

Camellia puhoatensis (Sect. *Archecamellia* – Theaceae), a new species from Vietnam

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Abstract

A new species of Theaceae, *Camellia puhoatensis* N.S. Lý, V.D. Luong, T.H. Le, D.H. Nguyen & N.D. Do, **sp. nov.**, is described and illustrated from Nghe An Province, North Central Coastal Region, Vietnam. It is most similar to *C. chrysanthoides*, *C. flavida* and *C. petelotii* within sect. *Archecamellia* in shape and colouration of leaf, petal, ovary and glabrous stamen, but differs by its young puberulous shoot, mature leaf sparsely puberulous abaxially and leaf base rounded or broadly obtuse, petiole and pedicel puberulous, tepals 12–13, ovary and style pubescent. The comparison between the new species and *C. velutina* and *C. dormoyana* is presented. Data on distribution, ecology, phenology, use and provisional conservation assessment of the new species are given along with an illustration and a colour plate.

Keywords

Camellia, section *Archecamellia*, taxonomy, Theaceae, Vietnam

Introduction

Camellia Linnaeus (1753) is the largest genus of the family Theaceae, with recent authors recognising species between 120 (Ming and Bartholomew 2007) and 280 (Chang 1981; Gao et al. 2005), distributed widely in East and Southeast Asia, from the Himalayas east to Japan and Indonesia (Chang and Ren 1998; Ming and Bartholomew 2007). The highest species diversity is found in China and Vietnam (Chang and Ren 1998; Ming 2000; Orel and Wilson 2012b). *Camellia* is distinguished from other genera of Theaceae by its usually large and apically dehiscent capsules and wingless (semi-)globose or polygonal seeds with an umbilicate hilum (Ming and Bartholomew 2007). The general introduction to the genus, with particular focus on Vietnam, was given in recent publications by various authors (e.g. Orel et al. 2012, 2013, 2014a, b; Luong et al. 2016a; Nguyen et al. 2018; Pham et al. 2019; Do et al. 2019a, b). So far, more than 75 species of *Camellia* have been reported in Vietnam, with many localised endemic species (e.g. Pitard 1910; Gagnepain 1941; Rosmann 1999; Tran 1998a, b; Pham 2000; Hakoda and Tran 2001; Hakoda et al. 2007; Orel 2006; Orel and Wilson 2010a, b, 2012a, b; Orel and Curry 2014; Orel et al. 2012, 2013, 2014a, b; Tran et al. 2012; Tran and Luong 2012, 2013; Tran and Le 2013, 2015; Luu et al. 2015, 2018; Luong et al. 2016a, b; Le et al. 2017; Nguyen et al. 2018; Pham et al. 2019; Do et al. 2019a, b), but the actual number is expected to be higher in the near future (Le and Luong 2016, Do et al. 2019b).

During recent extensive floristic surveys in the North Central coastal region in Vietnam, several interesting species of *Camellia* in yellow flower were collected by one of us (N.-D. Do) and colleagues in 2018–2019 (e.g. Tran and Luong 2013; Tran and Le 2015; Luong et al. 2016a, b; Le et al. 2017; Nguyen et al. 2018; Pham et al. 2019; Do et al. 2019a, b). Critical examination of living flowers, dried specimens and comparison with type material and protologues of all related yellow *Camellia* in Vietnam and China (e.g. Sealy 1958; Chang 1981; Chang and Bartholomew 1984; Gao et al. 2005; Ming 2000; Ming and Bartholomew 2007; Pham 2000; Orel and Curry 2014) led to the discovery of several new taxa, two of which were recently described and named *C. pukhangensis* D.N. Do, D.V. Luong, S. T. Hoang & H.T. Le and *C. ngheanensis* N.D. Do, V.D. Luong, N.S. Ly, T.H. Le & D.H. Nguyen (Do et al. 2019a, b), while some other collections are still awaiting description. In this paper, we describe a further new *Camellia* from the Pu Hoat Nature Reserve, Nghe An Province, Vietnam. The overall plant habit, somewhat ovate leaf blades, orbicular sepals and bright yellow tepal of these plants in Pu Hoat NR show similarities with *C. chrysanthoides* H.T. Chang, *C. flavida* H.T. Chang, *C. petelotii* (Merr.) Sealy and *C. dormoyana* (Pierre) Sealy (Sealy 1949, 1958; Chang 1979, 1981). However, it shows significant differences in its vegetative and floral structures (see Table 1) and we describe it here as a new species to science, *C. puhoatensis*.

Materials and methods

The descriptions are mainly based on measurements from mature individuals of living plants in the field, supplemented by measurements from herbarium specimens. Type

specimens of the most closely-related species of yellow camellias were examined from the following herbaria: DLU, HN, P, NSW and VNM (herbarium codes follow Thiers 2018). Hi-resolution digital images available were also accessed from botanical websites (e.g. <https://science.mnhn.fr/>, <http://www.cvh.org.cn/>, <https://avh.ala.org.au/>, <https://plants.jstor.org/>). All morphological characters were described using the general terminology and standard works of Sealy (1958), Chang (1981), Chang and Bartholomew (1984), Chang and Ren (1998), Gao et al. (2005), Ming (2000) and Ming and Bartholomew (2007). The conservation status was assessed, based on field observations in accordance with the IUCN Red List Categories and Criteria version 3.1 (IUCN 2017).

Taxonomic treatment

Camellia puhoatensis N.S. Lý, V.D. Luong, T.H. Le, D.H. Nguyen & N.D. Do, sp. nov.
urn:lsid:ipni.org:names:77210595-1

Figures 1, 2

Diagnosis. *Camellia puhoatensis* is morphologically similar to *C. chrysanthoides*, *C. flavida* and *C. petelotii*, but differs in having young puberulous shoots, mature leaves sparsely puberulous abaxially with leaf bases rounded or broadly obtuse, petioles and pedicels puberulous, tepals 12–13 and the ovary and styles pubescent.

Type. VIETNAM. Nghe An Province: Que Phong District, Dong Van Commune, Pu Hoat NR, 19°43'31"N, 105°05'43"E, 270 m elev., 30 December 2018, *Do Ngoc Dai, Le Thi Huong, Nguyen Danh Hung, DHH-682* (holotype VNM; isotypes P, DLU).

Description. Shrub to tree, 2–7 m tall; *young shoots* puberulous then glabrous when aging, purple towards terminals; semi-mature branches brown, smooth, glabrous, leaf scars prominent; *adult branches* and trunk light grey, smooth with lighter-coloured patches and covered by lichens; *axillary leaf buds* rudimentary, roughly triangular, flat, with rounded apex, pubescent, brown, bud scales small but prominent, 1–3 mm long. *Leaves:* juvenile leaves forming a narrow tube when young, soft, somewhat pendulous, purple in colour; young leaves slightly serrate, shiny, purple, adaxially glabrous, abaxially puberulous; developing leaves descending, narrow, shiny, purple to green-purple tinted, abaxial surface puberulous; mature leaves serrate, irregularly towards the apex, 17–23 × 5.0–6.5 cm; petiole 8–16 × 4–5 mm, puberulous; lamina thin, coriaceous, oblong ovate or oblong, leaf apex acuminate or narrowly acuminate, base rounded or broadly obtuse, adaxially dark green and glabrous, abaxially pale green and sparsely puberulous; primary vein continues as a shallow channel on the adaxial side of the petiole, 2.0–2.5 mm wide proximally, less than 1.0 mm distally, proximally light green and shiny on both sides; secondary venation pinnate, indistinctly brochidodromous, partially eucamptodromous on some leaves, with 10–13 pairs; midribs and lateral veins sunken adaxially; veins distinct proximally, less so towards the apex and the margins; tertiary venation very indistinct, sometimes lacking, more prominent at the leaf margins. *Flowers* usually solitary, sometimes together in groups of 2 flowers borne on a short bracteate shoot, terminal, rarely axillary, lacking scent, 4.5–6.0 cm in diameter;

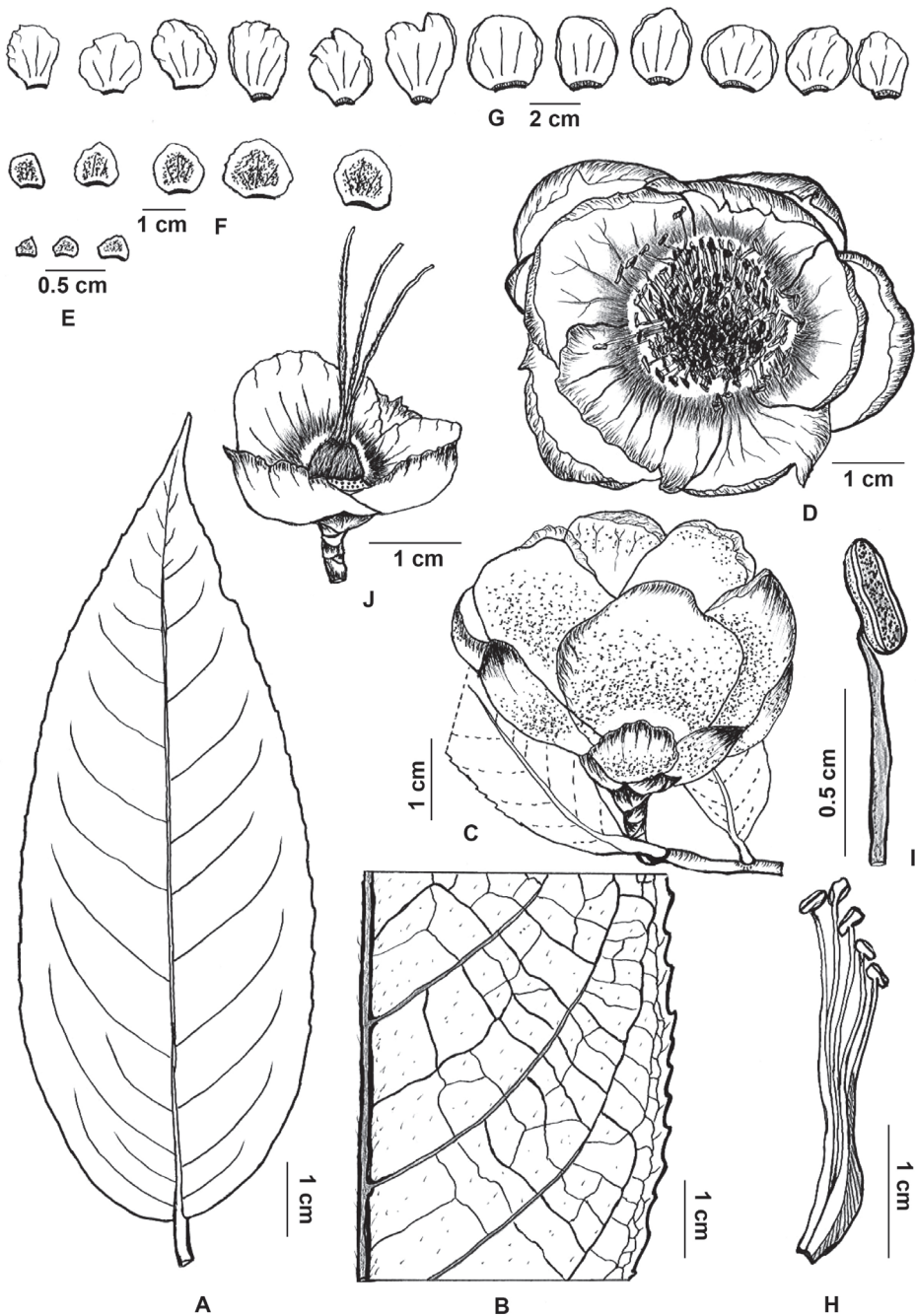


Figure 1. *Camellia puhoatensis*. **A** Leaf, adaxial view **B** venation detail of leaf (abaxial surface) **C** flower (lateral view) **D** flower (top view) **E** bracteoles (inner surfaces shown) **F** sepals (adaxial surfaces) **G** petals (adaxial surfaces) **H** androecium (one part) **I** stamen **J** gynoecium (with sepals and petals). Drawn from the holotype by Van-Dung Luong.

pedicel stout, covered by purplish-red perulae, 7–10 mm long, puberulous; flower buds unevenly globose in shape, 2.2–2.6 × 2.0–2.3 cm, yellowish-red tinted, open flowers somewhat circular; *bracteoles* (sensu Sealy 1958) 3–4, opposite, orbicular, 1.5–2.5 × 1.5–3.0 mm, abaxially red to yellow-red tinted, adaxially paler, glabrous, margins ciliate, persistent; *sepals* 5, persistent, orbicular or subglobose, 0.6–1.5 × 0.8–1.8 cm, abaxially dull red and pubescent, adaxially pale yellowish and glabrous, margins ciliate; *petals* 12–13, arranged in 3 whorls, bright yellow, sometimes with large red patch on the outer ones; outermost whorl comprising 3 or 4 petals, orbicular to broadly obovate, 2.2–2.8 × 1.6–2.3 cm, abaxially pubescent, adaxially glabrous; middle whorl comprising 4 or 5 petals, broadly obovate, 2.4–3.3 × 1.8–2.5 cm, abaxially pubescent, adaxially glabrous; innermost whorl of 3 or 4 petals, orbicular to broadly obovate, 2.3–2.5 × 1.7–2.2 cm, abaxially pubescent, adaxially glabrous, basally united with outermost filaments 5–7 mm. *Androecium* numerous stamens, in 4–5 whorls, light yellow, 2.5–2.8 cm long, glabrous; outer filaments basally united for 1.5–1.8 cm forming a cup, inner ones basally united for 3–5 mm, free above union; *anthers* yellow, 2.2–2.8 × 1–1.5 mm, with two longitudinal striations, dorsifixed. *Gynoecium* superior, 3–(4)-loculed, ovoid terminating into 3–(4) styles, 2.5–3.0 × 3.0–3.5 mm, slightly longitudinal striations, pubescent, 2 ovules per locule; *styles* free to the base, 1.8–2.3 cm long, pubescent. *Capsule* not seen.

Phenology. Flowering from November to January of the next year.

Distribution and habitat. *Camellia puhoatensis* is currently found only from the type locality. It grows on moist fertile and sandy soils along mountain streams and hill slopes in evergreen broad-leaved forests in Pu Hoat Nature Reserve, Vietnam, at elevations of 270–450 m.

Provisional conservation assessment. At present, only a single population of about 300 scattered mature individuals of *Camellia puhoatensis* was observed in the type locality, with an estimated extent of occurrence (EOO) less than 100 km² and an area of occupancy (AOO) less than 1 km². The population is highly threatened due to loss of habitat within its range and high market demands for wild, yellow-flowered camellias which are intensively collected for sale by local people. Therefore, *C. puhoatensis* is preliminarily categorised as Critically Endangered [B1ab (i, ii, iii) + 2ab (ii, iii), D], according to the IUCN Categories and Criteria (IUCN 2017).

Etymology. The specify epithet '*puhoatensis*' refers to the type locality.

Uses. Leaves and flowers were harvested and used for tea by the local people.

Additional specimens examined. Paratypes. VIETNAM. Nghe An Province: Que Phong District, Dong Van Commune, Pù Hoạt NR, 19°48'45"N, 105°5'39"E, 320 m elev., 2 September 2018, *Đỗ Ngọc Đài, Nguyễn Danh Hùng, Lê Thị Hương, DHH 120* (VNM); the same locality, 19°48'31"N, 105°05'43"E, 280 m elev., 16 January 2019, *Đỗ Ngọc Đài, Nguyễn Danh Hùng, Lê Thị Hương, DHH 790* (DLU), *DHH 791* (HN).

Vernacular name. Vietnamese language: Trà hoa vàng pù hoạt.

Taxonomic notes. The current infrageneric classification of *Camellia* is derived from three previous publications (Sealy 1958; Chang and Bartholomew 1984; Ming 2000) and was based on the assessment of morphological characteristics. The taxo-

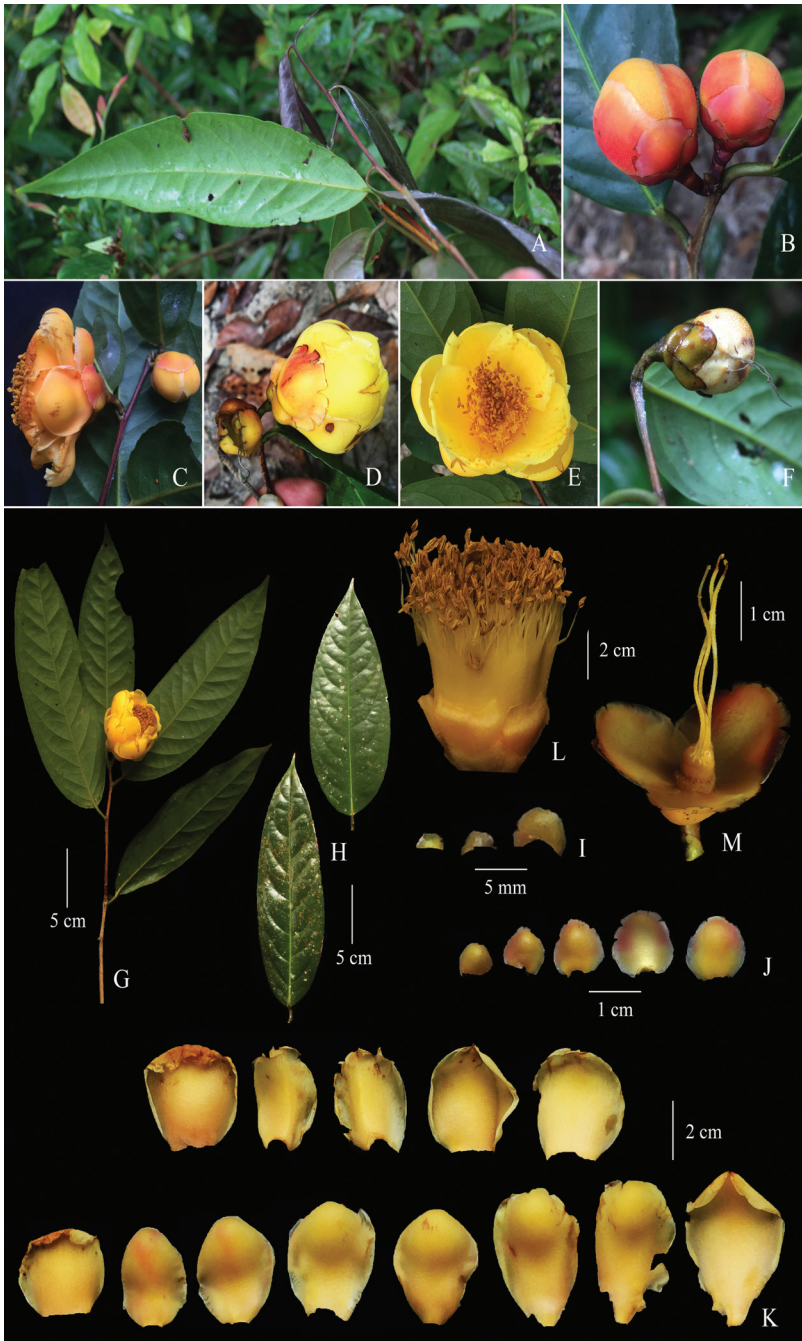


Figure 2. *Camellia puhoatensis*. **A** young shoot **B** terminal buds **C** solitary bud and axillary flower (side view) **D** flower and pollinated flower (side view) **E** close-up of flower (front view) **F** immature fruit **G** a part of branch showing leaves abaxial and opening flower **H** leaves adaxially **I** bracteoles **J** sepals **K** petals **L** androecium with stamens **M** gynoecium (with sepals and styles). Photos by Ngoc-Dai Do, the colour plate prepared by Ngoc-Sam Ly.

onomic system of Sealy (1958) and Chang and Bartholomew (1984) are used to describe and determine the placement of new taxa within *Camellia*. These systems are the most detailed and comprehensive study of the genus and also provide the basis for our current understanding of the genus. The taxonomic system of Ming (sensu Ming and Bartholomew 2007) was used for supplementary data only as it appears to be superficially similar to the system of Sealy (Orel and Wilson 2010a). In this paper, we have followed the Sealy's (1958) taxonomic system to consider the placement of the new species within Section *Archecamellia* Sealy of *Camellia*. Morphologically, *C. puhoatensis* possesses a solitary or paired flowers at terminal (sometimes axillary), stout, thick and erected pedicel, 3–4 persistent bracteoles, 5 persistent sepals (undifferentiated bracteoles and sepals), large yellow flowers with 12 tepals that are inner ones basally connate and adnate to androecium, androecium free above the union with the petals or unified for some distance to form a fleshy cup, filaments glabrous, gynoecium 3(–4)-loculi, styles 3(–4) and free to the base. These characteristics are not only identical to the species of sect. *Archecamellia* Sealy (sensu Sealy 1958; sensu Chang and Bartholomew 1984), but also share with species of sect. *Stereocarpus* which possesses 2 or 4 bracteoles (sensu Sealy 1958), terminal flowers (sensu Chang and Bartholomew 1984), stamens in 3–4 whorls, ovary with 3–5 locules (sensu Ming 2000), as well as sharing with species of sect. *Chrysantha* Chang, such as distinct peduncle, small floral bracteolates, yellow flowers, three carpels of gynoecium and separate styles (sensu Chang 1979). As characterized by Sealy (1958), sect. *Archecamellia* shares several traits with sect. *Stereocarpus*. These include a solitary and erected flower at the end of the branches, persistent bracteoles and sepals, stamens united with the petals and glabrous filaments. However, traits that are distinctive to sect. *Archecamellia* include (6–)11–16 indistinct bracteoles and sepals, 8–14 petals, glabrous or pubescent gynoecium and 3 or 5 free styles (vs. 2 or 4 bracteoles and 5 or 6 sepals, ca. 12 petals, glabrous gynoecium and a single style in sect. *Stereocarpus*). The sect. *Chrysantha* also shares several traits with sect. *Archecamellia* in having yellow and pedicellate flowers, persistent bracteoles and sepals, glabrous or hairy filaments and gynoecium, but it can be distinguished from sect. *Archecamellia* by the axillary flowers, distinct bracts and sepals and 3–5 cleft styles (Chang 1979). Section *Archecamellia* is currently comprised of 19 species (Sealy 1958; Ming 2000; Orel and Wilson 2012a; Do et al. 2019a). The new species is most similar to *C. chrysanthoides* H.T.Chang, *C. flavida* H.T.Chang and *C. petelotii* (Merr.) Sealy in having the same plant habit, somewhat oblong leaves, yellow flowers, glabrous 3-loculed gynoecium with 3 styles free to the base. A detailed morphological comparison between *C. puhoatensis* and these three species is provided in the above diagnosis and in Table 1. Moreover, *C. puhoatensis* also resembles *C. dormoyana* (Pierre) Sealy of sect. *Stereocarpus* (Sealy 1958) and *C. velutina* V.T. Pham et al. of sect. *Chrysantha* (Pham et al. 2019) by somewhat oblong leaves, yellow flowers and glabrous stamens. However, *Camellia dormoyana* is easily distinguished from *C. puhoatensis* by having the young shoots, mature leaves and petioles all glabrous, the sessile pedicel and 5–6 bracteoles abaxially velutinous, the abaxial petals silky velutinous, the ovary being glabrous and with five locules and the styles united for their entire length and glabrous.

Table 1. Morphological comparison of *C. puhoatensis* with its most closely-related taxa (based on Sealy 1958; Chang and Bartholomew 1984; Tran and Hakoda 1998; Pham et al. 2019).

Characters	<i>C. puhoatensis</i>	<i>C. chrysanthoides</i>	<i>C. flavida</i>	<i>C. petlotii</i>	<i>C. velutina</i>	<i>C. dormoyana</i>
Young shoot	puberulous	glabrous	glabrous	glabrous	glabrous	glabrous
Leaf blade	oblong ovate or oblong, 17–23 × 5–6.5 cm, base rounded or broadly obtuse, abaxially sparsely puberulous	oblong, 10–18 × 3.0–6.5 cm, base cuneate, glabrous	elliptic to oblong, 6.0–10 × 2.1–4.5 cm, base broadly cuneate, glabrous	broadly oblong or oblong-oval, 14.5–18 × 4.5–7.5 cm, base broadly cuneate, glabrous	oblong to elliptic, 15–22 × 5–11 cm, base broadly cuneate to rounded, glabrous	oval or oblong or ovate, 11–18(–25) × 5.5–8.5 cm, base cuneate to rounded, glabrous
Petiole	puberulous	glabrous	glabrous	glabrous	glabrous	glabrous
Flower	solitary (2 flowers), terminal, rarely axillary	solitary, mostly axillary	solitary, terminal and axillary	solitary, terminal	solitary, terminal or axillary	solitary, terminal
Pedicle	7–10 mm long	3–4 mm long	1–2 mm long	10–12 mm long	10–13 mm	sessile
Bracteoles	3–4, glabrous	4–6, abaxially pubescent	4–5, glabrous	(6–)8–10, abaxially puberulous	2(–3), abaxially velutinous	5–6, abaxially silky velutinous
Sepals	5, abaxially pubescent	5, abaxially puberulent	4–6, glabrous	5, abaxially puberulous	5, adaxially velutinous	abaxially silky velutinous
Petals	12–13, abaxially pubescent	8–9, abaxially puberulent	8, glabrous	ca. 14, abaxially puberulous	10(–11), velutinous	12, silky velutinous
Stamen	glabrous	glabrous	glabrous	glabrous	glabrous	glabrous
Ovary	3–(4) loculi, ovoid, pubescent	ovoid, 3 loculi slightly tomentose	globose, 3 loculi, glabrous	globose, 3 loculi, glabrous	3 loculi, ovoid, glabrous	globose, 5 loculi, glabrous
Style	3–(4), free to base, pubescent	3, free to base, glabrous or sparsely pubescent	3, free to base, glabrous	3, free to base, glabrous	3, free to base, glabrous	5, united, glabrous

Similarly, *C. velutina* is readily distinguished from *C. puhoatensis* by its glabrous young shoots, mature leaves and petioles, sepals that are silky velutinous abaxially and velutinous adaxially, the 10 (occasionally 11) petals that are silky velutinous and glabrous ovary and style (see Table 1).

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Several new records, synonyms, and hybrid-origin of Chinese begonias

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Abstract

Begonia is a mega-genus with about 2500 species by most estimates, with China having over 210 accepted species. After field surveys, literature review and examination of herbarium specimens, some new taxa, new records, synonyms and the hybrid-origin of some taxa have been confirmed. Here, we report that *Begonia dioica* Buch.-Ham. ex D.Don and *B. flagellaris* Hara, both from Xizang (Tibet) are new to China; *Begonia lipingensis* Hance, *B. muliensis* T.T.Yu and *B. sizemoreae* Kiew are synonyms of *B. circumlobata* Hance, *B. taliensis* Gagnepain and *B. longiciliata* C.Y.Wu, respectively; and *Begonia* × *lancangensis* S.H.Huang and *B.* × *malipoensis* S.H.Huang & Y.M.Shui are natural hybrids.

Keywords

Begoniaceae, China, the Himalayas, natural hybrid, Nepal, stolon, taxonomy, Tibet

Introduction

Begonia is a mega-genus with an estimated 2500 species (Tian et al. 2018) and, so far, there are about 1978 known accepted species (Hughes et al. 2015–present). China has over 210 accepted names of *Begonia* and its southwest region is one of the distribution centres of this genus. In the past two years, ten *Begonia* species were newly described

(Chen et al. 2018a, 2019; Ding et al. 2018; Li et al. 2018, 2019; He et al. 2019; Tian et al. 2019; Tong et al. 2019; Wang et al. 2019a) and many more are likely awaiting discovery and description in China. At the same time, several newly-recorded Chinese *Begonia* species (Yang et al. 2015; Wang et al. 2019b) and synonyms (Shui and Chen 2017; Chen et al. 2018b) have also recently been reported. With the support of the National Natural Science Foundation of China, we conducted many field surveys along with a review of literature and herbarium specimens related to Chinese *Begonia*. The diversity of Chinese *Begonia* is now better understood and several taxonomic issues have been resolved. Here, we report two new records, three new synonyms and two hybrid-origins of *Begonia* in China. Their conservation status was evaluated according to Guidelines for Using the International Union for Conservation of Nature (IUCN) Red List Categories and Criteria (v. 14) (IUCN Standards and Petitions Subcommittee 2019).

New records

In September 2017, Daike Tian and his associates searched for wild begonias in Xizang (Tibet) of China. During this trip, two new records of stoloniferous begonias were discovered, namely *Begonia dioica* Buch.-Ham. ex D. Don (Don 1825) from Chentang town of Dingjie County and *B. flagellaris* H. Hara (Hara 1973) from Jilong town of Jilong County. Both species are distributed near the border between China and Nepal. At the time, *B. dioica* had only immature fruits with persistent tepals, while very few plants of *B. flagellaris* were still in bloom.

Begonia dioica Buch.-Ham. ex D. Don [sect. *Diploclinium*]

Fig. 1

走茎秋海棠 (Chinese name)

Begonia dioica Buch.-Ham. ex D. Don [sect. *Diploclinium*] D. Don, *Prodr. Fl. Nepal.* 223. 1825: 223; R. Camfield & M. Hughes, *Eur. J. Taxon.* 396: 35. 2018.

Description. Tuberous, creeping, stoloniferous, dioecious, deciduous herb, 3–11 cm high. All plant parts glabrous. Tubers 2–3 (1–2 old, one new). **Stolon:** usually one to three developing from previous year's tuber, red, slender, 5–60 cm long, 1–2 mm thick, usually unbranched, rarely branched or towards the apex with many fibre-like branches in large individuals, one to many tiny white aerial bulbs on stolon tips, gradually turning red after stolons touch moss or rock surface. **Stipule:** lanceolate, 3–4 × 1–2 mm, glabrous, caduceous. **Leaf:** 1 per plant, basal, petiole green to red, 1–22 cm long, 1.5–5 mm thick, adaxially shallowly grooved along the full length; lamina narrowly deltate-ovate, basifixed, symmetric, 2.5–17 × 1.5–10 cm, upper surface green, underside green, pink green or red, venation palmate, 8–9, green to red, adaxially impressed, abaxially prominent, tertiary even secondary veins invisible; base shallowly cordate, auricles non-

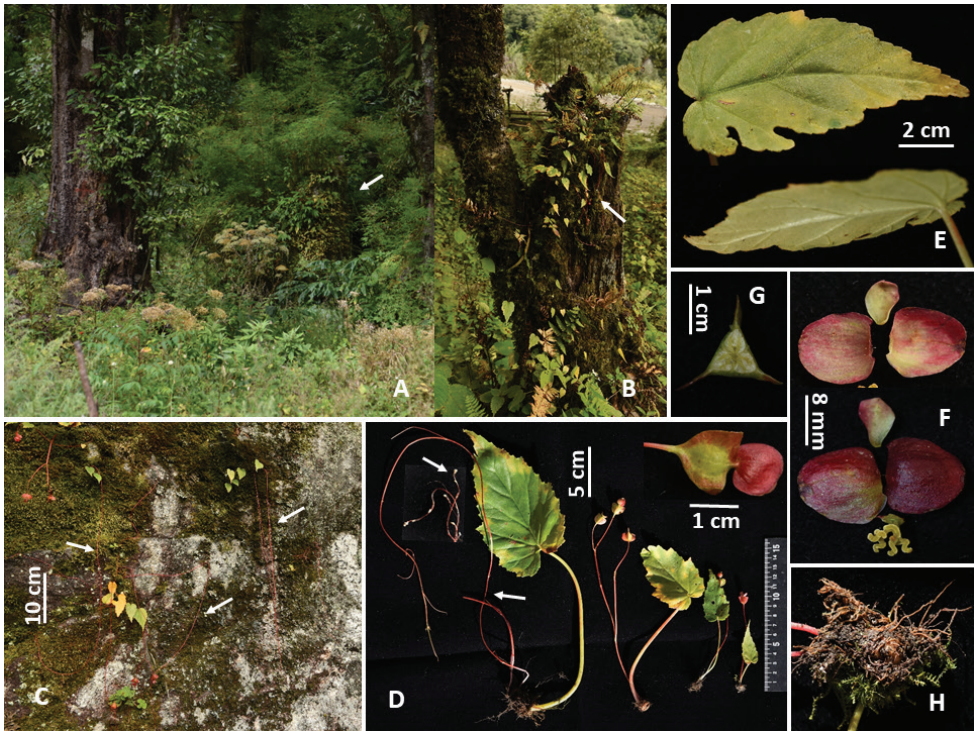


Figure 1. Habitat and morphology of *Begonia dioica* (Photos by Daike Tian) **A, B** habitat (rock-moss surface and tree trunk, arrows indicate begonia plants) **C** individuals with long red stolons (arrows indicate stolons) **D** plants of different size and stolons with small whitish aerial bulbs (arrows indicate tiny bulbs) **E** leaves showing glabrous adaxial (upper) and abaxial (low) surfaces **F** female flowers with three tepals (upper: adaxial view, low: abaxial view) **G** cross-section of ovary with bilamellate axile placentae and three locules **H** tubers under moss.

overlapped, margin crenate to dentate or double serrate; apex acuminate. **Inflorescence:** cymose, usually 1, terminal, 8–22 cm long, rachis pink to red, 6–10 cm long, 1–2 mm thick; peduncle branched up to three times, primary 5–10 cm long, secondary and tertiary 3–5 mm long, with 2–5 female flowers or 3–5 male flowers. **Bract:** lanceolate 2–8 × 1–2 mm, caduceous. **Male flower:** pedicel 10–25 mm long; tepals 4; outer tepals ovate-orbicular, 6–15 × 5–10 mm, pink to red, margin entire; inner tepals elliptic, 4–8 × 2–4 mm, white to pale pink; androecium with 15–20 stamens; filaments 1–2 mm long, unequal, fused at base into a short column; anther obovate, 1 mm long, dehiscent via short slits near the tip, not hooded, connective not extended. **Female flower:** pedicel 12–30 mm long; bracteoles absent; tepals 3 (occasionally 2), persistent, outer two larger, elliptic-ovate, nearly equal, 6–15 × 6–10 mm, pink to red, inner one smaller, lanceolate, 6–7 × 3–5 mm, white to pink; ovary 3-locular, placentae bifid; styles 3, persistent, deeply forked once and spirally 1.5–2 circled. **Fruit:** pendulous, capsule ellipsoid, 7–10 × 6–8 mm; wings 3, unequal or nearly equal, red or reddish-green, rounded-triangular, 2–6 × 7–12 mm, stalk red, 15–40 mm long, 0.8–1 mm thick.

Specimen collected from China. XIZANG (Tibet): Chentang Zhen of Dingjie Xian, 27°50'54.11"N, 87°26'30.70"E, alt. 2427 m, on rock surface and tree trunks. 19 Sept 2017, *Daiké Tian, Yan Xiao and Zhu Lu TDK3306* (CHS).

Distribution and phenology. Southern Xizang of CHINA, northern PAKISTAN, northern INDIA, NEPAL and BHUTAN; alt. 1350–2430 m; Flowering July to September, fruiting August to November.

Conservation status. Least Concern (LC). *Begonia dioica* has numerous suitable habitats throughout its distribution range (Camfield and Hughes 2018). However, it should be considered as Critically Endangered (B2ab(v)) for China at the country level because only one population has been found so far and a continuing decline in the number of mature individuals is predicted due to road construction and other human activities.

Remarks. Most of the individuals develop long stolons only from tubers formed in the previous year. The stolons are often branched in large individuals and the branch tops produce one to many tiny whitish bulbs, which grow larger as they touch the surface of a rock, tree trunk, soil or moss and then can develop into small plants in the second year. The tepals of female flowers are always persistent, even as the fruits mature.

Begonia flagellaris Hara [sect. *Diploclinium*]

Fig. 2

鞭状秋海棠 (Chinese name)

Begonia flagellaris Hara [sect. *Diploclinium*] *J. Japan. Bot.* 48(12): 358–359, f. 3 (1973).

Description. Tuberous, stoloniferous, dioecious, deciduous herb, 2–20 cm tall. Tubers usually 2–4 (1–3 old, red-brown, one new, white) connected, 3–15 mm diameter. **Stolon:** developing from underground tubers or inflorescence; usually one per plant, green, unbranched to rarely branched, glabrous, slender, 10–50 cm long, 2–5 mm thick, aerial bulbs produced at stolon tips, 1–5 mm thick. **Leaf:** usually one basal large and none to several smaller cauline (on stolons or peduncles), petiole green, 2–28 cm long, 1.5–7 mm thick, sparsely hairy; lamina basifixed, symmetric or nearly so, cordate, 2.5–26 × 1.2–28 cm, adaxial surface green, with short warty-base hairs, underside pale green, sparsely hairy; venation palmate, 9–11, green, adaxially impressed, abaxially prominent, base cordate, auricles non-overlapped to slightly overlapped, margin irregularly serrate to occasionally double serrate, rarely one to few shallowly lobed; apex acuminate. **Inflorescence:** simple umbellate, 1–2 from the lower part of the stem, 6–20 cm long, rachis green to pink, 4–17 cm long, 2–3 mm thick; peduncle nearly erect, glabrous. **Male flower:** white to pinkish, pedicel 14–28 mm long, 1 mm thick, top sparsely hairy; corolla 18–24 × 10–12 mm, tepals 4, outer 2, ovate, subequal, 7–12 × 7–11 mm, upper one centre thick and concave, adaxially white hairy, up 1 mm long, less hairy on lower tepal; inner 2, glabrous, obovate to obovate-lanceolate, 7 × 4–5 mm; androecium leaning towards upper tepal, stamens 10–14, filaments free, about 1 mm long, anther elliptic, up to 1.5 mm long, 0.8 mm wide, apex obtuse.

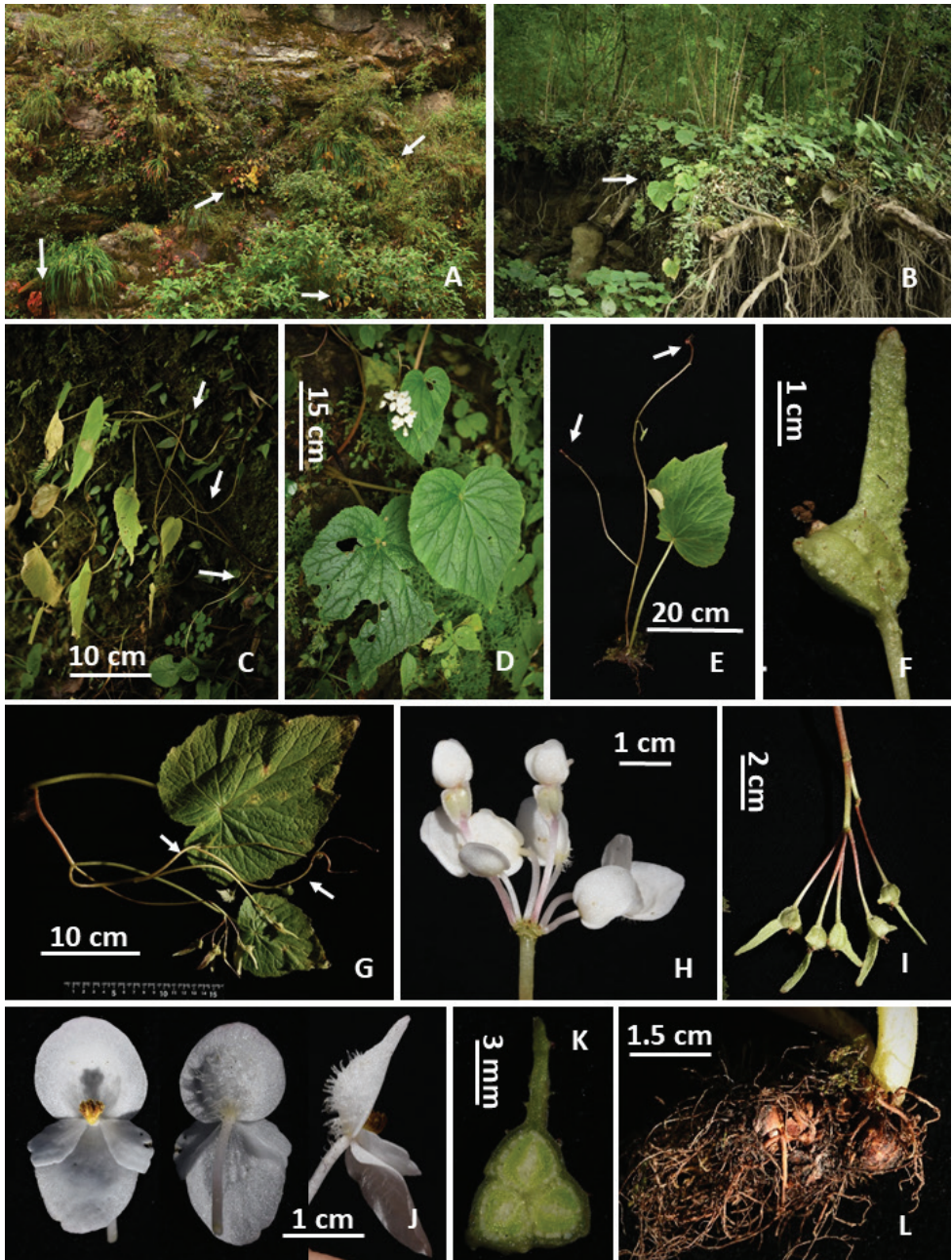


Figure 2. Habitat and morphology of *Begonia flagellaris* (Photos by Daike Tian) **A, B** habitat (rock hill or under bamboos, arrows indicate begonia plants) **C** individuals with long stolons **D** flowering plant **E** individual with aerial bulbs on stolon tips (arrows indicate tiny aerial bulbs) **F** fruit with extremely unequal wings **G** large individual with stolons (arrows indicate stolons) and fruits **H** simple umbellate inflorescence with white male and female flowers **I** infructescence **J** male flowers in front, dorsal and side views, respectively **K** cross-section of an ovary with the bilamellate axile placenta and three locules **L** underground tubers.

