b Plant perennial, not winged or angled, smooth*E. quinqueflora*
- 6a Stigmas 37
- 6b Stigmas 28
- 7a Culms acutely angled, spikelet not proliferous *E. tetraquetra*
- 7b Culms terete, spikelet usually proliferous at base *E. congesta*
- 8a Annual, persistent style base not spongy thickened*E. atropurpurea*
- 8b Perennial, persistent style base spongy thickened.....9
- 9a Only lowermost glumes empty, surrounding the spikelet base completely or 3/4 of it.....*E. uniglumis*
- 9b 2 or 3 basal glumes empty, the lowermost glume surrounds about 2/3 of the spikelet base*E. palustris*

***Fimbristylis* Vahl, Enum. Pl. 2: 285. 1805.**

***Fimbristylis acuminata* Vahl, Enum. Pl. 2: 285. 1805.**

Type. INDIA, *König* s.n. [holotype: C, (C10010413 image!)].

Description. Plant annual, tufted. Culm terete, up to 22 cm long. Leaf reduced to the bladeless sheath. Involucral bract absent. Inflorescence terminal with a single erect or slightly nodding spikelet. Spikelet lanceolate-ovoid, 5–10 × 1.5–3 mm. Glumes pale green or brown-tinged, ovate, 3–4 × 2–2.5 mm, apex obtuse and mucronate. Style flattened, apically ciliate, 2.5 mm long. Stigmas 2, ciliate. Stamens 2, as long as glumes. Achene brownish-black, obovoid, 1.5 × 1–1.5 mm, biconvex, with 6–7 rows of transversely wavy reticulation in each face, pitted with hexagonal cells, shortly stipitate. (Fig. 2B).

Distribution. Nepal (new record), Bhutan, India, China, Bangladesh, Sri Lanka, Laos, Malaysia, Thailand, Indonesia, Philippines, Vietnam, New Guinea and Australia.

Ecology. Grows in flood plains, riverbanks and semi-dry paddy fields; 70–676 m elev.

Phenology. Flowering in August–September; fruiting in October–December.

Specimens examined. **Nepal, Kaski:** Pokhara Valley, Sita Paila, 28°10'30.92"N, 83°59'40.36"E, 676 m elev., 11 Oct 2020, *P. Bhandari & A. Bhandari* 20101101 (KATH, TUCH); **Jhapa:** Kachankawal RM, Baniyani, 26°26'15.94"N, 88°3'1.28"E, 70 m elev., 04 Dec 2020, *S. Chaudhary* 20120406 (KATH).

***Fimbristylis ferruginea* (L.) Vahl, Enum. Pl. 2: 291. 1805.**

Scirpus ferrugineus L., Sp. Pl. 1: 50. 1753.

Type. JAMAICA, Collector unknown s.n. [Herb. van Royen], [lectotype, designated by Adams in Cafferty and Jarvis 2004, pg. 180: L, (L0052731 image!)]].

Description. Plant tufted, 20–50 cm tall. Culm many, irregularly angled, bladeless sheath present. Leaves shorter than culm, ligulate, 1.5–3 mm wide, margin scabrous. Involucral bracts overtopping spikelet, to 9.5 cm long. Inflorescence terminal with 4–6 spikelets, sometimes with one or two spikelets. Spikelets ovoid, 5–10 × 2–4 mm. Glumes broadly ovoid, 3–3.5 × 2.5–3 mm, puberulous apically, apiculate, vein single. Style dorsoventrally flattened, 1–1.5 mm long, apically ciliate. Stigmas 2, ciliate, slightly shorter than style. Stamens 3, double the length of the achene. Achene obovoid, biconvex, creamy, 1.2–1.5 × 1 mm, surface smooth, obscurely pitted with hexagonal cells, distinctly stipitate. (Fig. 2C).

Distribution. Nepal (new record) and pantropical.

Ecology. Grows in flood plains and riverbanks; 676–684 m elev.

Phenology. Flowering in July–August; fruiting in September–December.

Specimens examined. Nepal, Kaski: Pokhara Valley, Sita Paila, 28°10'34.29"N, 83°59'42.20"E, 684 m elev., 27 Jun 2020, *P. Bhandari, R. Chapagain & A. Bhandari 20062704* (KATH); Pokhara Valley, Sita Paila, 28°10'30.92"N, 83°59'40.36"E, 676 m elev., 11 Oct 2020, *P. Bhandari & A. Bhandari 20101102* (KATH); Pokhara Valley, Sita Paila, 28°10'34.29"N, 83°59'42.20"E, 684 m elev., 21 Dec 2020, *P. Bhandari 20122103* (KATH).

Note. A few populations were observed with one or two spikelets, emulating a pseudo-lateral inflorescence appearance.

***Fimbristylis nutans* (Retz.) Vahl, Enum. Pl. 2: 285. 1805.**

Scirpus nutans Retz., Observ. Bot. 4: 12. 1786.

Type. MALAYSIA, Malacca, *J.G. König* s.n. [lectotype, designated by Fischer 1932, pg. 69: LD (LD1283267 image!)]].

Description. Perennial tufted herb. Leaves reduced to a tubular, bladeless sheath. Involucral bract glume-like, 3.5 mm long. Inflorescence consisting of a single terminal spikelet. Spikelet slightly nodding, ovoid with spirally arranged glumes. Glumes 2–4 × 1.5–3 mm, rust-brown, oblong-elliptic, margin membranous, apiculate. Style 3.5 mm long, flattened with ciliate margin. Stigmas 2. Stamens as long as style. Achene white, obovate, 1.5 × 1 mm, biconvex, with transverse wavy reticulation, basal stipe indistinct. (Fig. 2D).

Distribution. Nepal (new record), India, China, Myanmar, Malaysia, Indonesia, Thailand, Papua New Guinea, Sri Lanka, Vietnam and Australia.

Ecology. Grows in marshy areas, edges of the lake; sometimes forming a floating island of vegetation, associated with *Eleocharis* species and *Fimbristylis* species; 700 m elev.

Phenology. Flowering in July–August; fruiting in September–October.

Specimen examined. **Nepal, Kaski:** Pokhara Valley, Dipang Lake, 28°10'57.90"N, 84° 4'9.28"E, 700 m elev., 17 Sep 2019, *P. Bhandari & V. Adhikari KAS13* (KATH).

Fimbristylis salbundia (Nees) Kunth, Enum. Pl. 2: 230. 1837.

Trichelostylis salbundia Nees, Contr. Bot. India 105. 1834.

Type. INDIA, Silhet, *N. Wallich* 3526 [lectotype, designated by Halder and Dey 2016, pg. 357, 359: K (K000974061 image!).]

Description. Plant rhizomatous, not tufted. Culm up to 130 cm, 5-angled. Leaf reduced to the bladeless sheath, up to 18 cm, tubular. Involucral bracts setaceous to 1 cm long. Inflorescence a compound anthela. Spikelet ovoid, 3.5–4 × 1.5–2 mm, with spirally arranged glumes. Glumes elliptic-ovoid, 1.8–2 × 1 mm, middle part chestnut brown, margin membranous, 3-veined, apex obtuse to acute, not mucronate. Style 1 mm, trigonal, basally inflated, not ciliate. Stigmas 3, as long as style, plumose. Stamens 3, 2 mm long. Achene obovoid, trigonal, 0.5–0.7 × 0.5 mm, sparsely verruculose with transversely oblong epidermal cells in more than 9 vertical rows on each face. (Fig. 2E).

Distribution. Nepal, India, China, Myanmar, Bangladesh, Sri Lanka, Philippines, Vietnam, Thailand, Indonesia and New Guinea.

Ecology. Grows in marshy areas; 760–835 m elev.

Phenology. Flowering in July–September; fruiting in October–December.

Specimens examined. **Nepal, Dang:** Tulsipur, near Damargau, Angare, 835 m elev., 17 Dec 2020, *B. Subedi 20121704* (KATH); **Kaski:** Pokhara Valley, Gunde Lake, 28°11'30.29"N, 84°2'21.58"E, 760 m elev., 30 Dec 2020, *P. Bhandari & N.L. Bhandari 20123005* (KATH, TUCH).

Note. The protologue of *Fimbristylis salbundia* [\equiv *Trichelostylis salbundia*] was based on two collections of Wallich, i.e. *Wallich* 3499 and 3526 from 'Nepalia' and 'Silhet', respectively (Wallich 1828; Nees 1834). All collections representing 3499 were later annotated as *F. quinquangularis* (Vahl) Kunth., except 3499c at B, which was *F. salbundia* (Nees) Kunth (Clarke 1907). The collection 3499c at B was destroyed in 1943, during the Second World War (Halder and Dey 2016). Subsequently, the occurrence of *F. salbundia* was not reported in the published works (Koyama 1978; Press et al. 2000; Rajbhandari and Rai 2017; Shrestha et al. 2018; POWO 2019; Govaerts et al. 2021). The rediscovery of *F. salbundia* after 200 years confirms the occurrence of this taxon in Nepal.

Fimbristylis salbundia is very similar to *F. quinquangularis*, but can be distinguished, based on the nature of its leaf sheaths and achene character. *Fimbristylis salbundia* is characterised by the presence of bladeless sheaths and sparsely verruculose achene, surface pitted with more than nine vertical rows of transversely oblong epidermal cells. However, *Fimbristylis quinquangularis* has leaf sheaths with blades and densely verruculose achene with up to six vertical rows of transversely linear-oblong epidermal cells.

***Fimbristylis thomsonii* Boeckeler, Linnaea 37(1): 37. 1871.**

Type. INDIA, Mount Khasia, *J.D. Hooker & T. Thomson* 12 [lectotype, designated by Dey and Halder 2015, pg. 230, 231: P (P00051618 image!)].

Description. Plant more than 20 cm. Blade less sheath lacking. Leaf-blade flat, 2 mm wide, margin scabrous, ligulate. Involucral bract shorter than inflorescence, to 4.5 cm. Inflorescence terminal in compound anthela with more than 20 spikelets. Spikelets 5–7 × 1.5–3 mm, elliptic, ovoid to oblong, reddish. Glumes boat-shaped, ovate, chestnut brown, 3–3.5 × 2 mm, mid-vein keeled, arising from the base and excurrent into a mucro, 3 more lines arising each side of mid-vein from base to apex, surface glabrous, margin membranous. Style 1.5 mm long, base inflated, 3-angled, not ciliate. Stigmas 3. Stamens 3, 3 mm long. Achene white, shiny, trigonous, obovate, 1.5 × 1 mm, verruculose. (Fig. 2F).

Distribution. Nepal (new record), India, China, Myanmar, Bangladesh, Laos, Malaysia, Philippines, Vietnam and Thailand.

Ecology. Grows in grassland, near *Schima-Castanopsis* forest; 1020 m elev.

Phenology. Flowering and fruiting in April.

Specimen examined. Nepal, Kaski: Pokhara, Kharchyang-Aghihare Community Forest, Bhirsvara, 28°9'34.27"N, 83°59'32.80"E, 1020 m elev., 25 Apr 2020, *P. Bhandari & A. Bhandari* KAS28 (KATH).

Keys to the species of *Fimbristylis* in Nepal

- 1a Stigmas 3 2
- 1b Stigmas 2 12
- 2a Glumes distichous at least in the lower part of spikelet..... 3
- 2b Glumes spirally arranged..... 5
- 3a Inflorescence reduced to single spikelets; involucral bract glume-like *F. ovata*
- 3b Inflorescence with more than two spikelets; involucral bract setaceous or foliaceous..... 4
- 4a Perennials; involucral bract foliaceous; inflorescence a compound anthela; glumes glabrous *F. fusca*
- 4b Annual; involucral bract setaceous; inflorescence a simple or sub-compound anthela; glumes apically sparsely ciliate *F. fimbristyloides*
- 5a Leaf-sheath ligulate, with a fringe of short hairs 6
- 5b Leaf-sheath eligulate..... 7
- 6a Stem strongly compressed; involucral bract exceeding inflorescence; achene smooth..... *F. complanata*
- 6b Stem not compressed; involucral bract shorter than inflorescence; achene verruculose *F. thomsonii*
- 7a Spikelets in clusters *F. falcata*
- 7b Spikelets solitary 8
- 8a Culm 3-angled..... 9
- 8b Culm 4 or 5-angled..... 10

- 9a Plant stoloniferous; culm with all leaves with a blade *F. pierotii*
- 9b Plant not stoloniferous; culms with 1–3 leafless sheaths *F. umbellaris*
- 10a Culm 4-angled; leaf blade bilaterally flattened, ensiform; spikelet globose *F. littoralis*
- 10b Culm 5-angled; leaf blade (if present) dorsoventrally flattened, linear; spikelets elongated 11
- 11a Leaves with a blade; achene distinctly verruculose with 4–7 rows of transversely oblong epidermal cells *F. quinquangularis*
- 11b Leaves reduced to bladeless sheath; achene sparsely verruculose with more than 9 rows of transversely linear-oblong epidermal cells *F. salbundia*
- 12a Spikelets 1 to 3 13
- 12b Spikelets several to many (sometimes, one or two spikelets in *F. ferruginea*, but glume is always apically puberulous) 15
- 13a Leaves with a blade; achene smooth, pitted with hexagonal cells *F. schoenoides*
- 13b Leaves reduced to a bladeless sheath; achene coarsely rugulose with transverse wavy reticulation 14
- 14a Involucral bracts glume-like; spikelet nodding; achene margin verruculose *F. nutans*
- 14b Involucral bract absent; spikelet erect; achene margin not verruculose *F. acuminata*
- 15a Leaves eligulate 16
- 15b Leaves ligulate 20
- 16a Annual 17
- 16b Perennial 18
- 17a Style base fringed with a whorl of long pendent hairs covering the upper half of the nut *F. squarrosa*
- 17b Style minutely ciliate at the top *F. aestivalis*
- 18a Rhizome creeping; culm sparsely tufted; spikelets not angular *F. rigidula*
- 18b Rhizome not creeping; culm densely tufted; spikelets slightly angular by the keeled glumes 19
- 19a Leaves flat or canaliculate, apex abruptly acuminate; glumes keel glabrous *F. cymosa* var. *spathacea*
- 19b Leaves flat, apex subobtusely; glumes keel puberulous *F. fuscinox*
- 20a Plant bearing stolons *F. stolonifera*
- 20b Plant tufted, lacking stolons 21
- 21a Glumes puberulous, broadly ovoid, margin apically ciliate, apiculate; achene smooth, obscurely pitted with hexagonal cells *F. ferruginea*
- 22b Glumes glabrous, margin hyaline, 3-veined, acute to apiculate; achene reticulate with transversely oblong cells 22
- 22a Spikelets 1–1.5 mm wide, angular by the keeled glume; glumes to 1.5 mm long *F. bisumbellata*
- 22b Spikelets 2–4 mm wide, terete; glumes not keeled, over 1.5 mm long *F. dichotoma*

***Fuirena* Rott., Descr. Icon. Rar. Pl. 70. 1773.**

***Fuirena umbellata* Rottb., Descr. Icon. Rar. Pl. 70, t. 19, f. 3. 1773.**

Type. SURINAME, *D. Rolander* s.n. (lectotype, designated by De Moraes 2012, pg. 65: SBT 1.3.1.47, image!).

Description. Perennial rhizomatous herbs. Culm solitary, lowermost node swollen, 120 cm tall, acutely 5-angled, glabrous to puberulous. Leaves linear-lanceolate, 13–17 × 1.5–1.7 mm, 5-veined, apex acuminate, margin ciliate; ligule brownish, hyaline, truncate. Lower involucral bracts leaf-like, 2–10 cm long, sheath densely pubescent; upper bracts much shorter, not or hardly sheathing. Inflorescence with 8–14 glomerulate clusters of spikelets; glomerulate bearing 6–30 spikelets arising from a white villous pedicle. Spikelets greenish-brown, ovoid-ellipsoid, 4–7.5 × 2–3 mm. Glumes 2–2.5 × 1.5 mm, ellipsoid to oblong, membranous, blackish to brownish tinged, abaxially pilose towards the emarginated apex, 3-veined costa ending in a short puberulent, 0.7–1 mm awn. Perianth segments 6 in two whorls; outer 3, needle-like, whitish, apically scabrous, as long as or shorter than the stalk of inner bristles; inner bristles 3, obovoid to oblong, whitish to brownish, 1–1.5 × 0.5–0.7 mm, membranous, margin ciliate, apically densely ciliate, base gradually narrowed down into a twisted 0.5 mm stalk, apex emarginate, veins 3, ending in a short recurved awn. Stamens 3, 2.5 mm long. Anthers oblong, 0.8–1 mm long. Style 1 mm long. Stigmas 3, 1 mm long, plumose. Achene brown, ellipsoid to obovoid, 3-sided, 0.8 × 0.7–1 mm (including stipitate base), apex with a 3 mm punctate conical whitish beak. (Fig. 2G).

Distribution. Nepal and pantropical.

Ecology. Grows in marshy areas; 70–149 m elev.

Phenology. Flowering and fruiting in January–March.