Female flower: pedicel 20–35 mm long, 1 mm thick; tepals 5, unequal, glabrous; ovary hairy, 3-locular, placentae bifid; stigmas and styles 3. **Fruit:** pendulous, capsule ellipsoid, 6–9 × 4.5–5 mm; wings 3, unequal, green, adaxially wing extremely long, narrowly triangular, 10–28 × 5–7 mm, lateral wings extremely narrow to nearly absent; stalk red at lower part, 24–40 mm long, 1 mm thick.

Specimen collected from China. XIZANG: Jilong Xian, Jilong Zhen, under bamboos, 28°21'41"N, 85°21'12"E, alt. 2030 m, 23 Sept 2017, *Daike Tian, Yan Xiao and Zhu Lu, TDK3343* (CHS); on steep slope under forest or rocky hill, 28°21'48"N, 85°21'43"E, alt. 2360 m, same date, *Daike Tian, Yan Xiao and Zhu Lu, TDK3344* (CHS).

Distribution and phenology. CHINA: Xizang, Jilong Xian, Jilong Zhen, border of China and Nepal; NEPAL. Alt. 1650–2900 m. Flowering August to September (early October), fruiting September to November.

Conservation status. Near Threatened (NT). *Begonia flagellaris* is distributed in both Nepal and China, and there are many individual plants in each population. However, this species should be considered as Endangered (B1ab(iii)) for China because only two populations have so far been found and both are by the roadside.

Remarks. Stolons develop from underground tubers or the top of inflorescence (usually on larger plants), with several small leaves. Hara (Hara 1973) compared the similarity between this species and *B. picta* J.E.Smith (Smith 1805); however, the two are quite different in appearance. *Begonia flagellaris* is mostly similar to *B. adscendens* C.B.Clarke (1890: 26), but differs mainly by having long stolons and more hairs on the outer tepals of the male flowers.

New synonyms

Begonia circumlobata Hance, *J. Bot.* 21: 203, 1883 (Hance, 1883)

Fig. 3

-*Begonia lipingensis* Irmscher, *Mitt. Inst. Allg. Bot. Hamburg* 6: 353, 1927 (Irmscher 1927). syn. nov. Type: China, Kweitschou (Guizhou), Liping, alt. 600 m, 21 July 1917, *Handel-Mazzetti 10909* (holotype: WU0038812, WU!; isotype: E00265121, E!)

Type. China, Canton (Guangdong), 05 Oct 1881, *Rev. Benjamin Couch Henry s.n.* (BM000944652, BM!).

Note. *Begonia lipingensis* has been treated as a species differing from *B. circumlobata* in *Flora Reipublicae Popularis Sinica* (Ku 1999) and *Flora of China* (Gu et al. 2007). The species was based on small-sized mature plants that were collected from Liping County of Guizhou Province, China (Fig. 3A–C). However, the species could not be separated when comparing the specimens and living plants in the wild. Many specimens stored in herbaria of China or other countries were identified with both

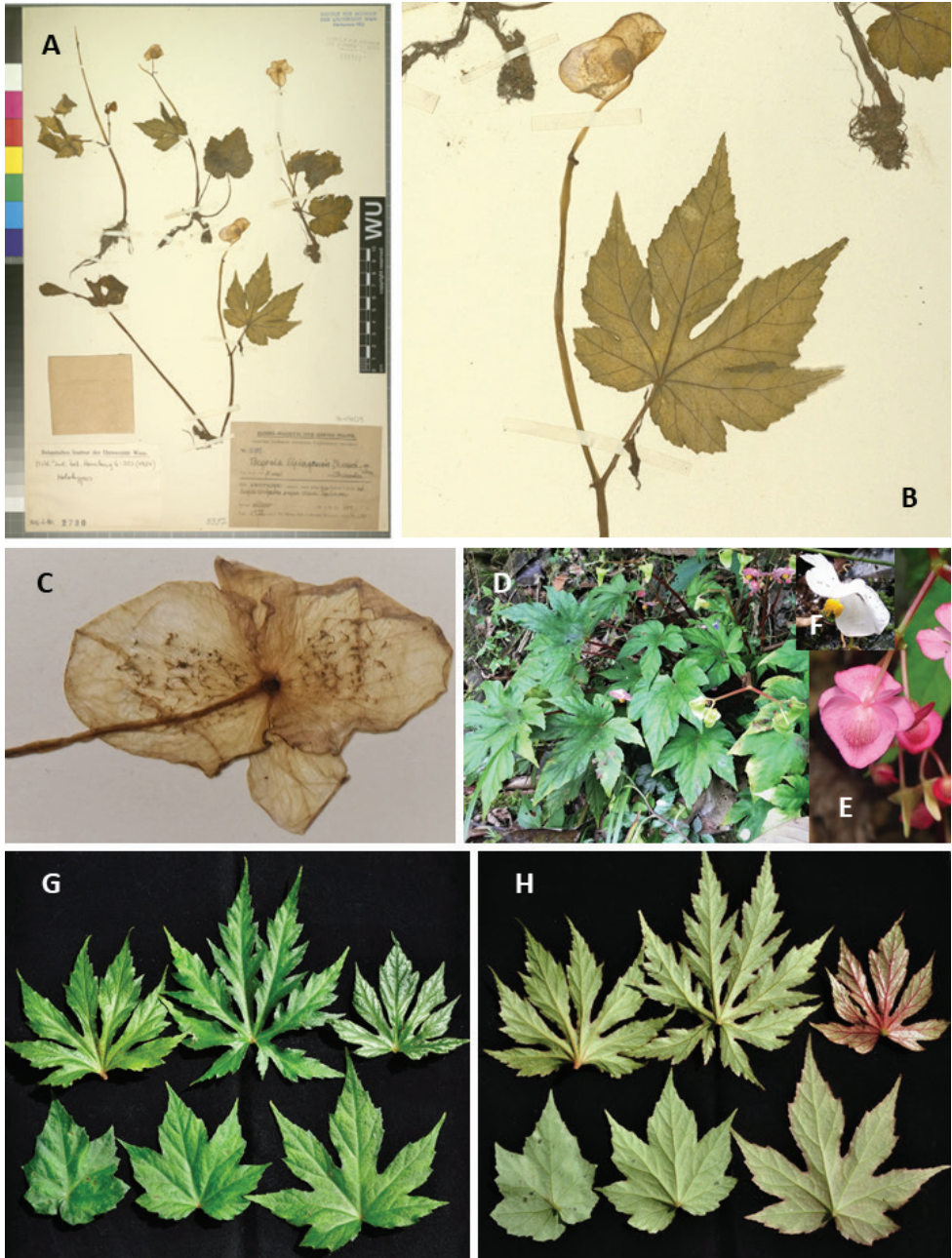


Figure 3. *Begonia lipingensis* and *B. circumlobata* (E–H photos by Daike Tian) **A–E** *Begonia lipingensis*: **A** holotype (WU) (digitalised by Herbarium of Institut für Botanik der Universität Wien) **B** close-up view of type leaf **C** close-up of male flower from holotype, showing abaxial hairs on the middle of outer tepals **D** wild blooming plants **E, F** male flowers showing colour variation **G, H** *Begonia circumlobata*: adaxial (**G**) and abaxial (**H**) views showing variations of leaf lobes and colour in a single small population.

names. After our careful review of type specimens and comprehensive field surveys on a large number of populations of both entities, it was confirmed that no differences could be found between them. Since *B. lipingensis* was described later, it should be considered as a synonym of *B. circumlobata*.

Begonia circumlobata displays significant variation in plant size, morphology of leaves, and flowers (Fig. 3E–H). The leaves may be shallowly to very deeply lobed in the same population, even for the same individual and very few of the plants are shallowly double-lobed like *B. jinyunensis* C.I Peng, B.Ding & Q.Wang (Ding et al. 2014) (Fig. 3G, H). The leaves of most plants are pure green on two sides, while others may have deep green leaves with abxially red surface. Occasionally, variegated plants with white-spotted leaves could be seen in some populations such as in Huangsang National Nature Reserve of Suining, Hunan Province. Flowers can be white, whitish-pink, pink or nearly red (Fig. 3D, E).

Distribution and phenology. *Begonia circumlobata* is widely distributed in at least seven provinces of China, from western Hubei to Hunan, Jiangxi, Fujian, Guangdong, Guangxi and Guizhou, growing on flat areas, steep slopes or rock surfaces along or near stream and valley. Alt. 200–1230 m (Fig. 4). Flowering June to September, fruiting July to October.

Conservation status. Least Concern (LC) due to wide distribution and usually large populations. However, in some places, a small number of plants with variegated

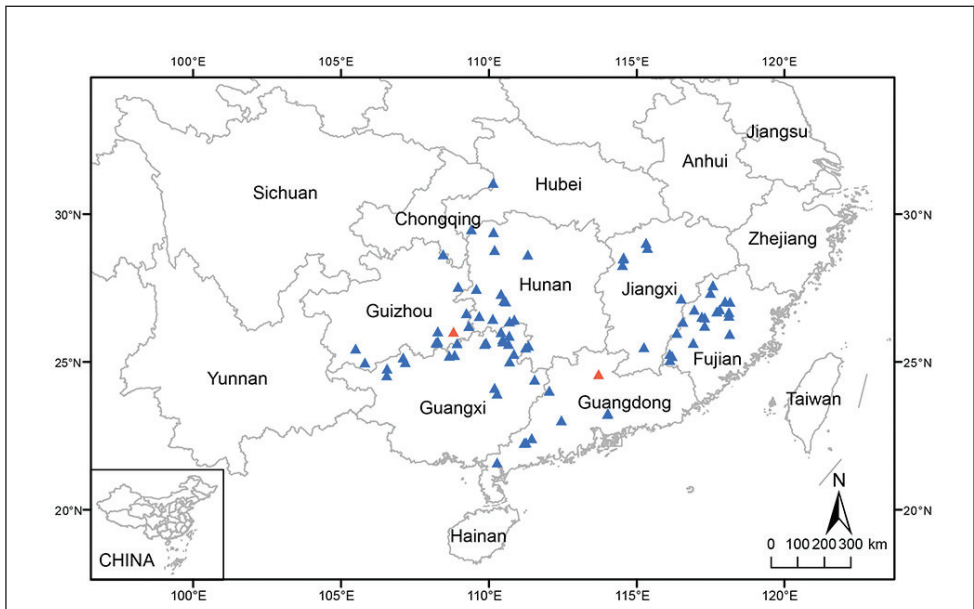


Figure 4. Distribution map of *B. circumlobata* (including syn. *B. lipingensis*) Triangles show distribution based on specimens and field surveys and red triangles indicate type locality of *B. circumlobata* (Guangdong) and *B. lipingensis* (Guizhou), respectively.

leaves (adaxially white spots) have high value as ornamentals. Therefore, these variegated individuals may be over-collected by humans.

Remarks. *Begonia circumlobata* has sparsely hairy leaf blades and outer tepals of male flowers (Fig. 3C). It is most similar to *B. jinyunensis* and *B. laminariae*, particularly in the morphology of its leaves, flowers and fruits. *Begonia circumlobata* is also easily confused with some individuals of *B. pedatifida* Lév. (Léveillé 1909), particularly when examining herbarium specimens. Unpublished morphological and molecular data (Tian et al.) suggests that *B. jinyunensis* should be treated as a subspecies of *B. circumlobata*. At the same time, a study is ongoing concerning the taxonomic relationship of *B. circumlobata*, *B. lamariae* Irmsch. (Irmscher 1951) and *B. pedatifida*. Since plants with intermediate morphology amongst these three taxa exist in the wild, it appears that gene flow or natural hybridisation might occur between them.

***Begonia longiciliata* C.Y.Wu, Acta Phytotaxon. Sinica 33(3): 251, 1995 (Wu and Ku 1995)**

Fig. 5

-*Begonia sizemoreae* Kiew, Gard. Bull. Singap. 54(6): 95–100, 2004. syn. nov. Type: Vietnam, Ha Tay Province: Ba Vi National Park, no date, *R. Kiew* 5304 (holotype: SING!; isotype: HN!).

Type. China, Guizhou: Anlong, alt. 990 m, 14 May 1960, *Guizhou Exped. 5117* (holotype: KUN!; isotype: PE!).

Note. *Begonia longiciliata* (Fig. 5) is mostly close to *B. rex* Putz. (Putzey, 1857), but differs mainly by its narrower tepals of both its male and female flowers and longer anthers (up to 4 mm long) with acuminate tips that occur towards the apex of the androeium (Fig. 5I). Notably, it has large variation in leaf colour, variegation patterns and flower colour varying from white, pink to even nearly red (Fig. 5). *Begonia rex* is only found in India, while *B. longiciliata* has a wide distribution from Guizhou, Guangxi and southern Yunnan of China, to the north of both Laos and Vietnam (Fig. 7). The name *longiciliata* probably refers to the long fibre-like hairs found on the adaxial leaf surface in some populations of this taxon in Guizhou Province (type locality) (Fig. 6B), but most populations have glabrous adaxial leaf surface or nearly so (Fig. 6C) particularly in Yunnan Province. It is also similar to *B. annulata* K.Koch (Koch, 1837) in leaf morphology, but can be easily separated by the latter's hairy (vs. glabrous) tepals of both male and female flowers and fruits (Camfield and Hughes 2018).

Begonia longiciliata has been wrongly treated as *B. rex* in China (Ku 1999; Gu et al. 2007) and was even treated as a new species (*B. sizemoreae*) in 2004 (Kiew 2004), based on a type specimen collected in Ba Vi National Park in northern Vietnam. The material from China, Vietnam and Laos is mostly similar; the imaged type plants of *B. sizemoreae* from northern Vietnam are nearly identical to plants of *B. longiciliata* from China; *B. longicilata* and *B. sizemoreae* are distributed mostly along the China-Viet-

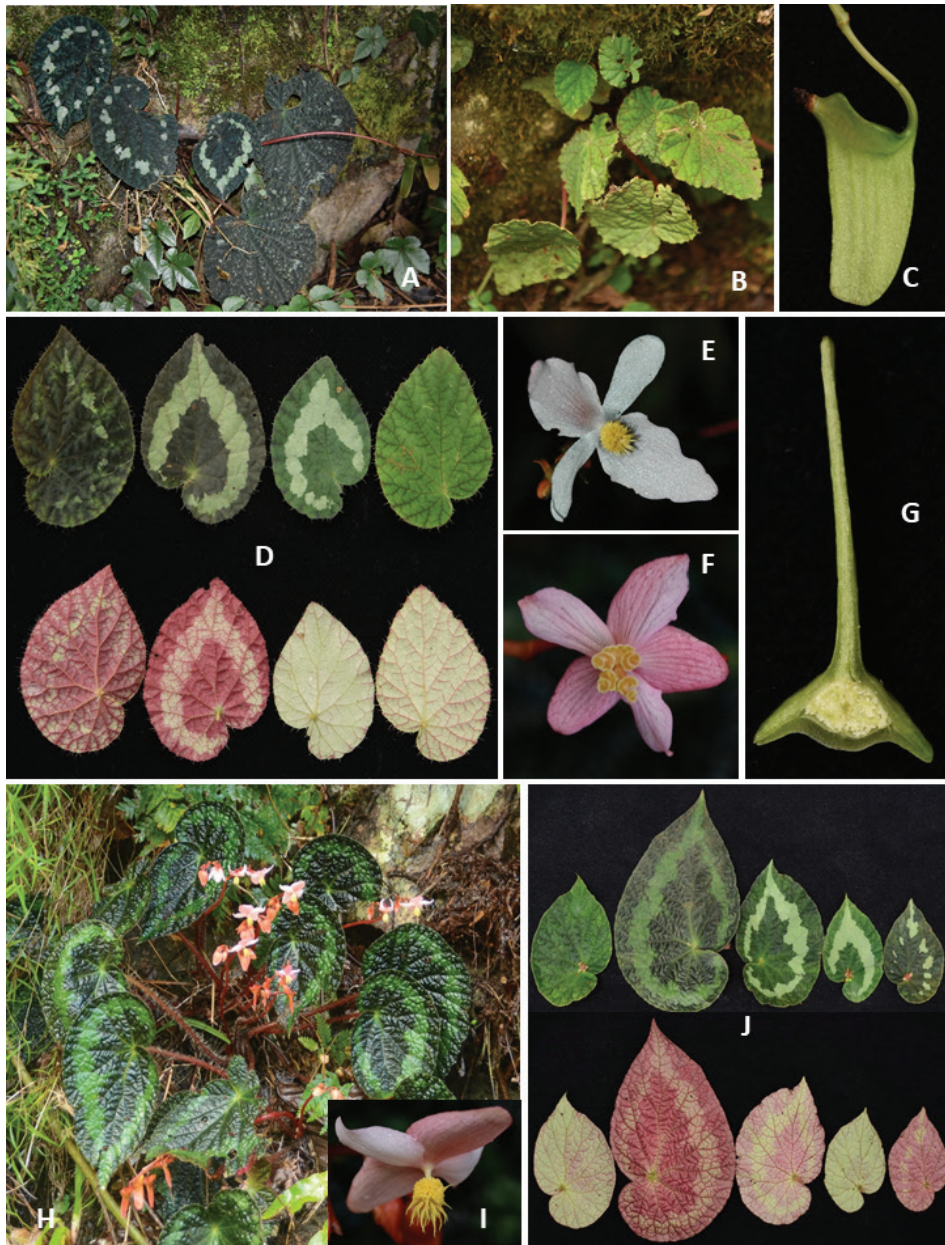


Figure 5. Morphological variation of *Begonia longiciliata* in China (Photos by Daike Tian) **A–E** population from Guizhou Province: **A** individual with dark green leaves and white variegation (near white ring or isolated white spots) **B** pure green-leaved individual **C** fruit with one long wing and two short wings **D** comparison of adaxial (upper) and abaxial (low) views of leaf variation in colour and variegation **E** male flower (deep-pink one not shown) **F–J** population from Yunnan province: **F** female flower, showing pink variant **G** cross-section of ovary showing two locules and bilamillate placenta **H** dark-green leaved individual with a light-green ring band **I** male flower showing very long anther in upper portion of androecium **J** comparison of adaxial (upper five leaves) and abaxial (lower five leaves), showing differences in leaf colour and variegation of different individuals.



Figure 6. Comparison on hairy and glabrous adaxial leaf surface of *B. longiciliata* **A** plant with hairs (cultivated as *Begonia* U388, American Begonia Society Conference 2012) **B** Guizhou population with hairs (arrow direction) **C** Yunnan population with glabrous adaxial leaf surface. (Photos by Daike Tian).

nam boundary regions; recently, the species was recorded as *B. sizemoreae* in northern Laos (Ding et al. 2020); no stably different key characteristics are found between *B. longiciliata* and *B. sizemoreae*. Therefore, *B. sizemoreae* is considered by us as a synonym of *B. longiciliata*.

Specimens examined. CHINA: **Yunnan, Jiangcheng:** Kukazai Qushui, 14 Dec. 1991, Guoda Tao 49032; Tukahe, 18 Dec 1991, Guoda Tao 47818, 49127 (HITBC); Jiahe, 23 Sept 2015, Daike Tian et al. TDK2659 (CHS). Pingzhangzhai, Pingzhang village, Jiahe, 30 Oct 2012, Jiangcheng Survey Team 5308260564 (IMDY); Jiahe to Xiaoheijiang, 21 Oct 2011, Daike Tian et al. TDK252, TDK253 (CHS); Jiangcheng county to Daheishan, 21 Oct 2011, Daike Tian et al. TDK257 (CHS). **Jinping:** Riverside, 22 Oct 2008, Xiaohua Jin 9467 (PE); Laomeng, 22 Nov 2007, Yumin Shui et al. 80105 (KUN). **Lüchun:** Laomenghe, 22 May 1974, Lüchun Team 1092 (KUN); Huanglianshan, 30 Oct 1995, Sugong Wu et al. 379 (KUN), 31 Oct 1995, Sugong Wu et al. 3354 (KUN), Sugong Wu et al. 3354 (PE), 01 Nov 1995, Sugong Wu et al. 2609 (KUN); Xiaoheijiang, 18 Oct 2000, Yumin Shui & Wenhong Chen 13132, 13797 (KUN); Erpu to Banpo, 22 Oct 2000, Yumin Shui & Wenhong Chen 13620, 13696 (KUN); Erpu to Dapu, 23 Oct 2000, Yumin Shui & Wenhong Chen 14138 (KUN); 24 Oct 2000, Yumin Shui & Wenhong Chen 13848 (KUN); Xinzhai, Erpu, 03 Nov 2007, Yumin Shui et al. 72970 (KUN); Shiyazi, Daheishan, 22 Nov. 2011, Jianghai He et al. HLS0353 (KUN); Lüchun county to Manhao of Gejiu county, 25 Aug 2013, Daike Tian et al. TDK1281, TDK1283 (CHS); Daheishan, 23 Sept 2015, Daike Tian et al. TDK2661 (CHS); Dashuigou, 23 Sept 2015, Daike Tian et al. TDK2663 (CHS); Cheli of Pinghe, 23 Sept 2015, Daike Tian et al. TDK2680 (CHS); Xiaoheijiang, Xinzhai of Pinghe, 24 Sept 2015, Daike Tian et al. TDK2683, 2685 (CHS). **Luquan:** Mayu, 30 Oct 1995, Sugong Wu et al. 379 (PE). **Mengla:** Xishuangbanna Tropical Botanical Garden, Menglun, 21 Sept 2015,

Daike Tian et al. TDK2629 (CHS) (cultivated). **Guangxi, Longlin:** Jinzhongshan, 23 May 1977, Zhou Fakai 3-0701 (GXMI); Same locality, 24 Sept 1984, Chinese Medicine Team 0185 (GXMI). **Tian'e:** Xiangyang, 01 May 1978, Tian'e Team 4-6-0255 (GXMI). **Guizhou, Anlong:** Huali of Tingya, 14 May 1960, Zhisong Zhang & Yongtian Zhang 3320 (PE); Xiaojiatang, Lishu village of Dushan, 15 Oct 2017, Daike Tian et al. TDK3473 (CHS); Xiaohanhe, Pojing of Dushan, 15 Oct 2017, Daike Tian et al. TDK3474 (CHS). **Xingyi:** Daojiao, Gongqiao of Zerong, 14 Oct 2017, Daike Tian et al. TDK3460 (CHS). **Zhenfeng:** 19 Sept 1936, Shiwei Deng 90987 (IBSC). **Unknown county:** Feb 1921, M. Cavalerie, unknown collection no. (P06841311) (P); Oct 1917, M. Esquirol, unknown collection no. (P05495115) (P).

LAOS: Phongsaly, Tan et al. L0559 (HITBC) (Ding et al. 2020).

VIETNAM: Ba Vi National Park, Ha Tay province, R. Kiew 5304 (SING, HN); Tonkin (Mountain Bavi), Dec 1887, B. Balansa 3765 (P); Tonkin, 29 Apr 1936, M. Polane 25811 (P).

Distribution and phenology. **CHINA:** **Guangxi** (Longlin, Tian'e), **Guizhou** (Anlong, Xingyi, Zhenfeng), **Yunnan** (Jiangcheng, Jinping, Lüchun, Luquan); **LAOS** (Phongsaly); **VIETNAM** (Ba Vi) (Fig. 7). Alt. 300–1300 m. Flowering May to November, fruiting June to December.

Conservation status. Near Threatened (NT). *Begonia longiciliata* has a relatively broad distribution, particularly in the borders of China, Laos and Vietnam (Fig. 7); however, the size of most populations is small and the habitats are fragmented. Its distribution range is extremely narrow in both Guangxi and Guizhou provinces of China. Several populations exist with less than 20 or even 10 individuals. In these two provinces, the population size continues to decrease, with very little seedling recruitment,

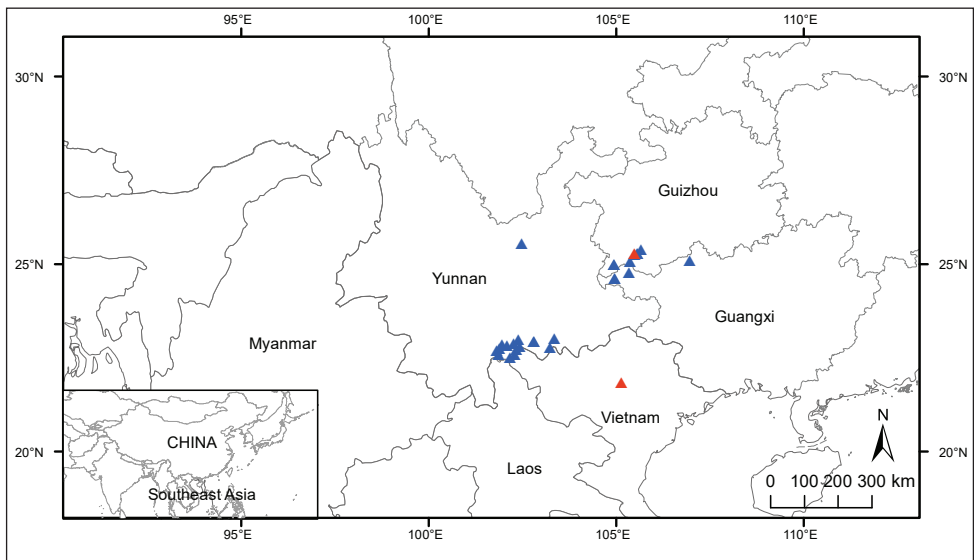


Figure 7. Distribution of *Begonia longiciliata* (including syn. *B. sizemoreae*) Triangles show distribution based on specimens and field survey and red triangles indicate type locality of *B. longiciliata* (Guizhou, China) and *B. sizemoreae* (Bavi, Vietnam), respectively.

due to habitat deterioration and disturbance from agricultural activities. This species also needs an environment that has a high level of humidity to survive well. Additionally, because of its beautiful foliage, wild plants are at risk of overharvesting, therefore, it should be considered Vulnerable (B2ab(iv)) in China.

Remarks. *Begonia longiciliata* has been treated as a synonym of *B. rex* for a long time in China (Ku 1999; Gu et al. 2007). Several horticultural cultivars have been produced by crossing it with other *Begonia* taxa at Kunming Botanical Garden of China (Tian et al. 2001, 2002). However, *B. rex* has not been collected or observed in the wild in China. It was recorded in several locations from Arunachal Pradesh (Camfield and Hughes 2018) (called southern Tibet by China), a currently China-India disputed region. In addition, *B. longiciliata* was previously cultivated under the code U3888 (with long hairs on adaxial leaf surface, Fig. 6A) by the American Begonia Society and these cultivated plants were correctly identified as *B. longiciliata* by Golding (Golding 2004), but were later treated by other researchers as *B. rex* (Ku 1999; Gu et al. 2007) or *B. sizemoreae* (Tebbutt 2005). *Begonia longiciliata* is officially established, based on our extensive field surveys, literature review, specimen examination and the observation of plants in cultivation. According to their morphological similarity and adjacent distribution, *B. longiciliata* and *B. rex* are similar to each other and they may have differentiated possibly due to geographic isolation. Further investigation is needed on their relationship and whether it is more reasonable to treat *B. longiciliata* as a subspecies or variety of *B. rex*.

***Begonia taliensis* Gagnepain, Bull. Mus. Natl. Hist. Nat. 15: 279, 1919**

Fig. 8

-*Begonia muliensis* T.T.Yu, Bull. Fan. Mem. Inst. Biol., 1:119, 1948 (Yu 1948). syn. nov.

Type: China, Sichuan: no locality data, no date, T.T. Yü, 14024 (A!)

Type. China, Yunnan: Tali (Dali), 4 Sept. 1883, J.M. Delavay 220 (Lectotype, P!, designated here).

Note. *Begonia taliensis* is relatively widely distributed in many counties from Yunnan Province to Sichuan Province in China (Fig. 9). It exhibits considerable variation in size of plant, leaf and inflorescence, shape of lobes, leaf colour and blade variegation patterns (Fig. 8). However, its net-like pattern of red lines on the fruits is a stable character (Fig. 10F, left corner). There is no distinction in distribution and morphology between it and *B. muliensis* (isotype, Fig. 10D) (HU). In addition, when *B. taliensis* was described and published, the author (Gagnepain 1919) cited three collections of specimens: Ducloux 5184 (B), Delavay 220 (P), and Henry 8946 (P) (Fig. 10). Unfortunately, he did not assign a type specimen. Of these, Ducloux 5184 and Delavay 220 were collected from Dali in Yunnan Province and both are significantly different only in plant size. However, Henry 8946 was collected from somewhere (possibly near Kangding County) in Sichuan Province. Dali and Kangding are at least 600 km apart. In fact, Henry 8946 is a specimen of *B. imitans* Irmsch. (1939: 51) (Fig. 10C) (lobed over 2/3). The relationship between *B. taliensis* and *B. imitans* remains unknown and



Figure 8. Habitat and morphology of *B. taliensis* (Photos by Daike Tian) **A** habitat **B** population with pure-green leaves **C, D** blooming individuals with variegated leaves **E** comparison of variegated and solid green-leaved individuals (adaxially and abaxially views) **F–H** inflorescence of large individuals and young fruits with red lines (**G**) **I** underground tubers (usually 2–3 connected) with numerous roots.

further study is undergoing. Based on our literature review, field survey and type specimens, Delavay 220 is designated here as the lectotype of *B. taliensis* and Dulcoux 5184 as its syntype. The syntype Henry 8946 belongs to another species and should not be considered for future nomenclatural decisions.

Distribution and phenology. CHINA: Sichuan (Daocheng, Dechang, Luding, Meigu, Mianning, Muli, Panzhihua, Shimian, Tianquan, Yanbian, Xide); Yunnan (Dali, Eyuan, Heqing, Lijiang, Yangbi, Yongsheng, Zhongdian) (Fig. 9). Alt. 1000–3200 m. Flowering July to October, fruiting August to November.

Conservation status. *Begonia taliensis* has a relatively-wide distribution (recorded or observed in nearly 20 counties of two provinces in China, Fig. 8), but the size of most

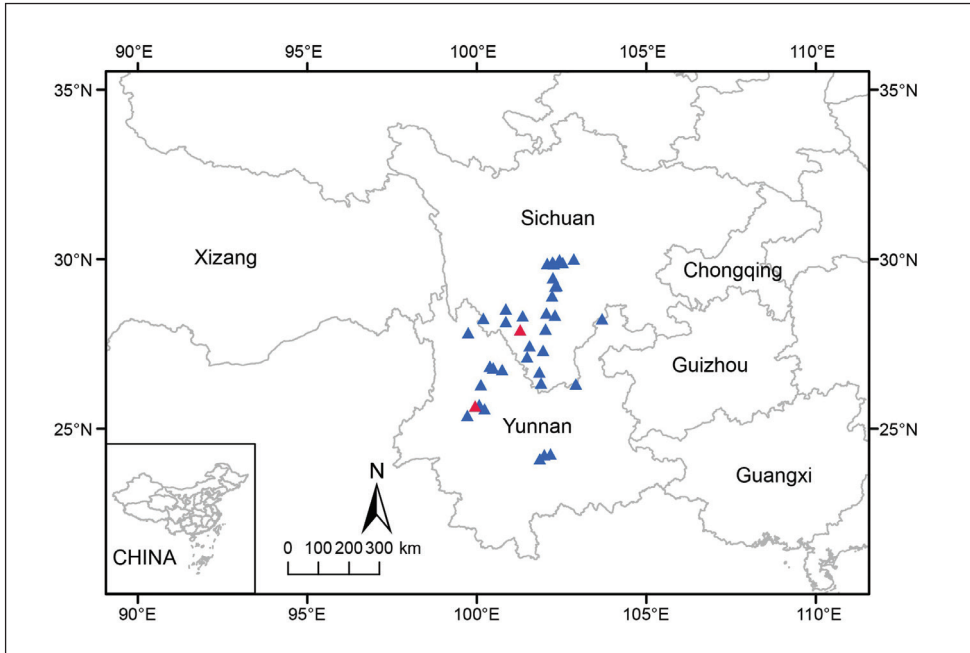


Figure 9. Distribution map of *Begonia taliensis* (syn. *B. muliensis*) Triangles show distribution sites, based on specimens and field surveys and red triangles indicate type locality of *B. muliensis* (Muli of Sichuan) and *B. taliensis* (Dali of Yunnan), respectively.

populations is usually small. In addition, many of its distribution sites are near roadsides; therefore, the habitats could be easily disturbed by human activities. Additionally, this species is used as an ornamental due to its beautiful foliage and flowers or as a vegetable by local residents (Yang et al. 2018). Continuous human collection for different purposes may cause a decrease in population size and individual numbers. Therefore, its conservation status should be currently considered Near Threatened (NT).

Remarks. The leaf colour of *B. taliensis* varies amongst populations and occasionally even amongst the individuals of a small population. The plants usually have leaves with abaxially purple-red blotches. Sometimes, a few plants or even all individuals of a small population are pure green in leaf colour. The leaf could be shallowly to 1/2 deeply lobed (vs. over 2/3 deeply lobed for *B. imitans*) depending on plant size or distribution site. The flower number ranges from around 10 for a small flowering individual to over 100 for a large one.

Hybrid-origin taxa

Natural hybridisation is very common in *Begonia* and 50 populations of 31 natural hybrids involving 29 species have been recorded in Chinese wild begonias (Tian et al. 2017). Based on morphological and molecular analysis (Tian et al. 2017),



Figure 10. Comparison of types of *Begonia taliensis* (A–C) and *B. multiensis* (D) **A** Ducloux No. 5184 (Yunnan) **B** Delavay No. 220 (Yunnan) **C** Henry 8946 (Sichuan) **D** T.T. Yü #14024 (Sichuan) (**A** accessed JSTOR and imaged by Botanical Museum Berlin-Dahlem **B, C.** Photos by Daike Tian at Herbarium Museum of Paris **D** accessed JSTOR, Imaged by Herbarium of the Arnold Arboretum, Harvard University).

two previously published species are considered to be of hybrid origin: *B. lancangensis* S.H.Huang (Shui and Huang 1999: 13) and *B. malipoensis* S.H.Huang & Y.M.Shui (Huang and Shui 1994). Therefore, these two species are formally recognised here as hybrids.

***Begonia* × *lancangensis* S.H.Huang**

Fig. 11A, B

-*Begonia lancangensis* S.H.Huang, *Acta Bot. Yunnanica* 21:13, 1999; S.H. Huang & Y.M. Shui in C.Y. Wu (ed.), *Fl Yunnan* 12: 230, 2006; T.C. Ku et al. in C.Y. Wu & P.H. Raven (eds), *Fl. China* 13: 181, 2007.

Note. *Begonia lancangensis* was described and published in 1999 and its type collection was made from Fazhan He of Lancang County in Yunnan Province. Since then, no additional specimens have been collected. During our field surveys in 2010 and 2017, respectively, we did not find any plants of this taxon in the type locality and only observed *B. acetosella* Craib (Craib 1912: 347) (Fig. 11C, D), *B. handelii* Irmsch. (Irmscher 1921) (Fig. 11E, F) and *B. palmata* D.Don (Don 1825). Based on the intermediate morphology of *B. lancangensis* and the overlapping distributions of *B. acetosella* and *B. handelii*, it is hypothesised that *B. lancangensis* is very likely a natural hybrid of these two species. To further investigate this, by artificially crossing *B. acetosella* and *B. handelii*, we produced, at Kunming Botanical Garden, a hybrid that was morphologically almost the same as *B. lancangensis* (Fig. 11A, B). Therefore, we confirmed that *B. lancangensis* is a natural hybrid. It is very similar to the hybrid (unpublished) in the same section of *B. acetosella* × *B. silletensis* subsp. *mengyanensis* Tebbitt & K.Y.Guan (Tebbit and Guan 2002), which has hairy stems and petioles and larger leaves (Tian et al. 2017).

Distribution and phenology. CHINA: Yunnan, Lancang, only seen in type locality, alt. 1600 m; LAOS: Luang Namtha Province, Nam Ha National Biodiversity Conservation Area, Near Na Lun Village, alt. 687 m (Ding et al. 2020). Flowering March to May, fruiting April to July.

Conservation status. Regionally Extinct (RE). The living plants of *Begonia* × *lancangensis* have not been found in the type locality during field surveys after its first description. Recently, however, other researchers found wild plants in Laos (Ding et al. 2020).

Remarks. Like *B. acetosella*, *B. handelii* and *B. silletensis* C.B.Clarke (Clarke 1879), dioecious *Begonia* × *lancangensis* has berry-like fruits and was previously classified in section *Sphenanthera*, but has recently been integrated into section *Platycentrum* (Moonlight et al. 2018). In the wild, *B. acetosella*, *B. handelii* and *B. silletensis* often have overlapping distributions, meaning natural cross fertilisation is possible due to their overlapping flowering periods. The hybrid plants are usually very few and, therefore, rarely observed, due to a low chance of a natural cross. Natural crossings may generate new hybrids in the future.

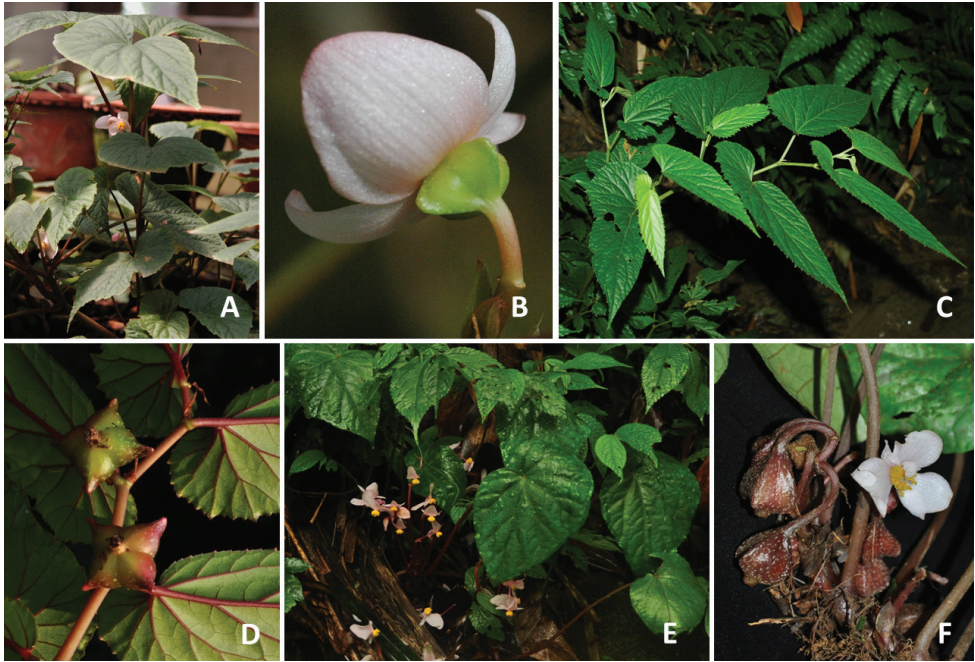


Figure 11. *Begonia* × *lancangensis* and its parents (*B. acetosella* and *B. handelii*) (Photos by Daike Tian) **A, B** male plant and female flower of *B. × lancangensis* **C, D** plant and fruits of *B. acetosella* **E, F** male and female flowering plants of *B. handelii*.