Specimens examined. **Nepal, Jhapa:** Kachankawal RM, Aambari Road, Thulo Kechana, 26°25'36.56"N, 87°59'15.75"E, 70 m elev., 05 Feb 2021, *P. Bhandari, A. Neupane & S. Chaudhary* 21020504 (KATH, TUCH); **Jhapa:** Salbadi, 26°40'26.75"N, 88°0'51.90"E, 149 m elev., 05 Feb 2021, *P. Bhandari, A. Neupane & S. Chaudhary* 21020503 (KATH).

Note. Published literature of Nepalese flora (Koyama 1978; Press et al. 2000; Rajbhandari and Baral 2010; Rajbhandari and Rai 2017; Shrestha et al. 2018) had not previously reported this species. However, the present finding supports Govaerts et al. (2021), which had reported its distribution in Nepal.

The Nepalese populations bear perianth segments in two whorls. The outer whorl consists of three very short needles like bristles, while the inner whorl consists of three obovate-oblong perianth segments.

Keys to the species of *Fuirena* in Nepal

- 1a Perennial with short rhizome; basal node of culm swollen; inner perianth segments obovate, gradually narrowed at base.....***F. umbellata***
- 1b Annual lacking rhizome; culm lacking swollen structure; inner perianth segments subquadrate, abruptly narrowed at base.....***F. ciliaris***

***Machaerina* Vahl, Enum. Pl. 2: 238. 1805.**

***Machaerina rubiginosa* (Biehler) T.Koyama, Bot. Mag. (Tokyo) 69(812): 65. 1956.**

Fuirena rubiginosa Biehler, Pl. Nov. Herb. Spreng. 3. 1807.

Type. NEW ZEALAND, *Forster* s.n. [lectotype, designated by Garnock-Jones 1986, pg. 125: K (K000883942 image!)].

Description. Plant rhizomatous. Culms tufted, compressed to subterete, 0.7–1.2 m tall. Leaves shorter than or equalling the culm, blade biconvex with obtuse edges, apex acute. Inflorescence paniculate, laxly arranged. Spikelets ovoid, with two flowers. Glumes lanceolate, 5–6 × 2.5–3 mm, brownish, mid-vein keeled, lower part greenish, margin ciliate, apex acuminate. Style base densely sericeous. Style short, to 1.5 mm. Stigmas 3, to 6 mm long. Stamens 3, longer than achene. Anther 2.5 mm long. Achene trigonous, ellipsoid, yellowish-orange, shiny, 4–5 × 1.5–1.8 mm. (Fig. 2H).

Nepali name. Gudh

Use. Culm is collected to weave handmade mats (locally called ‘gundri’).

Distribution. Nepal (new record), India, China, Bangladesh, Sri Lanka, Vietnam, Malaysia, Indonesia, Philippines, New Guinea and Australia.

Ecology. Grows in the floating island and marshy areas; 762 m elev.

Phenology. Flowering in July–September; fruiting in December–January.

Specimen examined. Nepal, **Kaski:** Pokhara Valley, Gunde Lake, 28°11'30.29"N, 84°2'21.58"E, 762 m elev., 09 Dec 2020, *P. Bhandari* & *V. Thapa* 20120913 (KATH, TUCH).

Note. This is the first report of this genus in Nepal. The genus *Machaerina* shows morphological similarities to the genera *Cladium* and *Rhynchospora*. *Cladium* is differentiated by its solid stem and ellipsoid achene lacking disc. *Machaerina* is differentiated from *Rhynchospora* by its leaf characters; the leaves in *Machaerina* are distichously arranged, whereas in *Rhynchospora*, they are tristichously arranged.

***Scleria* P.J.Bergius, Kongl. Vetensk. Acad. Handl. 26: 142 (–144) 1765.**

***Scleria rugosa* R.Br., Prodr. Fl. Nov. Holland. 240. 1810.**

Type. Australia, Queensland, Endeavour River, 1770, *J. Banks* & *D. Solander* s.n. [lectotype, designated by Simpson 2019, pg. 207: BM (BM000833641 image!)].

Description. Plant annual. Stem suberect, culm tufted, glabrous, 3-angled, to 10 cm long. Basal sheath glabrous, leaf sheath sparsely ciliate, not winged; contraligule round, barbate. Leaf-blade linear, glabrous, 2.5–7 × 0.25–3 cm. Involucral bracts leaf-like, to 11 cm long, glabrous. Inflorescence paniculate with 1–3 distant branches, each branch, with 1–3 spikelets. Peduncle recurved, slightly winged, margin ciliate. Spikelets unisexual; male spikelets linear-lanceolate, shortly peduncled, margin ciliate, glumes to 2 mm long, lanceolate, the mid-vein of the two outer ones ciliate; female spikelets with up to 5 glumes. Glumes ovate-lanceolate, 2–4 × 1–1.5 mm, beset with long, patent

hairs, vein prolonged into a mucro. Achene spherical-globose, 1.5×1.5 mm, whitish or greyish, smooth, shiny, apex with a whitish beak. Disc thick, lobe yellowish-brown, shallowly 3-lobed, rounded-obtuse, margin reflexed. (Fig. 2I).

Distribution. Nepal (new record), India, China, Myanmar, Bangladesh, Sri Lanka, Malaysia, Thailand, Indonesia, Philippines, Vietnam, New Guinea, Japan, Korea and Australia.

Ecology. Understorey of *Schima-Castanopsis* forest and edges of water canal; 71–755 m elev.

Phenology. Flowering in August–September; fruiting in October–December.

Specimens examined. **Nepal, Kaski:** Pokhara Valley, Niureni Lake, $28^{\circ}11'32.96''\text{N}$, $84^{\circ}2'53.63''\text{E}$, 755 m elev., 08 Sep 2020, *P. Bhandari 20090802* (KATH); **Kaski:** Pokhara Valley, Niureni Lake, $28^{\circ}11'32.96''\text{N}$, $84^{\circ}2'53.63''\text{E}$, 749 m elev., 30 Dec 2020, *P. Bhandari & N.L. Bhandari 20123007* (KATH); **Jhapa:** Kachankawal RM, Baniyani, $26^{\circ}26'15.94''\text{N}$, $88^{\circ}3'1.28''\text{E}$, 71 m elev., 04 Dec 2020, *S. Chaudhary 20120410* (KATH).

Keys to the species of *Scleria* in Nepal

- 1a Annual, rhizome absent 2
- 1b Perennial, rhizome present 5
- 2a Glumes beset with long, patent hairs; disc shallowly lobed *S. rugosa*
- 2b Glumes glabrous; disc obsolete or tri-lobed 3
- 3a Inflorescence spiciform, unbranched, lacking leafy bracts; disc obsolete
..... *S. pergracilis*
- 3b Inflorescence paniculate, having a terminal and lateral panicles, leaf bracts present; disc tri-lobed 4
- 4a Achene spherical with dark purplish beak, deeply pitted; disc lobe acuminate at apex *S. biflora*
- 4b Achene ellipsoid or subglobose with white beak, not deeply pitted; disc lobe acute at apex *S. parvula*
- 5a Plant much robust; achene cancellate; disc lobe obtuse or rounded at apex
..... *S. terrestris*
- 5b Plant smaller; achene smooth or slightly rugulose; disc lobe acute at apex, often bidentate *S. levis*

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Three new species of *Impatiens* (Balsaminaceae) from southern Western Ghats, Kerala

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Abstract

Three new species of *Impatiens*, *Impatiens achudanandanii*, *I. danii*, and *I. shailajae*, are described from Thiruvananthapuram and Idukki districts of Kerala state (SW-India). *Impatiens achudanandanii* is similar to *I. courtallensis* and *I. herbicola*; *I. danii* to *I. goughii* and *I. shailajae* is to *I. minae* and *I. scapiflora*. The newly described taxa are readily distinguished from their allied species by unique character combinations, viz. shape of lateral sepal, lower sepal, dorsal petal, seed and pollen morphology. Detailed descriptions along with illustrations and photographs are provided.