***Begonia* × *malipoensis* S.H.Huang & Y.M.Shui**

Fig. 12

-*Begonia malipoensis* S.H.Huang & Y.M.Shui, *Acta Bot. Yunnanica* 16:333, 1994.

Note. *Begonia malipoensis* was described for the first time in 1994 and its type locality is Douchidian of Malipo Xian, Yunnan Province (Huang and Shui 1994). In the wild, it grows closely with *B. hemsleyana* Hook.f. (Curtis et al. 1899) (Fig. 12F) and *B. versicolor* Irmisch (Irmischer 1939) (Fig. 12E, F). Later, Daike Tian (Tian 1999) conducted field surveys on the diversity of *B. versicolor* in southeastern Yunnan and found a few plants of *B. malipoensis* in the same locality and at Daweishan National Nature Reserve of Pingbian County, Yunnan Province. Based on the very limited number of individuals and intermediate morphology between *B. hemsleyana* and *B. versicolor*, *B. malipoensis* is considered a natural hybrid and this supposition was confirmed by artificial cross experiments (Tian 1999). From natural hybrids, one type, with densely white-spotted leaves, was selected as a new cultivar, *B. × malipoensis* ‘White Snow’ (Tian et al. 2001). The hybrid status of *B. × malipoensis* was further supported by molecular evidence (Tian et al. 2018).

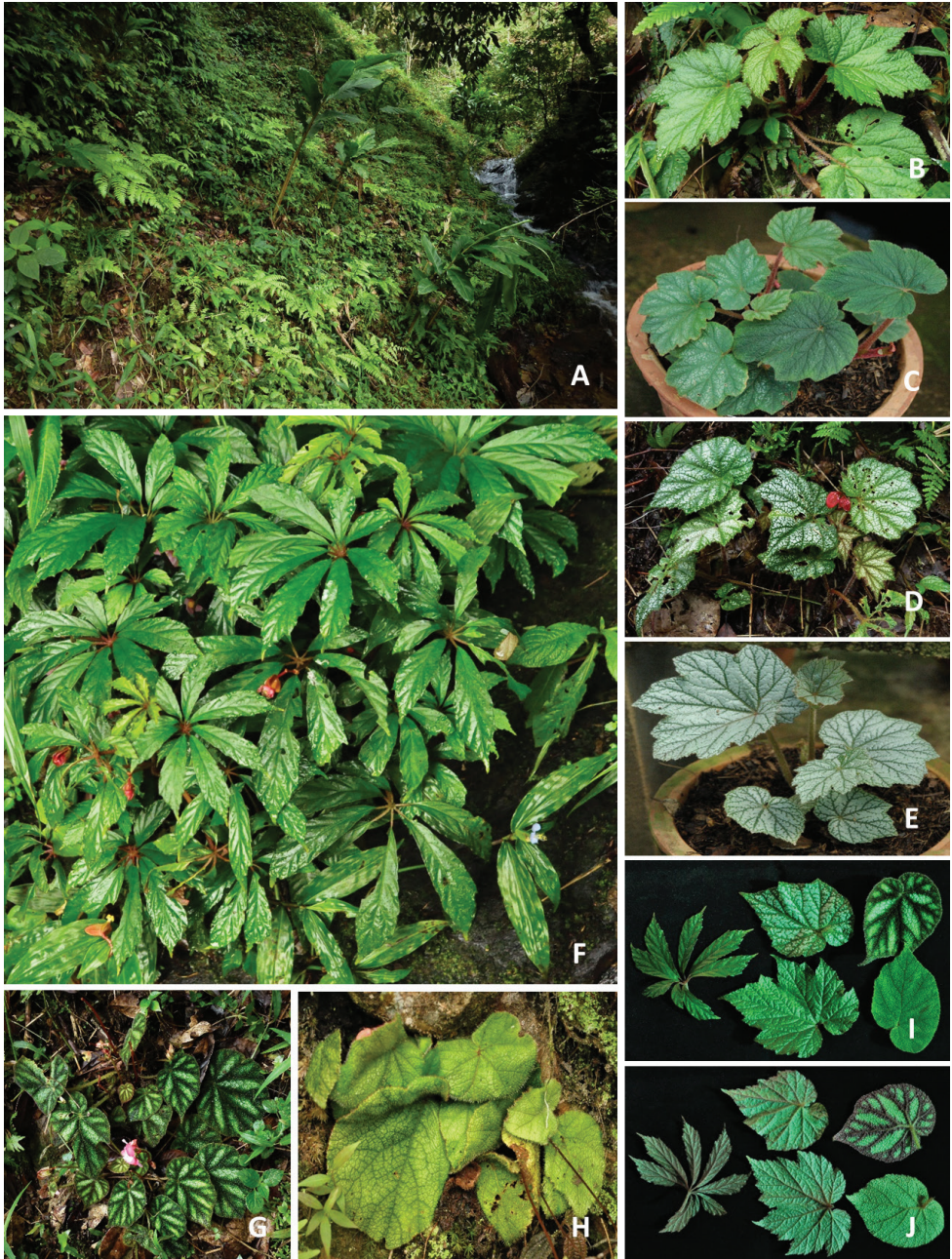


Figure 12. *Begonia* × *malipoensis* and its parents (*B. hemsleyana* and *B. versicolor*) (Photos by Daike Tian) **A** habitat of a natural hybrid zone of *B. versicolor* × *B. hemsleyana* **B–E** variation of *B. × malipoensis* **F** *B. hemsleyana* **G, H** *B. versicolor* with variegated and pure green leaves **I, J** comparison of *B. × malipoensis* (middle two leaves) and its parents *B. hemsleyana* (left) and *B. versicolor* (right two leaves) (**I** adaxial view **J** abaxial view).

The hybrid *B. × malipoensis* is derived from either *B. hemsleyana* × *B. versicolor* or *B. versicolor* × *hemsleyana*. No significant differences were observed in the hybrid when either *B. hemsleyana* or *B. versicolor* acts as the mother plant. However, based on a presumed closer distance with mother plants and molecular data (Tian et al. 2017), more wild hybrids occurred with *B. hemsleyana* as a mother plant in Malipo county, while more with *B. versicolor* as mother plant were observed in a hybrid zone in Pingbian county.

Distribution and phenology. *B. × malipoensis* has only been seen in Malipo and Pingbian counties in Yunnan Province. Flowering June to July, fruiting July to September.

Conservation status. Critically Endangered (C2a(i)). It is extremely narrowly distributed with less than 100 mature individuals and can only be found in the hybrid zones of two locations in China. The hybrid plants are continuously collected by horticultural researchers or plant enthusiasts, mainly for ornamental purposes.

Remarks. *B. × malipoensis* is difficult to bloom under ex-situ cultivation. When the seeds from an artificial cross between *B. hemsleyana* and *B. versicolor* were sown, the plants produced had various types of leaf colour and colour patterns (Tian 1999).

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Paraboea dolomitica (Gesneriaceae), a new species from Guizhou, China

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Abstract

Here we describe *Paraboea dolomitica* Z.Y. Li, X.G. Xiang & Z.Y. Guo, a new species of Gesneriaceae from Guizhou, China. Based on recent extensive observations, this new species is morphologically similar to *Paraboea filipes* (Hance) Burtt, in having obovate leaf blades, 1–4-flowered cymes and purplish corolla, but differs from that species by the combination of denticulate leathery leaves, sparsely brown haired peduncles, two woolly bracts, reniform anthers and two glabrous staminodes. Additionally, molecular data support this new species as a member of a clade that includes *P. crassifolia*, *P. tetrabracteata*, *P. peltifolia*, *P. vetutina*, *P. dushanensis*, *P. dictyoneura*, *P. xiangguiensis* and *P. guilinensis*, but it is distinct from them in leaf position, inflorescence, peduncle, bract and capsule. The conservation status of this species is considered to be “Vulnerable” (VU) according to the IUCN Red List Categories and Criteria.

Keywords

Gesneriaceae, limestone flora, new species, *Paraboea*

Introduction

Paraboea was published by Clarke (1883) as a section of the *Didymocarpus* Wall. and subsequently treated as a distinct genus by Ridley (1905). Burttt (1984) recircumscribed *Paraboea* based on the indumentum instead of fruit morphology, and many species were transferred to *Paraboea* from the genus *Boea* Comm. ex Lam. Xu et al. (2008) revised this genus and recognised 89 species and five varieties. Using ITS and *trnL-F*, a recent molecular phylogenetic study indicated that *Trisepalum* C.B. Clarke and *Phylloboea* Benth. were nested in *Paraboea*, and consequently 15 new combinations in *Paraboea* were made (Puglisi et al. 2011). Further, Puglisi et al. (2016) established a new genus *Middletonia* segregated from *Paraboea*.

To date, *Paraboea* (C.B. Clarke) Ridley contains approximately 142 species and is distributed in southern China, northeastern India, the eastern Himalayas, Burma, Thailand, Cambodia, Laos, Vietnam, Malaysia, Philippines and Indonesia east to Sulawesi, occurring mostly in limestone regions (Xu and Burttt 1991; Xu 1994; Li and Wang 2004; Xu et al. 2008; Chen et al. 2008; Puglisi et al. 2011; Xu et al. 2012; Wen et al. 2013; Xu et al. 2017a; Puglisi and Phutthai 2018). Xu et al. (2017b) summarised that there are ca. 28 species in China, mainly in limestone areas of south and southwest China. Since then, one new species and one new record have been discovered in China (He et al. 2018; Lu et al. 2019). During our expeditions to Wuyang River, Zhenyuan County and Yuntai Mountain, Shibing County, Guizhou, China in 2016 and 2017, an unidentified species of *Paraboea* was collected. Based on morphological and molecular data, we concluded that it is a significant new species, which we describe here.

Materials and methods

Morphological observations

Morphological observations and measurements of the new species were carried out, based on living plants in the field and dry specimens in herbarium (PE and QNUN, herbarium acronyms according to Index Herbariorum; Thiers 2020). The photographs were taken in the field. All morphological characters were studied under dissecting microscopes and are described using the terminology presented by Wang et al. (1998).

Taxon sampling and DNA sequencing

A total of 60 species of *Paraboea* were sampled. Based on Roalson and Roberts (2016) and Xu et al. (2017a), seven species (*Middletonia evrardii* (Pellegr.) C. Puglisi, *Middletonia monticola* (Triboun & D.J. Middleton) C. Puglisi, *Middletonia multiflora* (R.Br.) C. Puglisi, *Isometrum farreri* Craib, *Kaisupeea herbacea* (C.B. Clarke) B.L. Burttt, *Ornithoboea arachnoidea* (Diels) Craib and *Ornithoboea wildeana* Craib) were selected as

outgroups. No material of *P. filipes* (Hance) Burtt, the most morphologically-similar species, was available for analysis.

Total genomic DNA was extracted from leaves dried in silica gel using the Plant Genomic DNA Kit (CW Biotech, Beijing, China). The nuclear internal transcribed spacer (ITS) and chloroplast *trnL^{UAA}-F^{GAA}* (including intron and spacer) were used in this study. The primers for ITS were ITS-5P (5'-GGA AGG AGA AGT CGT AAC AAG G-3') and ITS-8P (5'-CAC GCT TCT CCA GAC TAC-3') (Möller and Cronk 1997) and primers for *trnL-F* were *c* (5'-CGA AAT CGG TAG ACG CTA CG-3') and *f* (5'-ATT TGA ACT GGT GAC ACG AG-3') (Taberlet et al. 1991). The selected DNA regions were amplified with standard polymerase chain reaction (PCR) and products were analysed by MajorBio company (Beijing, China). Voucher information and GenBank accession numbers are listed in Appendix 1. Except for sequences of the new species that were generated in this study, others are from GenBank.

Alignment and Phylogenetic analysis

Sequences were aligned using the default parameters in CLUSTAL X v1.83 (Thompson et al. 1997) and manually adjusted with BIOEDIT v5.0.9 (Hall 1999). Phylogenetic analyses were carried out using Maximum Parsimony (MP) and Bayesian Inference (BI) methods in PAUP v4.0b10 (Swofford 2003) and MrBayes v3.2.0 (Ronquist and Huelsenbeck 2003), respectively. For MP analyses, heuristic searches were performed with 1000 random sequence addition replicates, tree-bisection-reconnection (TBR) branch swapping, MulTrees in effect and steepest descent off. Gaps were treated as missing data, characters were equally weighted and their states were unordered. Internal branch support was estimated by using 1000 bootstrap replicates (Felsenstein 1985), as described above. For BI analyses, the nucleotide substitution model was determined by the Akaike Information Criterion (AIC) in Modeltest v3.06 (Posada and Crandall 1998). Four chains of the Markov Chain Monte Carlo (MCMC) were run over 3 million generations, sampling one tree every 1000 generations, starting with a random tree. Majority rule (> 50%) consensus tree was constructed after removing the burn-in period samples (the first 25% of the sampled trees).

Results

The concatenated DNA matrix had a length of 1944 aligned characters (ITS: 993 bp and *trnL-F*: 951 bp), of which 838 were variable and 475 are parsimony-informative. MP and BI analyses resulted in congruent topologies except for some clades with low supported values (Fig. 1). The genus *Paraboea* was supported as a monophyletic with strong support values. The major phylogenetic relationships amongst *Paraboea* were consistent with Xu et al. (2017a). The two samples of the new species from different sites are shown as a distinct clade (Posterior Probability (PP) = 1.00, Bootstrap

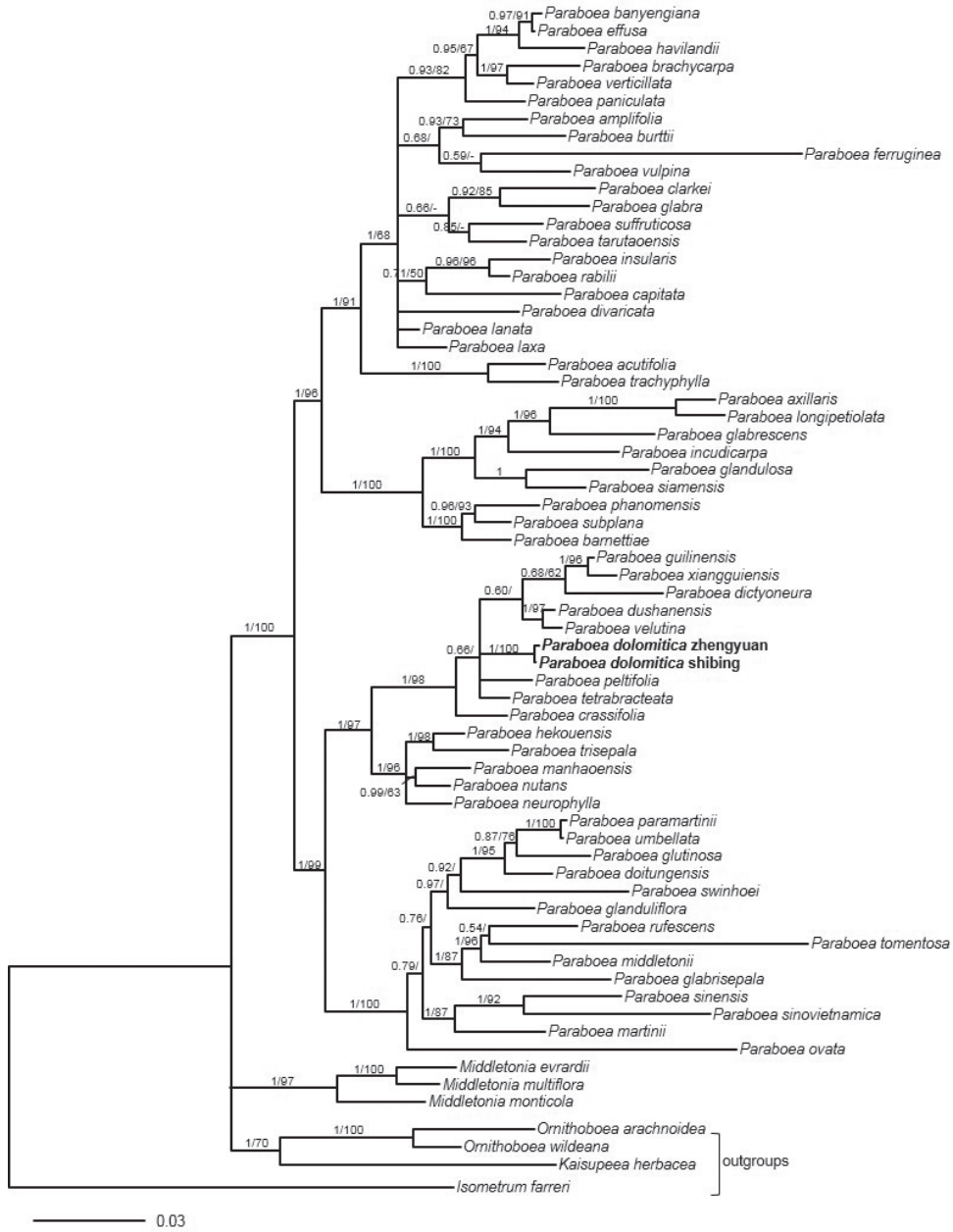


Figure 1. The majority consensus tree of the Bayesian Inference method based on ITS and *trnL-F* regions. Bayesian posterior probabilities and bootstrap support values (> 50%) are shown above the branch. The new species is highlighted in bold.

value (BS) = 100%). The new species forms a monophyletic clade with *P. crassifolia*, *P. tetrabracteata*, *P. peltifolia*, *P. vetutina*, *P. dushanensis*, *P. dictyoneura*, *P. xiangguiensis* and *P. guilinensis* (PP = 1.00, BS = 98%), but its sister group is uncertain (Fig. 1).

Taxonomic treatment

***Paraboea dolomitica* Z.Y. Li, X.G. Xiang & Z.Y. Guo, sp. nov.**

urn:lsid:ipni.org:names:77210596-1

Figs 2, 3

Diagnosis. *Paraboea dolomitica* is morphologically similar to *P. filipes*. Both of them have obovate leaf blades, 1–4-flowered cymes and a purplish corolla, but *P. dolomitica* differs from *P. filipes* by its leathery leaves with denticulate margins (*vs.* papery leaves with subentire margins in *P. filipes*), peduncles sparsely covered with brown hairs (*vs.* sparsely sericeous-lanate when young and glabrate when mature), two woolly bracts (*vs.* two glabrous bracts), reniform anthers (*vs.* oblong anthers), two staminodes 0.3 cm long (*vs.* 1 staminodes 0.02 cm long), and flowering during April and May (*vs.* flowering during September and October) (Table 1).

Phylogenetic analysis suggested that *P. dolomitica* was nested in a clade including *P. crassifolia* (Hemsl.) Burtt, *P. tetrabracteata* F. Wen, Xin Hong & Y. G. Wei, *P. peltifolia* D. Fang et Z. Zeng, *P. vetutina* (W. T. Wang et C. Z. Gao) Burtt, *P. dushanensis* W. B. Xu & M. Q. Han, *P. dictyoneura* (Hance) Burtt, *P. xiangguiensis* W. B. Xu & B. Pan and *P. guilinensis* L. Xu et Y. G. Wei, but *P. dolomitica* can be easily differentiated from them in leaf position, inflorescence, peduncle, bract and capsule. The detailed morphological comparison of the species most morphologically similar to *P. dolomitica* is listed in Table 1.

Type. China. Guizhou: Shibing County, Yuntai Mountain, 27°06'80.7"N, 108°07'00.0"E, elevation 885 m, on rock faces of a karst dolomite cave, 2 May 2017, Z.Y. Guo 20170047 (holotype: PE!; isotypes: PE!, QNUN!).

Perennial herbs. Rhizomes subterete, 1.5–6.0 cm long, 0.3–0.5 cm diam. Roots slender, fibrous. Leaves crowded near stem apex, opposite; blade leathery, obovate to elliptic, 2.5–4.5 cm long, 1.0–1.5 cm wide, apex acute or rounded, base rounded to broadly cuneate, margin denticulate, involute; adaxial surface with arachnoid covering when young, but glabrescent when mature, abaxially densely brown woolly; principal vein depressed above, raised beneath, lateral veins 3–6 on each side of midrib, tertiary venation inconspicuous; petiole 0.8–2.0 cm long, 0.2–0.3 cm broad, densely covered with appressed velvety hairs. Cymes axillary, umbel-like 1–4-flowered; peduncle 3–5 cm long, 0.05–0.08 cm in diameter, sparsely lanate and glandulose-pubescent. Bracts 2, 0.3–0.4 cm long, linear, woolly beneath; pedicel 0.8–2.2 cm long, 0.05–0.1 cm in diameter, sparsely lanate with glandular hairs. Calyx 5-parted, 0.4–0.6 cm long, 0.1–0.15 cm in diameter, apex acute, densely brown woolly; segments linear. Corolla oblique-campanulate, zygomorphic, purplish, 1.0–1.2 cm long, outside and inside glabrous; tube 0.5–0.6 cm long; throat ca. 0.7 cm in diameter; adaxial lip 2-lobed, lobes orbicular or deltoid, abaxial lip 3-lobed, lobes oblong-elliptic or oblong. Stamens 2, glabrous; filaments 0.5–0.6 cm long, ca. 0.08 cm in diameter, yellow, curved at the upper part; anthers reniform, ca. 0.3 cm long, 0.2 cm broad; staminodes 2, linear, ca. 0.3 cm long. Pistil glabrous, ovary linear, stigma capitate. Capsule linear, 1.5–1.8 cm long, 0.15–0.2 cm broad, glabrous, slightly twisted.

Table 1. Morphological comparisons between *Paraboea dolomitica* and its relatives its relatives based on morphological observation and phylogenetic analyses.

Characters	<i>P. dolomitica</i>	<i>P. filipes</i>	<i>P. dicyconeura</i>	<i>P. crassifolia</i>	<i>P. dushanensis</i>	<i>P. petrifolia</i>
Rhizome	1.5–6.0 cm long, ca. 0.3–0.5 cm diam.	up to 2.5 cm long, ca. 0.3 cm diam.	1.5–2.5 cm long, 0.7–0.8 cm diam.	0.5–1.5 cm long, 0.5–0.9 cm diam.	4–10 cm long, 0.2–0.6 cm diam.	2–7 cm long, 0.5–1 cm diam.
Stem	crowded near the stem apex, opposite	absent	absent or up to 10 cm basal or crowded near the stem apex, rosette	absent or up to 15 cm basal or crowded near the stem apex	absent	present
Leaf position	crowded near the stem apex, opposite	basal, rosette	basal or crowded near the stem apex, rosette	basal or crowded near the stem apex	congested at the apex of rhizome	spiral at the stem apex
Leaf blade	leathery, obovate to elliptic, 2.5–4.5 × 1.0–1.5 cm, margin denticulate	papery, obovate to obovate-oblong, (1–) 2–5 × (0.3–) 0.7–2.2 cm, margin shallowly crenate or subentire	thick papery, oblanceolate, 7–19 × 1.2–4.5 cm, margin serrate to dentate or subentire	thick papery, obovate or ovate, 3–16 × 1.5–7 cm, margin crenate to dentate or subentire	leathery, cuneate to attenuate, 4–8 × 0.7–1.5 cm, margin crenate to shallowly repand	papery, obovate to oblanceolate, spatulate or subspatulate, 6–33.5 × 3–14.3 cm, margin crenate-serrate
Cymes	1–4-flowered	1–4-flowered	5–20-flowered	4–12-flowered	1–5-flowered	2–15-flowered
Peduncle	3–5 cm long, sparsely lanate with glandular hairs	3–7 cm long, glabrescent	8–21 cm long, pannose to sparsely pannose	3–12 cm long, woolly to pannose	3–5 cm long, ferruginous matted indumentum	4–6 cm long, woolly
Bract	2, linear, 0.3–0.4 cm long	2, narrowly oblong-ovate, ca. 0.1 cm long	2 or 3, lanceolate to narrowly oblong, 0.5–1.3 cm long	2, linear to subulate, 0.2–0.5 cm long	2, linear-lanceolate, 0.3–0.5 cm long	2, lanceolate-triangular, 0.2–0.3 (–0.4) cm long
Calyx	5-parted	5-parted	5-parted	5-parted	5-parted	2-lipped
Corolla	purplish	purplish	purplish	purplish	purple-blue	white
Anther	reniform	narrowly oblong	oblong	oblong	elliptic	reniform
Staminodes	2, 0.3 cm long	1, ca. 0.02 cm long	3, 0.2–0.45 cm long	2, 0.2–0.25 cm long	3, 0.25–0.3 cm long	2, 0.2 cm long
Capsule	1.5–1.8 cm long, slightly twisted	0.5–1.1 cm long, not twisted	1.5–6 cm long, spirally twisted to nearly straight	2–4.5 cm long, spirally twisted	1.2–3.1 cm long, not twisted	1–3.6 cm long, not twisted
Flowering	April and May	September and October	April and May	June and July	May and June	March and April

Note: The morphological characters of *P. filipes*, *P. dicyconeura*, *P. crassifolia* and *P. petrifolia* are from Li and Wang (2004) and the characters of *P. dushanensis* are from Xu et al. (2017a).

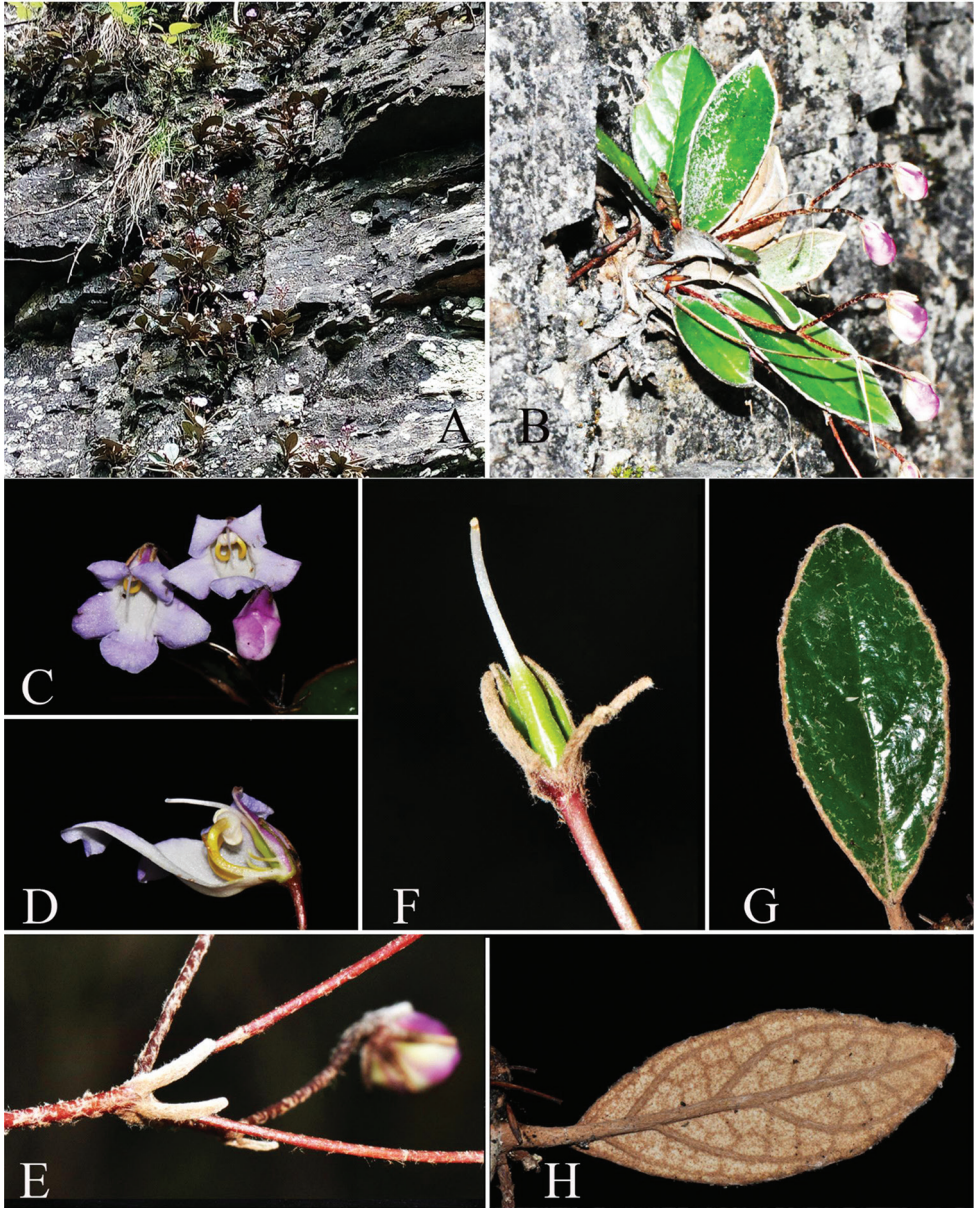


Figure 2. *Paraboea dolomita*. **A** Habitat **B** flowering habit **C** flower face view **D** opened corolla showing stamens, staminodes and pistil **E** bracts **F** pistil with calyx **G** adaxial leaf blade; and **H** abaxial leaf blade.

Distribution. *Paraboea dolomita* is known from Yuntai Mountain, Shibing County and Wuyang River, Zhenyuan County, Guizhou, China.

Phenology. Flowering occurs in April and May and the fruiting occurs between June and August.



Figure 3. *Paraboea dolomitica*. **A** Flowering habit **B** opened corolla showing stamens, staminode and pistil **C** pistil with calyx and **D** capsule. Drawn by Zhaowen Wu based on holotype and isotypes.

Etymology. The specific epithet refers to the habitat of this new species, the dolomite karst area.

Habitat and ecology. *Paraboea dolomitica* grows on rock faces of dolomite karst area, at an elevation of ca. 650–855 m. Accompanying plants in the habitat are sparse and include trees, such as *Platycarya strobilacea* Sieb. et Zucc., *Cotinus coggygria* Scop., and herbs such as *Selaginella moellendorffii* Hieron., *Paphiopedilum micranthum* T. Tang et F. T. Wang, *Viola diffusa* Ging., *Galium aparine* Linn. var. *echinospermum* (Wallr.) Cuf. and *Carex* sp.

Additional collections. China. Guizhou: Zhenyuan County, Wuyang River, 27°06'80.7"N, 108°07'00.0"E, elevation 650 m, on rock faces, 3 August 2016, Guo ZY, GZY1608721 (PE and QNUN), GZY1608723 (PE and QNUN), GZY1608724 (PE and QNUN).

Proposed IUCN conservation status

The new species has only been found in Shibing County and Zhenyuan County, Guizhou, China. The populations and habitats are vulnerable to human activities such as road construction and deforestation for crops. According to field observations, it has several known populations of less than 300 mature individuals according to field observations. The species is considered to be “Vulnerable” (VUD1) according to the IUCN Red List Criteria (IUCN 2017), based on Criterion D1 and population size, estimated to be fewer than 1000 mature individuals.

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Appendix I

GenBank accession numbers (species: voucher, trnL-F, ITS). The dash indicated that there is no data

Ingroups: *Paraboea acutifolia*, JN934711, FJ501314; *Paraboea amplifolia*, JN934712, JN934754; *Paraboea axillaris*, KU203943, KU203848; *Paraboea banyengiana*, JN934713, JN934755; *Paraboea barnettiae*, AJ492306, KU203847; *Paraboea birmanica*, HQ632866, HQ632958; *Paraboea brachycarpa*, FJ501465, KU203870; *Paraboea burttii*, JN934714, JN934756; *Paraboea capitata*, AJ492298, FJ501315; *Paraboea clarkei*, JN934715, JN934757; *Paraboea crassifolia*, FJ501472, FJ501318; *Paraboea dictyoneura*, FJ501463, KJ475415; *Paraboea divaricata*, JN934717, JN934759; *Paraboea doitungensis*, KU203941, KU203846; ***Paraboea dolomitica*, Z.Y. Guo 20170047**, MT379849, MT379851; ***Paraboea dolomitica*, GZY 1608721**, MT379850, MT379852; *Paraboea dushanensis*, MF358716, MF358698; *Paraboea effusa*, JN934718, JN934760; *Paraboea ferruginea*, FJ501471, KU203862; *Paraboea glabra*, JN934719, JN934761; *Paraboea glabrescens*, JN934743, JN934785;

Paraboea glabrisepala, JN934720, JN934762; *Paraboea glanduliflora*, JN934721, JN934763; *Paraboea glandulosa*, HQ632867, JN934784; *Paraboea glutinosa*, JN934722, JN934764; *Paraboea guilinensis*, MF358717, MF358701; *Paraboea havilandii*, JN934724, JN934766; *Paraboea hekouensis*, KU203938, KU203843; *Paraboea incudicarpa*, JN934725, JN934767; *Paraboea insularis*, KU203952, KU203857; *Paraboea lanata*, FJ501467, –; *Paraboea laxa*, FJ501466, –; *Paraboea longipetiolata*, KU203946, KU203851; *Paraboea martinii*, MF358718, MF358702; *Paraboea manhaoensis*, KU203937, KU203842; *Paraboea middletonii*, KU203940, KU203845; *Paraboea neurophylla*, JN934727, JN934769; *Paraboea nutans*, MF358719, MF358703; *Paraboea paniculata*, JN934728, JN934770; *Paraboea paramartinii*, JN934729, JN934771; *Paraboea peltifolia*, MF358720, –; *Paraboea phanomensis*, KU203950, KU203855; *Paraboea rabilii*, KU203951, KU203856; *Paraboea rufescens*, JN934730, JN934772; *Paraboea siamensis*, KU203948, KU203853; *Paraboea sinensis*, JN934731, JN934773; *Paraboea sinovietnamica*, MF358722, MF358706; *Paraboea subplana*, JN934744, JN934786; *Paraboea suffruticosa*, JN934732, JN934774; *Paraboea swinhoei*, FJ501475, JN934775; *Paraboea tarutaensis*, JN934734, JN934776; *Paraboea tetrabracteata*, MF358723, MF358707; *Paraboea tomentosa*, KU204043, KU203971; *Paraboea trachyphylla*, JN934735, JN934777; *Paraboea trisepala*, JN934736, JN934778; *Paraboea umbellata*, JN934737, FJ501317; *Paraboea velutina*, JN934738, JN934780; *Paraboea verticillata*, JN934739, JN934781; *Paraboea vulpina*, JN934740, JN934782; *Paraboea xiangguiensis*, MF358728, MF358711.

Outgroups: *Middletonia evrardii*, KU203885, KU203790; *Middletonia monticola*, KU203884, KU203789; *Middletonia multiflora*, MU203886, MU203791; *Isometrum farreri*, JF697585, HQ327464; *Kaisupeea herbacea*, FJ501459, FJ501309; *Ornithoboea arachnoidea*, JN934709, FJ501312; *Ornithoboea wildeana*, JN934710, JN934752.

Aristolochia yachangensis, a new species of Aristolochiaceae from limestone areas in Guangxi, China

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Abstract

Aristolochia yachangensis B.G.Huang, Yan Liu & Y.S.Huang, a new species from limestone areas in Guangxi, China, is described and illustrated. It is morphologically most similar to *A. fangchi* Y.C.Wu ex L.D.Chow & S.M.Hwang, *A. petelotii* O.C. Schmidt and *A. championii* Merr. & Chun in shape of leaf blade, anther, gynostemium and inflorescence on old woody stems. However, it can be easily distinguished from the latter by shape of inflorescence, length of upper and lower portions of perianth tube, colour of the limb and throat. A table and a key to distinguish the new species from other morphologically similar *Aristolochia* species are also provided.

Keywords

Aristolochia, limestone flora, new taxa, north-western Guangxi, taxonomy

Introduction

The genus *Aristolochia* L. (s. l.) contains 600 species and widely distributes in tropical, subtropical and temperate regions of the world (González 2012; Zhu et al. 2019c). Based on recent studies on molecular phylogeny, chromosome and morphology of *Aristolochia*, some researchers have suggested that an old genus *Isotrema* Raf. should be

reinstated to accommodate species of *Endodeca* Raf. and *Aristolochia* subgen. *Siphisia* (Duch.) O.C.Schmidt (Zhu et al. 2019a). However, many researchers still advise to use the name *Aristolochia* rather than *Isotrema* (Do et al. 2019; Peng et al. 2019; Cai et al. 2020). In this paper, we use the name *Aristolochia* to describe a new species, because the genus name *Isotrema* is still controversial.

Currently, there are more than 70 species of *Aristolochia* known from China, including many new species that have been described from Yunnan, Guangxi, Guangdong, Zhejiang and Hainan in recent years (Gong et al. 2018; Zhu et al. 2018, 2019b, 2019d; Li et al. 2019; Peng et al. 2019; Zhou et al. 2019). As one of the most biodiverse regions of China, Guangxi has 22 *Aristolochia* species (Peng et al. 2019; Zhu et al. 2019c), including *A. bambusifolia* C.F.Liang ex H.Q.Wen, *A. longlinensis* Yan Liu & L.Wu and *A. gongchengensis*, Y.S.Huang, Y.D.Peng & C.R.Lin, which are endemic in the region (Qin and Liu 2010; Huang et al. 2015; Wu et al. 2015)

During a fieldwork in Yachang Orchid National Nature Reserve of north-western Guangxi, China in April 2019, we discovered a special flowering plant of Aristolochiaceae and speculated that it might be a new species of *Aristolochia*, based on its flower structure. We investigated this species at the same location again and collected specimens of young capsules in May 2019. In order to obtain more detailed morphological data, we came back to the same location once again and collected specimens of mature capsules in July 2019. After consulting Flora of China (Hwang et al. 2003) and other relevant literature (Merrill and Chun 1940; Liang 1975; Chow and Huang 1975; Hwang 1981; Cheng et al. 1988; Ma 1989a, 1989b; Ma and Cheng 1989; Wen 1992; Liu and Deng 2009; Xu et al. 2011; Huang et al. 2013, 2015; Wu et al. 2013, 2015; Do et al. 2014, 2015a, 2015b, 2016, 2017, 2019; Huong et al. 2014; Zhu et al. 2015, 2016, 2017a, 2017b, 2018, 2019b, 2019d; Do and Nghiem 2017; Gong et al. 2018; Li et al. 2019; Peng et al. 2019; Zhou et al. 2019; Cai et al. 2020), as well as comparisons amongst this unknown species and its morphologically most similar species, we confirmed that this species was clearly different from the known *Aristolochia* species. Hence, it is here described and illustrated as a new species.

Material and methods

Field observations have been conducted in flowering and fruiting *phases* at the type locality more than once. Measurements and assessments of morphological characters of the new species were based on living plants in the wild and specimens gathered from the type locality. All specimens were deposited in the herbarium of Guangxi Institute of Botany (IBK), as well as the herbarium of Guangxi Botanical Garden of Medicinal Plants (GXMG). The comparisons amongst *Aristolochia yachengensis* B.G. Huang, Yan Liu & Y.S.Huang, *A. fangchi* Y.C.Wu ex L.D.Chow & S.M.Hwang, *A. petelotii* O.C.Schmidt and *A. championii* Merr. & Chun were based on the descriptions from herbarium specimens (including types) at CDBI, CSH, CZH, GXMG, GXMI, GZAC, GZTM, HEAC, HITBC, IBK, IBSC, K, KUN, NAS, PE, PEM, SM and protologues

(Schmidt 1933; Merrill and Chun 1940; Liang 1975). Images of type specimens and dried herbarium specimens were gathered from JSTOR Global Plants (<http://plants.jstor.org>), Chinese Virtual Herbarium Website (<http://www.cvh.ac.cn/>) and Sharing Platform of IBK (<http://www.gxib.cn/spIBK/>). The materials about current habitat status and threatened factors were recorded in field observations. The assessment of risk of extinction of the new species was based on the IUCN Red List of Threatened Species Categories and Criteria and Guidelines for Using the IUCN Red List Categories and Criteria (IUCN 2001; IUCN Standards and Petitions Committee 2019).

Taxonomic treatment

Aristolochia yachangensis B.G.Huang, Yan Liu & Y.S.Huang, sp. nov.

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Figures 1–3, 4A–D

Diagnosis. *Aristolochia yachangensis* is morphologically similar to *A. fangchi* Y.C.Wu ex L.D.Chow & S.M.Hwang, *A. petelotii* O.C.Schmidt and *A. championii* Merr. & Chun, but can be distinguished from them by stems irregularly striate, sparsely yellowish-brown pubescent or glabrous; leaf blade 1.5–3 cm wide; cymes on old woody stems; basal portion of perianth tube 2–3 cm long, shorter than the upper; limb yellow, with dark purple mural-like stripes; throat yellow; capsule ellipsoid. Detailed morphological comparisons amongst the four species of *A. yachangensis*, *A. championii*, *A. petelotii* and *A. fangchi* are summarised in Table 1.

Type. CHINA. Guangxi Zhuang Autonomous Region: Baise City, Leye County, Huaping Town, Zhongjing (Yachang Orchid National Nature Reserve), 24°49.367'N, 106°24.029'E, 1341 m a.s.l., 29 July 2019, Z. C. Lu et al. 20190729YC4141 (holotype: IBK!; isotypes: IBK!, GXMG!).

Description. Shrubs climbing. Stems terete, irregularly striate, sparsely yellowish-brown pubescent or glabrous. Branchlets densely yellowish-brown pubescent. Leaf blade leathery, lanceolate to elliptic-lanceolate or linear-lanceolate, 5–15 × 1.5–3 cm, apex narrowly acuminate, base rounded or broadly cuneate, margin entire, adaxially glabrous except the pubescent midnerve and lateral veins, abaxially shallowly yellowish-brown pubescent, basal veins 3, lateral veins 5–8 pairs, conspicuous on both surfaces; petiole 1–1.5 cm long, slightly distorted, densely yellowish-brown pubescent. Cymes on old woody stems, 1–5-flowered; pedicel 1–2 cm long, pendulous, densely yellowish-brown pubescent; bracteole ovate-lanceolate, ca. 4 × 2 mm, densely yellowish-brown pubescent; perianth tube horseshoe-shaped; basal portion of tube 2–2.5 × 0.6–1 cm, shorter than the upper part, near the base of inner dark purple, densely villous, outside of tube mauve, densely yellowish-brown pubescent; upper portion of tube 2.5–3 × 0.5–0.8 cm, inner yellow, with dark purple stripes; limb subrotund-peltate, 4–6 cm in diam., yellow, with dark purple mural-like stripes, abaxially densely brown pubescent, margin shallowly 3-lobed, lobes apex mucronate; throat suborbicu-

Table 1. Morphological comparisons of key characters amongst *Aristolochia yachangensis*, *A. fangchi*, *A. petelotii* and *A. championii*.

Characters	<i>A. yachangensis</i>	<i>A. fangchi</i>	<i>A. petelotii</i>	<i>A. championii</i>
Young stem	irregularly striate, sparsely yellowish-brown pubescent or glabrous	obscurely striate, brown villous	striate, densely spreading yellowish-brown villous	striate, densely yellowish-brown villous
Leaf blade	lanceolate to elliptic–lanceolate or linear–lanceolate, 5–15 × 1.5–3 cm, base rounded or widely cuneate, lateral veins 5–8 pairs	oblong to ovate–oblong, rarely ovate–lanceolate, 6–15 × 3–5.5 cm, base rounded or cordate, lateral veins 4–6 pairs	narrowly ovate, ovate–oblong or lanceolate–ovate, 14–22.5 × 7–13 cm, base shallowly cordate, lateral veins 4–6 pairs	lanceolate to elliptic–lanceolate or linear–lanceolate, 15–30 × 2–5 cm, base rounded or shallowly cordate, lateral veins 6–15 pairs
Pedicel	1–2 cm long, densely yellowish-brown pubescent	5–7 cm long, densely brown villous	4–4.5 cm long, densely brown villous	3–4 cm long, densely brown villous
Perianth tube	basal portion of tube 2–2.5 × 0.6–1 cm, shorter than the upper part, outside of tube mauve, densely yellowish-brown pubescent	basal portion of tube 4–5 × 1–1.5 cm, longer than the upper, outside of tube purple, with white blotches or not, densely villous	basal portion of tube 5–6.5 × 1–2 cm, longer than the upper, outside of tube pale-yellow or mauve, densely villous	basal portion of tube 5–7 × ca. 1.5 cm, longer than the upper, outside of tube mauve, densely villous
Limb	yellow, with dark purple mural-like stripes	dark purple, with white blotches	dark-purple, with white stripes	dark purple
Throat	yellow	white	milk-white mixed with black	yellow, with dark purple pots
Capsule	ellipsoid, 6–10 × 2.5–3.5 cm, glabrous	cylindrical, 5–10 × 3–5 cm, villous	narrowly ellipsoid, 10–15 × 5–8 cm, yellowish-brown villous	ellipsoid, 6–8 × ca. 3 cm, villous

lar, 0.5–1 cm in diam., yellow; anthers oblong, 2–4 × 1 mm, adnate to the gynostemium base, opposite to the lobes; ovary terete, ca. 1.5 × 0.3–0.5 cm, 6–angled, densely brown pubescent; gynostemium 3–lobed, margin glabrous and papillary. Capsule ellipsoid, 6–10 × 2.5–3.5 cm, 6–angled, glabrous.

Phenology. The new species was observed flowering from March to May and fruiting from June to August.

Etymology. The specific epithet is derived from the type locality, Yachang Orchid National Nature Reserve, Guangxi, China. The Chinese name is given as “雅长马兜铃”.

Distribution and habitat. At present, *Aristolochia yachangensis* was found only in Yachang Orchid National Nature Reserve of north-western Guangxi, China. It grows on limestone hillside at an elevation of ca. 1340 m. The slope direction is to the south-west, the slope is up to 40°, the tree layer is up to 15 m tall, the canopy cover is 70%, the shrub layer cover is 80% and the herb layer cover is 45%. Its associated species include *Quercus variabilis* Blume (Fagaceae), *Celtis sinensis* Pers. (Ulmaceae), *Platycarya longipes* Wu (Juglandaceae), *Toxicodendron succedaneum* (L.) Kuntze (Anacardiaceae), *Yua thomsonii* (Laws.) C.L.Li (Vitaceae), *Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) Underw. ex A.Heller (Pteridiaceae), *Miscanthus sinensis* Andersson (Gramineae) etc.

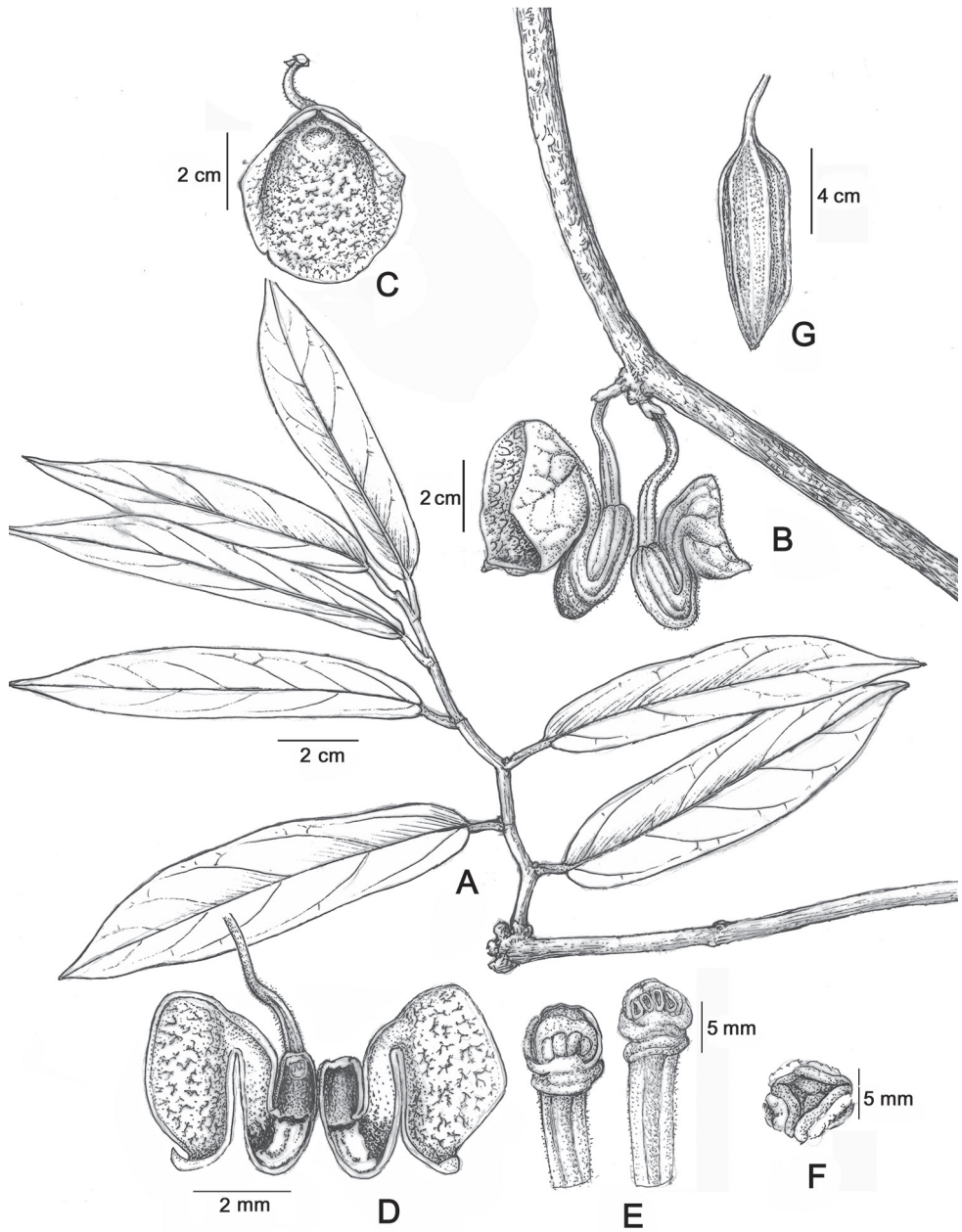


Figure 1. *Aristolochia yachangensis* B.G.Huang, Yan Liu & Y.S.Huang, sp. nov. **A** habit **B** flowering branch **C** flower (front view) **D** longitudinally dissected flower (showing the inside structure) **E** anthers and gynostemium (lateral view) **F** old phase of gynostemium (vertical view) **G** capsule. Drawn by Wenhong Lin (IBK).

Conservation status. Thus far, *Aristolochia yachangensis* has been found only from the type locality. The only subpopulation is located within a protected region and has seven individuals, including two mature ones. Based on the present study, its Extent of

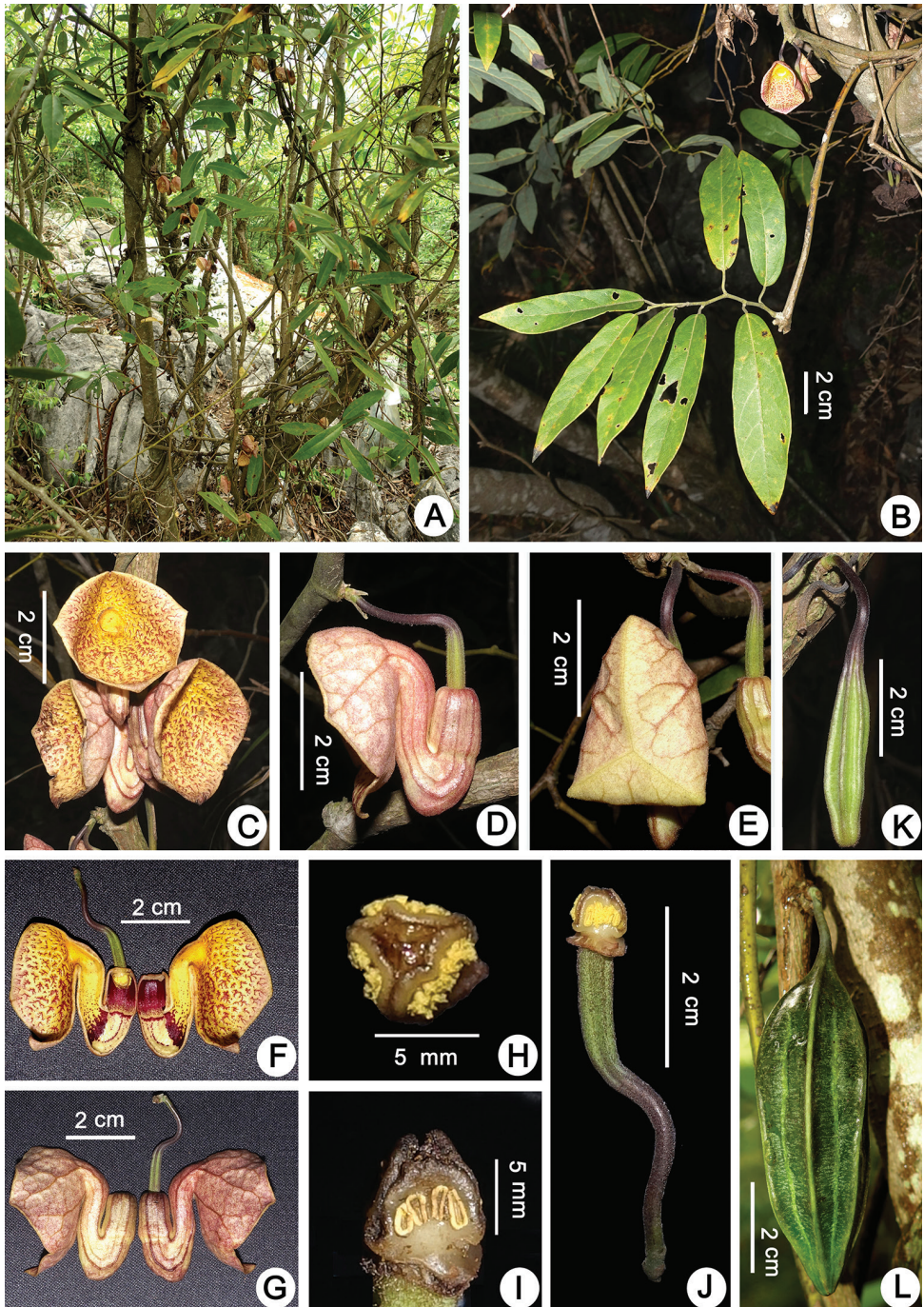


Figure 2. *Aristolochia yachangensis* B.G.Huang, Yan Liu & Y.S.Huang, sp. nov. **A** habitat **B** flowering branch **C** flowers (front view) **D** flower (lateral view) **E** flower bud **F** longitudinally dissected flower (showing the inside structure) **G** longitudinally dissected flower (dorsal view) **H** old phase of gynostemium (vertical view) **I** old phase of anthers and gynostemium (lateral view) **J** ovary **K** young capsule **L** mature capsule. Photographed by Shuwan Li.

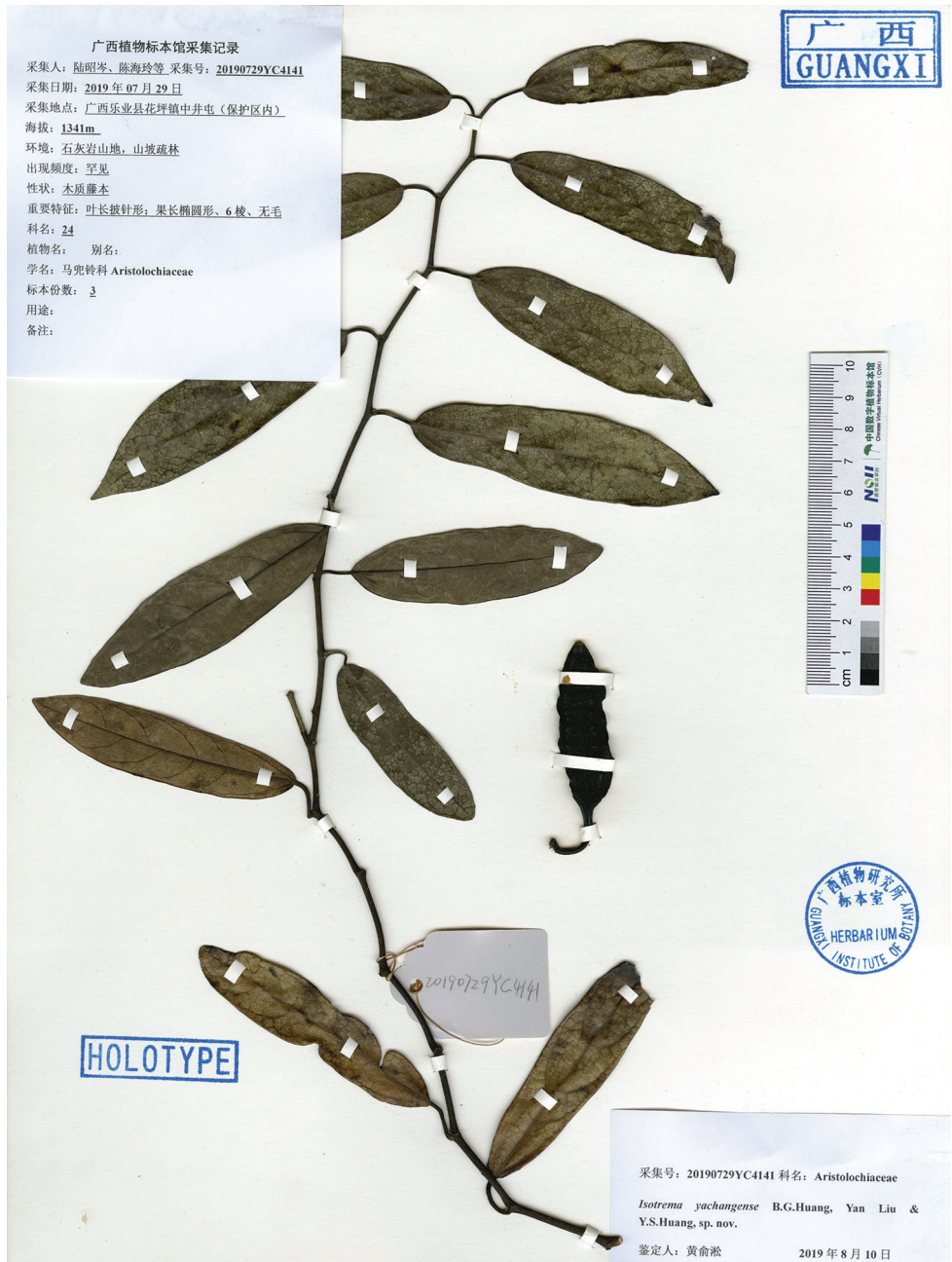


Figure 3. Holotype of *Aristolochia yachangensis* B.G.Huang, Yan Liu & Y.S.Huang, sp. nov. Z. C. Lu et al. 20190729YC4141 (IBK).

Occurrence (EOO) is less than 100 km² and the known Area of Occupancy (AOO) is less than 0.5 km². According to Guidelines for Using the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Committee 2019), *A. yachangensis* should

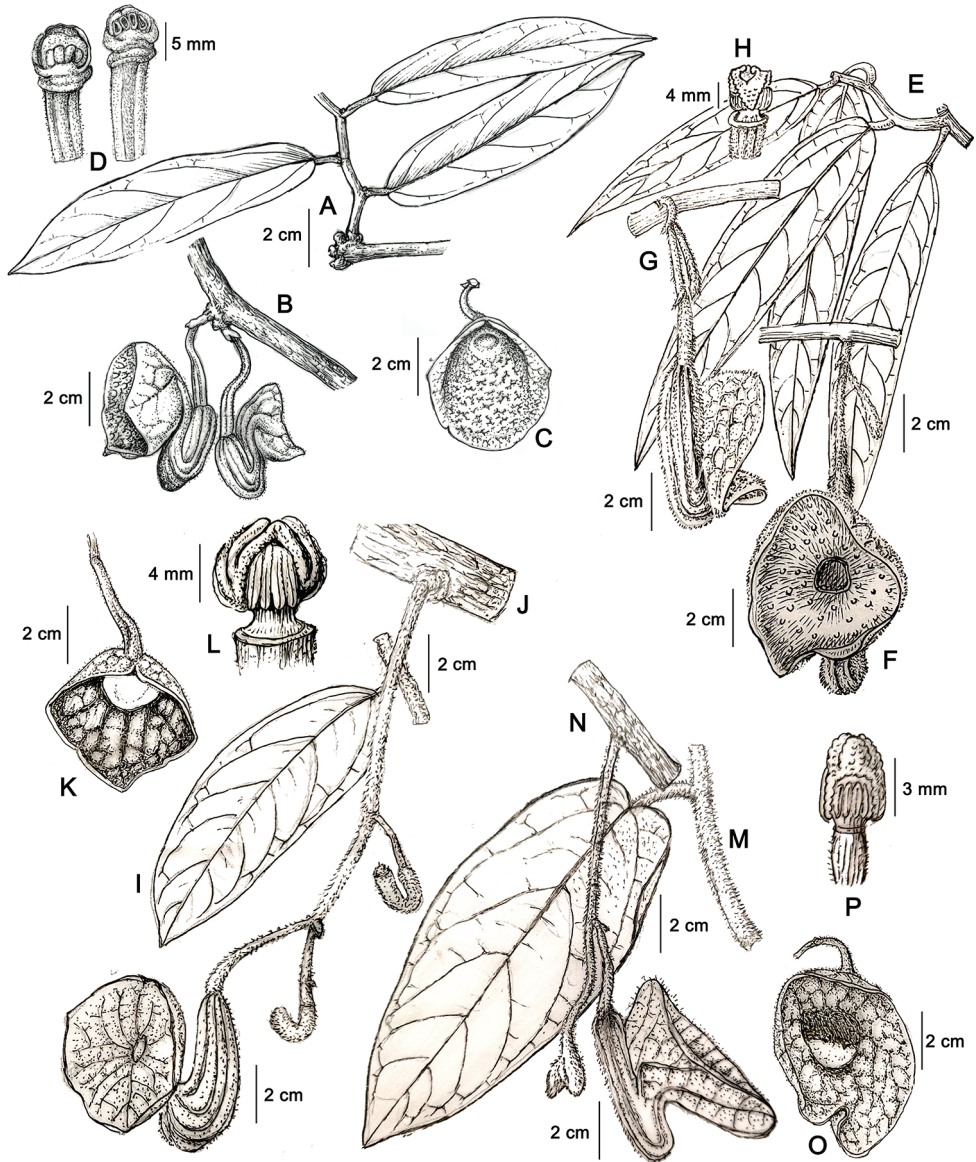


Figure 4. **A–D** *Aristolochia yachangensis* B.G.Huang, Yan Liu & Y.S.Huang, sp. nov. **A** habitat **B** inflorescence and flowers (lateral view) **C** flower (front view) **D** anthers and gynostemium **E–H** *A. championii* Merr. et Chun: **E** habitat **F** inflorescence and flower (front view) **G** flower (lateral view) **H** anthers and gynostemium **I–L** *A. fangchi* Y. C. Wu ex L. D. Chow et S. M. Hwang: **I** habitat **J** inflorescence and flower (lateral view) **K** flower (front view) **L** anthers and gynostemium **M–P** *A. petelotii* O. C. Schmidt: **M** habitat **N** inflorescence and flower (lateral view) **O** flower (front view) **P** anthers and gynostemium. Illustration by Wenhong Lin (based on the illustrations from *Flora Reipublicae Popularis Sinicae*).

be given a Vulnerable (VU) status, based on the criteria D2 of IUCN. As a newly-found species, however, it is probable that more subpopulations of *A. yachangensis* could be found in similar habitats of limestone areas of north-western Guangxi and southern Guizhou, China in the future.

Additional specimens examined (paratypes). CHINA. Guangxi Zhuang Autonomous Region: Baise City, Leye County, Huaping Town, Zhongjing (Yachang Orchid National Nature Reserve), 24°49.367'N, 106°24.029'E, 1341 m a.s.l., 21 April 2019, *Y. J. Luo & S. W. Li* 20190421001 (IBK); the same location, 17 May 2019, *Y. J. Luo et al.* YC4439 (IBK).

Discussion

Aristolochia yachangensis is unique in morphology. It is mostly similar to *A. fangchi*, *A. petelotii* and *A. championii*, but can be distinguished from all other *Aristolochia* species mainly based on the morphological characters of inflorescence, perianth tube, limb and throat. *A. yachangensis* can be further distinguished from morphologically-close species with the following key.

Key to *Aristolochia yachangensis* and morphologically-close species

- 1 Limb adaxially papillate or upper papillate, lower smooth..... 2
- Limb adaxially smooth..... 3
- 2 Basal portion of tube shorter than the upper; limb adaxially yellow, with dark purple stripes 4
- Basal portion of tube longer than the upper; limb adaxially dark purple
..... *A. championii*
- 3 Limb adaxially yellow 5
- Limb adaxially dark purple or reddish-purple, sometimes with yellow or white blotches..... 6
- 4 Leaf blade narrowly ovate to ovate-oblong, base cordate; petiole 4–5 cm long; limb 3–4 cm in diam *A. huanjiangensis*
- Leaf blade lanceolate to elliptic-lanceolate or linear-lanceolate, base rounded or broadly cuneate; petiole 1–1.5 cm long; limb 4–6 cm in diam
..... *A. yachangensis*
- 5 Leaf blade ovate to narrowly ovate; limb ca. 2.5 cm in diam.; lobes of gynostemium pubescent *A. pilosistyla*
- Leaf blade oblanceolate to lanceolate-elliptic; limb 4–6 cm in diam.; lobes of gynostemium glabrous..... *A. versicolor*
- 6 Limb small, ca. 3 cm × 1.5–2 cm, adaxially without blotches.... *A. fulvicoma*
- Limb large, 4–13 cm in diam..... 7

- 7 Leaf blade lanceolate–oblong or narrowly oblong, base narrowly auriculate, lateral veins 8–12; limb 8–13 cm in diam *A. westlandii*
- Leaf blade ovate, oblong or ovate-oblong, rarely ovate-lanceolate, base cordate or rounded; limb no more than 8 cm in diam **8**
- 8 Leaf blade base rounded, rarely cordate; limb dark purple, with pale yellowish blotches *A. fangchi*
- Leaf blade base cordate; limb dark purple or reddish-purple, with white blotches or pale yellowish, without blotches..... *A. petelotii*

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A study of community structure and beta diversity of epiphyllous liverwort assemblages in Sabah, Malaysian Borneo

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Abstract

We evaluated the species richness and beta diversity of epiphyllous assemblages from three selected localities in Sabah, i.e. Mt. Silam in Sapagaya Forest Reserve, and Ulu Senagang and Mt. Alab in Crocker Range Park. A total of 98 species were found and a phytosociological survey was carried out based on the three study areas. A detailed statistical analysis including standard correlation and regression analyses, ordination of species and leaves using centered principal component analysis, and the SDR simplex method to evaluate the beta diversity, was conducted. Beta diversity is very high in the epiphyllous liverwort assemblages in Sabah, with species replacement as the major component of pattern formation and less pronounced richness difference. The community analysis of the epiphyllous communities in Sabah makes possible their detailed description and comparison with similar communities of other continents.

Keywords

Lejeuneaceae, liverworts, Malesia, Marchantiophyta, statistical analyses

Introduction

Beta-diversity can be defined as the change or turnover in species composition among particular sites (Anderson et al. 2011). This pattern provides a platform into understanding processes that form and maintain biodiversity (e.g., Tuomisto et al. 2003; Chase 2010; Anderson et al. 2011; Kraft et al. 2011). According to Whittaker (1972), the level of beta-diversity in plant communities is associated with two mechanisms known as habitat heterogeneity and dispersal limitation. This has brought the attention of ecologists to further assess the patterns of beta-diversity and to investigate the mechanisms behind observed patterns through specifically designed data collection (Smith 1982; Bolnick et al. 2002; Harrison et al. 2006; Philippot and Hallin 2011; Myers et al. 2013). Hence, epiphyllous liverworts communities seem to give advantages and provide an excellent system for the study of beta diversity (Kraichak 2014) in numerous ways. First, they can be easily sampled and obtained in a large number within a relatively small area and extended across multiple habitat types and scales (Kraichak 2014). They usually occur and thrive well in moist and warm forests of tropical and subtropical regions (Chen and Wu 1964) and can be preserved intact for later examination (Richards 1932). Besides, due to their simple morphological structure and poikilohydric status, they rely greatly on air moisture as the condition of survival, allowing reliable quantification of particular resource levels and fluctuations (Monge-Najera 1989; Pócs 1996; Gradstein 1997; Pócs and Tóthmérész 1997; Zotz et al. 1997).

Liverworts commonly occur as epiphytes and epiphylls in tropical rainforests (Gradstein 1997; Gehrig-Downie et al. 2013). The epiphylls or epiphyllous liverworts (i.e. species found growing on the living leaves of vascular plants) constitute a special life form, occurring in permanently moist and warm evergreen forests in tropical and subtropical regions. They are considered as the most important component in epiphyllous assemblages, in which an average of 4–8, but sometimes much more, up to 25 species, can grow on a single leaf (Lücking 1995; Gehrig-Downie et al. 2013). In addition, they often exhibit high rates of endemism, especially in montane forests above 1,500 m elevation (Pócs 1996). Epiphyllous liverworts have been described since the 18th century; the first report of an epiphyllous liverwort, i.e., *Jungermannia flava* Sw. (= *Lejeunea flava* (Sw.) Nees), was given by Swartz in 1788. Since then, epiphyllous liverworts have attracted and captured the interest of numerous botanists and ecologists because of their unique habitat, their life strategies, and adaptations necessary for surviving in such microhabitat (Goebel 1890; Ruinen 1961; Winkler 1967, 1970; Pócs 1996; Sonnleitner et al. 2009). About one thousand species of epiphyllous bryophytes have been described. Apparently, they have certain morphological characters which allow them to colonize and survive in this ephemeral environment. Epiphylls have long been recognised as the phyllosphere of vascular plant communities (Ruijn 1961). Several studies have been conducted on morphological and life-history characters related to the survival of epiphylls and the correlation of microclimatic variables with the distribution of epiphyllous communities (Gradstein 1997; Gignac 2001; Wanek and Pörtl 2005; Frego 2007; Sonnleitner et al. 2009; Hylander et al. 2013; Malombe et al. 2016).

Sabah, located at the East of Malaysia, consists of several unique landscapes and regions of higher altitudes that offer promising biological sites for the study of epiphyllous liverworts. Much of this region has been declared either as state parks under the management of Sabah Parks or conservation areas under the management of Yayasan Sabah Group. For example, the Crocker Range, the longest range in Sabah extending from Kudat (northern tip of Borneo) to Sipitang (southern part of Sabah) (Suleiman et al. 2017), has the highest mountain peak in Southeast Asia (Mount Kinabalu, 4059 m a.s.l.), together with other 16 peaks that exceed 1,000 m above sea level (Usui et al. 2006). Meanwhile, huge areas of unique landscapes (basin, valley, coast, canyon and river) that have been protected host a remarkable biological diversity with a staggering number of plant species.

A fair number of bryophyte studies have been published and reported from Sabah (e.g., Mizutani 1974; Inoue 1989; Yamada 1989; Piippo 1989; Frahm et al. 1990; Akiyama et al. 2001; Suleiman et al. 2006; Andi et al. 2015; Zhu et al. 2017). However, no specific study focused on epiphyllous liverwort communities has been conducted in tropical rainforests of Sabah and within Malaysia. Therefore, the present study is aimed to evaluate the species richness and beta diversity of epiphyllous assemblages from three selected localities in Sabah by performing a phytosociological survey and detailed statistical analysis.

Materials and methods

Study area

1) Ulu Senagang

Ulu Senagang is located in the western part of Sabah (Fig. 1), near the boundary of Tenom and Keningau districts. It is part of the Crocker Range Park (CRP) and located in the south eastern zone of the park. The CRP was shaped by the Crocker Range Formation where the lower part is of Paleocene to Middle Eocene age (Hutchison 2005). The most dominant parental soil types found in the Crocker Range are sandstone and mudstone (Dinor et al. 2007). The temperature on the lowlands of CRP is within 22–40 °C throughout the year. CRP has one of the highest precipitation areas in Sabah. However, the eastern part of the park, including Ulu Senagang, has a relatively low rainfall with less than 2,000 mm/year (Usui et al. 2006). The forest vegetation zone of Ulu Senagang is lowland rainforest and it is classified as hill dipterocarp forest. According to Majit et al. (2011), the forest type of this area is considered as a young secondary forest due to past disturbance from human activities and forest fires.

2) Mount Silam

Mount Silam is a small coastal mountain located at the south-eastern part of Sabah in Lahad Datu district (Fig. 1). Most of the mountain is made up of ultrabasic rock. Standing at only 884 m a.s.l., this mountain experiences frequent cloud cap formation which usually develops from the early afternoon until the end of the day. The forest above 770 m

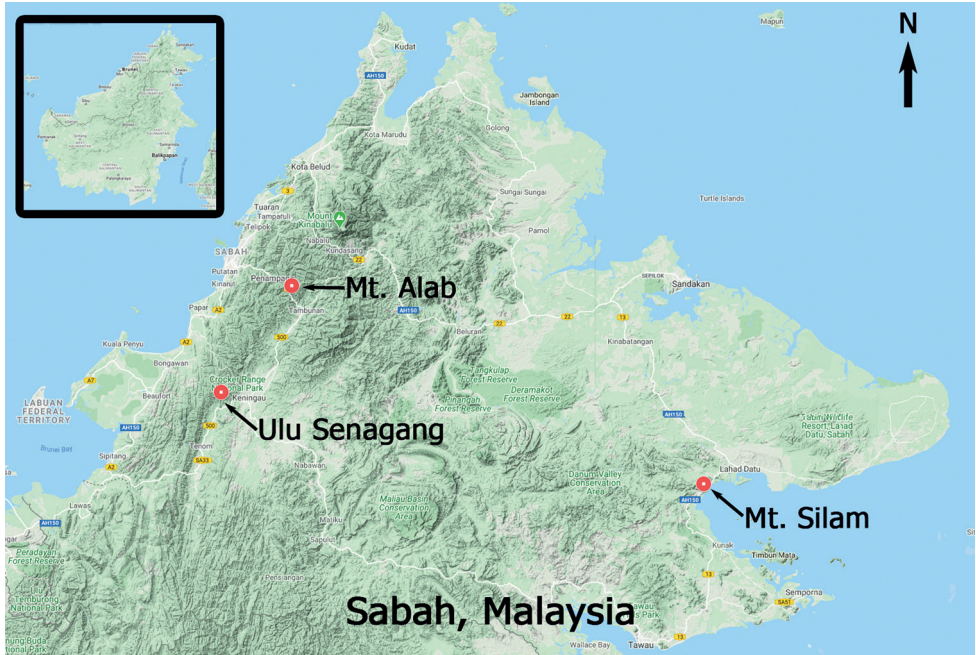


Figure 1. The three selected localities in the present study.

is stunted, showing a classic ‘Massenerhebung effect’, which is the compression of forest zones on a small mountain (Proctor et al. 1988). The altitudinal gradient of Mount Silam can be divided into four layers which are the lowland ultramafic forest (200–300 m), upland ultramafic forest (330–540 m), lower montane ultramafic forest (540–770 m) and the upper montane ultramafic forest (>770 m) (Sabah Forestry Department 2017). The lowland climate of Mount Silam is humid tropical with an average precipitation of 2,132 mm/year. The annual mean temperature is 27 °C and the mean monthly relative humidity is about 85%. However, the summit region receives higher rainfall of up to 2,700 mm/year and relative humidity of 90–91% (Bruijnzeel et al. 1993). The mean temperature of the summit region is 18.8–27.7 °C (Proctor et al. 1988).

3) Mount Alab

Mount Alab is located in the northern zone of the Crocker Range Park in Tambunan district. This area shares the same geological formation and soil types with Ulu Senagang. This mountain is the second highest peak of CRP with 1964 m a.s.l. The forest vegetation zone of this area is upper montane rainforest, called also “cloud- or “mossy-forest”. It is classified as a primary forest and dominated by montane plants from the Fagaceae, Myrtaceae and Ericaceae. Mount Alab receives the highest rainfall in CRP with more than 4000 mm/year. The mean air temperature and relative humidity of this mountain are about 15 °C and 99%, respectively (Majuakim and Anthony 2016). The peak of Mount Alab is persistently covered with clouds from mid-day, resulting in high abundance of bryophytes.

Sampling and data analysis

During our present study in Malaysia, by the selection and guidance of the second author, we studied 23 rainforest habitats in Sabah. Of these we could take representative samples of the epiphyllous communities in 12 habitats at different altitudes. The routine followed the sampling protocol of Pócs (1978). For the present study, we selected three sites: Crocker Range Park, W of Keningau district at Ulu Senagang Substation (a lowland rainforest at 525–570 m elevation); Crocker Range Park, NNW of Tambunan district at Gunung Alab Substation (mossy elfin forest or cloud forest at 1900–1940 m elevation); and Mt. Silam, Sapagaya Forest Reserve of Lahad Datu district (lower montane rainforest at 600–740 m elevation). From the shrub layer of each site, 50 average sized leaves well-covered by epiphylls were collected randomly and prepared for further study. From a coenological point of view, each leaf was considered to be a different stand of the epiphyllous assemblage. The species composition on each leaf was identified, yielding a total of 98 species. That is, the present study is based on a 98×150 presence-absence data matrix, as given separately for the three study areas in Tables 2–4. In addition, the area of each leaf was also measured.

The epiphyllous liverwort assemblage data served as a basis for a detailed statistical survey. The relationship between the number of species and leaf area was graphically illustrated by a scatterplot, and standard correlation and regression analyses were conducted to evaluate its linear component. Centered (i.e. covariance-based) principal component analysis (Podani 2001) was used to generate a simultaneous ordination of species and leaves, the biplot. In addition, beta diversity and related structural phenomena were evaluated by the SDR simplex method developed by Podani and Schmera (2011).

Results and discussion

The localities of epiphyllous collections and phytosociological survey

Table 1 shows the enumeration of rainforest habitats visited during the period of 30 July to 17 August, 2018 in which epiphyllous liverworts were collected. In Tables 2–4, each column represents the epiphyll flora of one leaf. The leaf area in cm^2 and the number of species of each leaf are indicated. The X and + symbols mean presence only, while the black dots in Table 3 indicate the dominant species on each leaf. The species

Table 1. The three investigated habitats in the present study.

	Locality	Forest type	GPS coordinates	Elevation (m)
Table 2.	1822. Ulu Senagang Substation, Crocker Range Park, Keningau district	Lowland rainforest below waterfalls, with 50 m high canopy of Dipterocarpaceae	05°21.776'N, 116°01.713'E	525–570
Table 3.	1811. Mt. Silam, Sapagaya Forest Reserve, 22 km WSW of Lahad Datu district, from the telecommunication towers to the summit ridge of Mt. Silam	Lower montane rainforest with 15–20 m high canopy with <i>Shorea tenuiramulosa</i> and <i>Borneodendron enigmaticum</i> .	04°57'12"N, 118°9'39"E	600–740
Table 4.	1823. Mt. Alab Substation, Crocker Range Park, Tambunan district	Mossy cloud (elfin) forest, about 6 m high canopy of <i>Phyllocladus hypophyllus</i> , <i>Rhododendron</i> , <i>Dacrydium</i> and <i>Nepenthes</i> spp.	05°49.320'N, 116°20.499'E	1900–1940

Table 5. The comparison of the epiphyllous assemblages of three localities in terms of the number of occurrences of constituting liverwort species.