Keywords

Balsaminaceae, endemic species, *Impatiens*, Western Ghats

Introduction

Balsaminaceae A. Rich consists of about 1,000 species, mainly distributed in tropical Africa, Madagascar, southern India, and Sri Lanka (see e.g., Yuan et al. 2004). This family includes annual or perennial herbs (more or less succulent) or subshrubs. (Stevens 2012). It comprises the monotypic genus *Hydrocera* Blume ex Wight & Arn. and the genus *Impatiens* L. having variously united and characteristic petals with dehiscent fruits (Mabberley 2008; Bhaskar 2012). *Impatiens* is mainly distributed in the tropics and subtropics of the Old World, whereas few species occur in temperate regions of Eurasia and North America. Five diversity hotspots for *Impatiens* have been recognized, i.e. tropical Africa, Madagascar, southern India and Sri Lanka, the eastern Himalayas, and southeast Asia (Song et al. 2003; Yuan et al. 2004). During the past two decades, extensive contributions to the taxonomy of the genus *Impatiens* were made (Yu et al. 2015; Fischer and Rahelivololona 2015a, b, c, 2016; Fischer et al. 2017). Yu et al. (2015) divided *Impatiens* into two subgenera *Clavicarpa* and *Impatiens* with 7 sections viz. *Semeiocardium*, *Impatiens*, *Tuberosae*, *Racemosae*, *Uniflorae*, *Scorpioidae* and *Fasciculatae*. The three new species described here belong to the subgenus *Impatiens* characterized by 5–carpellate (rarely 4) ovary, many ovules per locule; fusiform, linear, cylindrical or clavate capsule; pollen 4–aperturate (rarely 3–aperturate), oblong, circular, elliptic or quadrate.

Impatiens is represented by more than 210 taxa in India, mostly distributed through the Eastern Himalayas and the Western Ghats (see e.g., Bhaskar 2012). More than 106 species are endemic to the Western Ghats, of which 80% are endangered (Bhaskar 2012). Moreover, several endemic taxa have been recently reported from various parts of the Western Ghats (Hareesh et al. 2015; Chhabra et al. 2016; Vishnu et al. 2020).

The interiors of Kerala forest ranges are bestowed with rich biodiversity and many of which warrant keen exploration. During such field explorations, in a span of two years, we came across three interesting species of the genus *Impatiens* from Thiruvananthapuram and Idukki districts of Kerala. Critical analysis of the specimens revealed that these cannot be ascribed to any known species of *Impatiens* and hence described here as new.

Materials and methods

Extensive field surveys were conducted in Kerala during the period 2019–2021. Analysis of relevant literature (Hooker and Thomson 1860; Hooker 1875, 1904–1906, 1908a, b, 1910, 1911; Dessai and Janarthanam 2011; Bhaskar 2012; Hareesh et al. 2015; Ramasubbu et al. 2015, 2017; Bhaskar and Sringswara 2017; Mani et al. 2018) and careful examination of preserved specimens preserved at various herbariums (TBGT, KFRI, MH, USE, K, CALI, and CMPR) (acronyms according to Thiers (2021) [continuously updated]) were undertaken to complete the study. Furthermore, distribution map was created using QGIS Version 3.14.

Results and discussion

***Impatiens achudanandanii* Kumar V.S.A., M.G. Govind & Sindhu Arya, sp. nov.**

urn:lsid:ipni.org:names:77219068-1

Figs 1, 2, 7

Type. INDIA. Kerala, Thiruvananthapuram, Kallar forest area, along the streams of highland 8.7599°N, 77.1169°E, 1200 m a.s.l., 26 August 2019, Kumar V.S.A., M.G. Govind & Arya.S, 1056 (holotype TBGT!, isotype MH! CALI!).

Diagnosis. *Impatiens achudanandanii* is similar to *I. courtallensis* Ramasubbu, from which it differs by the color of the flowers (whitish-creamy with yellow spot at throat in *I. achudanandanii* vs. milky-white in *I. courtallensis*), the shape of the fruit, the shape, number and hairiness of the seeds (ovoid, 2–3 seeded fruit and seed glabrous in *I. achudanandanii* vs. fusiform, 3–5 seeded and with minute hairs in *I. courtallensis*), the shape of the dorsal petal (ovoid-circular in *I. achudanandanii* vs. orbicular, recurved in *I. courtallensis*), the shape of the lateral united petals (basal lobe ovate-obovate, distal lobe round in *I. achudanandanii* vs. basal lobe oblong, distal lobe spherical in *I. courtallensis*), the shape of lower sepal (saccate and tip pointed in *I. achudanandanii* vs. boat shaped and tip outwardly curved in *I. courtallensis*) and the size and color of the pollen grains ($10 \times 16 \mu\text{m}$ whitish-yellow in *I. achudanandanii* vs. $16 \times 18 \mu\text{m}$ squarish, milky-white in *I. courtallensis*).

Description. Annual, succulent, straggling, glabrous herb, 15–20 cm high; stems terete, unbranched with purple dots, nodes slightly swollen, internode elongated, 1–1.5 cm. Leaves opposite, decussate, 2–2.5 \times 1–1.2 cm long, shortly petiolate, petiole 0.5 mm, coriaceous, linear, acuminate, entire, base truncate, slightly cordate, reflexed upwards, leaf margin distinctly serrate, leaf blade 1–2 mm, extra petiolar glands absent. Inflorescence 2–3 together, flowers simple, pedicellate, axillary, 2–3 mm across, whitish-creamy with yellow spot on the throat; pedicels 0.5–0.8 cm long. Sepals—lateral 2, linear-lanceolate aristate, 0.5–1 mm long, faintly nerved, white. Lower sepal boat shaped, tip of the lower sepal pointed, 1.0–1.2 \times 0.5–0.8 mm, horizontal, spur minute, 0.2 mm, yellow. Petals—dorsal ovate, 1.5–1.8 \times 0.5–0.8 mm, beaked, dorsally keeled, apiculate, lateral united petals stipitate, not clawed, 2 lobed, margin smooth 1–1.5 mm long, basal lobe small, ovate, distal lobe round, dorsal auricle not prominent, end sharp. Ovary ovoid, 0.5 mm long. Fruit: capsules small, ovoid, turgid, 3–5 \times 2–3 mm, acute, red shaded, 2–6 seeded; seed hexagonal, smooth, compressed, 1–2 \times 0.5–1 mm. Pollen grains $10 \times 16 \mu\text{m}$ whitish-yellow.

Etymology. *Impatiens achudanandanii* is named in honor of Mr. V.S. Achudanandan, former Chief Minister of the state of Kerala for his ardent efforts in conservation of the pristine environment of Western Ghats, especially Mathikettan shola.

Phenology. August to November.

Distribution and habitat. *Impatiens achudanandanii* is distributed in the highlands above 1200 m. So far, the specimen has been observed only in the type locality. The populations are scattered and under the threat of grazing and other anthropogenic