Locality	Ulu Senagang	Mt. Silam	Mt. Alab	Total
<i>Leptolejeunea maculata</i> (Mitt.) Schiffn.	32	26	4	62
<i>Drepanolejeunea pentadactyla</i> (Mont.) Steph.	5	24	18	47
<i>Cheilelejeunea trapezia</i> (Nees et al.) R.M.Schust. & Kachroo	15	21	7	43
<i>Microlejeunea punctiformis</i> (Taylor) Steph.	6	4	16	26
<i>Leptolejeunea elliptica</i> (Lehm. & Lindenb.) Schiffn.	3	1	21	25
<i>Leptolejeunea epiphylla</i> (Mitt.) Steph.	32	.	.	32
<i>Cololejeunea planissima</i> (Mitt.) Abeyw.	22	.	.	22
<i>Cololejeunea gotschei</i> (Steph.) Mizut.	19	.	.	19
<i>Cololejeunea lanciloba</i> Steph.	11	.	.	11
<i>Cololejeunea longifolia</i> (Mitt.) Mizut.	11	.	.	11
<i>Leptolejeunea vitrea</i> (Nees) Schiffn.	8	.	.	8
<i>Cololejeunea hildebrandii</i> (Austin) Steph.	5	.	.	5
<i>Cololejeunea peponiformis</i> Mizut.	5	.	.	5
<i>Colura corynophora</i> (Nees et al.) Trevis	2	9	.	11
<i>Colura conica</i> (Sande Lac.) K.I.Goebel	2	6	.	9
<i>Lejeunea</i> sp. 2	5	1	.	6
<i>Colura acroloba</i> (Steph.) Ast	4	1	.	5
<i>Colura superba</i> (Mont.) Steph.	1	4	.	5
<i>Drepanolejeunea tricornua</i> Herzog	.	37	.	37
<i>Leptolejeunea amphiophthalmia</i> Zwickel	.	11	.	11
<i>Cololejeunea mutabilis</i> Benedix	.	8	.	8
<i>Colura</i> sp.	.	7	.	7
<i>Cololejeunea equialbi</i> Tixier	.	6	.	6
<i>Cololejeunea metzgeriopsis</i> (K.I.Goebel) Gradst. et al.	.	6	.	6
<i>Colura superba</i> (Mont.) Steph.	.	5	.	5
<i>Drepanolejeunea tenera</i> K.I.Goebel	16	.	13	29
<i>Lejeunea</i> sp.	18	.	5	23
<i>Drepanolejeunea vesiculosa</i> (Mitt.) Steph.	3	.	12	15
<i>Frullania</i> sp.	4	.	3	7
<i>Lejeunea flava</i> (Sw.) Nees	1	.	6	7
<i>Drepanolejeunea dactylophora</i> (Nees et al.) Schiffn.	.	7	26	35
<i>Cololejeunea haskariana</i> (Lehm. & Lindenb.) Schiffn.	.	1	12	13
<i>Metalejeunea cucullata</i> (Reinw. et al.) Grolle	.	6	1	7
<i>Cololejeunea papillosa</i> (K.I.Goebel) Mizut.	.	2	5	7
<i>Cheilelejeunea oclusa</i> (Herzog) T.Kodama & N.Kitag.	.	1	1	2
<i>Drepanolejeunea thuaitesiana</i> (Mitt.) Steph.	.	.	32	32
<i>Diplasiolejeunea jovet-astiae</i> Grolle	.	.	26	26
<i>Cololejeunea peraffinis</i> (Schiffn.) Schiffn.	.	.	22	22
<i>Cololejeunea ensifera</i> Tixier	.	.	11	11
<i>Leptolejeunea subdentata</i> Herzog	.	.	10	10
<i>Frullania ramuligena</i> (Nees) Mont.	.	.	9	9
<i>Cololejeunea dozyana</i> (Sande Lac.) Schiffn.	.	.	8	8
<i>Cololejeunea macounii</i> (Underw.) A.Evans	.	.	8	8
<i>Cololejeunea stephanii</i> Benedix	.	.	8	8
<i>Colura tenuicornis</i> (A.Evans) Steph.	.	.	7	7
<i>Cololejeunea sphaerodonta</i> Mizut.	.	.	5	5
<i>Colura verdoornii</i> Herzog & Ast	.	.	5	5
<i>Drepanolejeunea</i> aff. <i>serricalyx</i> Herzog	.	.	5	5

are arranged according to their frequency in the analysed communities. Table 5 shows the comparison of the three assemblages, their similarities and differences, in which species with at least 10% occurrence in Tables 2–4 are included only. Those with frequency less than 5 out of 50 are omitted.

Species/leaf area relationships and beta diversity analyses

The number of species vs leaf area relationships are shown by the scatter plot in Fig. 2. Although the variance of the number of species per leaf is fairly high, there is a definite increase of species number over area. Since the number of points is large, and therefore the degrees of freedom is also large ($n = 148$), the resulting Pearson correlation, $r = 0.22$ with a probability point of $p = 0.007$, is a highly significant result. The regression equation is $N = 0.01A + 4.93$ in which N is the estimate of species number at leaf area A expressed in cm^2 .

The entire data set was evaluated by centered principal component analysis. The first two ordination axes explain 14% and 10% of the total variance. Although these percentages may appear low at first sight, the biplot diagram for axes 1–2 (Fig. 3) is well-interpretable. The leaves from the three sites form separate clusters, oriented away from the origin in three directions. The three sites do not separate completely, the species-poor leaves are positioned around the centroid. The length and position of arrows indicate species that are most responsible for the differences between the three sites. It is seen that site number 1 in Fig. 3, i.e. Mt. Alab has a fairly large number of species

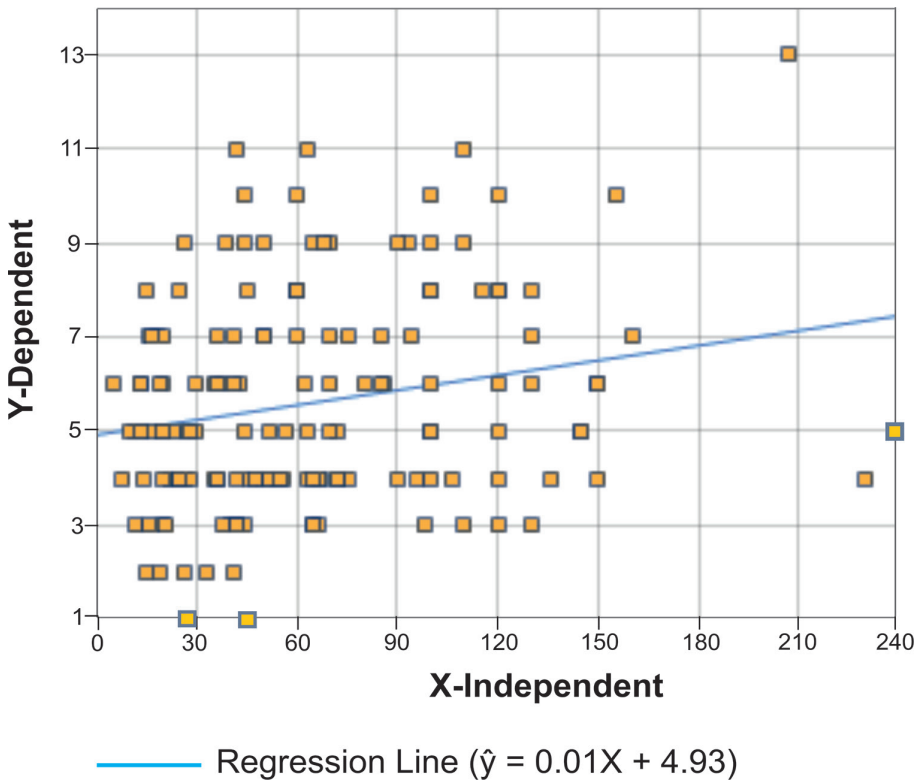


Figure 2. Leaf area (in cm^2 , x axis) – number of epiphyllous liverwort species (y axis) relationship based on 150 leaves collected in three rainforest sites in Sabah.

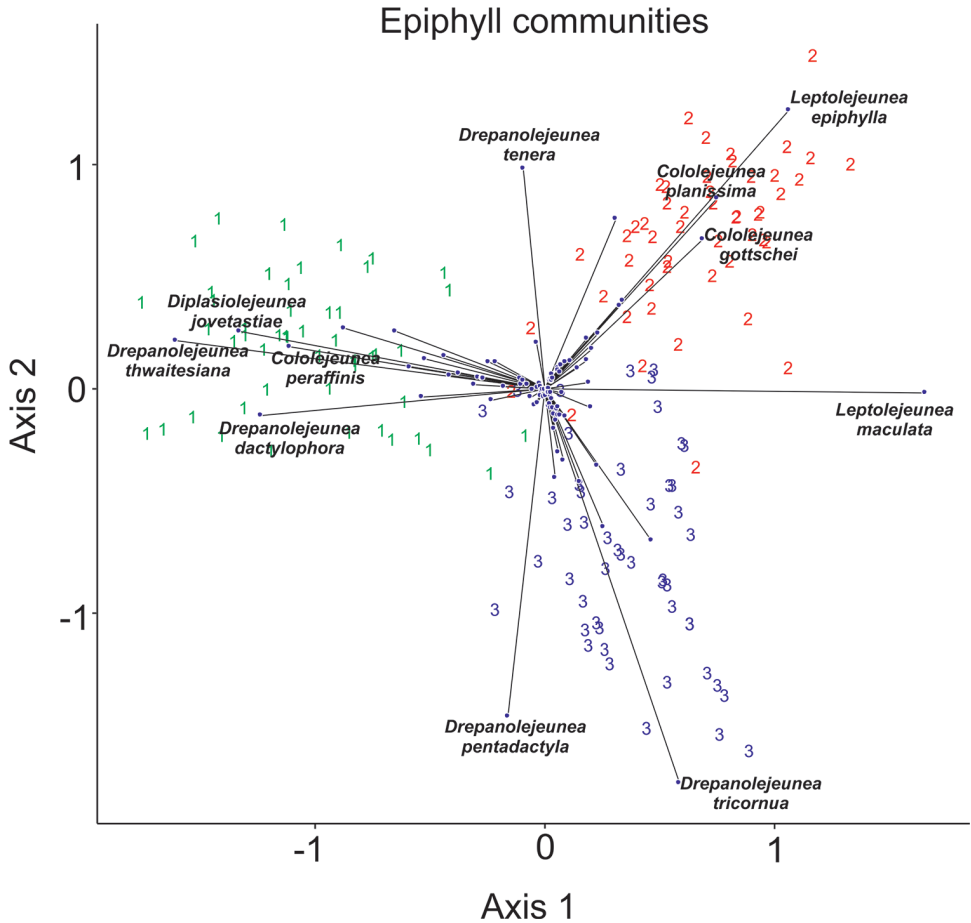


Figure 3. The Principal Components ordination biplot of the three groups of epiphyllous assemblages, each containing 50 leaves. Numbers identify forest sites **1** mossy cloud (elfin) forest, Mt. Alab (Table 4) **2** lowland rainforest, Ulu Senagang (Table 2) **3** lower montane rainforest, Mt. Silam (Table 3).

that typically occur there, such as *Diplasiolejeunea joveastiae* Grolle, *Drepanolejeunea thwaitesiana* (Mitt.) Steph., *D. dactylophora* (Nees, Lindenb. & Gottsche) Schiffn. and *Cololejeunea peraffinis* (Schiffn.) Schiffn. Site 2 in Ulu Senagang is mostly characterized by the presence of *Leptolejeunea epiphylla* (Mitt.) Steph., *Cololejeunea gottschei* (Steph.) Mizut. and *C. planissima* (Mitt.) Abeyw., whereas *Drepanolejeunea tenera* K.I.Goebel occurs in both sites. In site 3 (Mt. Silam, a lower montane rainforest near to the sea, exposed to rain carrying winds), *Drepanolejeunea pentadactyla* (Mont.) Steph. and *D. tricornua* Herzog appear most typical. Most species are positioned near the origin, showing that they are either relatively rare as *Cololejeunea macounii* (Underw.) A.Evans or *Colura superba* (Mont.) Steph. or common to all the three sites like *Leptolejeunea maculata* (Mitt.) Schiffn.

The SDR simplex plot and associated percentages obtained for the entire study area (three sites taken together) demonstrate that there is an extremely high beta di-

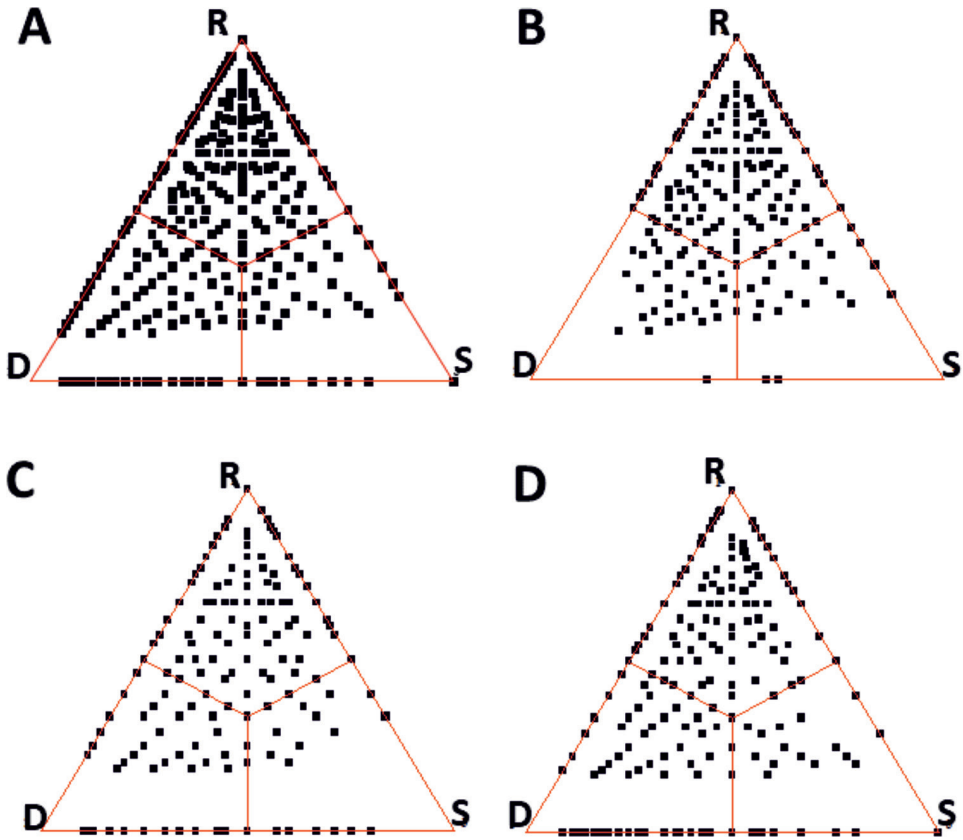


Figure 4. Ternary (or simplex) plot for the epiphyllous liverwort assemblages based on presence-absence data for three rainforest sites in Sabah **A** all sites taken together **B** mossy cloud (elfin) forest, Mt. Alab **C** lowland rainforest, Ulu Senagang **D** lower montane rainforest, Mt. Silam.

versity (91%) of epiphyllous assemblages in the study sites, leaving only a 9% share by similarity (Fig. 4A). Beta diversity is dominated by turnover (species replacement, $R = 66\%$) while richness difference (D) is 25%. Its graphical manifestation is that most of the points (each representing a pair of leaves) lie within or near the upper third of the triangle (R – replacement). The anti-nestedness fraction within beta diversity, corresponding to points lying on the left edge of the triangle, is 11% – this is caused by pairs of leaves that do not have a single species in common. Nevertheless, quite many points lie on the bottom side, demonstrating that nestedness is also characteristic of the epiphyllous bryophyte assemblages – the species occurring in certain leaves are subsets of the species assemblage of other leaves ($D + S$ – Anti-nestedness fraction = 22.5%). The three simplex diagrams obtained for the three forests (Fig. 4B–D) show that the very high overall beta diversity is not merely the result of between-site differences; their beta diversity is 81%, 80% and 80.5%, leaving 19–20% for the similarity component. That is, the liverwort assemblages on the leaves of rainforest trees are extremely diverse. A major difference between the sites is in the partitioning of beta in which species

replacement is the highest in the cloud forest, i.e. in Mt. Alab (60%), and the lowest in the lowland montane forest in Mt. Silam (50.5%). This explains why nestedness is much less conspicuous in the cloud forest than elsewhere in which only a few points fall onto the bottom side of the plot.

Conclusion

The overall conclusion is that the major component of pattern formation in epiphyllous liverwort assemblages from Sabah is species replacement (50–60% for individual forests, 66% for combined data), while richness difference is less pronounced (20–25%). This is in contrast to the results of a study performed on similar assemblages in southern Thailand (Pócs and Podani 2015), where differences in species number were much more influential than species replacement (50% versus 37%). In any case, beta diversity – the sum of richness difference and species replacement – is extremely high in both studies, leaving only 10–20% similarity in the species composition of leaf surfaces. The ecological explanation is that the assemblage of a given leaf is likely to be formed by a random choice from the liverwort species pool of the forest, species follow one another haphazardly as allowed by the size of the leaf. In Sabah, the three forests selected for the present study were floristically very different, forming three clusters in the PCA ordination plane with a couple of characteristic species in each. Their separation was not sharp at all, species-poor leaves were arranged around the centroid regardless of their origin, and three sites were overlapping. Extended studies involving more forests from Malaysia, as well as from other areas in south-eastern Asia, may give further insight into the structure of this special type of plant communities.

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How many type specimens can be stored in old lesser-known herbaria with turbulent histories? – A *Juncus* case study reveals their importance in taxonomy and biodiversity research

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Abstract

Many herbarium sets in Europe are still being catalogued and it is likely that many old-type collections are yet to be discovered. This research has the potential to facilitate the study of the biodiversity of many regions, especially regions for which collections are extremely scarce. This has been confirmed by a case study using *Juncus* (Juncaceae) examining the turbulent history of botanical collections at the WRS� herbarium and the evaluation of its importance to the study of taxonomy and biodiversity since 1821. The analysis revealed that the WRS� collection is rich in types (ca. 3.6%) and we identified 76 (of 78) new, historically and nomenclaturally important specimens (types, original material and so-called “topotypes”). Some of these type specimens represent duplicates of these that were stored in Berlin and destroyed during World War II. Many of the type specimens are from the United States of America, South Africa, India, and Canada. The largest number of *Juncus* type specimens stored at WRS� originate from South Africa (42.3% of all type specimens), even though *Juncus* is rare in Africa. Our study highlights that uncatalogued old collections that are under-explored and under-exploited have the potential to facilitate the discovery of specimens important for the study of biodiversity, conservation, taxonomy and nomenclature.

Keywords

biodiversity, conservation, historical collections, Juncaceae, *Juncus*, plant taxonomy

Introduction

The Natural History Museum of Wrocław University (Muzeum Przyrodnicze Uniwersytetu Wrocławskiego) is the oldest natural history museum in Poland and its history dates back to 1814, when it was founded by Prof. Johann Ludwig Christian Gravenhorst as the Zoological Museum. Currently, it houses both the botanical and zoological collections. The beginning of the herbarium in its present form was the Herbarium Horti Botanici Universitatis Wratislaviensis, which was established by Prof. Ludolph Christian Treviranus in 1821 (Wiktor 2002; Wanat 2013). The Herbarium Silesiacum was independently founded by the Silesian Association of Native Culture (Schlesische Gesellschaft für Vaterländische Cultur) and, until 1945, it was housed on Tamka Island, Wrocław. It developed independently from the other botanical collections, but following the Second World War, it was merged with the main part of the herbarium.

Many distinguished botanists have worked in the WRS� herbarium (Museum of Natural History, University of Wrocław, Poland, in Polish: Zielnik WRS�), including the directors or curators of Wrocław's botany collections, for example, Ludolf Christian Treviranus (1821–1830), Christian Gottfried Nees von Esenbeck (1830–1852), Heinrich Robert Goeppert (1852–1884), Heinrich Gustav Adolf Engler (1884–1889), Ferdinand Cohn (1884–1893) and Ferdinand Pax sen. (1893–1927). The Herbarium Silesiacum was curated by Julius Milde (1865–1870), Gustav Wilhelm Körber (1871–1885), Rudolf von Uechtritz (1886), Theodor Schube (1890–1929) and Emil Schalow (1930–1944) (Wiktor 2002).

Professor H.R. Goeppert expanded the botany collections and established the Botanical Museum (Botanisches Museum) in 1853 (Wanat 2013). The first known catalogue of the Museum (Goeppert 1884) included 26 different collections, including the Herbarium of the World, the Herbarium Silesiacum, the Herbarium Mycologicum, a wood collection and several fruit and seed sets. Goeppert also opened another museum in 1878 – The Museum of the Botanical Garden (Mularczyk 1998). In 1888, all these several botanical collections belonging to the University were moved to a building that is today located at 6/8 Kanonia Street. However, they still consisted of two separate collections (the Botanical Museum in charge of Prof. Cohn and collections of the Herbarium and the Museum of the Botanical Garden in charge of Prof. Engler). Due to the efforts of Prof. Engler, a private Silesian plant collection assembled by Rudolf von Uechtritz was purchased at this time and M. Winkler donated his herbarium to the Museum, which he had compiled for 30 years (Wiktor 2002).

At the end of nineteenth century, Ferdinand Pax (the elder) merged all the University botanical collections under the name of the Botanical Museum. His own collections were also included in the Museum at this time. Before merging, von Uechtritz's herbarium of Silesian plants was handed over to the Herbarium Silesiacum (then still independent) on his initiative. In exchange for Uechtritz's herbarium, the Botanical Museum later received the Herbarium Henschelianum (part of the Herbarium Silesiacum) with ca. 100,000 sheets.

As a result of these mergers and gifts, the Wrocław herbarium had acquired an extensive and significant collection of specimens from Europe (especially the Mediter-

ranean) and the rest of the world. These were collected by botanists such as Hubert Winkler (a student of F. Pax the elder) in East Africa, Cameroon, Java, Sumatra and Borneo. In 1938, a collection of ca. 50,000 herbarium sheets (including numerous types) was donated to the Museum by Carl Adolf Georg Lauterbach, who travelled extensively in New Guinea and Melanesia. By 1914, the Herbarium had 540,000 sheets which, by 1939, had grown to ca. 600,000 sheets (Wiktor 2002; Wanat 2013). The oldest and most valuable collections of the Herbarium Silesiacum were those made by H.G. Mattuschka (1776 and 1779), A.J. Krockner (1787, 1790, 1814, 1823), A. Henschel (1830), a herbarium of fungi assembled by W.G. Schneider and an old herbarium of Paolo (Silvio) Boccone, a Cistercian monk, who moved to Wrocław in 1694 and donated his herbarium that consisted mainly of Mediterranean plants (Treviranus 1831; Rostański 1963). This herbarium is not mentioned by Stafleu et al. (1976), but is the oldest plant collection of a scientific nature in Poland. In 1935, the Herbarium Silesiacum housed over 80,000 sheets (Wanat 2013).

In autumn 1944, during the Second World War, German authorities evacuated all university botanical collections from Wrocław. The Herbarium Generale (combination of the various merged herbaria) was then located in Piotrowice castle near Kąty Wrocławskie (ca. 43 km S.W. of Wrocław), the Herbarium Lauterbachii in Siedlęcín near Jelenia Góra (ca. 95 km W. of Wrocław) and the other botanical sets in the garrison church in Oleśnica near Wrocław (ca. 27 km N.E. of Wrocław), which were unfortunately lost in a fire. The Herbarium Silesiacum was lodged, in turn, in the attic of one of the primary schools in south Wrocław (in the Tarnogaj district); however, it was not protected from destruction and the dusty and damp collection was rediscovered after the war unbound, mixed together with litter and broken glass (Wiktor 2002; Wanat 2013).

Shortly after the war, Polish authorities failed to discover traces of herbarium sets in the dilapidated buildings – these were found in the Piotrowice castle, Siedlęcín and south Wrocław only in 1946–1947, but only the Herbarium Lauterbachii was salvaged undamaged. The recovered collections were entrusted to Prof. Józef Mađalski, who was invited to Wrocław from Lviv (former Poland, now in the Ukraine). The war had damaged many of the specimens and repairs were successfully undertaken by Polish botanists. Rostański (1963) assessed the war damage in both herbaria (i.e. Herbarium Generale and Herbarium Silesiacum) as, after the war, only 200,000 herbarium sheets were discovered out of 600,000 that belonged to the University in 1939, together with 30,000 herbarium sheets from the former Herbarium Silesiacum which, in 1939, housed 80,000 sheets (it was confirmed then that the oldest Silesian flora sets of H.G. Mattuschka and A.J. Krockner had been destroyed).

Currently, the collections are estimated to contain over 515,000 sheets, including ca. 410,000 vascular plants, 27,000 bryophytes, 38,400 fungi and myxomycetes, 27,000 lichens and 12,600 algae (Mirek et al. 1997; K. Świerkosz, pers. comm., 2019). The herbarium WRSL has had a turbulent history and has enormous importance in the botanical history of Poland.

The aim of this investigation was to assess the value of the WRSL botanical collection using the genus *Juncus* as a case study. Type and other nomenclaturally and

historically important specimens “hiding” in such under-appreciated collections are important for taxonomy, nomenclature and biodiversity studies. Using the WRS� herbarium, we address the importance of collections like WRS� as reservoirs of valuable data that are relevant to experts who are involved in taxonomic revision.

Methods

Assessing the significance of the WRS� collection

The WRS� herbarium is currently divided into three parts: the Herbarium Generale, the Herbarium Lauterbachi and the Herbarium Silesiacum. The Herbarium Generale (about 375,000 specimens including about 75,000 spore-bearing organisms) holds the plant and fungal material from around the world, excluding Lower Silesia, Poland, the Herbarium Lauterbachi (about 50,000 sheets) contains plants from New Guinea and Melanesia and the Herbarium Silesiacum (about 90,000 specimens) (K. Świerkosz, pers. comm., 2019) houses plants from Lower Silesia, Poland.

Generally, the importance of particular natural collections depends not only on their size, but also can be measured on the percentage or the absolute share of type specimen types (Sutory 1997). In 2017, digitalisation of the WRS� collection was initiated and was subsequently able to be accessed via GBIF.org (Świerkosz 2017); this work is on-going but only 25,000 specimens (4.9%) are currently listed in a database (K. Świerkosz, pers. comm., 2019). Therefore, we decided to assess the importance of using specimens of the genus *Juncus* (Juncaceae) stored in the Herbarium Generale (to date, no *Juncus* specimens from WRS� are included in GBIF.org database to facilitate this task). The reasons for this choice were: 1) type specimens of *Juncus* have never previously been assessed in the WRS� Herbarium; 2) the genus *Juncus* is rich in species from regions where the herbarium has geographical strengths, 311 are listed by Kirschner et al. (2002a, b) and 3) the first author of this paper is a specialist in *Juncus* taxonomy, which considerably aided the analysis of specimen status.

We evaluated the following factors (Sutory 1997): 1) the originality of the collection, including the number of types and other historically-important specimens; 2) the size of the collection, i.e. the total number of specimens; 3) the geographical scope of the collection; 4) the length of the period represented by the collection; 5) the number of duplicates and 6) the physical condition of the collection (well-prepared, well-preserved and undamaged and well-stored material with appropriate labels). Herbarium sheets with plants representing a single taxon that were gathered in the same locality and on the same date by the same collector, were regarded as duplicates. Additionally, we analysed the specimens with respect to: 1) the person who collected the material in the field; 2) the collection from which they came (i.e. to whom they belonged before accession in WRS�) and 3) the floras/exsiccatae from which they came.

We catalogued all *Juncus* specimens ourselves, paying particular attention to all types and other historical material, which we identified, based on the latest mono-

graph (Kirschner et al. 2002a, b), from which we took the current nomenclature of the genus. The localities and dates of sets for historical collections, especially those of C.F. Ecklon & C.L.P. Zeyher and J.F. Drège, were deciphered from literature (Meyer 1832; Drège 1847, 1848; Buchenau 1875, 1890, 1906), which enabled us to recognise many *Juncus* types.

The *Juncus* sets are stored in seven herbarium boxes indexed as separate fascicles, numbered 151–157 and an extra 43 herbarium sheets were kept in a separate folder. We analysed 2,192 herbarium sheets in total. We treated a separate collection with its own label as a separate herbarium sheet, as specimens from three different localities could have been mounted on one herbarium sheet (we treated these as three separate herbarium sheets). We identified 2,222 taxonomic records, since part of the material represents mixed sets. We conducted our research from scratch, since only two *Juncus* types identified in the Herbarium Generale had been previously labelled using a red label. Thus, no other *Juncus* types stood out from other herbarium sheets. Our results were also compared with those within the Global Plants Database (plants.jstor.org, accessed on 16 Apr 2020) and additional herbaria, not mentioned by Kirschner et al. (2002a, 2002b) that store other type specimens/duplicates of names we assessed, are added to the last column of Table 1 and marked with an asterisk (*). Duplicates of selected type specimens stored at WRS� were also compared with those stored in other herbaria (present in the Global Plants Database). When comparisons were made, we considered the physical condition of specimens, quantity of materials, different annotations, kinds of labels and plant parts.

Results

Type and other historically-important material

We found 78 specimens that are historically or nomenclaturally important (Table 1): two holotypes, 20 isoelectotypes, 14 isotypes, 29 syntypes (including one probable syntype of *Juncus exsertus* Buchenau (1875: 435)), three paratypes, one isoneotype, five sheets of historically-relevant material (for names not validly published) or additional material from type localities collected by the author of the name (so-called “topotypes”) and four sheets of probable original material to be analysed in the future (Fig. 1). Holotypes, isotypes and isoelectotypes constitute 46.2% of all types (and other historically- and nomenclaturally-important specimens) of *Juncus* specimens recognised at the WRS�. The most significant discovery was the identification of the three following *Juncus* types in the WRS� Herbarium (see also remarks for them in Table 1, last column of rows 46, 56, 20):

1) ISOTYPE of *Juncus lomatophyllus* Spreng. (1821: 108) [sine dato, *Bergius s.n.* (*J. lomatophyllus* Spreng., Bergius’sches Exemplar, bestimmt von K. Sprengel, 11 Jan 1875, det. Fr. Buchenau)]. – Holotype in B, destroyed. Isotype (the only duplicate known) rediscovered at WRS�.

Table 1. A list of historically- and nomenclaturally-important *Juncus* specimens identified in the Herbarium Generale at WRSL. A sequence of species alphabetically according to the basionym *Juncus* names. No. – Successive Number; N.f. – Number of fascicle (= herbarium box) at WRSL; underline text – new findings after examination of the protologues; grey rows – indicate types that were stored in Berlin and were destroyed during the WWII; * – asterisk indicates additional herbaria where Global Plants (plants.jstor.org) records duplicates.

No.	N.f.	Kind of type and type of (basionym)	Current name	Locality (label data)	Herbarium label data (original spelling)	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronym (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.:)
1	151	Authentic/original material of <i>Juncus antoniianus</i> Steud. in W. Lechler, <i>Berberid. Amer. Austral.</i> (1857: 56), nom. inval.	<i>Juncus balticus</i> subsp. <i>andicola</i> (Hook. 1848: 8, pl. 714) Snogerup in Snogerup, Zika & Kirschner, <i>Prelia</i> 74 (2002: 258)	PERU. S. Antonio	Jun 1854 <i>W. Lechler 1808</i> (as <i>Juncus andicola</i> , 04 Dec 1887, Fr. Buchenaus)	W. Lechler, Pl. Peruvianae ed. R. F. Hochenacker / Herbarium Henschelianum	Authentic/original material: Peru, San Antonio, Jun 1954, <i>W. Lechler 1808</i> , G. GOET, K. KW*. Rem.: After Kirschner et al. (2002b: 74) erroneous collection date of Jun 1954 to be corrected to Jun 1854.
2	151	Isotype of <i>Juncus atratus</i> Krock., <i>Fl. Siles.</i> 1 (1787: 562)	<i>Juncus atratus</i> Krock., <i>Fl. Siles.</i> 1 (1787: 562)	POLAND, Breslau [Wrocław], Oderdämme bet Carlowitz [Karlówice, now a settlement within Wrocław city]	10 Jul 1892 <i>A. Callier 721</i>	A. Callier Flora Silesiaca exsiccata / Herbarium Wagnerianum	T: Silesia, <i>A.J. Krock</i> ; syn: not extant; Breslau, Oderdämme bet Carlowitz [Karlówice between Wrocław and Opole, Poland], 10 Jul 1892, <i>A. Callier [Fl. Siles. Exs.] 721</i> ; neo: S, designated by Kirschner et al. (2002a: 178); isomeo: L, PRC, W, WU. Rem.: After Kirschner et al. (2002a: 178) erroneous locality translated as 'Karlówice [village] between Wrocław and Opole, Poland' which is on the Stobrawa river [not Odra] and is ca. 55 km SE from the Karlówice [settlement] in Wrocław on the Odra river. The status of the type was corrected (iso to isomeo) in accordance with the <i>Sprengelien Code</i> .
3	154	Synype of <i>Juncus brimmius</i> Buchenaus, <i>Junc. S. Amer.</i> (1879: 403)	<i>Juncus ebracteatus</i> E. Mey., <i>Syn. Junc.</i> (1822: 28)	PERU. Im paludosis prope Azangaro	Jun 1854 <i>W. Lechler 1749</i> , det. Fr. Buchenaus, 22 Jan 1879	W. Lechler, Pl. Peruvianae ed. R.F. Hochenacker / Herbarium Henschelianum	T: Bolivia, La Paz, Larecája, 2700–3800 m, <i>G. Mamdon 1436</i> ; syn: BM, G, K, MO, NY, P; Peru, Azangaro, <i>W. Lechler 1749</i> ; syn: BR, G, GOET, K, O, P, S.
4	152	Isotype of <i>Juncus buchenani</i> Sved., <i>Juncac. Regn. Esp. (Bih. Kongl. Svenska Vetensk.-Akad. Handl.)</i> 23(3), no 6 (1897: 9)	<i>Juncus marginatus</i> Rosk., <i>De Juncis</i> (1801: 38)	BRASILIA, Brasiliae civit. Rio Grande do Sul, Quinta	07 Dec 1892 <i>C.A.M. Lindman 857</i>	Herb. Brasil. Regnell. Musci bot. Stockholm	T: Brazil, Rio Grande do Sul, Quinta prope opp. Rio Grande, 7 Dec 1892, <i>C.A.M. Lindman 4857</i> ; holo: S; iso: GH, W [cf. <i>Juncus buchenani</i> Dörfl. 1897. an prius?]. Rem.: After Kirschner et al. (2002a: 48) collection <i>No. 4875</i> (probably to be corrected).

No.	N.f.	Kind of type and type of (botany)	Current name	Locality (label data)	Date	Leg. et det.	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.):
5	152	Probably original material of <i>Juncus biflorus</i> var. <i>halophilus</i> Buchenau & Fernald, <i>Rhodora</i> 6 (1904: 39)	<i>Juncus ranarius</i> Songon & E.P. Perrier in PC. Billot, <i>Annou. Fl. France Allemagne</i> (1859: 192)	CANADA, Rivière du Loup	Aug 1902	W.W. Eggleston 3036	Plants of the Lower St. Lawrence	T: Canada, Quebec, Rivière du Loup, 2 Aug 1902. E.F. Williams & M.L. Fernald; holo: GH; iso: CM*, K, L, P, PH*. Paratypes (see protologue): Rivière du Loup, 15 Aug 1892, G.G. Kennedy; Rivière du Loup, 8 Aug 1902, J.R. Churchill, W.W. Eggleston, M.L. Fernald. See also protologue for many other paratypes. Rem.: After Kirschner et al. (2002b: 15) collection should be of E.F. Williams & M.L. Fernald but the herbarium label is marked as 'Type'. According to the protologue the paratype should be collected by J.R. Churchill, W.W. Eggleston, M.L. Fernald (instead of W.W. Eggleston only) and with the exact collection date (8 Aug 1902).
6	152	Holotype of <i>Juncus bulbosus</i> f. <i>submicronatus</i> Pročková, <i>Ann. Bot. Fenn.</i> 47 (2010: 412)	<i>Juncus bulbosus</i> f. <i>submicronatus</i> Pročková, <i>Ann. Bot. Fenn.</i> 47 (2010: 412)	POLAND, Wrocław Leśnica, ad ripam et in aqua piscinae eutrophicae et in aqua piscinae eutrophicae, situ meridiano-occidentali lacus	31 May 1999	J. Pročková 99053/11	Herbarium J. Pročková	T: Poland, Dolny Śląsk, Wrocław Leśnica, ad ripam et in aqua piscinae eutrophicae, situ meridiano-occidentali lacus, 31 May 1999, J. Pročková; holo: WRSL; iso: WRSL; para: B, BIL, BM, BR, C, DBN, DRAPN, E, GOET, H, HAL, HBG, KRA, L, LAU, LG, LISU, M, MA, MSB, P, PBMA, POZ, S, TRN, TUB, WA, WRSL, WSRP, ZBI. Rem.: After Pročková (2010: 420–423)
7–11	152	Isotype of <i>Juncus bulbosus</i> f. <i>submicronatus</i> Pročková, <i>Ann. Bot. Fenn.</i> 47 (2010: 412)	<i>Juncus bulbosus</i> f. <i>submicronatus</i> Pročková, <i>Ann. Bot. Fenn.</i> 47 (2010: 412)	POLAND, Wrocław Leśnica, ad ripam et in aqua piscinae eutrophicae et in aqua piscinae eutrophicae, situ meridiano-occidentali lacus	31 May 1999	J. Pročková 99053/12 to 6	Herbarium J. Pročková	T: Poland, Dolny Śląsk, Wrocław Leśnica, ad ripam et in aqua piscinae eutrophicae, situ meridiano-occidentali lacus, 31 May 1999, J. Pročková; holo: WRSL; iso: WRSL; para: B, BIL, BM, BR, C, DBN, DRAPN, E, GOET, H, HAL, HBG, KRA, L, LAU, LG, LISU, M, MA, MSB, P, PBMA, POZ, S, TRN, TUB, WA, WRSL, WSRP, ZBI. Rem.: After Pročková (2010: 420–423).
12	152	Paratype of <i>Juncus bulbosus</i> f. <i>submicronatus</i> Pročková, <i>Ann. Bot. Fenn.</i> 47 (2010: 412)	<i>Juncus bulbosus</i> f. <i>submicronatus</i> Pročková, <i>Ann. Bot. Fenn.</i> 47 (2010: 412)	GERMANY, Leipzig, Dahlen, 2. Teich in Richtung Schmannewitz, Teichschlamm.	03 Aug 1984	Peter Güte 34378 (WRSL 69420)	Flora des Bezirkes Leipzig Herb. Univ. Lipsiensis, Pflanzen der DDR	T: Poland, Dolny Śląsk, Wrocław Leśnica, ad ripam et in aqua piscinae eutrophicae, situ meridiano-occidentali lacus, 31 May 1999, J. Pročková; holo: WRSL; iso: WRSL; para: B, BIL, BM, BR, C, DBN, DRAPN, E, GOET, H, HAL, HBG, KRA, L, LAU, LG, LISU, M, MA, MSB, P, PBMA, POZ, S, TRN, TUB, WA, WRSL, WSRP, ZBI. Rem.: After Pročková (2010: 420–423).