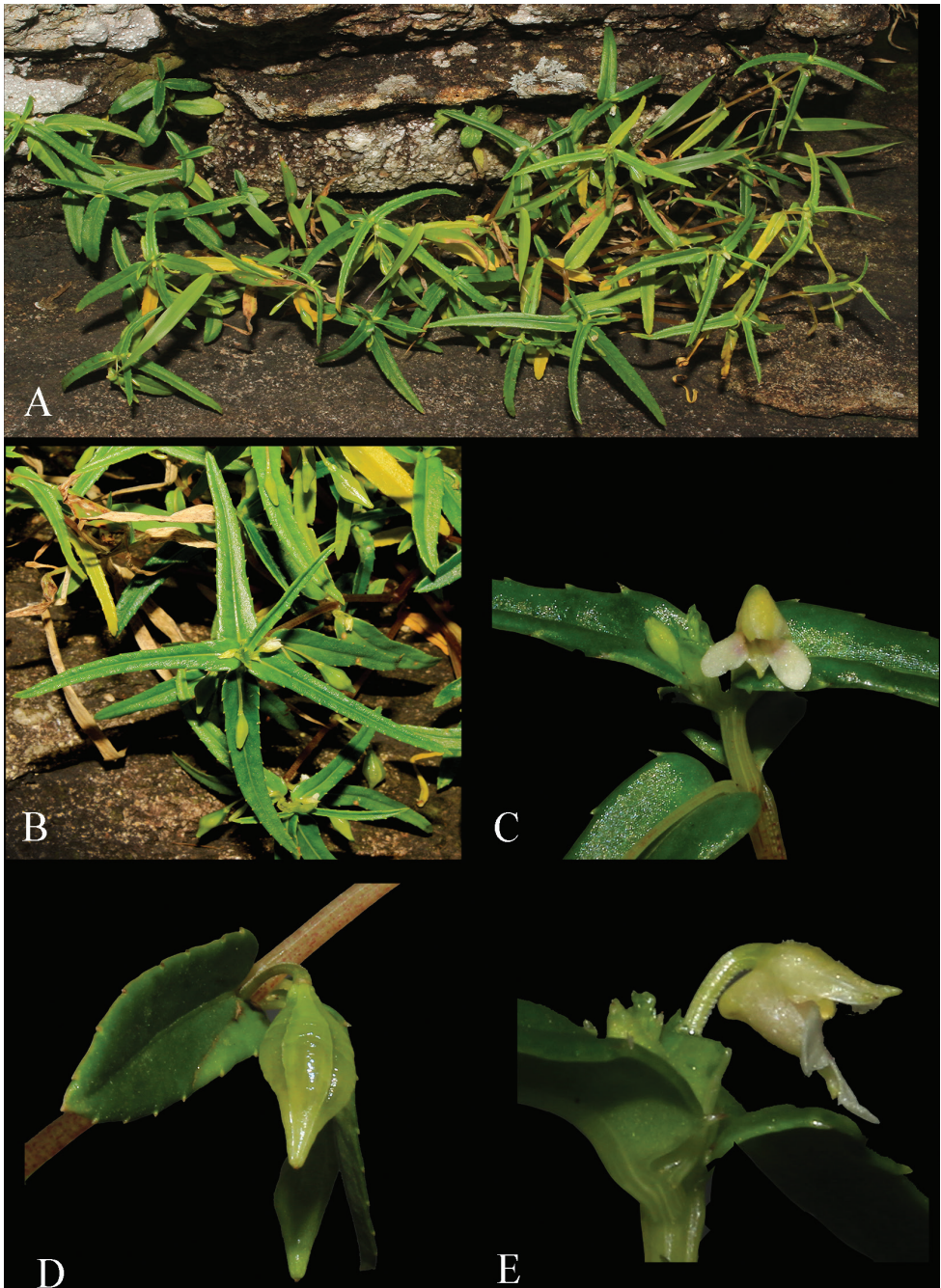


Figure 1. *Impatiens achudanandanii* **A** habit **B** twig **C** flower **D** fruit **E** side view of flower. Photos by Govind.

pressures. The plants are found to grow associated with seasonal ditches near the shade of huge rocks. Species of *Eriocaulon*, *Utricularia reticulata* and *Drosera indica* were found to grow in the nearby vicinity of this species

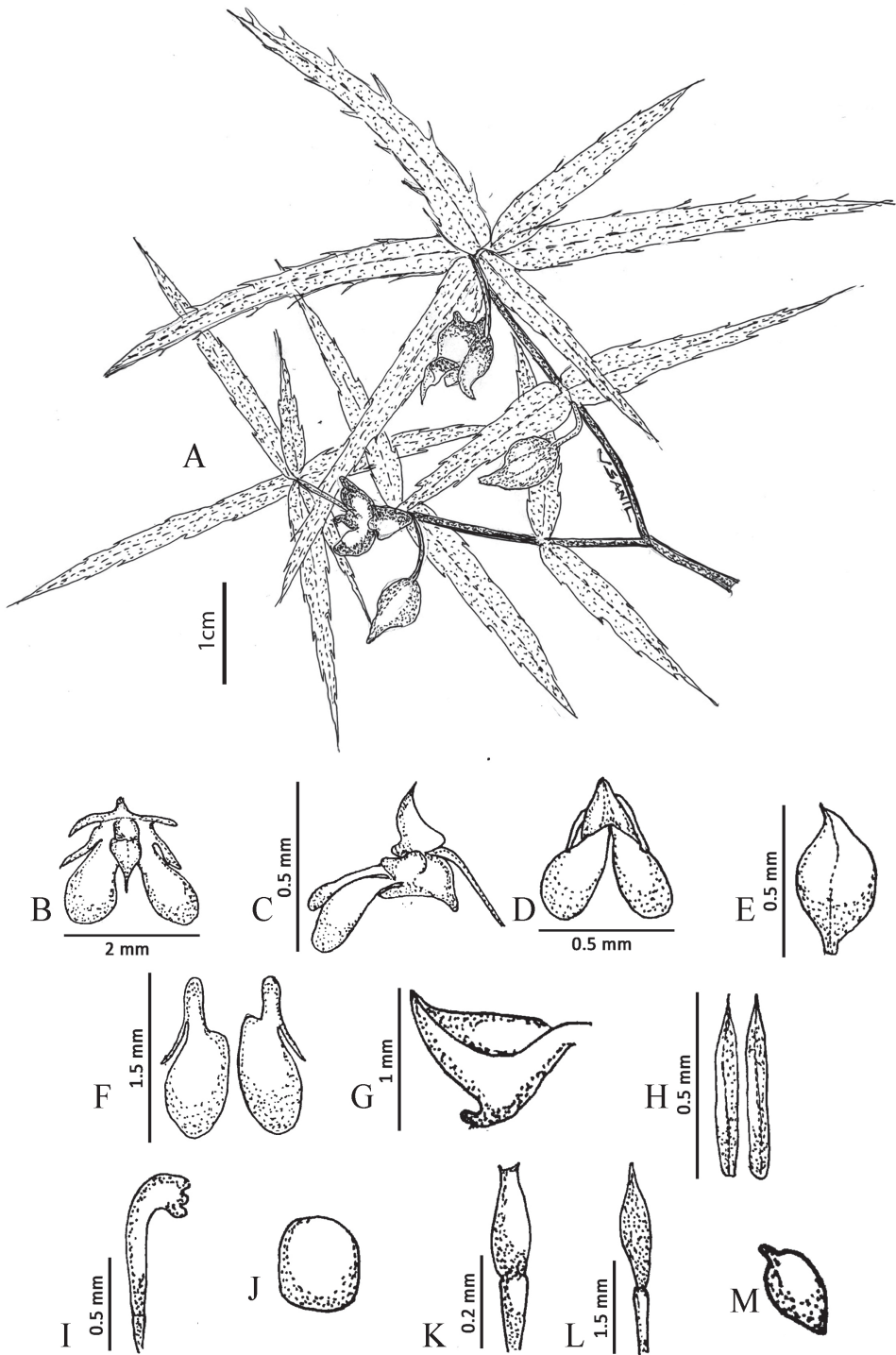


Figure 2. *Impatiens achudanandanii* **A** habit **B** flower (front view) **C** flower (lateral view) **D** petals **E** dorsal petal **F** lateral petals **G** lower sepal **H** lateral sepal **I** stamen **J** pollen **K** gynoecium **L** fruit **M** seed. Illustrations by V.S. Anilkumar.

Conservation status. *Impatiens achudanandanii* is assessed as Critically Endangered (CE) according to the IUCN categories using the criterion d (IUCN 2019). There were only three to four populations (10–15 individuals per population) observed within 1 km. The habitat of the species was severely affected by stamping of wild elephants and land-slides.

Other notes. *Impatiens achudanandanii* belongs to the section *Uniflorae* under the subgenus *Impatiens*, characterized by ellipsoidal shape of seed and capsules that are short and conspicuously turgid at middle. The new species resembles *I. courtallensis*, a species reported from Courtallam hills of Tamil Nadu and also *I. herbicola*, a common high altitude species. The shape of dorsal petal, minute size of flower and the presence of spur distinguished the newly described species from its allied taxa. *Impatiens achudanandanii* is distinct from its other allied taxon *I. herbicola* with respect to spur (present in *I. achudanandanii* vs. absent in *I. herbicola*), color of the flower (whitish-creamy with yellow spot at throat in *I. achudanandanii* vs. bluish or yellowish in *I. herbicola*), size of the flower (2–3 mm in *I. achudanandanii* vs. 5–9 mm in *I. herbicola*), shape of the fruit (ovoid 2–6 seed in *I. achudanandanii* vs. gibbously ovoid with many seeded in *I. herbicola*), shape of lateral united petals (basal lobe obovate-ovate in *I. achudanandanii* vs. oblong in *I. herbicola*), shape of dorsal petal (circular, faintly keeled in *I. achudanandanii* vs. orbicular and thickly keeled in *I. herbicola*) as well as size and color of the pollen (10 × 16 µm whitish-yellow in *I. achudanandanii* vs. 21 × 23 µm, yellow in *I. herbicola*).

Specimen examined. *Impatiens achudanandanii* INDIA. Thiruvananthapuram, Kallar. 22 August 2019, Arya & Kumar V.S.A. 1057 (MH!, TBGT!); 10 September 2019, M.G. Govind 957 (TBGT!). *Impatiens herbicola* INDIA. Thiruvananthapuram, Kallar. 22 August 2019, Kumar V.S.A. & Arya 1037 (TBGT!); 4 September 2019, Arya & Kumar V.S.A. 1097 (TBGT!).

***Impatiens danii* M.G. Govind, Sindhu Arya, V. Suresh & Kumar V.S.A., sp. nov.**

urn:lsid:ipni.org:names:77219072-1

Figs 3, 4, 7

Type. INDIA. Kerala, Idukki, Munnar, along the streams of highland 10.0889°N, 77.0595°E, 800 m a.s.l., 16 October 2019, M.G. Govind & Kumar V.S.A., 1078 (holotype TBGT!, isotype MH! CAL!).

Diagnosis. *Impatiens danii* is similar to *Impatiens goughii* Wt. (1831:160) but different in terms of color of flower (white with yellow blotch on the throat in *I. danii* vs. purple with white blotch on the throat in *I. goughii*), nature of peduncle and pedicel (non– sticky, smooth 3–3.5 cm in *I. danii* vs. sticky, viscous 7–8 cm in *I. goughii*), bracts (absent in *I. danii* vs. present and minute in *I. goughii*), shape of spur (curved and equal or longer than flower in *I. danii* vs. straight and shorter than flower in *I. goughii*), shape of dorsal auricle (short, lanceolate and equals the length of wings in *I. danii* vs. long and filiform and half the length of wings in *I. goughii*), capsule (ovate

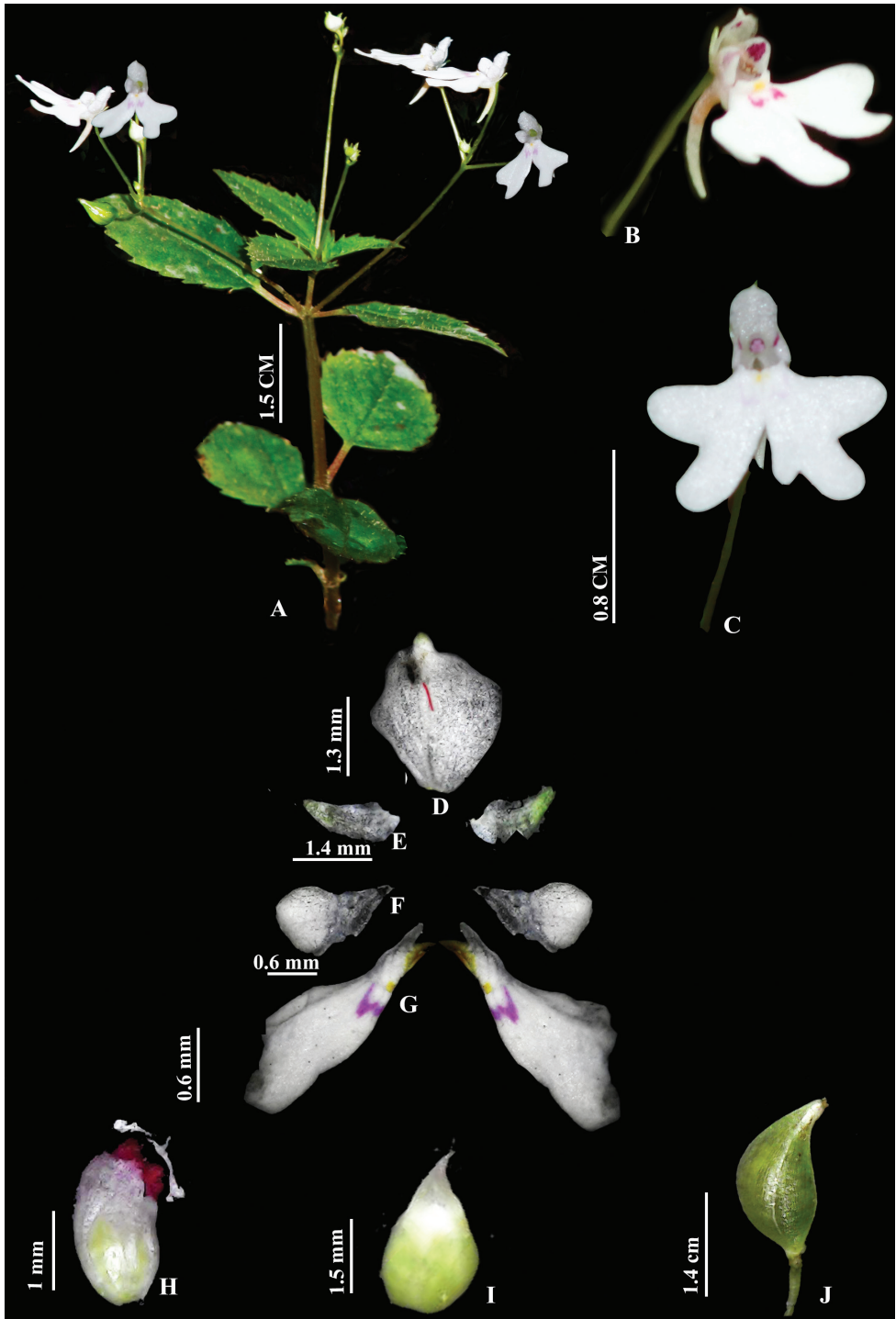


Figure 3. *Impatiens danii* **A** habit **B** flower (lateral view) **C** flower (front view) **D** dorsal petal **E** lateral sepal **F, G** lateral united petals **H** stamen **I** gynoecium **J** fruit. Photos by Govind.

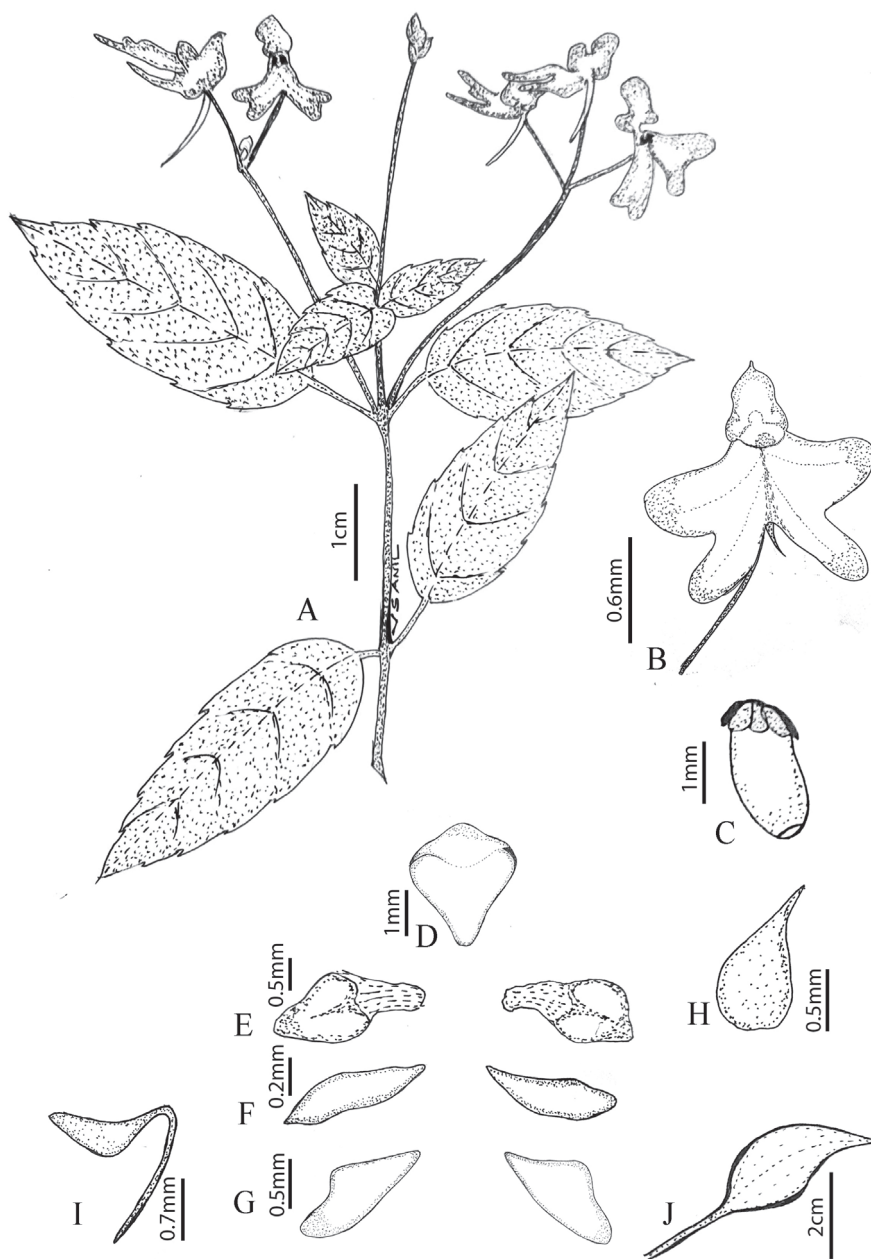


Figure 4. *Impatiens danii* **A** habit **B** flower **C** stamen **D** dorsal petal **E** basal lobe **F** lateral sepal **G** lateral united petals (distal lobe) **H** gynoecium **I** lower sepal with spur **J** fruit. Illustration by V.S. Anilkumar.

in *I. danii* vs. ellipsoidal in *I. goughii*) and shape of seed (ellipsoidal with bands of hairs in *I. danii* vs. ovoid with short hairs in *I. goughii*).