No.	N.f.	Kind of type and type of (basionym)	Current name	Locality (label data)	Herbarium label data (original spelling)	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.:)
13	152	Paratype of <i>Juncus bulbosus</i> E. submicronotatus Proćków, Ann. Bot. Fenn. 47 (2010: 412)	<i>Juncus bulbosus</i> f. <i>submicronotatus</i> Proćków, Ann. Bot. Fenn. 47 (2010: 412)	CZECH REPUBLIC. Bohemia meridionalis, distr. České Budějovice; ad margines turfossae stagnorum, prope rivulum Borovnický potok haud procul ab vico Borovnice, copiose, ca. 450 m s. m.	24 Aug 1962 <i>J. Kučera 154</i> (WRSL 26580)	Plantae Czechoslovaecae Exsiccatae. Cura Sectionis Botanicae Musei Nationalis Pragae Editae. Centuria II	T: Poland, Dolny Śląsk, Wrocław Leśnica, ad ripam et in aqua piscinae europlicatae, situ meridiano-occidentali lacus, 31 May 1999, <i>J. Proćków</i> ; holo: WRSL; iso: WRSL; para: B, BIL, BM, BR, C, DBN, DRAPN, E, GOET, H, HAL, HBG, KRA, L, LAU, LG, LISU, M, MA, MSB, P, PBMA, POZ, S, TRN, TUB, WA, WRSL, WSRP, ZBL. Rem.: After Proćków (2010: 420–423).
14	152	Paratype of <i>Juncus bulbosus</i> E. submicronotatus Proćków, Ann. Bot. Fenn. 47 (2010: 412)	<i>Juncus bulbosus</i> f. <i>submicronotatus</i> Proćków, Ann. Bot. Fenn. 47 (2010: 412)	POLAND, distr. Siedlice, Krzymosze, na obniżonej ziemi w borze bagiennym obok toru [on bare soil in marshy forest next to a railway track].	27 Jul 1974 <i>Z. Glowacki s. n.</i> (WRSL 35948)	Ziwnik Zakładu Biologii Wyszzej Szkoły Nauzycieliskiej w Siedleach	T: Poland, Dolny Śląsk, Wrocław Leśnica, ad ripam et in aqua piscinae europlicatae, situ meridiano-occidentali lacus, 31 May 1999, <i>J. Proćków</i> ; holo: WRSL; iso: WRSL; para: B, BIL, BM, BR, C, DBN, DRAPN, E, GOET, H, HAL, HBG, KRA, L, LAU, LG, LISU, M, MA, MSB, P, PBMA, POZ, S, TRN, TUB, WA, WRSL, WSRP, ZBL. Rem.: After Proćków (2010: 420–423).
15	152	Isolectotype of <i>Juncus caespiticus</i> E. Mey. in J.G.C. Lehmann, Pl. Preiss. 2 (1846: 47)	<i>Juncus caespiticus</i> E. Mey. in J.G.C. Lehmann, Pl. Preiss. 2 (1846: 47)	AUSTRALIA, ad fluvium Canning, Perth, novae Hollandiae.	02 Nov 1839 <i>Preis. (L. Preis) 1733</i>	Herbarium Schumann	T: [Western Australia, Perth, Canning R.] ad fluvium Canning (Perth) novae Hollandiae, 2 Nov 1839, <i>L. Preis [Pl. Austral. Ozeal.] 1733</i> ; lecto: W, designated by Kirschner et al. (2002a: 38); islector: BM, BREM, G*, K, L, LD*, MEL, NSW, P, W. Rem.: The status of the type corrected (iso to islector) in accordance with the <i>Shenzhen Code</i> .
16	155	Iso type of <i>Juncus caffer</i> Bertr., <i>Mém. Reale Acad. Sci. It. Bologna</i> 3 (1851: 253, Pl. 19, fig. 3).	<i>Juncus kraussii</i> Hochst. in C. Krauss <i>Flora</i> 28 (1845: 342) subsp. kraussii	MOZAMBIQUE. 'Inhambane Mozambici'	06 Dec 1848 <i>Fornasinio s. n.</i>		T: Mozambique, 'Inhambane Mozambici', 6 Dec 1848, <i>Fornasinio</i> , holo: BOLO.
17	152	Syn type of <i>Juncus capensis</i> subsp. <i>angustifolius</i> var. <i>ecklonii</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 485) [Abb. <i>Naturwiss. Ver. Bremen</i> 4 (1875: 485)]	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA. Paludosa ad pedem montis diaboli	19 & 28 Nov 1827 [after Buchenau 1875: 485]	Herbarium Henschelianum	T: Cape, Teufelsberg, <i>C.F. Ecklon 897, Unio Itin.</i> , no 35 [annotated by E. Meyer under no 18]; syn: BOL, JE*, S, W. Rem.: Additional remark by Buchenau (1875: 485): 'Un. it. No. 35'.
18	152	Syn type of <i>Juncus capensis</i> subsp. <i>angustifolius</i> var. <i>ecklonii</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 485) [Abb. <i>Naturwiss. Ver. Bremen</i> 4 (1875: 485)]	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA. Paludosa planities capensis	Dec 1827 [after Buchenau 1875: 485]	Herbarium Henschelianum	T: Cape, Teufelsberg, <i>C.F. Ecklon 897, Unio Itin.</i> , no 35 [annotated by E. Meyer under no 18]; syn: BOL, S, W. Rem.: Kirschner et al. (2002a: 36) did not mention this type (<i>C.F. Ecklon 899</i>) but it is listed by Buchenau (1875: 485) in the protologue of the new taxon; additionally, the specimen really seen by Buchenau (with his own handwritten label); Kirschner et al. (2002a: 36) listed var. <i>ecklonii</i> as homotypic with <i>Juncus capensis</i> var. <i>angustifolius</i> E. Mey.; syn: JE*, W*.

No.	N.f.	Kind of type and type of (botany)	Current name	Locality (label data)	Date	Herbarium label data (original spelling)	Leg. et det.	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.):
19	152	Syn type of <i>Juncus capensis</i> subsp. <i>angustifolius</i> var. <i>sphagnetorum</i> f. <i>frondescens</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 490) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 490)]	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA. Cape, Tafelberg	sine dato	<i>J.F. Drege aa</i> (det. as <i>Juncus capensis</i> var. <i>angustifolius</i> E. M.), (det. as <i>Juncus capensis</i> Thbg. subsp. <i>angustifolius</i> var. <i>sphagnetorum</i> f. <i>frondescens</i> , det. Fr. Buchenau 11 Jan 1874)	Herbarium Henschelianum	T: Cape, Tafelberg, <i>J.F. Drege aa</i> , syn: K*, P. S. W; Gipe! des Tafelberges, <i>C.L.P. Zeyher 47</i> ; syn: B, destroyed.	
20	152	Isolectro type of <i>Juncus capensis</i> subsp. <i>longifolius</i> var. <i>gracilior</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 483) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 483)]	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA. Cap. B. Spei.	05 Mar 1816	<i>C.H. Bergius s.n.</i> , det. K. Sprengel (gesamm. von Bergius, det. Fr. Buchenau 11 Jan 1875)	Herbarium Henschelianum	T: Caput bonae spei, 5 Mar 1816, <i>Bergius</i> ; lecto (as holotype) B, destroyed, <i>vide</i> A.A. Obermeyer, <i>in</i> A.A. Obermeyer, J. Lewis & R.B. Faden, <i>Fl. S. Afr.</i> 4/2 (1985: 83); syn: W. Rem.: There are more specimens mentioned in the protologue of a new taxon (Buchenau, 1875: 484) thus the lectotype was designated. Isolectrotype (the only duplicate known) rediscovered at WRSI (the specimen includes the collection date (i.e. 5 Mar 1816), as in the the protologue). The syntype (Bergius specimen at W) does not have the collection date. The status of the type corrected (iso to isolectro) in accordance with the <i>Shenzhen Code</i> .	
21	152	Syn type of <i>Juncus capensis</i> subsp. <i>longifolius</i> var. <i>gracilior</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 483) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 483)]	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA. [Cape] zwischen Paarl und Franschehoek	sine dato	<i>J.F. Drege b</i> (det. as <i>Juncus capensis</i> β. <i>angustifolius</i> E. M.), (det. as <i>J. capensis</i> subsp. <i>longifolius</i> var. <i>gracilior</i> Buchenau, det. Fr. Buchenau 11 Jan 1875)	Herbarium Henschelianum	T: Caput bonae spei, 5 Mar 1816, <i>Bergius</i> ; lecto (as holotype) B, destroyed, <i>vide</i> A.A. Obermeyer, <i>in</i> A.A. Obermeyer, J. Lewis & R.B. Faden, <i>Fl. S. Afr.</i> 4/2 (1985: 83); isolectro: W. Rem.: A specimen not mentioned by Kirschner et al. (2002a: 37), but listed by Buchenau (1875: 484), thus it is a syntype because there are more specimens within the protologue of a new taxon; syn: S*. The status of the type corrected (iso to isolectro) in accordance with the <i>Shenzhen Code</i> .	

No.	N.f.	Kind of type and type of (basonym)	Current name	Locality (label data)	Date	Leg. et det.	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.):
22	152	Holotype of <i>Juncus capensis</i> subsp. <i>parviflorus</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 491) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 491)]	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA, ad ripas fl. Zonder-Einde, Zwelendamd	Nov 1836	<i>C. Krauss s.n.</i> (det. as <i>Juncus capensis</i> Thbg. subsp. <i>parviflorus</i> Buchenau, leg. Ferd. Krauss, det. Fr. Buchenau, 11 Jan 1875; det. by C. Krauss as <i>Juncus cephalotes</i> Thunb.)	Herbarium Henschelianum	T: Cape, Swellendam, Rivier Zondereinde, Nov 1838, C. <i>Krauss s.n.</i> ; holo: WRSLS; iso: W. Rem.: Buchenau (1875: 491) listed only one specimen stored at 'Herbarium der schlesischen Gesellschaft für vaterländische Cultur und des naturhistorischen Vereines der preussischen Rheinlande und Westfalens', i.e. in Wroclaw. Thus, this holotype of the name was confirmed by the following: 1) it was observed by Buchenau on 11 Jan 1875 and 2) it is only one specimen that lacks a clearly written collection year, which was misread by Buchenau in the protologue (1875: 491) as 'Nov 1838', however, identical sheets (from Herbarium R. v. Uechtritz & Herbarium Schumann, both at WRSLS) read 'Nov 1836'. Compare also with A.A. Obermeyer, in A.A. Obermeyer, J. Lewis & R.B. Faden, <i>Fl. S. Afr.</i> 4/2 (1985: 83). The status of the type corrected (iso to holo (for WRSLS), and lecto to iso (for W)) in accordance with the <i>Shenzhen Code</i> . Rem.: see above
23	152	Isotype of <i>Juncus capensis</i> subsp. <i>parviflorus</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 491) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 491)]	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA, ad ripas fl. Zonder-Einde, Zwelendamd	Nov 1836	<i>C. Krauss s.n.</i> (det. as <i>Juncus cephalotes</i> Thunb.)	Herbarium Schumann	
24	152	Isotype of <i>Juncus capensis</i> subsp. <i>parviflorus</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 491) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 491)]	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA, ad ripas fl. Zonder-Einde, Zwelendamd (Cap. B. spei.)	Nov 1836	<i>C. Krauss s.n.</i> (det. as <i>Juncus cephalotes</i> Thunb.)	Herbarium R. v. Uechtritz	Rem.: see above
25	152	Synotype of <i>Juncus capitatus</i> var. <i>physomitrioides</i> Baen., <i>Prosp. Herb. Eur.</i> (1873: 4); <i>Schriften Königl. Phys.-Okon. Ges. Königsberg</i> 14 (1873: 16).	<i>Juncus capitatus</i> Weigel, <i>Observ. Bot.</i> (1772: 28)	POLAND, Danzig [Gdańsk], Strand bei Zoppot [Sopot]	08 Jul 1872	<i>C. Baenitz s.n.</i>	Herbarium Schumann	T: Danzig, Strand bei Zoppot [Poland, Gdańsk, Sopot], 8 Jul 1872, <i>K.G. Baenitz</i> ; sym: L; additional authentic material from the same site: 5 Jul 1876, <i>K.G. Baenitz</i> [<i>Herb. Eur.</i>] 1506 (LD, W).
26	152	Additional material from type locality (collected by the author of the name) of <i>Juncus capitatus</i> var. <i>physomitrioides</i> Baen., <i>Prosp. Herb. Eur.</i> (1873: 4); <i>Schriften Königl. Phys.-Okon. Ges. Königsberg</i> 14 (1873: 16).	<i>Juncus capitatus</i> Weigel, <i>Observ. Bot.</i> (1772: 28)	POLAND, Danzig [Gdańsk], Ad mare balticum [Zoppot [Sopot]]	05 Jul 1876	<i>C. Baenitz 1506</i>	Dr. C. Baenitz, Herbarium Europaeum	T: Danzig, Strand bei Zoppot [Poland, Gdańsk, Sopot], 8 Jul 1872, <i>K.G. Baenitz</i> ; sym: L; additional material from the same site, collected by the author of the name: 5 Jul 1876, <i>K.G. Baenitz</i> [<i>Herb. Eur.</i>] 1506 (LD, W).

No.	N.f.	Kind of type and type of (basonym)	Current name	Locality (label data)	Date	Herbarium label data (original spelling)	Leg. et det.	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.)
27	152	Additional material from type locality [collected by the author of the name] of <i>Juncus capitatus</i> var. <i>physcomitrioides</i> Baen., <i>Prosp. Herb. Eur.</i> (1873: 4); <i>Schriften Königl. Phys.-Ökon. Ges. Königsberg</i> 14 (1873: 16).	<i>Juncus capitatus</i> Weigel, <i>Observ. Bot.</i> (1772: 16)	POLAND: Danzig [Gdańsk], Ad mare balticum (Zoppot [Sopot])	05 Jul 1876	<i>C. Baenitz</i> 1506	Dr. C. Baenitz, Herbarium Europaeum	T: Danzig, Strand bei Zoppot [Poland, Gdańsk, Sopot], 8 Jul 1872; <i>K.G. Baenitz</i> ; syn: L; additional material from the same site, collected by the author of the name: 5 Jul 1876, <i>K.G. Baenitz</i> [<i>Herb. Eur.</i>] 1506 (LD, W).	
28	156	Synotype of <i>Juncus cephalotes</i> var. <i>minimus</i> Hochst., <i>Flora</i> 28 (1845: 342), p.p.	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. in arenos. plan. Cap.	Nov [18]38	<i>C. Krauss</i> s.n.	Herbarium R. v. Uechtritz	T: [South Africa, Cape] 'in arenosis planitie capensis', Nov 1828, <i>C. Krauss</i> ; syn: W; K [both mixed collections]. Rem.: The material needs to be revised because W & K contain mixed collections; after Kirschner et al. (2002a: 73), the collection date was Nov 1828 (to be corrected to Nov 1838).	
29	156	Synotype of <i>Juncus cephalotes</i> var. <i>minimus</i> Hochst., <i>Flora</i> 28 (1845: 342), p.p.	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. in arenos. plan. Cap.	Nov [18]38	<i>sine coll.</i> [<i>C. Krauss</i>] s.n.	Herbarium Schumann	T: [South Africa, Cape] 'in arenosis planitie capensis', Nov 1828, <i>C. Krauss</i> ; syn: W; K [both mixed collections]. Rem.: Original material was from Krauss because the identical label is on a sheet from Herbarium R. v. Uechtritz where 'Dr. Krauss' was added; the material needs to be revised because W & K contain mixed collections; after Kirschner et al. (2002a: 73), the collection date is Nov 1828 (to be corrected to Nov 1838).	
30	152	Synotype of <i>Juncus cephalotes</i> var. <i>minimus</i> Hochst., <i>Flora</i> 28 (1845: 342), p.p.	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. in arenosis plan. Cap.	Nov [18]38	<i>sine coll.</i> [<i>C. Krauss</i>] s.n. (det. as <i>Juncus cephalotes</i> Thbg. var. <i>urius</i> Behn., Fr. Buchenau, 23 Oct 1874)	Herbarium Henschelianum	T: [South Africa, Cape] 'in arenosis planitie capensis', Nov 1828, <i>C. Krauss</i> ; syn: W; K [both mixed collections]. Rem.: Original material was from Krauss because the identical label is on a sheet from Herbarium R. v. Uechtritz where 'Dr. Krauss' was added; the material needs to be revised because W & K contain mixed collections; after Kirschner et al. (2002a: 73), the collection date is Nov 1828 (to be corrected).	
31	152	Isotype of <i>Juncus cephalotes</i> var. <i>astulatus</i> Buchenau, <i>Monogr. Junc. Cap.</i> (1875: 451) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 451)]	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. Cape, Tafelberg	Oct 1827	<i>C.F. Ecklon</i> <i>Junc.</i> 13, 2.12 (as <i>Juncus capensis</i> var. <i>angustifolius</i> E. M., det. C.F. Ecklon)	Herbarium Schumann	T: South Africa, Cape, Tafelberg, Oct 1827, <i>C.F. Ecklon</i> 13; lector: BOL, <i>file</i> R.S. Adamson, <i>J. Linn. Soc., Bot.</i> 50 (1935: 32); isolecto: W*.	

No.	N.f.	Kind of type and type of (basonym)	Current name	Locality (label data)	Herbarium label data (original spelling)	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.)
32	152	Synotype of <i>Juncus cephalotes</i> var. <i>usulidatus</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 451) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 451)] or/and var. <i>varius</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 451) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 451)].	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. Paludosa montis tabularis septentr.	Nov 1826 C.F. Ecklon 901	Herbarium Schumann	T: [South Africa, Cape] Camps Bay, C.F. Ecklon s.n. (BOL); syn: PRC*, S*. Rem.: Mixed material containing var. <i>usulidatus</i> Buchenau & var. <i>varius</i> Buchenau, mentioned in both protologues, to be analysed.
33	152	Synotype of <i>Juncus cephalotes</i> var. <i>varius</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 451) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 451)].	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. Worcester beim Waterfall	sine dato	Herbarium Schumann	T: [South Africa, Cape] Camps Bay, C.F. Ecklon s.n. (BOL). Rem.: Kirschner et al. (2002a: 73) did not mention this type, but it is listed by Buchenau (1875: 452) within the protologue of the new taxon; however Buchenau (1875: 452) indicates stamens in this material.
34	153	Synotype of <i>Juncus clausonis</i> Trab. in J.A. Battandier & L.C. Trabut, <i>Fl. Algérie</i> , ed. 2 (1895: 84).	<i>Juncus sriatiatus</i> Schoub. ex E. Mey., <i>Syn. Junc.</i> (1822: 27)	ALGERIA. Ain Taya (Alger)	Jul 1889 J.A. Battandier & L.C. Trabur 586	Battandier et Trabut, Pl. d'Algérie	T: [Algeria] Ain Taya près Alger, Jun 1888, L.C. Trabur s.n. syn: G; Jul 1889, J.A. Battandier & L.C. Trabur 586; syn: G, L, MPU*.
35	157	Isotype of <i>Juncus delicatulus</i> Steud., <i>Syn. Pl. Glumac.</i> 2 (1855: 304)	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA. Africa australis [Cape, Grahamstown Valley]	sine dato J.F. Drège 1604e	Herbarium Henschelianum	T: Africa australis [Cape, Grahamstown Valley], J.F. Drège 1604e, holot: P; iso: G, S, W.
36	152	Synotype of <i>Juncus dregeanus</i> var. <i>conglomeratus</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 463) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 463)].	<i>Juncus dregeanus</i> Kunth, <i>Finem. Pl.</i> 3 (1841: 344) subsp. dregeanus	SOUTH AFRICA. Cap. Bon. Spei (Hassagaibosch [Assegaibosch])	sine dato C.L.P. Zeyher (C.F. Ecklon & C.L.P. Zeyher) Junc. 10, 26.1 (det. as <i>Juncus cephalotes</i> L'Harpe var. <i>conglomerata</i> Nees, det. Zeyher)	Herbarium Schumann	T: Hassagaibosch [Assegaibosch], C.F. Ecklon & C.L.P. Zeyher 10; syn: BOL, W; Albany, C.F. Ecklon; syn: n.u.
37	156	Probable synotype of <i>Juncus exsertus</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 435) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 435)]	<i>Juncus exsertus</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 435) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 435)]	SOUTH AFRICA. Worcester, Waterfall	sine dato C.F. Ecklon & C.L.P. Zeyher 1. 11 (det. as <i>Juncus punctatarius</i> Thbg)		T: [Cape Provinces, Swartkops River] Zwartkops Rivier, C.L.P. Zeyher 103; syn: B [destroyed after having been selected as type by R.S. Adamson, <i>J. Linn. Soc. Bot.</i> 50 (1935: 15)]; BOL; Worcester, Waterfall, C.F. Ecklon & C.L.P. Zeyher [as <i>Juncus punctatarius</i> 1. 11] p.p.; syn: B [destroyed]; PRE; Zondagrivier bei Graaff-Reinet [Sundays River at Graaff-Reinet], H. Bolus 188; syn: BOL, K*; Camdebooosberg, 4–5000 Fuss, J.F. Drège [<i>Juncus oxycarpus</i> ?]; syn: W [only]. Rem.: C.F. Ecklon & C.L.P. Zeyher [as <i>Juncus punctatarius</i> 1. 11] pro parte as a syntype of the name (Kirschner et al. 2002a: 239).
38	153	Synotype of <i>Juncus glaucus</i> var. <i>acutissimus</i> Buchenau, <i>Monogr. Junc. Cap</i> (1875: 417)	<i>Juncus inflexus</i> L., <i>Sp. Pl.</i> (1753: 326)	SOUTH AFRICA. Cape, Wodehouse, Klein Buffels Vallei near Gaatjie	sine dato J.F. Drège 8796 c	Herbarium Henschelianum	T: Cape, Wodehouse, Klein Buffels Vallei near Gaatjie, J.F. Drège 8796c; syn: E*, LE*, LD, S, W.

No.	N.f.	Kind of type and type of (basonym)	Current name	Herbarium label data (original spelling)		Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.)
				Locality (label data)	Date		
39	152	Synotype of <i>Juncus inaequalis</i> var. <i>viridescens</i> Buchenau, <i>Monogr. Junc. Cap.</i> (1875: 455) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 455)]	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. Worcester beim Waterfall	sine dato	C.F. Ecklon <i>Junc. 14., 1.11</i>	T: South Africa, Capes, Swellendam, C.L.P. Zeyher 4319, syn: BOL, K*, W [p.p., ut <i>Juncus isolepoides</i> Nees, <i>nom. inadm.</i>]; Hortentotis-Holland, C.L.P. Zeyher 46; syn: BOL, W, S*, C.F. Ecklon 14; syn: n.u.
40	152	Probable original material of <i>Juncus ximindatus</i> Drejer, <i>Naturhist. Tidsskr.</i> 2 (1838: 181)	<i>Juncus balticus</i> Willd., <i>Ges. Naturf. Freunde Berlin Mag. Neuesten Entdeck. Gesammten Naturk.</i> 3 (1809: 298) subsp. balticus × <i>filiformis</i> L., <i>Sp. Pl.</i> (1753: 326)	DENMARK. Thy. Jyllandia	sine dato	<i>Drejer.s.n.</i>	T: n.u. – BM*, C*, W*. Rem.: The protologue of <i>Juncus ximindatus</i> Drejer provided the following sites: Rors Klit in Thy district and at Bulbjerg (both found by Drejer) and Kollerup Klit in Vesterhanherred (found by Poulsen). However, they are cited only as geographic localities and not as specimens. Moreover, the date of collection in the protologue is July 1837. The specimen at WRSL was collected in Thy district, but no exact locality or collection date was provided; after Kirschner et al. (2002b: 141): type – n.u. [<i>non vidit</i>]. After Kirschner et al. (2002b: 141) place of publication is 'Bot. Tidsskr.' to be corrected to <i>Naturhistorisk Tidsskrift (Copenhagen)</i> , i.e. <i>Naturhist. Tidsskr.</i> .
41	154	Isolectotype of <i>Juncus involucreatus</i> Steud. ex Buchenau, <i>Abh. Naturwiss. Vereine Bremen</i> 4 (1875: 121)	<i>Juncus microcephalus</i> Humb., <i>Boopl. & Kunth., Gen. Sp.</i> 1 (1816: 237 [Quarto]), 190 [Folio]	PERU. Tabina	Jul 1854	W. Lechler 2078	T: Peru, Tabina, 1854, W. Lechler 2078; lecto: GOET, <i>vide</i> H. Basklev, <i>Fl. Neotrop. Monogr.</i> 68 (1996: 106); isolecto: G*, K, KW*, LE*, MO, O, S. Rem.: The status of the type corrected (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .
42	154	Isolectotype of <i>Juncus kotschyi</i> Boiss. in C.G.T. Kotschy, <i>Pl. Persiae Austar. tetraxicate series</i> edited by R.F. Hohenacker, printed label description], no. 446 (1845) & Boissier, <i>Diagn. Pl. Orient.</i> , ser. 1, 7 (1846: 101)	<i>Juncus fontanesii</i> subsp. kotschyi (Boiss.) Snogerup in K.H. Rechinger, <i>Fl. Iranica</i> 75 (1971: 25)	IRAN. In paludosi ad rad. M. Sabst-Buschom, pr. U. Schiras	31 May 1842	C.G.T. Kotschy 446	T: [Iran] m. Sabst-Buschon pt [ope] u. [rhem] Schiras, 31 May 1842, C.G.T. Kotschy [Pl. Pers. Austar.] 446; lecto: G-BOISS, <i>vide</i> S. Snogerup, in K.H. Rechinger, <i>Fl. Iranica</i> 75 (1971: 25); isolecto: B*, BM, CAS*, CGE, CORD*, E*, FI*, G, GOET*, HAL*, K, KW*, MO*, P, PR, S*, UPS. Rem.: The status of the type corrected (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .
43	154	Isolectotype of <i>Juncus kotschyi</i> Boiss. in C.G.T. Kotschy, <i>Pl. Persiae Austar. tetraxicate series</i> edited by R.F. Hohenacker, printed label description], no. 446 (1845) & Boissier, <i>Diagn. Pl. Orient.</i> , ser. 1, 7 (1846: 101)	<i>Juncus fontanesii</i> subsp. kotschyi (Boiss.) Snogerup in K.H. Rechinger, <i>Fl. Iranica</i> 75 (1971: 25)	IRAN. In paludosi ad rad. M. Sabst-Buschom, pr. U. Schiras	31 May 1842	C.G.T. Kotschy 446 (det. Fr. Buchenau, 31 Jan 1875, as <i>J. kotschyi</i>)	T: [Iran] m. Sabst-Buschon pt [ope] u. [rhem] Schiras, 31 May 1842, C.G.T. Kotschy [Pl. Pers. Austar.] 446; lecto: G-BOISS, <i>vide</i> S. Snogerup, in K.H. Rechinger, <i>Fl. Iranica</i> 75 (1971: 25); isolecto: B*, BM, CAS*, CGE, CORD*, E*, FI*, G, GOET*, HAL*, K, KW*, MO*, P, PR, S*, UPS. Rem.: The status of the type corrected (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .

No.	N.f.	Kind of type and type of (basionym)	Current name	Herbarium label data (original spelling)			T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.)
				Locality (label data)	Date	Leg. et det.	
44	154	Isolectotype of <i>Juncus kraussii</i> Hochst. in C. Krauss <i>Flora</i> 28 (1845: 342)	<i>Juncus kraussii</i> Hochst. in C. Krauss <i>Flora</i> 28 (1845: 342)	SOUTH AFRICA, ad ripas Notsinakama R., distr. George	Jan 1839	C. Krauss s.n. (C. Kraussii Specimen authenticum, Fr. Buchenau, 11 Jan 1875)	T: South Africa, George Distr., Notsinakama R., Jan 1839, C. Krauss; lecto: G-BOIS, fide S. Snogerup, <i>Willdenowia</i> 23 (1993: 57); isolecto: M. TUB*. Rem.: The status of the type corrected (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .
45	154	Isolectotype of <i>Juncus kraussii</i> Hochst. in C. Krauss <i>Flora</i> 28 (1845: 342)	<i>Juncus kraussii</i> Hochst. in C. Krauss <i>Flora</i> 28 (1845: 342)	SOUTH AFRICA, ad ripas Notsinakama R., distr. George	Jan 1839	C. Krauss s.n.	T: South Africa, George Distr., Notsinakama R., Jan 1839, C. Krauss; lecto: G-BOIS, fide S. Snogerup, <i>Willdenowia</i> 23 (1993: 57); isolecto: M. TUB*. Rem.: The status of the type corrected (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .
46	154	Iso type of <i>Juncus lomatoxyllus</i> Spreng., <i>Neue Entdeck. Pflanzenk.</i> 2 (1821: 108)	<i>Juncus lomatoxyllus</i> Spreng., <i>Neue Entdeck. Pflanzenk.</i> 2 (1821: 108)	SOUTH AFRICA, Cap. B. Spe.	sine dato	C.H. Bergius s.n. (<i>J. lomatoxyllus</i> Spreng., Bergiusches Exemplar, bestimmt von K. Sprengel, 11 Jan 1875, det. Fr. Buchenau)	T: 'in promontorio bonae spei' [Cape Peninsula], Bergius; holo: B, destroyed. Rem.: After Kirschner et al. (2002a: 31): holotype – B, destroyed. Iso-type (the only duplicate known) rediscovered at WRSJ.
47	156	Syn type of <i>Juncus maritimus</i> Trab., <i>Bull. Soc. Bot. France</i> 34 (1887: 396)	<i>Juncus punctatorius</i> L. f., <i>Suppl. Pl.</i> (1781: 208)	ALGERIA, Ain el Hadjar [Oran]	20 Jul 1887	J.A. Battandier & L.C. Trabut 294	T: [Algeria, Oran] Ain el Hadjar, 1100 m, 20 Jul 1887; J.A. Battandier & L.C. Trabut [<i>Pl. Alger.</i>] 294; syn: G, L, MPU*, PR, WU; [Algeria] Batna, B. <i>Badanus</i> [<i>Pl. Alger.</i>] 739; syn: n.u.
48	156	Authentic/original material of <i>Juncus minae</i> Strobl ex Nyman, <i>Consp. Fl. Eur.</i> (1882: 749), <i>nom. inval.</i>	<i>Juncus pygmaeus</i> Rich. ex Thuill., <i>Fl. Env. Paris</i> , ed. 2 (1800: 178)	ITALY, Ad oram maris Tyrrheni prope Finale	11 Apr 1874	P. Gabriel <i>Strobl</i> s.n	Authentic/original material: [Italy, Sicily] Flora Nebrodensis, prope Finale, G. <i>Strobl</i> (K, PR)
49	156	Authentic/original material of <i>Juncus minae</i> Strobl ex Nyman, <i>Consp. Fl. Eur.</i> (1882: 749), <i>nom. inval.</i>	<i>Juncus pygmaeus</i> Rich. ex Thuill., <i>Fl. Env. Paris</i> , ed. 2 (1800: 178)	ITALY, Ad oram maris Tyrrheni prope Finale	11 Apr 1874	P. Gabriel <i>Strobl</i> s.n. (det. Uechtritz, as <i>J. pygmaeus</i> Th.)	Authentic/original material: [Italy, Sicily] Flora Nebrodensis, prope Finale, G. <i>Strobl</i> (K, PR)
50	155	Isolectotype of <i>Juncus monticola</i> Steud., <i>Syn. Pl. Glumac.</i> 2 (1855: 301)	<i>Juncus wallichianus</i> J. Gay ex Laharpe, <i>Essai Monogr. Junc.</i> (1825: 51)	INDIA, In montibus Nilagiri	sine dato	R.F. Hohenacker 951	T: [India] in montibus Nilagiri, R.F. Hohenacker [<i>Pl. Ind. Orient.</i>] 951; lecto: P, fide K.L. Wilson & L.A.S. Johnson, <i>Telopea</i> 9 (2001: 364); isolecto: E, G*, JE*, K, L, MPU*, P, PR, S*, W. Rem.: The status of the type corrected (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .
51	155	Isolectotype of <i>Juncus monticola</i> Steud., <i>Syn. Pl. Glumac.</i> 2 (1855: 301)	<i>Juncus wallichianus</i> J. Gay ex Laharpe, <i>Essai Monogr. Junc.</i> (1825: 51)	INDIA, In montibus Nilagiri	sine dato	R.F. Hohenacker 951	T: [India] in montibus Nilagiri, R.F. Hohenacker [<i>Pl. Ind. Orient.</i>] 951; lecto: P, fide K.L. Wilson & L.A.S. Johnson, <i>Telopea</i> 9 (2001: 364); isolecto: E, G*, JE*, K, L, MPU*, P, PR, S*, W. Rem.: The status of the type corrected (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .

No.	N.f.	Kind of type and type of (botany)	Current name	Locality (label data)	Date	Leg. et det.	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.):
52	155	Isoecotype of <i>Juncus monticola</i> Steud., <i>Syn. Pl. Glumac.</i> 2 (1855: 301)	<i>Juncus multichianus</i> J. Gay ex Laharpe, <i>Essai Monogr. Junc.</i> (1825: 51)	INDIA. In montibus Nilagiri	sine dato	<i>R.F. Hohenacker 951</i>	Pl. Indiae or (M. Nilagiri) Ed. R.F. Hohenacker, 1851 / Herbarium R. v. Uechtritz	T: [India] in montibus Nilagiri, <i>R.F. Hohenacker [Pl. Ind. Orient.] 951</i> ; lecto: P. fide K.L. Wilson & L.A.S. Johnson, <i>Telopea</i> 9 (2001: 364); isolecto: E, G*, JE*, K, L, MPU*, P, PR, S*, W. Rem.: The status of the type corrected (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .
53	151	Synotype of <i>Juncus multibracteatus</i> Tineo in G. Gussone, <i>Fl. Sicil. Prodr. Suppl.</i> (1832: 105)	<i>Juncus acutus</i> L., <i>Sp. Pl.</i> (1753: 325) subsp. acutus	ITALY. In humentibus Castronuovo	sine dato	<i>Todarò 556</i>	Todarò Flora Sicula exicata / Herbarium M. Winkler	T: [Italy] "In humentibus Castronuovo", <i>A. Todarò 556</i> ; syn: BM, BR*, FI, K, W.
54	153	Probable original material of <i>Juncus sobotritorum</i> Rothm., <i>Wis. Zeitschr. Unt. Greifswald</i> 14 (1965: 79)	<i>Juncus sobotritorum</i> Rothm. <i>Wis. Zeitschr. Unt. Greifswald</i> 14 (1965: 79) (= <i>J. balticus</i> Willd. subsp. <i>balticus</i> s. J. <i>effusus</i> L. subsp. <i>effusus</i>)	GERMANY. Prov. Mecklenburg, Dünenmoor zwischen Wüstrow und Dierhagen/ Fischland-Dars	15 Sep 1961	<i>U. Schneider s.n.</i>	Flora Germanica / Herbarium Ulrike Schneider	T: [Germany, Mecklenburg] inter Wüstrow et Dierhagen prope Ribnitz-Megalopolitanae, 16 Sep 1961, <i>W. Rothmaler & U. Schneider</i> ; holo: <i>n. n.</i> [not given in the protologue; probably JE or GFW] Rem.: After Kirschner et al. (2002b: 141) the type material was collected on 16 Sep 1961, and by <i>W. Rothmaler & U. Schneider</i> .
55	155	Probable original material of <i>Juncus obtusatus</i> Engelm., <i>Trans. Acad. Sci. St. Louis</i> 2 (1868: 495), <i>nom. illeg., non Schult.</i> (1814), <i>nom. illeg.</i>	<i>Juncus covillei</i> var. obtusatus [Engelmann] C.L. Hitchc. in C.L. Hitchcock & al., <i>Vasc. Pl. Pacif. Northw.</i> 1 (1969: 193)	USA. California	sine dato	<i>H.N. Bolander s.n., det. Fr. Buchenau</i>	Herbarium Henschelianum	T: California, Mariposa, Big Tree Grove, <i>H.N. Bolander [G. Engelmann, Herb. Junc. Bor-Amer. Norm.] 42</i> ; syn: AAU, CAS*, DAO*, G*, K*, LE*, MO, NY*, PH*, PR, USCH*; <i>H.N. Bolander 6028</i> ; syn: MO. Rem.: A handwritten label by Fr. Buchenau.
56	155	Synotype of <i>Juncus oxycarpus</i> E. Mey. ex Kunth, <i>Enum. Pl.</i> 3 (1841: 336)	<i>Juncus oxycarpus</i> E. Mey. ex Kunth, <i>Enum. Pl.</i> 3 (1841: 336)	SOUTH AFRICA. Cap. b. spi. ((Cape Provinces) Liesbeek R)	sine dato	<i>C.H. Bergius s.n.</i> (det. Fr. Buchenau 11 Jan 1875 & remark by Buchenau: Bergiusches Exemplar mit der (fälschen) Bestimmung v. K. Sprengel; det. by K. <i>Juncus punctatus</i>)	Herbarium Henschelianum	T: [Cape Provinces] Liesbeek R, <i>C.H. Bergius</i> syn: B [destroyed]; Paarl, Berg Rivier, <i>J.F. Drège</i> as syn: K, P Rem.: A synotype at WRSJ is shown according to an original publication of Kunth (1841: 337). This is a new synotype (and its only known duplicate) discovered at WRSJ.
57	156	Synotype of <i>Juncus parvulus</i> E. Mey. ex Buchenau, <i>Monogr. Junc. Cap</i> (1875: 447) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1873: 447)]	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. Cape, Namaqualand, Modderfontein	05 Nov 1830	<i>J.F. Drège 2472b</i>	Herbarium Henschelianum	T: South Africa, Cape, Namaqualand, Modderfontein, 5 Nov 1830, <i>J.F. Drège 2472b</i> ; syn: BM*, BOL, E*, G*, K, L, LD*, LE*, NY*, PR, S, TUB*.