Description. Annual, erect herb, 10–20 cm high; stem simple to moderately branched, glabrous, often slightly pubescent terete, with few scattered, brown, sessile or

stipitate glands, particularly in the lower part of the stem. Lower and middle leaves opposite, petiolate to subsessile; petiole up to 1.5 cm long; lamina ovate to ovoid or elliptic-lanceolate, $3.5\text{--}8.5 \times 1\text{--}1.5$ cm, base rounded with auricled lobes, apex acuminate, margins crenate, dentate to serrate or serrulate (usually in upper leaves) with cuspidate teeth; surfaces glabrous; upper leaves alternate, sessile, oblong-lanceolate, smaller than lower leaves, apex acuminate, surfaces glabrous or sometimes with few glands, particularly on lower surface. Inflorescence peduncled, 8–12 flowered racemes arising from the axis of alternate leaves in the upper part of the stem; peduncle up to 5 cm long, glabrous, with small brown spots; bracteoles absent; pedicels slender, $1\text{--}1.5 \times 0.6\text{--}0.9$ cm, glabrous, with or without sparse brown spots. Flowers $1\text{--}1.2 \times 0.6\text{--}0.8$ cm, white; with yellow-purple blotch at throat. Lateral sepals 2, opposite, one on either side, ovate to lanceolate, $1.3\text{--}1.8 \times 0.6\text{--}0.8$ mm, base cordate, unequally parted, margins entire, apex acute, surfaces glabrous with conspicuous purple dots. Dorsal petal orbicular to oblong, $2\text{--}3 \times 1.5\text{--}2$ mm, apex slightly notched, margins entire or wavy, concave in the middle with spreading sides, slightly keeled on dorsal side, $0.5\text{--}0.8$ cm long. Lateral petals 2 lobed, lobes unequal with second lobe long and ovate, each lateral petal equal ca. $1\text{--}1.2 \times 1.0\text{--}1.2$ cm, margins (outer and inner) entire or wavy. Lower sepal saccate, white with curved spur. Spur equals the length of the lateral petal. Stamens $2\text{--}2.5$ mm; filaments $1\text{--}1.5$ mm long, anthers $0.8\text{--}1.5$ mm long, partly fused; pollen grains bilateral 12×14 μm milky white. Ovary oblong-elliptic, $2\text{--}3$ mm long, glabrous; style $0.1\text{--}0.4$ mm long. Capsules ovoid, $1\text{--}2.8$ cm long, $0.2\text{--}0.5$ mm broad, glabrous, green with purplish base and apex, 4–10 seeded; seeds green, oblong or sub ovoid, $2\text{--}3.6 \times 1.5\text{--}2$ mm, surface covered with hairs.

Etymology. The specific epithet '*danii*' is given in honor of Dr. Mathew Dan, Senior Scientist and Head, Plant Genetic Resource Division, Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Thiruvananthapuram, Kerala, as a recognition of his immense contributions in the field of systematics and conservation of angiosperms in the Western Ghats.

Phenology. August to November

Distribution and habitat. *Impatiens danii* is found to grow along the mud cliffs. Other taxa like *I. herbicola*, *I. munnaensis* and *Selaginella ciliaris* have been observed to grow along with this species.

Conservation status. *Impatiens danii* is known from a single location only (for a total of 50 individuals), and the AOO (Area of Occupancy) is 2 km^2 . On the basis of the IUCN Red List criteria (IUCN 2019) and the available data, we can apply the criteria B2 and C2ai and assess *I. danii* as Critically Endangered (CR).

Other notes. *Impatiens danii* belongs to the section *Uniflorae*, characterized by capsules that are short-fusiform, conspicuously turgid at middle, ca. 1 cm long, inflorescence a raceme with 2(–5) flowers and seed ellipsoid. Further the color of flower, blotches on throat, seed surface and shape of spur are distinct characters that delineate *I. danii* from other reported species.

Specimen examined. *Impatiens danii* INDIA. Munnar, Idukki. 6 July 2020, M.G. Govind 987 (TBGT!). *I. goughii* INDIA. Munnar, Idukki. 6 July 2020, M.G. Govind 988 (MH!).

***Impatiens shailajae* Sindhu Arya & Kumar V.S.A., sp. nov.**

urn:lsid:ipni.org:names:77219075-1

Figs 5–7

Type. INDIA. Kerala, Thiruvananthapuram, Sangili, along the cliffs associated with streams of evergreen forest, 10.0889°N, 77.0595°E, 800 m a.s.l., 20 October 2020, Sindhu Arya & Kumar V.S.A., 1088 (holotype TBGT!, isotype MH! CAL!).

Diagnosis. *Impatiens shailajae* is similar to *I. minae* Ratheesh, Anil Kumar & Sivad. but differs with respect to the leaves (broadly ovate thin, rounded apex and green in *I. shailajae* vs. broadly ovate-orbicular, thick, fleshy, deep pink in *I. minae*), spur of the flower (straight and white in *I. shailajae* vs. slightly curved and pink in *I. minae*), lateral united petals (with white transparent papillae and small dorsal appendages in *I. shailajae* vs. red tipped white papillae and absence of dorsal appendages in *I. minae*) and seed (green with long bands of spiral hairs in *I. shailajae* vs. brown with short hairs in *I. minae*)

Description. Scapigerous terrestrial herbs, 10–15 cm high; rootstock faintly tuberous, lithophytic herbs, densely pubescent. Tubers oblate, 4–6 × 2–3 mm. Leaves 2–4, radical, fleshy, 4.5–5.5 × 6.5–7.2 cm, ovate-orbicular or reniform, obtuse or rounded at apex, base cordate, margin crenate or serrate, thickly hairy, dark green above, with a tuft of uniseriate trichomes on upper surface and silky lanuginose hairs on lower surface, nerves pale green, primary veins usually 8, palmate; petioles up to 2.5 cm long, light pink. Scape racemose, straight, 3–4 flowered 8–10 cm long, glabrous. Flowers clustered at the apex, violet, each c. 1.5 cm across; pedicels 1.0–1.5 cm long; bracts thick, broadly ovate, obovoid, 4–5.5 × 2.5–3.2 mm, yellowish with dark purple spots. Lateral sepals 2, each 3.0–4.0 × 2.0–2.2 mm; lower sepals long-spurred, spur slender, 1.0–1.5 cm long, milky white, straight. Dorsal petal broadly orbicular to obovoid, saccate, 5–6 × 5–7 mm, adaxially keeled, glabrous with pubescent keeled part, dull white to yellow or pale purple; keel mucronate, mucro ca. 1 mm long, pale green; lateral united petals 3-lobed, violet, with a slightly curved band of dense white tipped clavate papillae just above base; basal lobes shorter than the distal lobes, ca. 0.5 cm long, broadly oblong, rounded; middle lobes oblong towards tip, 4 mm long, broadly obovate; distal lobes spherical, ca. 6 mm long. Stamens 5, connate, 1.5 × 1.6 mm; filaments white, anthers white. Pollen grains 15 × 19 µm, light pink. Ovary green, 1.7–1.8 × 1.0–1.3 mm, elliptic, broadly acute at apex, glabrous. Capsule glabrous, reddish green, broadly ellipsoid, apex acute, 1.3–1.8 cm long. Seeds 5–8, ca. 1 mm long, surface with tuft of hairs.

Etymology. *Impatiens shailajae* is eponymous to Mrs. K.K. Shailaja, former Health Minister of Kerala, honoring her efforts to tackle various epidemic and pandemic situations in the state of Kerala through scientific temper.

Phenology. August to November.

Distribution and habitat. The species grows in the unexplored core forest area along steep slippery cliffs, continuously wet by water flow. The species is found to grow along with *I. verticillata* and *Fimbristylis* spp. in the near vicinity.