No.	N.f.	Kind of type and type of (basonym)	Current name	Locality (label data)	Date	Herbarium label data (original spelling)	Leg. et det.	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.)
58	156	Synotype of <i>Juncus persicus</i> Boiss., <i>Diagn. Pl. Orient.</i> , ser. 1, 7 (1846: 101)	<i>Juncus persicus</i> Boiss., <i>Diagn. Pl. Orient.</i> , ser. 1, 7 (1846: 101)	IRAN. In planitie edita Kakkan m. Kuh-Daena	17 Jul 1842	C.G.T. <i>Körschy</i> 683	Th. Korsch; Pl. Pers. aust. Ed. R.F. Hohenacker 1845 / Herbarium Schumann	T: [Iran] Kakkan M Kuh-e Dinar. C.G.T. <i>Körschy</i> 683; syn: BM, CGE, E, F†, G, KW*, LE*, MO*, PR, WAG*.	
59	156	Synotype of <i>Juncus persicus</i> Boiss., <i>Diagn. Pl. Orient.</i> , ser. 1, 7 (1846: 101)	<i>Juncus persicus</i> Boiss., <i>Diagn. Pl. Orient.</i> , ser. 1, 7 (1846: 101)	IRAN. In planitie edita Kakkan m. Kuh-Daena	sine dato	C.G.T. <i>Körschy</i> 683 (det. Fr. Buchenau, 04 Feb 1875)	M. / Herbarium Henschelianum	T: [Iran] Kakkan M Kuh-e Dinar. C.G.T. <i>Körschy</i> 683; syn: BM, CGE, E, F†, G, KW*, LE*, MO*, PR, WAG*.	
60	156	Synotype of <i>Juncus pictus</i> Steud., <i>Syn. Pl. Glomac.</i> 2 (1855: 305)	<i>Juncus pictus</i> Steud., <i>Syn. Pl. Glomac.</i> 2 (1855: 305)	SOUTH AFRICA. Cape, Namaqualand, Kamiesberg, Leliefontein	sine dato	J.F. <i>Drège</i> 2472a	Herbarium Henschelianum	T: South Africa, Cape, Namaqualand, Kamiesberg, Leliefontein, J.F. <i>Drège</i> 2472a; syn: BM*, BOL, E*, G, K, KW*, L, LD†, NY*, P, PR, S.	
61	156	Synotype of <i>Juncus sikkinensis</i> var. <i>pseudocastaneus</i> Lingehsh., in W.Limpricht, <i>Repert. Spec. Nov. Regni Veg. Beih.</i> 12: 316 (1922)	<i>Juncus sikkinensis</i> Hook. f., <i>Fl. Brit. India</i> 6 (1892: 399)	CHINA/INDIA [?]. Tasienslu [Kangding]-Dawo [Dawu], Gata (Tailing) auf der Passalm Dhasachi la ka [Tschaschilaka] (Hai tse schan) am Dsharā (lara ri), 4360 m	02 Jul 1914	W. <i>Limpricht</i> 1869, det. Lingehsh., as <i>Juncus sikkinensis</i> var. <i>pseudocastaneus</i> Lingehsh. (on the additional label)	Flora von Ostr-Tibet	T: Ngata (Taining), Tschaschilaka, zwischen Tasienslu [Kangding] und Dawo [Dawu], Hai tse schan am Dshara, 2 Jul 1914, W. <i>Limpricht</i> 1869; syn: WRSLS, n.v., WU. Rem.: The specimen at WRSLS is mentioned by Kirschner et al. (2002a: 126) but marked as n.v. [non vid].	
62	152	Isolectotype of <i>Juncus nanarius</i> Songeon & E.P. Perrier in P.C. Billot, <i>Ann. Fl. France Allennagne</i> (1859: 192)	<i>Juncus nanarius</i> Songeon & E.P. Perrier in P.C. Billot, <i>Ann. Fl. France Allennagne</i> (1859: 192)	FRANCE. Moutiers (Savoie)	31 Jun & 24 Aug 1858	Perrier 1787 (det. J. Seasiak, 29 Jan 1975), as <i>Juncus ambigua</i> Guss. = <i>J. nanarius</i> Song et Perr.	Reliquiae Maillennae / Herbarium M. Winkler	T: France, Savoie, Moutiers, 31 Jun & 21 Aug 1858, A. Perrier; lecto: P. <i>fide</i> T.A. Cope & C.A. Stace, <i>Watsonia</i> 12 (1978: 123); isolecto: BM*, G, K, LD, W. Rem.: The status of this isolectotype should be validated while taking into account the following: 1) the analysis of the lectotype at P and 2) whether the lectotypification by Cope & Stace (1978: 123) is valid (the researchers did not specify which specimen at P they selected as a type and the original material of the name is usually very extensive).	
63	156	Synotype of <i>Juncus rupestris</i> f. <i>robusta</i> Buchenau, <i>Monog. Junc. Cap</i> (1875: 442) [Abh. Naturwiss. Ver. Bremen 4 (1875: 442)]	<i>Juncus rupestris</i> Kunth, <i>Enam. Pl.</i> 3 (1841: 344)	SOUTH AFRICA. Cape, Kamiesberge, Eselsfontein	sine dato	J.F. <i>Drège</i> 2471a	Herbarium Henschelianum	T: South Africa, Cape, Kamiesberge, Eselsfontein, J.F. <i>Drège</i> 2471a; syn: BOL, E*, G, K, LD, PR, S.	
64	156	Isolectotype of <i>Juncus schimperii</i> Hochst. ex A. Rich., <i>Tent. Fl. Abyssin.</i> 2 (1851: 338)	<i>Juncus punctatorius</i> L. f., <i>Suppl. Pl.</i> (1781: 208)	ETHIOPIA. In ripis uliginosis Adoom	01 Dec 1837	W. <i>Schimper</i> 56 (det. Fr. Buchenau, 11 Jan 1875 as <i>Juncus punctatorius</i> Thbg.)	Schimper iter Abyssinicum, Sectio prima: planae Adoenses / Herbarium Henschelianum	T: [Ethiopia]. In ripis uliginosis prope Adoom [Adua], 1 Dec 1837, W. <i>Schimper</i> [C.F. Hochstetter, <i>Herb. Un. It. Abyss.</i>] 56; lecto: P [as 'holo'], <i>fide</i> K.A. Lye, in S. Edwards, Schsbe D. & I. Hedberg, <i>Fl. Ethiop. & Eritr.</i> 6 (1997: 389); isolecto: BR*, G*, HAL*, MP*, MPU*, K, KW*, LC*, S*, TUB*, WAG*, WU. Rem.: The status of the type correct (iso to isolecto) in accordance with the <i>Shenzhen Code</i> .	

No.	N.f.	Kind of type and type of (basionym)	Current name	Herbarium label data (original spelling)			Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.)
				Locality (label data)	Date	Leg. et det.		
65	154	Synotype of <i>Juncus schlegelii</i> Buchenau, <i>Nachr. Königl. Ges. Wiss. Göttingen Geschichtl. Mitt.</i> 13 (1869: 255)	<i>Juncus himalensis</i> Klotzsch in J.F. Klotzsch & C.A.F. Garcke, <i>Bot. Ergebn. Reise Waldemar</i> (1862: 60, tab. 97)	INDIA, Western Himalaya, prov. Gährwal, Nêlong via Mûkha across the Damdâr or Hat-ka Tsâtra Pass tu Ussilla in the Tons Valley	26 Sep to 06 Oct 1855	<i>A. & H. Schlegelii</i> 9708, det. Fr. Buchenau	Herbarium Schlagintweit from India and High Asia	T: [Kashmir] Tibet, Dras, 'Matai up to the [Soje Pass', 14 Oct 1868, <i>A. & H. Schlegelii</i> 6668; syn. W. US*; India, Garhwal, 'Nêlong via Mûkha across the Damdâr', 6 Oct 1855; <i>A. & H. Schlegelii</i> 9708; syn. <i>n.v.</i>
66	156	Synotype of <i>Juncus schlechteri</i> Buchenau, <i>Bot. Jahrb.-Syst.</i> 24 (1898: 459)	<i>Juncus cephalotes</i> Thunb., <i>Prodr. Pl. Cap.</i> (1794: 66)	SOUTH AFRICA. Terra Capensis, Regio occidentalis, Bains Kloof	Nov 1896	<i>Fr. Schlechter</i> 9154	Planetae Schlechterianae Austro-Africanae	T: South Africa, Cape, Bains Kloof, <i>Fr. Schlechter</i> 9154; syn. BM*, BOL, BR*, E*, G*, L, LD, LE*, PR, PRE, S, WAG*.
67	157	Isotype of <i>Juncus singularis</i> Steud., <i>Syn. Pl. Glumac.</i> 2 (1855: 302)	<i>Juncus singularis</i> Steud., <i>Syn. Pl. Glumac.</i> 2 (1855: 302)	SOUTH AFRICA. Cape, between Vansadensberg and Betheldorp	1830	<i>J.F. Drège</i> 1604b	Herbarium Henschelianum	T: Cape, between Vansadensberg and Betheldorp 1830, <i>J.F. Drège</i> 1604b <i>p.p.</i> [some gatherings with <i>Juncus drageanus</i>]; holot: P; iso: B [destroyed, but picture deposited at W], G, S, W. Rem.: Mentioned by Kirschner et al. (2002a: 57) as a doubtful taxon.
68	156	Synotype of <i>Juncus sonderianus</i> Buchenau, <i>Monogr. Junc. Cap.</i> (1875: 476) <i>Ver. Bremen</i> 4 (1875: 476)	<i>Juncus sonderianus</i> Buchenau, <i>Monogr. Junc. Cap.</i> (1875: 476) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 476)]	SOUTH AFRICA. [Cape] Port Elizabeth	sine dato	<i>J.F. Drège</i> <i>e</i> det. F. Buchenau as Buchenau, 11 Jan 1875; det. J.F. Drège as <i>Junc. cap. ß. augustifol.</i> (E.M.)	Herbarium Henschelianum	T: [Cape] Port Elizabeth, <i>J.F. Drège</i> <i>e</i> ; syn. E*, G, HBG*, K, LD, LE*, P, S*, W [J.F. Drège <i>e</i> was generally proposed as a type by Adamson, <i>J. Linn. Soc., Bot.</i> 50 (1955: 26)]; [Cape] bei Cap Recife und Port Elizabeth, <i>C.F. Ecklon & C.L.P. Zeyher</i> 9; syn. BOL, LD*, W; S; <i>C.F. Ecklon & C.L.P. Zeyher</i> 780; syn. <i>n.v.</i> - W*.
69	156	Islectotype of <i>Juncus sparganiiifolius</i> Boiss. & Kotschy ex Buchenau, <i>Krit. Verz. Juncac.</i> (1879: 88)	<i>Juncus sparganiiifolius</i> Boiss. & Kotschy ex Buchenau, <i>Krit. Verz. Juncac.</i> (1879: 88)	TURKEY. In alvei glareosis dispersa et rara supra Ursusa pagum (Hatay, Aisuz)	02 Jul 1862	<i>C.G.T. Kotschy</i> 102	Th. Kotschy, Pl. Syriae bor. ex Amano occidentali supra Arsus 1862	T: Planetae Syriae borealis ex Amano occidentali supra Arsus, supra Ursusa pagum [Turkey, Hatay, Aisuz], 2 Jun 1862, <i>C.G.T. Kotschy</i> 102; lecto: Z, <i>file</i> S. Snogerup, in P.H. Davis, <i>Fl. Turkey</i> 9 (1986: 19); islecto: BM, G*, K, L, LE*, P; W [One of four isotype specimens from W bears a note in Buchenau's hand: 'An excellent new species' [translated], and should be given preference. Rem.: The status of the type corrected (iso to islecto) in accordance with the <i>Shenzhen Code</i> .
70	156	Islectotype of <i>Juncus spregelii</i> Nees ex Buchenau var. <i>gracilior</i> Buchenau, <i>Monogr. Junc. Cap.</i> (1875: 449) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 449)]	<i>Juncus stenopetalus</i> Adamson, <i>J. S. African Bot.</i> 8 (1942: 273)	SOUTH AFRICA. Worcester; Waterfall	sine dato	<i>C.F. Ecklon & C.L.P. Zeyher</i> 11, 1.12 (det. Fr. Buchenau, as <i>J. spregelii</i> N. ab. Es., 11 Jan 1875)	Herbarium Henschelianum	T: South Africa, Cape, Tulbagh Waterfall, <i>C.F. Ecklon & C.L.P. Zeyher</i> 11; lecto: BOL, <i>file</i> A.A. Obermeyer, in A.A. Obermeyer, J. Lewis & R.B. Faden, <i>Fl. S. Afr.</i> 4/2 (1985: 88); islecto: LD, S, W.
71	156	Islectotype of <i>Juncus spregelii</i> Nees ex Buchenau var. <i>gracilior</i> Buchenau, <i>Monogr. Junc. Cap.</i> (1875: 449) [<i>Abh. Naturwiss. Ver. Bremen</i> 4 (1875: 449)]	<i>Juncus stenopetalus</i> Adamson, <i>J. S. African Bot.</i> 8 (1942: 273)	SOUTH AFRICA. Worcester; Waterfall	sine dato	<i>C.F. Ecklon & C.L.P. Zeyher</i> 11, 1.12	Herbarium Henschelianum	T: South Africa, Cape, Tulbagh Waterfall, <i>C.F. Ecklon & C.L.P. Zeyher</i> 11; lecto: BOL, <i>file</i> A.A. Obermeyer, in A.A. Obermeyer, J. Lewis & R.B. Faden, <i>Fl. S. Afr.</i> 4/2 (1985: 88); islecto: LD, S, W.

No.	N.f.	Kind of type and type of (botany)	Current name	Locality (label data)	Date	Leg. et det.	Flora of / Herbarium	T: Type citation from protologue, including herbaria acronyms (according to Kirschner et al. (2002a, b)) and additional remarks (Rem.)
72	152	Isolectotype of <i>Juncus sulcatus</i> Hochst. in C. Krauss, <i>Flora</i> 28 (1845: 342)	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA. Ad rivulus in Zitzikamma, Uitenhage	Mar 1839	<i>C. Krauss</i> s.n. (det. Fr. Buchenau, as subsp. <i>angustifolius</i> var. <i>flaccidus</i> Behm., f. <i>depaup.</i> , 11 Jan 1875)	Herbarium Henschelianum	T: Cape, Uitenhage, Zitzikamma, Mar 1839, <i>C. Krauss</i> s.n.; lecto: W, <i>fide</i> Kirschner et al. (2002a: 36); isolecto: FI*.
73	152	Isolectotype of <i>Juncus sulcatus</i> Hochst. in C. Krauss, <i>Flora</i> 28 (1845: 342)	<i>Juncus capensis</i> Thunb., <i>Prodr. Pl. Cap.</i> 1 (1794: 66)	SOUTH AFRICA. Ad rivulus in Zitzikamma, Uitenhage	Mar 1839	<i>C. Krauss</i> s.n.	Herbarium Schumann	T: Cape, Uitenhage, Zitzikamma, Mar 1839, <i>C. Krauss</i> s.n.; lecto: W, designated by Kirschner et al. (2002a: 36); isolecto: FI*.
74	157	Synotype of <i>Juncus sylvaticus</i> var. <i>multiflorus</i> Roehel, <i>Pl. Banat. Rar.</i> (1828: 31, tab. 1) & <i>Juncus rocheilanus</i> Schult. & Schult. f., <i>Syst. Veg.</i> 7(2) (1830: 1658)	<i>Juncus thomasi</i> Ten., <i>App. Ind. Sem.</i> (1827: sine pag.)	SERBIA. Banatu [Banatus]	1815	<i>A. Roehel</i> s.n.	Herbarium R. v. Uechtritz	T: [Romania] Valle Kornia-Reva & ad pedes Krak-Sanozy Banatus, <i>A. Roehel</i> ; syn. n.n. – BM*, W*, Banatus, 1815, <i>A. Roehel</i> ; syn: W.
75	151	Isolectotype of <i>Juncus tommasinii</i> Parl., <i>Fl. Ital.</i> 2 (1852: 315)	<i>Juncus litoralis</i> C.A. Mey., <i>Verz. Pfl. Casp. Meer.</i> (1831: 34)	ITALY. [...] bog, Montfalcone Grado	sine dato	<i>M. Tommasin</i> s.n.	Ex herbario Florae Illyrico-litoral / Herbarium R. v. Uechtritz 27	T: [Italy] 'Nel paludi presso Montfalcone, Grado', <i>M.G.S. Tommasin</i> , lecto: FI, <i>fide</i> S. Snogerup, <i>Willdenowia</i> 23 (1993: 40).
76	157	Iso-type of <i>Juncus trifloris</i> var. <i>brachystylis</i> Engelm., <i>Trans. Acad. Sci. St. Louis</i> 2 (1868: 492)	<i>Juncus kelloggii</i> Engelm., <i>Trans. Acad. Sci. St. Louis</i> 2 (1868: 494)	USA. California, Mendocino Co., Ukiah	May 1866	<i>H.N. Bolander</i> ♂ <i>Kellogg</i> 46/46, det. Fr. Buchenau	Herbarium Henschelianum	T: USA, California, Mendocino Co., Ukiah, May 1866, <i>H.N. Bolander</i> 46/46 [<i>G. Engelmann</i> , <i>Herb. Junc. Bor.-Amer. Norm.</i>]; holo: MO; iso: BM*, CAS, F*, G*, GH*, K*, MIN*, NY, PH*, PR, RM*, RSA*, US, USCH*, YU*.
77	157	Isolectotype of <i>Juncus trifloris</i> var. <i>spilobus</i> Engelm., <i>Trans. Acad. Sci. St. Louis</i> 2 (1868: 492)	<i>Juncus trifloris</i> Engelm., <i>Trans. Acad. Sci. St. Louis</i> 2 (1868: 492)	USA. California, Yosemite Valley, De Long's ranch	10 Jun 1866	<i>H.N. Bolander</i> ♂ <i>Kellogg</i> 48/64, det. Fr. Buchenau	Herbarium Henschelianum	T: California, Yosemite Valley, De Long's Ranch, 4000 ft. [ca. 1280 m], 10 Jun 1866, <i>H.N. Bolander</i> 48/64 [<i>G. Engelmann</i> , <i>Herb. Junc. Bor.-Amer. Norm.</i> 30]; lecto: MO, <i>fide</i> E.J. Hermann, <i>Leaf. W. Bot.</i> 5 (1948: 114); isolecto: CAS, DAO*, G*, ISC*, K*, LE*, MICH, NEB*, NY, PH*, RM*, RSA*, US, USCH*, YU*.
78	156	Iso-type of <i>Juncus valdiviae</i> Steud., <i>Syn. Pl. Glumac.</i> 2 (1855: 296)	<i>Juncus procerus</i> E. Mey., <i>Linnaea</i> 3 (1828: 367)	CHILE. ad ripam fluvii Valdivia	Jan 1852	<i>R.A. Philippi</i> 43 (det. Fr. Buchenau, as <i>Juncus procerus</i> E. M., 3 Dec 1878)	R.A. Philippi, Pl. chilenses, W.R.F. Hohenacker / Herbarium Henschelianum	T: Chile, Valdivia, <i>R.A. Philippi</i> 43; holo: P; iso: FI*, G, GOET, K, KW*, MO, O, P, S.

2) SYNTYPE of *Juncus oxycarpus* E. Mey. ex Kunth (1841: 336) [sine dato, *C.H. Bergius s.n.* (det. Fr. Buchenau 11 Jan 1875 & remark by Buchenau: Bergiussches Exemplar mit der (falschen) Bestimmung v. K. Sprengel); det. by K. Sprengel as *Juncus punctatorius*]. – A syntype at WRS� shown, according to the original publication of Kunth (1841: 337). This is a new syntype (and its only duplicate known) discovered at WRS�.

3) ISOLECTOTYPE of *Juncus capensis* var. *gracilior* Buchenau (1875: 483) [05 Mar 1816, *Bergius s.n.*, det. K. Sprengel (gesamm. von Bergius, det. Fr. Buchenau 11 Jan 1875), current name: *Juncus capensis* Thunb. (1794: 66)]. – Additional specimens were mentioned in the protologue of the new taxon (Buchenau, 1875: 484). Thus, the lectotype was designated (in B, destroyed). Isolectotype (the only duplicate known) was rediscovered at WRS� (the specimen includes collection date (i.e. 5 Mar 1816), which corresponds to the date included in the protologue). The syntype (Bergius specimen at W) does not include a collection date.

The origin of *Juncus* type specimens at WRS� according to country is presented in Fig. 2.

Most of the types and other historically- and nomenclaturally-important specimens come from the following collections: Herb. Henschelianum (30 sheets, i.e. 16.2% of the *Juncus* set at WRS� – see below “A Herbarium/Collection name”), Herb. Schumann (13 sheets, 16.9%), Herb. R. v. Uechtritz (7 sheets, 1.7%), Herb. J. Pročkóv (6 sheets), Herb. M. Winkler (3 sheets) and others (19 sheets). Additionally, eight paratypes of *J. bulbosus* f. *submucronatus* Pročkóv (2010: 412) are stored in the Herbarium Silesiacum at WRS� (Pročkóv 2010) and, thus, are not included in the statistics in this study that covers Herbarium Generale only (as a separate set of two ones at WRS�).

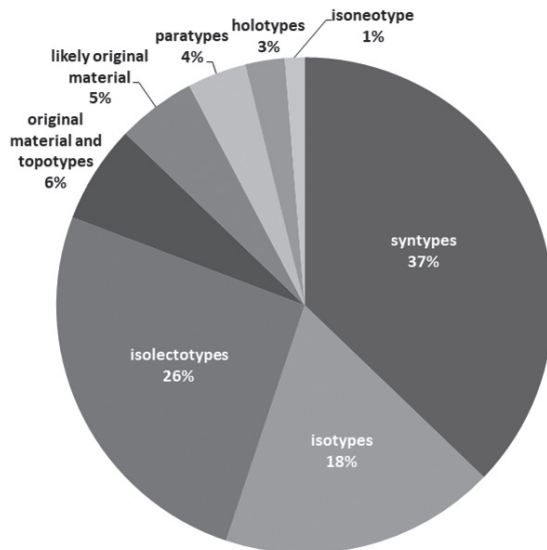


Figure 1. Percentage of different categories of *Juncus* specimens. Types, original material and specimens collected from the original type localities, by the author of the name (“topotypes”) at WRS�.

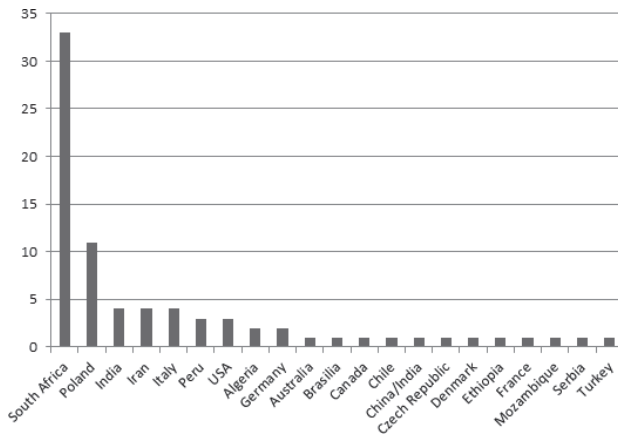


Figure 2. Origin of *Juncus* historically- and nomenclaturally-important specimens at WRS� according to country. Y-axis: number of herbarium sheets. Specimens most frequently originated from South Africa (42.3%). *Juncus* type specimens were collected by many distinguished botanists. Amongst these, the four individuals gathered 37.2% of *Juncus* specimens: C.F. Ecklon & C.L.P. Zeyher, C. Krauss and J.F. Drège.

Species

Approximately 70 *Juncus* species are represented in the collection, most of them from Europe. Species from the rest of the world are less numerous, but still relatively frequent: *J. capensis* Thunb., *J. subulatus* Forssk. (incl. *J. multiflorus* Desf.), *J. nodosus* L., *J. cephalotes* Thunb., *J. dichotomus* Elliott, *J. prismatocarpus* R. Br., *J. acuminatus* Michx., *J. xiphioides* E. Mey., *J. concinnus* D. Don, *J. wallichianus* J. Gay ex Laharpe (incl. *J. monticola* Steud.), *J. pelocarpus* E. Mey., *J. marginatus* Rostk., *J. microcephalus* Humb., Bonpl. & Kunth. and *J. punctorioides* L.f., *J. littoralis* C.A. Mey. (as *J. tommasinii* Parl.).

Date of collection

We found 2,193 herbarium labels with dates of collection recorded: 1,967 of these were collected before 1946, comprising ca. 89.7% of the *Juncus* set. The remaining 226 specimens were collected after 1945; 10.3% of the *Juncus* specimens.

Collector and herbarium collection name

In the *Juncus* set at WRS�, the sets of some individuals stand out in numbers of specimens (Fig. 3). The most outstanding collections of *Juncus* from particular included herbaria are (number of herbarium sheets are in parentheses): Herb. R. v. Uechtritz (415), Herb. M. Winkler (394), Herb. Henschelianum (185), Botanischer Tauschverein in Wien (80), Herb. Schumann (77), Herb. Wagnerianum (41), Herb. Dr. C. Baenitz (34), Herb. Emil Fiek (32), Herb. J.A. Allen (24), Reliquiae Mailleanae (24), Herb. F.

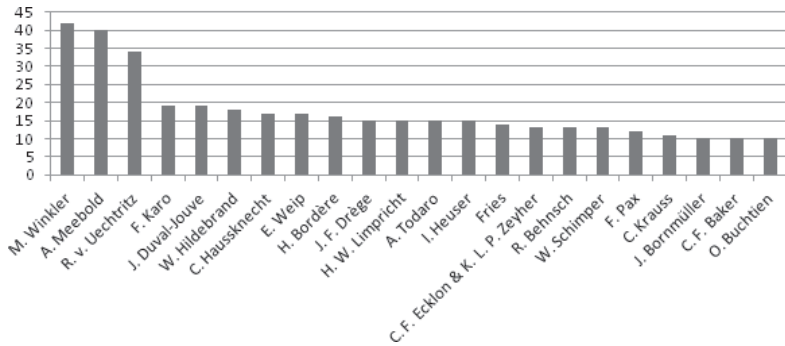


Figure 3. Collectors' names. Y-axis: number of herbarium labels analysed.

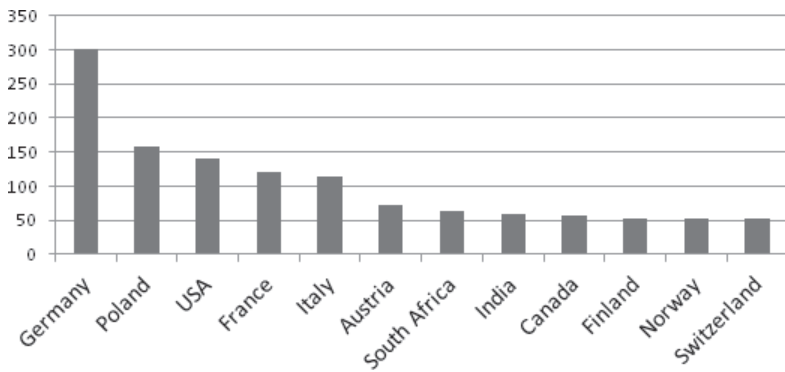


Figure 4. Country representation of *Juncus* specimens in WRS L. Y-axis: number of herbarium labels analysed. The African collection deserves particular attention (98 sheets (4.5%)), including sets from South Africa (64 sheets). The Asian collection (96 sheets) is dominated by plants from India (59). The percentage of plants from North America is as high as 10%.

Pax (21), Herbar P. Louis-Marie (20), Herb. A. Engler (18), Reliquiae Hildebrandianae (18), Herb. Felsmann (15), Herb. J. Duval-Jouve (14), Herb. Schlagintweit from India and High Asia (12), Herb. Hort. Bot. Calcuttensis (11) and Herbar Henri van Heurck (10). Almost half of the *Juncus* sp. sheets come from four individual collections. All were bought for, donated to or exchanged by the Museum. The number of duplicates in the collection is not large (4.6%, i.e. 103 out of 2,222 all taxonomic records).

Country of collection

Herbarium sheets from eastern Poland and Germany (defined according to their post-war borders) dominate and are shown in Fig. 4. For 336 *Juncus* sheets (15.3%), we were unable to establish the country of origin, because no or illegible information on the locality was present on herbarium labels.

Exsiccata series

In the WRS� *Juncus* set, the following exsiccatae are particularly well-represented (the number of herbarium sheets is shown in parentheses): Rchb. Fl. germ. excurs. (incl. Rchb. Fl. Germ. n.) (37), Cyperaceae, Juncaceae, Typhaceae et Sparganiaceae Hungaricae exsiccatae (24), Reise durch das südliche Spanien 1873 (mainly of M. Winkler) (22), Flora of Sikkim (15), Pl. Indiae or [ientalis] (M. Nilagiri), ed. R.F. Hohenacker (13), Todaro Flora Sicula exiccata (11), Flora des NW. Himalaya (10).

Discussion

The Herbarium Generale of the mid-sized WRS� herbarium is rich in specimens relevant to the nomenclature of *Juncus* and contains 78 specimens (3.6% of all *Juncus* specimens examined, see Table 1), with an average of 11 sheets per fascicle (i.e. herbarium box). Seventy-six (of 78) of these historically-important specimens (types, original material and specimens collected at the type locality by the author of the name) were not identified as such before our study. This significant number of types highlights the significance of the analysed set and of WRS� more broadly, for the study of taxonomy and nomenclature (Sutory 1997). To put this into context, the approximate percentages of types stored in other historically-important herbaria are as follows: K (5%), W (3.6%), BM (2.6%) [cited from herbaria websites, which include the total number specimens stored]. Our study revealed that the *Juncus* set at WRS� is a valuable collection globally with respect to the number of historically- and nomenclaturally-relevant specimens. Often, specimens included are associated with research conducted involving a given group of plants in the academic centre housing collections. The majority of *Juncus* specimens (ca. 89.7%) date from before the Second World War and specialists studying the genus *Juncus* did not work at WRS� during that time. This suggests that the rest of the WRS� collection might also contain similarly high percentages of such historically- and nomenclaturally-relevant specimens.

As the genus *Juncus* is rich in species (311 species, Kirschner et al. (2002a, b)), we consider that extrapolation of our results to other genera is appropriate. We assume that descriptions of taxa new to science before 1946 were equally common within most taxonomic groups and specimens belonging to different plant genera/families were sent to the WRS� herbarium equally often.

Only a small fraction of global herbarium specimens had been computerised by the end of last decade (Lughadha and Miller 2009). Despite the recent acceleration of the digitisation of herbarium collections (as of early 2015, the number of scanned specimens within the world's largest virtual herbaria was 18.4 million), we are far from fully digitising all collections (Seregin 2016). Even a small percentage (1–2%) of computerised specimens can drastically reduce research costs and help scientists focus on collections that are likely to contain the most information-rich specimens (O'Connell

et al. 2004). In herbarium management, it is cheaper to produce and distribute scans than facilitate botanist visits (Seregin 2016). Digitisation is also important because young people who do not live near a natural history museum or herbarium can access natural history data and learn to use it and this early involvement in science may cultivate a love for the study of biology (Watanabe 2019). The continued digitisation of the WRSL herbarium (currently only 4.9% digitally available) will certainly reveal new material for botanists' use.

Our results reveal the usefulness of lesser-known herbaria not only from a national or local point of view (Lavoie 2013), but also as a source of important collections and type specimens that are not duplicated in larger facilities (Snow 2005). For *Juncus*, only two of 78 nomenclaturally-relevant specimens identified here were cited by Kirschner et al. (2002a, 2002b), so 76 of the specimens in Table 1 were unknown before this study. Holotypes, isotypes and isolectotypes constitute 46.2% of all types (and other nomenclaturally important specimens) of *Juncus* recognised at the WRSL, highlighting the nomenclature relevance of the collection. Three specimens are particularly worth highlighting here: the holotypes of *Juncus lomatoxyllus* Spreng. and *Juncus capensis* var. *gracilior* Buchenau and a syntype of *J. oxycarpus* E. Mey. ex Kunth were originally stored in Berlin (the herbarium of the Botanischer Garten und Botanisches Museum Berlin-Dahlem, Freie Universität Berlin). These were destroyed during the Second World War (Hiepko 1987; Kirschner et al. 2002a) and our discovery of duplicates in WRSL will help with the correct application of these names.

Duplicates of nomenclaturally relevant specimens are often considered to be less important than holotypes, lectotypes and neotypes. Duplicates, however, may differ in physical condition, material quantity, different annotations, labelling, specimen content (plant parts, for example, young fruit vs. only a flowering twig, male vs. female flowers in diclinous plants, with roots vs. without roots) or may even represent mixed gatherings (different taxa). An isotype of *Juncus singularis* Steud. (*J.F. Drège 1604b*) at WRSL, for example, is a much larger, leafy specimen with five inflorescences, as compared with other specimens at G, P, S and W, listed and pictured at plants.jstor.org (accessed on 16 Apr 2020). Annotations by specialists can be very useful in understanding taxonomic concepts: 23 WRSL *Juncus* type specimens were annotated by Franz G.Ph. Buchenau (1831–1906), a *Juncus* specialist whose work remains unsurpassed to this day (annotations included new determinations and/or 'specimen authenticum' indications and were made by him throughout 1874–1875, 1878–1879 and 1887; see the 'Leg. et det.' column in Table 1). Thus, some 'ordinary duplicates' at WRSL are helpful for understanding taxonomists' thinking.

We also found that many of the historically- and nomenclaturally-important *Juncus* specimens stored at WRSL originate from South Africa (42.3%). This over-representation might be explained by the origin of the collection. German botanists (together with the British and the Dutch) were a dominant force in the floristic exploration of Africa from the 17th to the early 20th century. The WRSL herbarium is, thus, an important resource for international researchers working on the flora of that hugely biodiverse, but still under-explored, part of the world.

Conclusions

The history of German-Polish herbaria, including WRSL, is very turbulent. A detailed examination of *Juncus*, as a case study, confirms the value of the WRSL collection in historical terms. That a significant number of historically- and nomenclaturally-important specimens at WRSL was acquired passively (*Juncus* was of no special interest to German or Polish scientists at the time) suggests that more such specimens may be found within the collection for other genera. Digitisation and taxonomic revision of material will facilitate the confirmation of the richness of the collection.

Other large type collections contain well-preserved specimens, well-prepared catalogues (often available on-line) and are well-known to scientists. However, the WRSL collection is not only unique, as confirmed here, but not well-known to date.

Some *Juncus* type specimens, listed here, can be found easily in a large number of other collections. However, some are preserved only at WRSL because many types, previously stored in Berlin, were destroyed during the Second World War. Although we researched only a few parts of the WRSL collection, we are convinced that duplicates of many type specimens destroyed in Berlin can be found in Wrocław. Uncatalogued herbaria like WRSL with turbulent histories can be a source of collections important for the study of biodiversity.

We selected *Juncus* as a case study since the collection at WRSL covers the entire distribution range of the genus. Therefore, it likely reflects the general situation in other groups of plants in the herbarium.

Currently, many herbarium sets in Europe are still being catalogued (and many remain undigitised). However, many old collections are indeed valuable and their type and other historical collections have the potential to facilitate taxonomy and nomenclature and, in addition, enhance our knowledge of biodiversity through application of correct names.

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A review of *Calypogeia* (Marchantiophyta) in the eastern Sino-Himalaya and Meta-Himalaya based mostly on types

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Abstract

The eastern part of the southern macroslope of the Himalayan Range, Hengduan Mountains and the complex of smaller ranges from Hengduan southward to northern Indochina is one of the taxonomic hotspots of *Calypogeia* in Asia and the world. Two main circumstances hamper the understanding of taxonomic diversity of the genus in this area: the absence of recent and detailed descriptions and identification keys and the necessity of studying fresh material with surviving oil bodies in leaf cells. This study resulted in 1) eleven species confirmed for this vast land, 2) seven more taxa recorded but likely based on identification mistakes and 3) fourteen more taxa that are not yet recorded but may be expected in the area. All these taxa are discussed, and most of them are illustrated and described based on the types; an identification key is provided. The occurrence of North Holarctic taxa is hardly probable in the Sino-Himalaya, whereas new records of taxa known from the southern half of the Japanese Archipelago, Taiwan and southeastern mainland China are possible.

Keywords

Calypogeiaceae, East Asia, Hepaticae, Indochina, taxonomy, typification

Introduction

Calypogeia in East Asia has attracted only slight special attention from hepaticologists. Despite some recent advances in the systematic analysis of the genus based on the study of East Asian material (Buczowska et al. 2018; Bakalin et al. 2019a), *Calypogeia* should still be regarded as a group that is very difficult to identify, the taxonomy of which is hardly understood. There are two basic reasons for this outstanding difficulty: 1) the absence of reliable keys for identification and 2) the necessity of studying the living material to observe oil body characteristics. Meanwhile, if even fresh material is available and oil body characteristics are studied, the problem remains of where to place the material if almost no oil body characteristics are indicated in the descriptions (both original or based on other materials) and the keys. Therefore, the aforementioned reasons are distinctly related. The attempts to identify East Asian *Calypogeia* using European keys are questionable: 1) the records of some taxa occurring in the Sino-Himalaya should be strongly doubted, and 2) the synonymization of some Himalayan taxa with European analogs was hasty. Understandably, to some extent, this situation was provoked by the brevity of original descriptions in the literature of the second half of the 19th century and the first quarter of the 20th century.

The basic and inevitable tasks for progress in the knowledge of *Calypogeia* in the southern part of the East Asian floristic region should be the compilation of morphological descriptions as detailed as possible based on the study of types and the compilation of an identification key to the *Calypogeia* taxa recorded or expected in this area. The two tasks are the main goals of the present study.

Material and methods

The vast majority of *Calypogeia* based on material originating from the Sino-Himalaya, in the broad sense, were described by W. Mitten and F. Stephani. Fortunately for our purposes, Stephani also largely duplicated Mitten's collection, and many type materials (including syntypes, isotypes and isolectotypes) are now housed in G (acronyms follow Thiers 2020). The material from G therefore has irrefutable value for our work, and most of the studied material is from there, although some additional specimens were studied in JE, NICH, STR, TNS and VBGI. In total, 43 types were studied, and many of them were photographed and illustrated. The taxonomic part of the work has the following subchapters, determined by practical reasons:

- 1) Taxa undoubtedly occurring in the study area (e.g., if the type specimen is from there).
- 2) Doubtful records of taxa that have a very low probability of being observed there.
- 3) Taxa that are not recorded in the study area but may be expected. We treat the latter definition very broadly, as involving some taxa from as far as India and Japan that look reasonable taking into account, e.g., the undoubted occurrence of

Calypogeia granulata – a formerly Japanese endemic taxon – in Guizhou Province, China, confirmed by molecular genetic research (Buczowska et al. 2018).

- 4) A dichotomous key to the taxa observed (also including doubtful records) and expected in the study area.

Each taxon in the taxonomic section is annotated as usual, with data on studied type specimens, morphological description based on the type and other comments on morphology or ecology. When providing the distribution of taxa, we do not limit the data to the study area only, but largely also include data from other, nearby regions or areas that have distinct relations in mountain flora with the Sino-Himalaya, e.g., the mountain flora of Taiwan.

The valuable problem of the present work is the inability to evaluate the morphological variation parameters clearly for many species; since there are only a few specimens known (e.g. *Calypogeia marginella* is known from the type gathering only). In these cases, we accepted ‘narrow species concept’, to avoid the loss of information resulting from hasty synonymization and, therefore, to keep by now as much taxa accepted as possible. In addition, we followed general estimations on the morphological variability of taxa in *Calypogeia* obtained in our previous works in this group (Buczowska et al. 2018; Bakalin et al. 2019a).

Study area

It is quite difficult to describe the ‘Sino-Himalaya’ using definite terminology. In very general terms, it is a large territory including the Himalaya Range with some spurs as well as mountain ranges in Southwest China, where it generally includes the Hengduan Shan – a very unclear term for the large mountain massif stretching from the Tibetan Plateau to the southeast until intersection with the mountainous northern end in Indochina. Despite the unclear definition, “the biogeographic unit informally known as the ‘Sino-Himalayan region’” (Váňa and Long 2009: 487) was widely used in the literature starting from the beginning of the 20th century. Váňa and Long identified the Sino-Himalaya in its common sense, including “Pakistan Himalaya, Indian Himalaya (Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Darjeeling District of West Bengal, Assam, Meghalaya, Manipur and Arunachal Pradesh), Nepal, Bhutan and western China (Yunnan, Sichuan and Xizang (Tibet))” (Váňa and Long 2009: 487). A similar view was maintained by many botanists, including bryologists (e.g., Dalton et al. 2013). The accepted above treatment of the Sino-Himalaya does not mean that this is a monomorphous and floristically indivisible unit. The strong and noticeable differentiation along the longitudinal gradient was evident even at the beginning of the 20th century, when several new expeditions explored this land more carefully than before. Moreover, even at this time, it was evident that some distant regions in the Sino-Himalaya have more common species than some nearer ones (Ward 1925). Ward (1925) also noted the possible wide spread of Sino-Himalayan taxa by rivers going in very diverse

directions, from the Brahmaputra in the west (draining to the Bay of Bengal) to the Yangtze River in the east (making a strong curve in southern Hengduan and then draining to the East China Sea), with many large rivers between, such as the Mekong River (draining to southernmost Indochina). Ward (1921) identified the watershed between the Mekong and Salween Rivers as an important phytogeographic boundary.

The eastern Sino-Himalaya is identified here as the land included in the Sino-Himalaya eastward of eastern Nepal. The Meta-Himalaya is identified as an area surrounding the southeastern part of the Sino-Himalaya, although not belonging to the Sino-Himalaya in its common sense. It includes eastern Sichuan, western Guizhou, eastern Yunnan and the mountains of northern Indochina. This is an area where Sino-Himalayan species deeply penetrate, although sometimes represented by transformed races or the speciation derivatives of species status (liverwort examples are in Bakalin et al. 2018, 2019a). This broad definition is more natural than may be expected from superficial examination. The deep relationships, e.g., between the floras of western Sichuan and northern Vietnam, were stressed by Takhtajan (1978, 1986). Chen et al. (2018) subdivided East Asia (treated by them as a plant kingdom) into two ‘subkingdoms’, conditionally calling them the *Rhododendron* flora and the *Metasequoia* flora, where the *Rhododendron* flora is somewhat related to the eastern Sino-Himalaya until it mildly contacts the *Metasequoia* flora along a line through the middle of Sichuan and Guizhou Provinces in China. Neither the *Rhododendron* subkingdom nor the *Metasequoia* subkingdom of East Asia extend southward to the Indochina Peninsula (Chen et al. 2018), despite the vegetation at upper elevations in the mountains of northernmost Vietnam not being Paleotropic. Indeed, Averyanov et al. (2003: 74) provided evidence that the characteristic flora at elevations above 1400 m a.s.l. even slightly southward of Phan Xi Pang Mt. “approximates the floras typical for the Sikang-Yunnan floristic province of the Holarctic floristic kingdom”.