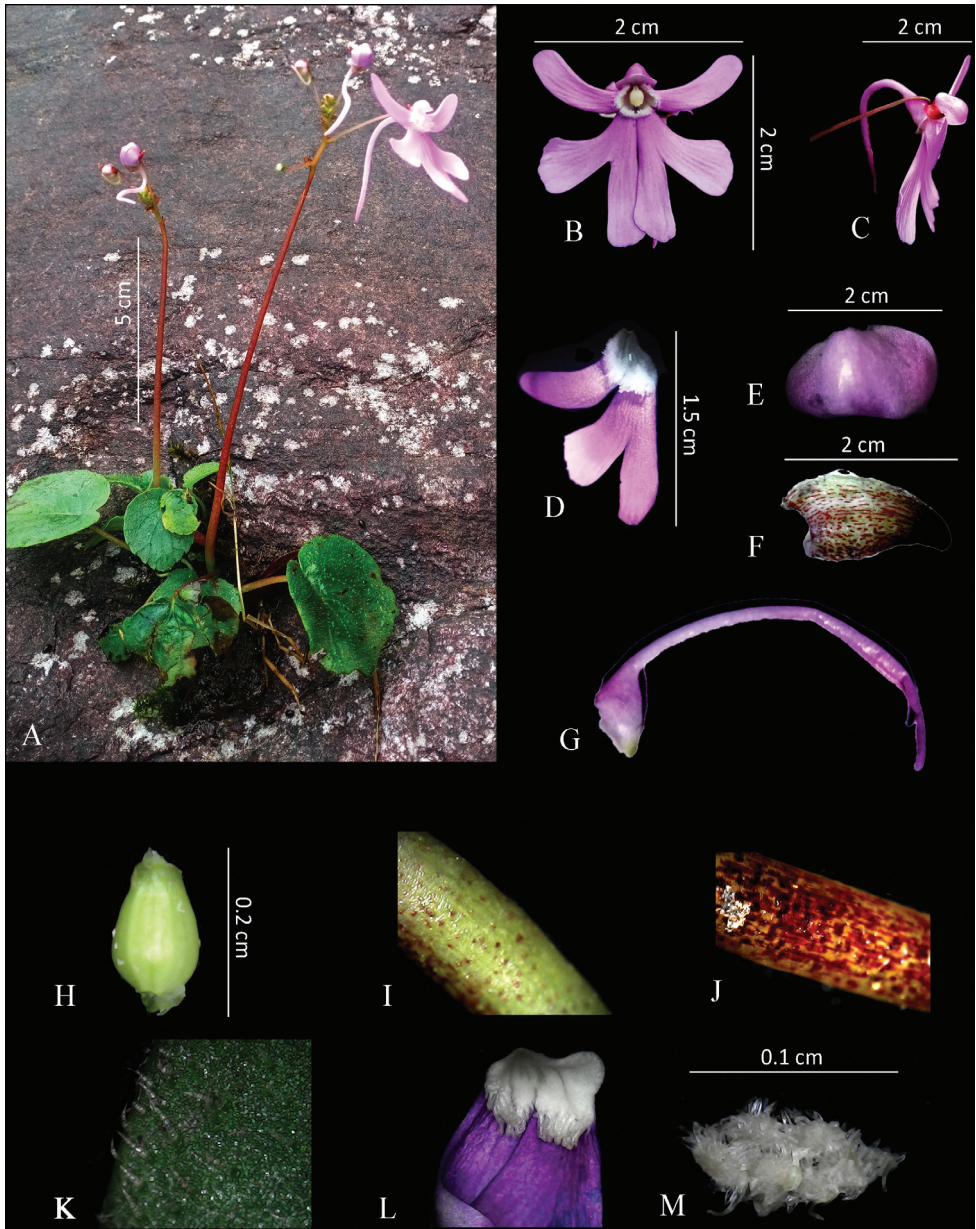


Figure 5. *Impatiens shailajae* **A** habit **B** flower (front view) **C** flower (lateral view) **D** lateral petal **E** dorsal petal **F** lateral sepal **G** lower sepal with spur **H** gynoecium **I** scape lower surface **J** scape upper surface **K** leaf trichomes **L** papillae on petals **M** seed. Photos by Arya Sindhu.

Conservation status. The species was scattered in 3–4 population with 7–10 individuals per population. The population is well conserved without any disturbance as it was obtained from the interiors of protected forest. However, considering the lesser

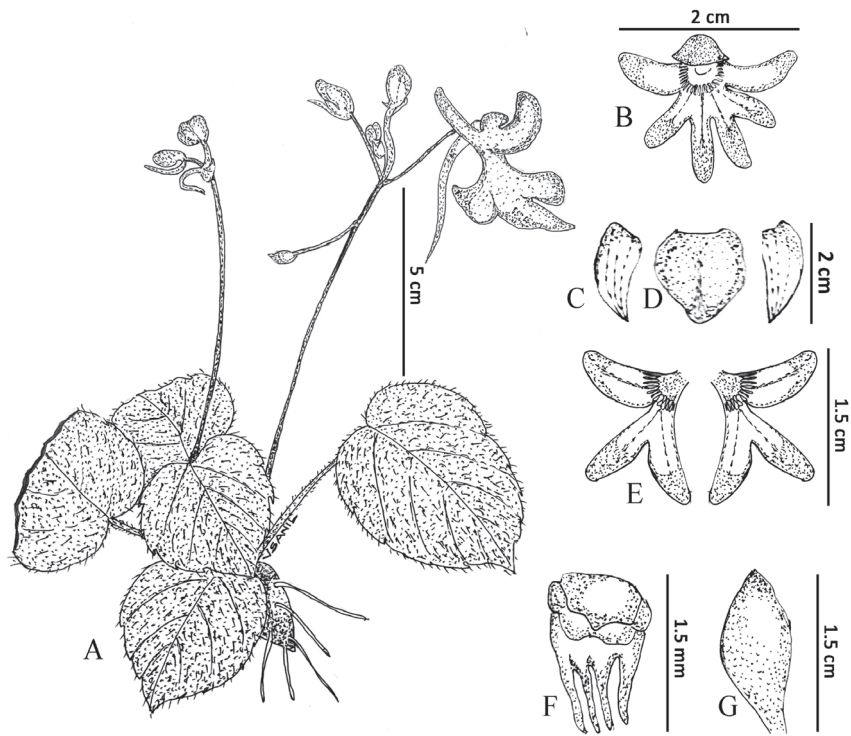


Figure 6. *Impatiens shilajae* **A** habit **B** flower **C** lateral sepal **D** dorsal petal **E** lateral petal **F** stamen **G** gynoecium. Illustration by V.S. Anilkumar.

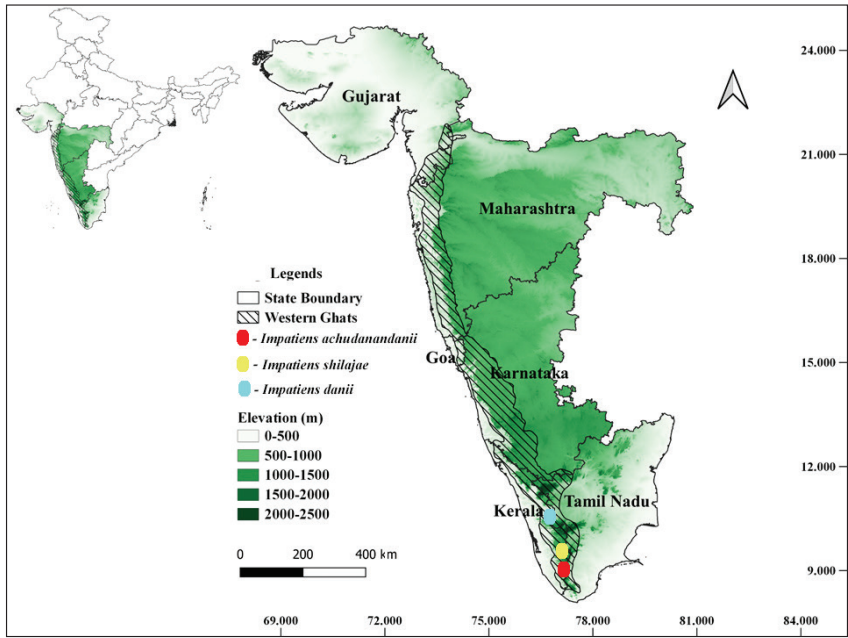


Figure 7. Distribution map of *Impatiens achudanandanii*, *Impatiens danii* and *Impatiens shilajae*.

number of populations distributed across hardly 0.5 km, the species is assessed here as Critically Endangered (CE) by applying the criterion d (IUCN 2019).

Other notes. *Impatiens shailajae* belongs to section *Tuberosae*, characterized by many-flowered racemose inflorescence; capsule clavate or linear, seed ellipsoid or ovoid and lateral sepals 4 with inner 2 fully developed (Yu et al. 2015). *Impatiens shailajae* also shares similarity with *I. scapiflora* but is distinct with respect to the color and shape of papillae on the standard petal, tuberous stolon and trichomes on the leaf. Further, the shape of dorsal petal and its keel is distinct in this new taxon which is easily visible at first glance. All these character combinations along with its undisturbed habitat (localized distribution) and micromorphology (prominent seed hair banding pattern and pollen morphology) further support the status of newly described species.

Specimen examined. *Impatiens shailajae* INDIA. Thiruvananthapuram Sangili, 15 October 2020, Arya & Kumar V.S.A. 2011 (MH!, TBGT!). *I. scapiflora* INDIA. Idukki, 18 August 2019 Arya & Kumar V.S.A. 490 (TBGT!).

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