The area treated in this work covers four floristic provinces in the sense of Takhtajan (1978, 1986):

- 1) Sikang-Yunnan floristic province that covers western Sichuan, western Yunnan, northeastern Myanmar, northern Laos and northwestern Vietnam (including the Hoang Lien Range). Takhtajan (1978, 1986) stressed that this large province undoubtedly should be split into several independent provinces in the future when new data are available.
- 2) North Burma (= Myanmar) floristic province.
- 3) East Himalayan province, including eastern Nepal (excluding low elevations with tropical vegetation), Darjeeling, Sikkim, Bhutan, the Assam Himalaya and the southern and southeastern flanks of Xizang (Tibet), where the monsoon climate is still pronounced. Takhtajan (1978) also noted the absence of a sharp floristic border in the eastern part, where it gradually transmutes into the central Chinese province.
- 4) Eastern part of the central Chinese province (western Guizhou, eastern Sichuan and eastern Yunnan).

We do not include Chinese Tibet (Xizang) to the eastern Sino-Himalaya as was done, e.g., by Vaňha and Long (2009) and Dalton et al. (2013) because of the strong

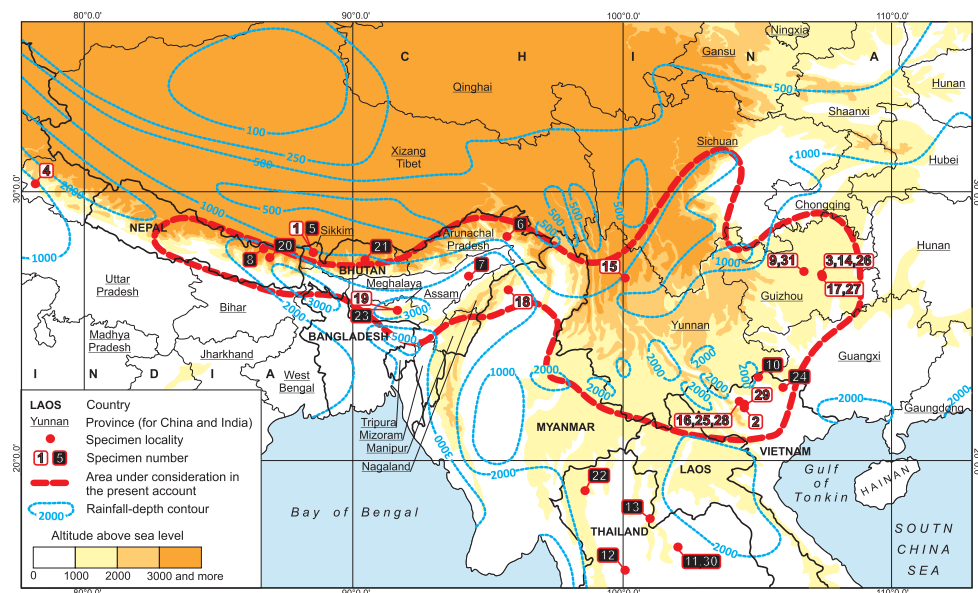


Figure 1. The area considered in the present paper. *Calypogeia aeruginosa* (1, 2), *Calypogeia angusta* (3), *Calypogeia apiculata* (4), *Calypogeia arguta* (4–14), *Calypogeia cordistipula* (15), *Calypogeia granulata* (16, 17), *Calypogeia lunata* (18–22), *Calypogeia marginella* (23), *Calypogeia tosana* (24–26), *Calypogeia sinensis* (27, 28), *Calypogeia vietnamica* (29), *Calypogeia goebelii* (30), *Calypogeia japonica* (31). White solid squares – specimens examined, black solid squares – specimens not seen.

difference in the vegetation and taxonomic composition compared with other parts of the eastern Sino-Himalaya. Moreover, the Tibetan Plateau is part of other floristic region (Irano-Turanian, cf. Takhtajan 1978) characterized by the dominance of relatively younger taxa of dry Central Asian or even ancient Mediterranean origin.

To identify the general character of the vegetation in the study area, this is alpine vegetation in forest-free landscapes at high elevations extending down to the vegetation developed above tropical communities, starting from the mountain subtropics. The Sino-Himalaya is dominated by a strong monsoon climate and has a distinct cool season with at least occasional snowfall, even at the southern extremes, such as peaks of the Hoang Lien Range. The area under consideration is depicted in Fig. 1.

Taxonomic treatment

Taxa confirmed in the area

Calypogeia aeruginosa Mitt., J. Proc. Linn. Soc., Bot. 5 (18): 107. 1860 [1861].

Figure 2A

Type. INDIA. Sikkim: 12000 ped. alt. (4000 m a.s.l.), J.D. Hooker, no. 1319 (isotype: G [G00064244/5286!]).

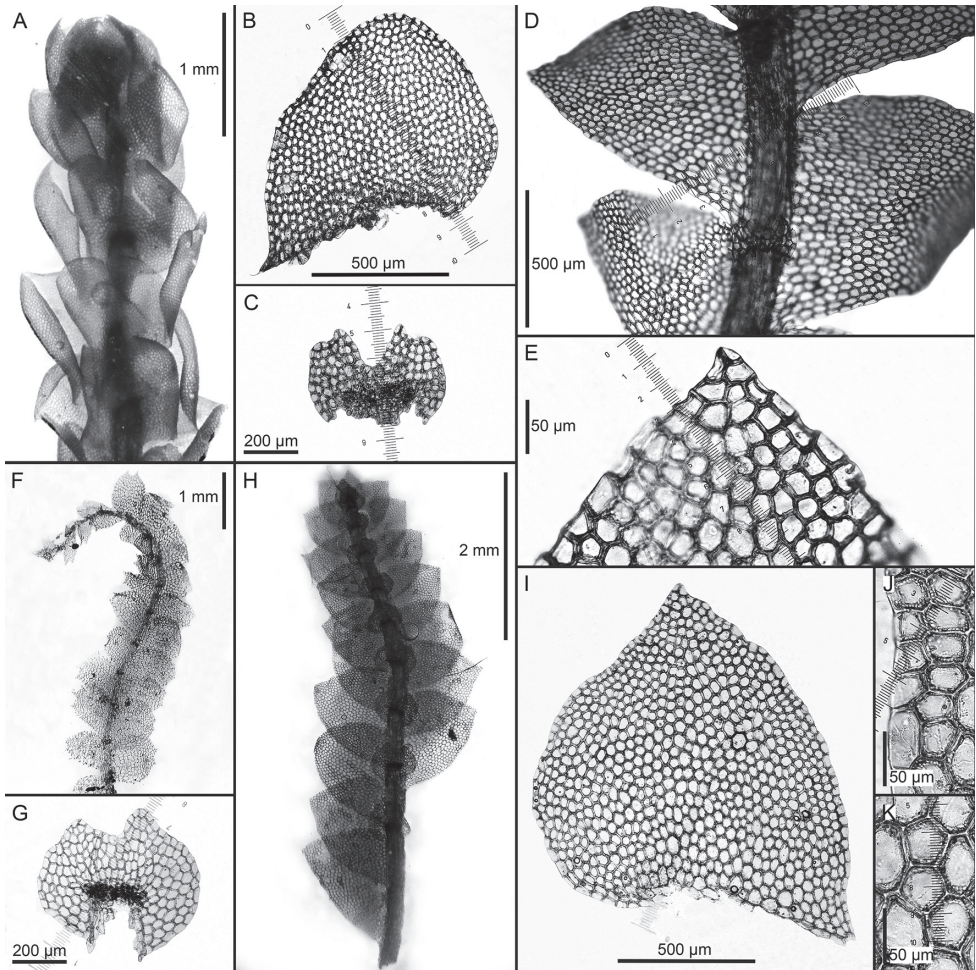


Figure 2. *Calypogeia aeruginosa* Mitt.: **A** plant habit, fragment, ventral view *Calypogeia angusta* Steph.: **B** leaf **C** underleaf *Calypogeia apiculata* (Steph.) Steph.: **D** plant habit, fragment, ventral view **E** leaf apex *Calypogeia arguta* Nees et Mont.: **F** plant habit, fragment, ventral view *Calypogeia cordistipula* (Steph.) Steph.: **G** underleaf **H** plant habit, fragment, ventral view **I** leaf **J** leaf margin cells **K** leaf middle cells. Scale bars: 1 mm (**A**, **F**); 500 µm (**B**, **D**, **G**); 200 µm (**C**, **G**); 50 µm (**E**, **J**, **K**); 2 (N); 2 mm (**H**). **A** from Isotype G00064244/5286; **B**, **C** from Lectotype G00067716; **D**, **E** Holotype G00061103; **F** Holotype STR (n. 163); **G–K** from Lectotype G00061105/10811.

Remarks. This taxon is broadly Sino-Himalayan-Taiwan-Japanese endemic, distributed within this large area quite disjunctively (although this may reflect the data deficiency). It was described from Sikkim (Mitten 1860), later recorded from Taiwan (Wang et al. 2011) and eastward from southernmost Japan (Inoue 1969; Yamada and Iwatsuki 2006). A questionable record is from Hawaii under the name *Calypogeia waialealeensis* (H.A. Mill. & Kuwah.) H.A. Mill. (Miller 1967) – the name synonymized with *C. aeruginosa* by Inoue (1969). From the geographic point of view, this synonymization should be doubted and the status of the populations from Hawaii should be rechecked,

including molecular-genetic methods implementing. We recently found *C. aeruginosa* in northern Vietnam (Buczowska et al. 2018) which may imply its broader distribution in the Meta-Himalaya. The taxon is very distinctive among congeners due to transversely elliptic underleaves as large as or larger than leaves and may be rather mistaken at the time of collection for *Leucolejeunea* due to size, color, leaf orientation and large underleaves (obscuring the fact that the lejeuneaceous lobule is absent here).

***Calypogeia angusta* Steph., Bull. Herb. Boissier (sér. 2) 8 (9): 663 (395). 1908.**

Figures 2B, C, 3A–G

Type. JAPAN. Ozoresan: 11 October 1902, U. Faurie, 1181 (Lectotype (designated here): G [G00067716!]).

Remarks. The species was described in Japan (Stephani 1908) and was recently recorded in Chinese Guizhou (Bakalin et al. 2015). We may suggest that some reports of *Calypogeia muelleriana* from China may likely belong to this taxon due to rounded leaf lobes; if the underleaves are not considered, they are much more deeply divided and commonly bisbifid. The description based on the lectotype is as follows: plants more or less rigid, barely translucent, slightly glistening, yellowish brownish in the herbarium, well-developed plants 900–1700 µm wide; stem 200–300 µm wide, sparsely ventrally branched; rhizoids in obliquely spreading, brownish fascicles; leaves contiguous to subimbricate (overlapping 2/5 of adjacent leaf), obliquely inserted and oriented, convex, with apices turned to the ventral side, obliquely ovate, apex rounded, entire to somewhat crispate, 500–750 × 500–800 µm; underleaves 1.1–1.4 as wide as stem, decurrent for ¼ of stem width or less, bisbifid or with one additional lateral tooth on each side, sinus V-shaped, undivided portion 1–2 cell high; midleaf cells 25–55 × 25–37 µm, thin walled with small to moderate size, concave trigones, cuticle smooth.

***Calypogeia apiculata* (Steph.) Steph., Bull. Herb. Boissier (sér. 2) 8 (9): 668 (400). 1908.**

Figures 2D, E; 3H, I

= *Calypogeia gollanii* Steph. ex Bonner Index Hepaticarum, 1963. nom. inval. (Art. 38.1(a); no description). Authentic material (invalid names have no types): INDIA. NW Himalaya: Mussoorie W. Gollan 01 Nov 1900 (original material, probably scheduled as the type): G [G00067720/23987!]. Syn. nov.

* – About 80% of type specimens in liverwort herbarium in G have two codes: the first one was provided in pre-computer time, whereas the second one was provided in the digitalization process. The papers before 2000-th cited the only old number, whereas now it is better to cite the new one (linked with the picture in the database). However, we guess, the best choice is to cite both, because only in this case we may identify the numbers widely used before with the recent ones. Therefore, in our citation we use the new number first (sometimes only that, if no old number is available) and then, after slash, the old one.

Basionym. *Kantius apiculatus* Steph., *Hedwigia* 34 (2): 51, 1895.

Type. Java. Prof. Stahl (Lectotype (designated here): G [G00061103!]).

Remarks. The species was originally described from Java (Stephani 1895) and recorded from Borneo (Chuah-Petiot 2011) and Sri Lanka (Long and Rubasinghe 2014). *Calypogeia gollanii* in India is the synonym of *C. apiculata*. Although *Calypogeia gollanii* is regarded as the synonym of *C. azurea* in the <https://bryophyteportal.org/>, the plants correspond in all ways to *C. apiculata* Steph., although the leaf cuticle is very loosely (although obviously) papillose. *Calypogeia azurea* does not occur in East Asia (Buczowska et al. 2018) and has much wider underleaves. *Calypogeia apiculata* may also be mistaken for *C. sphagnicola* (due to small underleaves) – generally *Sphagnum* swamp species that could hardly be expected in the Sino-Himalaya. In addition, *Calypogeia sphagnicola* has highly distanced and smaller leaves and smooth leaf cuticles. Presumably, the reports of *C. sphagnicola* in China may actually represent *C. apiculata*.

The description based on the lectotype of *C. apiculata* is as follows: plants 1.0–2.2 mm wide, 3–5 cm long, pale yellowish brownish in the herbarium; stem ~180 µm wide; rhizoids sparse to numerous in obliquely spreading fascicles, leaves distant to contiguous, nearly planar to slightly convex, rarely incurved to dorsal side (probably due to long drying and repeated soaking), 600–1100 × 450–800 µm, obliquely ovate, apiculate, very rarely shortly bidentate, decurrent in ventral base for 0.5–1.0 of stem width; underleaves as wide as stem or slightly wider, bilobed, undivided portion (1–)2 cells high, lateral teeth absent, decurrent for 1/3 of stem width or less; cuticle in leaves and underleaves very finely verruculose; cells in the midleaf 37–58 × 25–35 µm, thin-walled, trigones very small and concave.

***Calypogeia arguta* Nees et Mont., *Naturgesch. Eur. Leberm.* 3: 24. 1838.**

Figures 2F, 3J

= *Calypogeia pusilla* Steph. *Species Hepaticarum* 6: 450. 1924. Type: INDIA. India Orientalis: Madura A. Vella 1910 (Lectotype (designated here): G [G00067728/10974!]).

Type. Montagne (holotype: STR [(n. 163)!]).

Remarks. The species is described in “südlichen Frankreich, auf der Erde” (Nees 1838: 24), has generally suboceanic-Mediterranean (Damsholt 2002: 460) distribution, is widely distributed in Mediterranean areas in southern Europe (hardly spreading northward to Nordic countries) and North Africa, widely penetrates Asia along areas of the former Tethys Ocean surroundings and extends eastward to New Guinea; within North America, it is substituted by *Calypogeia sullivantii* Austin, a morphologically very similar taxon. In the genetic sense, this polymorphous taxon probably includes several cryptic or semicryptic species. *Calypogeia pusilla*, described from Indian Madura, represents in morphological respects the only depauperate form of typical *C. arguta*.

Within East Asia, *Calypogeia arguta* is recorded from Assam, Sikkim, (Robinson 1964; Bapna and Kachroo 2000), eastern Nepal (Noguchi et al. 1966), several localities in China, namely, Guangxi (Zhu and So 2003), Hong Kong (Zhang and Lin

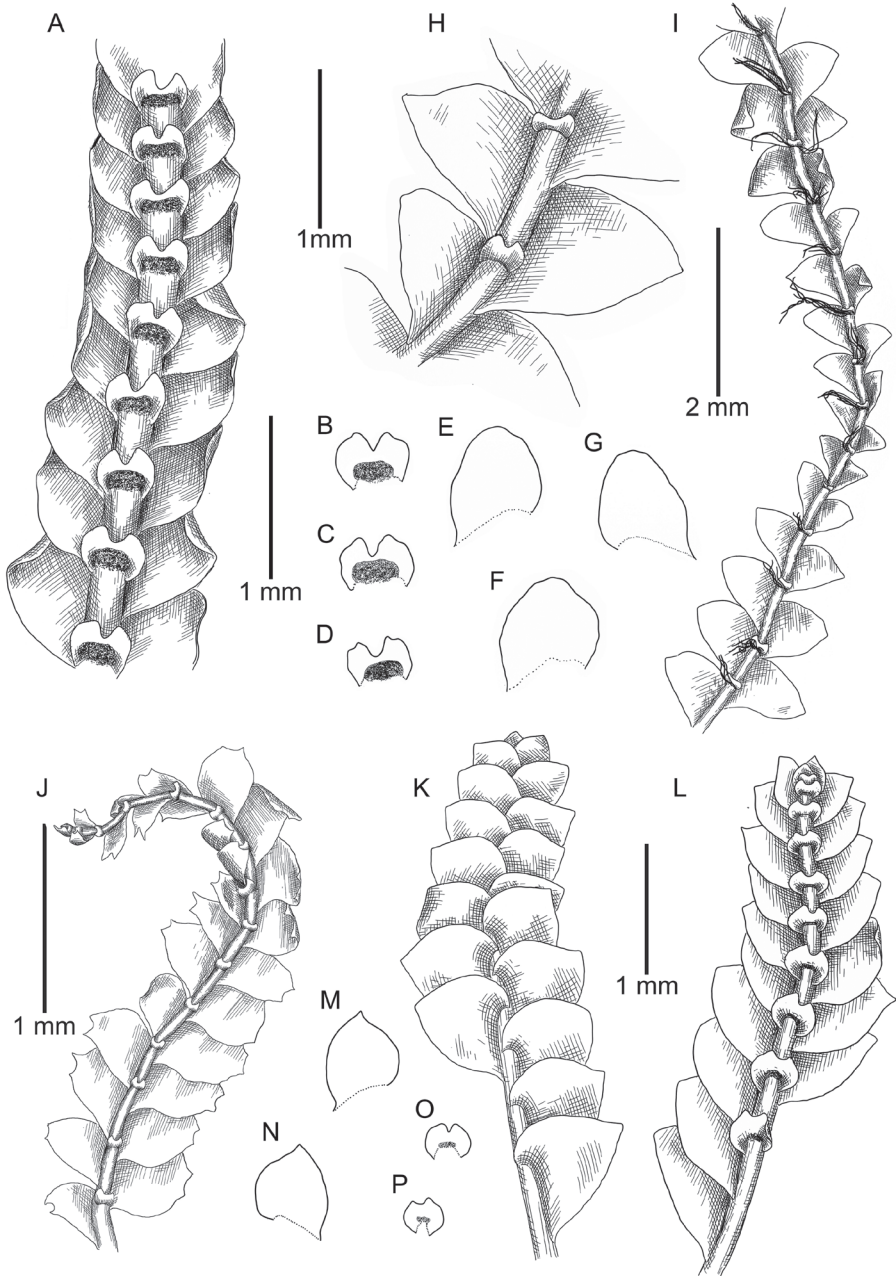


Figure 3. *Calypogeia angusta* Steph.: **A** plant habit, fragment, ventral view **B, C, D** underleaves **E, F, G** leaves *Calypogeia apiculata* (Steph.) Steph.: **H** plant habit, fragment, ventral view **I** plant habit, fragment, ventral view *Calypogeia arguta* Nees et Mont.: **J** plant habit, fragment, ventral view *Calypogeia cordistipula* (Steph.) Steph.: **K** plant habit, fragment, dorsal view **L** plant habit, fragment, ventral view **M, N** leaves **O, P** underleaves. **A–G** from Lectotype G00067716; **H, I** lectotype G00061103; **J** holotype STR (n. 163); **K–P** from Lectotype G00061105/10811.

1997), Jiangxi (Fang et al. 1998), Jiangsu, Guangdong, Hainan, Taiwan (Piippo 1990), Liaoning, Shaanxi, Shandong, Hubei, Yunnan, Henan, Anhui, Zhejiang, Hunan, Fujian, Guangxi, Macau (<http://www.catalogueoflife.org/annual-checklist/2019/>), and Guizhou Provinces (Bakalin et al. 2015). At the northern edge of East Asia the species is recorded from Kuril Islands (Bakalin et al. 2009), Japan and Korean Peninsula (<http://www.catalogueoflife.org/annual-checklist/2019/>). In Southeast Asia it is known from Vietnam (Shu et al. 2017), Thailand, Andaman Islands, Nicobar Is, Malaya, Borneo, Sulawesi, Java (<http://www.catalogueoflife.org/annual-checklist/2019/>).

***Calypogeia cordistipula* (Steph.) Steph. Species Hepaticarum 3: 400. 1908.**

Figures 2G–K, 3K–P

= *Cincinnulus cordistipulus* Steph. Mémoires de la Société des Sciences Naturelles et Mathématiques de Cherbourg 29: 210. 1894.

Type. CHINA. Yunnan: Hokin Delavay, no 1623 (Lectotype (designated here): G [G00061105/10811!]).

Remarks. *Calypogeia cordistipula* (Steph.) Steph was reported by Piippo (1990) for Chinese Yunnan (based on the type) but later synonymized with *C. neesiana* (Piippo et al. 1997). However, the two species are quite different. The differences from *C. neesiana* include acute leaf apex, slightly larger cells, acute sinus in underleaves, absence of distinctly elongated cells along leaf margin, no pale coloration (in the present specimen, we suspect blue oil bodies because plants become somewhat blackish-grayish as is common for blue-oil-bodied taxa). We suggest that *C. neesiana* does not occur in the Sino-Himalaya and that all records of that species may actually belong to *C. cordistipula*.

The description based on the lectotype is as follows: plants greenish brownish to grayish brown, 1.5–2.1 mm wide, translucent, slightly glistening; stem ~2500 µm wide, branching not seen; rhizoids common, in brownish fascicles erect to upward obliquely spreading; leaves obliquely inserted, subhorizontally oriented, overlapping 1/2 of the next leaf in the base, loosely concave to almost planar, with apex slightly turned to dorsal side, not or for 1/3 of stem width decurrent, 800–1200 × 800–1200 µm, obliquely widely ovate-triangular, apex acute, never divided; underleaves appressed to the stem to obliquely spreading, 1.8–2.5 as wide as stem, decurrent for 1/2–2/3 of stem width, divided by U- to V-shaped sinus into two lobes without additional teeth, lobes obtuse, undivided portion 3–5 cells high; midleaf cells 40–50 × 40–68 µm, thin-walled, trigones small to very small, concave, cuticle virtually smooth.

***Calypogeia granulata* Inoue, J. Jap. Bot. 43 (10/11): 468. 1968.**

Figures 4A–K, 5A–E

Type. JAPAN. Saitama Prefecture: Kuroyama, 500 m a.s.l., 24 June 1968 H. Inoue 18004 (holotype: TNS [174361!]; isotype: G [G00114896!]).

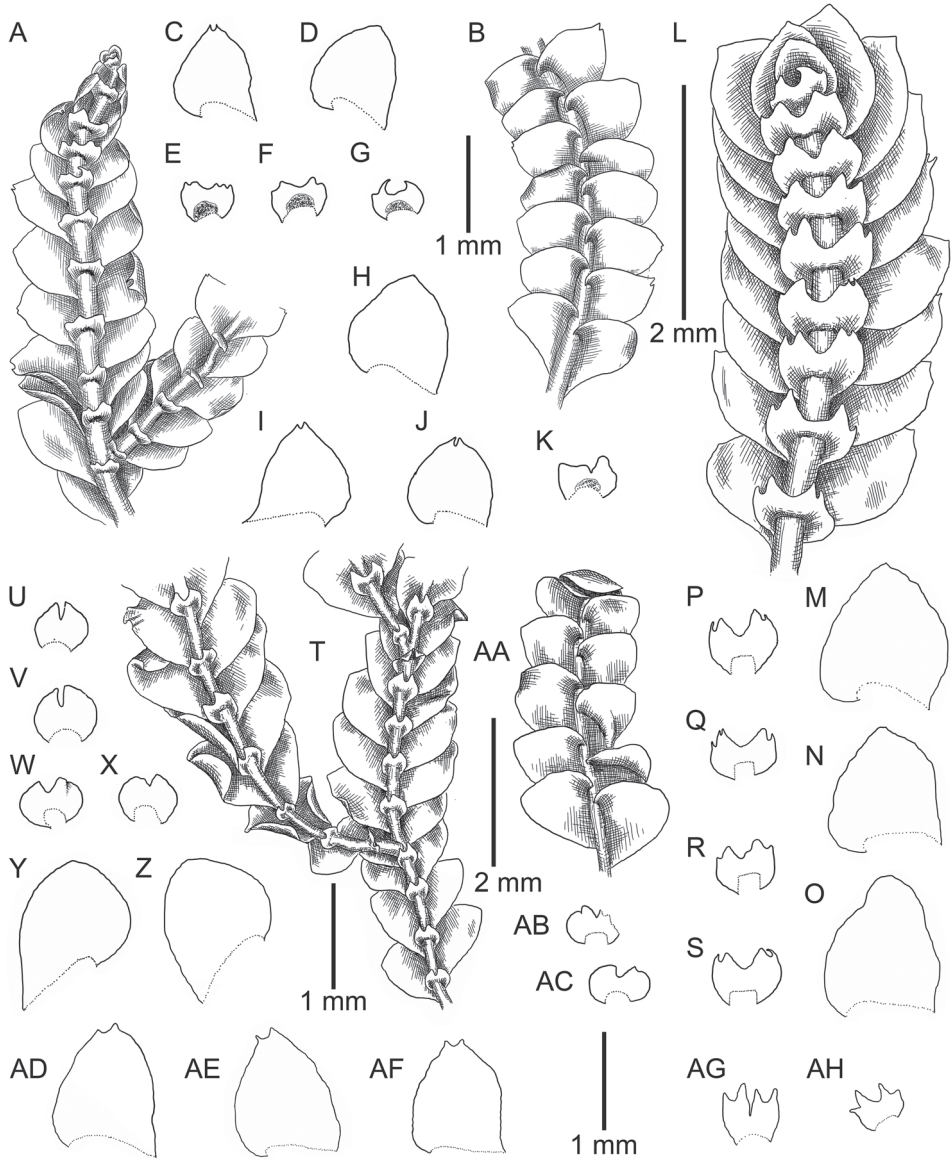


Figure 4. *Calyptogeia granulata* Inoue: **A** plant habit, fragment, ventral view **B** plant habit, fragment, dorsal view **C, D, H, I, J** leaves **E, F, G, K** underleaves *Calyptogeia lunata* Mitt.: **L** plant habit, fragment, ventral view **M, N, O** leaves **P, Q, R, S** underleaves *Calyptogeia marginella* Mitt.: **T** plant habit, fragment, ventral view **U, V, W, X, AB, AC** underleaves **Y, Z** leaves **AA** plant habit, fragment, dorsal view *Calyptogeia tosana* (Steph.) Steph. **AD, AE, AF** leaves **AG, AH** underleaves. **A–G** from Syntype G00114896; **L, P–S** from Long no 10664, JE **H–K** from 18004 TNS 174361; **M–O** from Syntype G00064229/5288; **T–Z** from Syntype G00113555/5289; **AA, AB, AC** from Syntype JE-04005904; **AD, AE, AF, AG, AH** from Lectotype G00047274/26013.

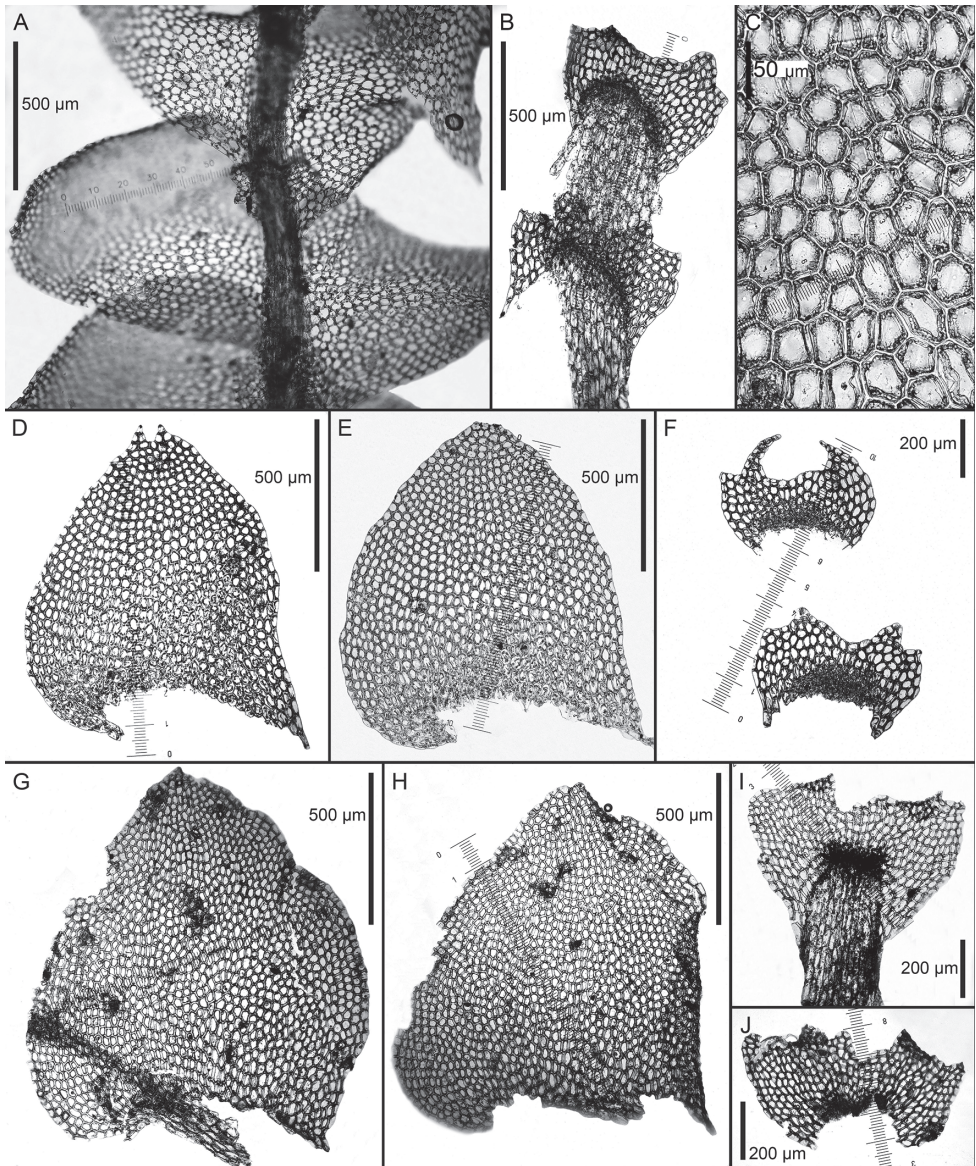


Figure 5. *Calypogeia granulata* Inoue: **A** plant habit, fragment, ventral view **B, F** underleaves **C** leaf middle cells **D, E** leaves *Calypogeia lunata* Mitt.: **G, H** leaves **I, J** underleaves. Scale bars: 500 µm (**A, B, D, E, G, H**); 200 µm (**F, I, J**); 50 µm (**C**). **A, B, C** from Holotype 18004 TNS 174361; **D, E, F** from Isotype G00114896; **G, H, I, J** Syntype G00064229/5288.

Calypogeia granulata was previously treated as a Japanese endemic taxon. Later, however, it was recorded (also confirmed by DNA testing) for northern Vietnam and Guizhou Province in China (Buczowska et al. 2018; Bakalin et al. 2018). Moreover, strong infraspecific genetic variation was observed within the taxon. It is worth mention-

ing that some Japanese populations are farther from the type that was also sequenced than the genetic distance between the type and the accessions from Guizhou and Vietnam (cf. Buczkowska et al. 2018). Two specimens named *C. granulata* from Japan (Buczkowska et al. 2018) are so well distanced from the bulk of other so-named specimens that they may be regarded as discrete subspecies (if not separate species!). The variation in oil body color was additionally observed in the species. The taxon was described as having blue-grayish oil bodies, but oil bodies are totally gray to grayish in Guizhou material. Whether these colors represent the stage preceding morphological deterioration or a real morphological peculiarity of geographically distanced populations is currently unknown.

Morphologically, the taxon is similar to *Calypogeia tosana* (due to bisbifid underleaves and acute, sometimes incised leaves), from which it differs in underleaves decurrent for 2/3–3/3 of stem width and oil bodies indicated even in the original label as grayish blue “with numerous granules” (= finely granulate).

The description based on type specimens is as follows: plants green, strongly glistening, translucent, 1.5–2.1 mm wide, 1–3 cm long; stem greenish, soft, 220–320 μm wide, sparsely ventrally branched; rhizoids sparse to common, in unclear loose fascicles, obliquely spreading, grayish; leaves contiguous to subimbricate (overlap 1/3 of above situated leaf), very obliquely to subhorizontally inserted, slightly convex, apical third turned to ventral side, not or shortly decurrent, when flattened — obliquely triangular-ovate, 900–1000 \times 900–1000 μm , very shortly incised or apex apiculate; underleaves obliquely spreading, decurrent for 1/3–2/3 of leaf length, commonly bisbifid, divided by U-shaped sinus, undivided area 2–3 cell high, 250–300 \times 550 μm , 1.1–1.6 as wide as stem; cells in the midleaf thin-walled, with vestigial trigones, 32.5–52.5 \times 30.0–37.5 μm , cuticle smooth.

***Calypogeia japonica* Steph., Sp. Hepat. (Steph.) 6: 448. 1924.**

Figures 6R–Z, AA–AF, 7J–L

= *Calypogeia ovifolia* Inoue Mem. Natl. Sci. Mus. (Tokyo) 16: 100. f. 1: 1–2, 2. 1983.

Type: JAPAN. Between Ashi-kosen and Mt. Torihana, Asahi Mts., Yamagata Pref., ~600 m, H. Inoue, no. 32885 (holotype TNS [TNS76048!]).

Type. JAPAN. “Japonia, Uematsu” (neotype by Furuki and Ota (2001): G [G00047413/9720!]).

Remarks. For a long time regarded as a Japanese endemic species, it was later reported from Fujian (Zhu et al. 2002, as *C. tsukushiensis* Amakawa) and Guizhou (Bakalin et al. 2015) provinces of China, the Korean Peninsula (Choi et al. 2011) and the southern Kurils (Bakalin et al. 2019c). The distinctive features of the species are biconcentric oil bodies in midleaf cells, deeply divided, not decurrent underleaves (similar to that in *C. neogaea* (R.M. Schust.) Bakalin) and rounded leaves (similar to that in *C. integristipula*). Dry plants may be likely mistaken for *C. muelleriana* with which, however, the distribution area may overlap in the southern Kurils only.

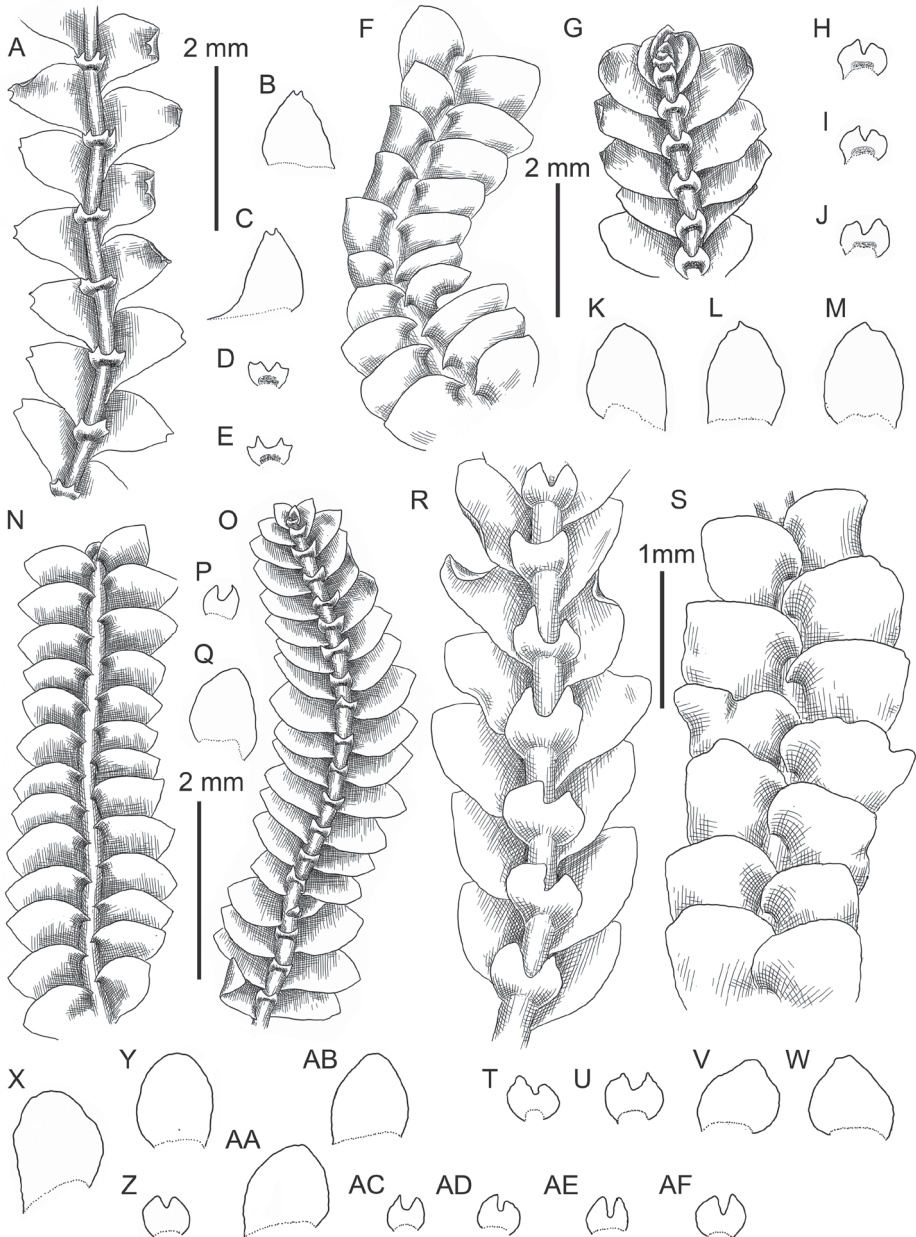


Figure 6. *Calypogeia goebelii* (Schiffn.) Steph.: **A** plant habit, fragment, ventral view **B, C** leaves **D, E** Underleaves *Calypogeia ceylanica* S.Hatt. et Mizut.: **F** plant habit, fragment, dorsal view **G** plant habit, fragment, ventral view **H, I, J** underleaves **K, L, M** leaves *Calypogeia cuspidata* (Steph.) Steph.: **N** plant habit, fragment, dorsal view **O** plant habit, fragment, ventral view **P** underleaf **Q** leaf *Calypogeia japonica* Steph. **R** plant habit, fragment, ventral view **S** plant habit, fragment, dorsal view **T, U, Z, AC, AD, AE, AF** underleaves **V, W, X, Y, AA, AB** leaves. **A–E** from Syntype G00115804; **F–M** isotype G00064248; **N–Q** lectotype G00069713; **R–W** from Neotype G00047413/9720; **X–Z, AE, AF** from G00047412/9717; **AA–AD** from holotype of *Calypogeia ovifolia* H. Inoue TNS76048.

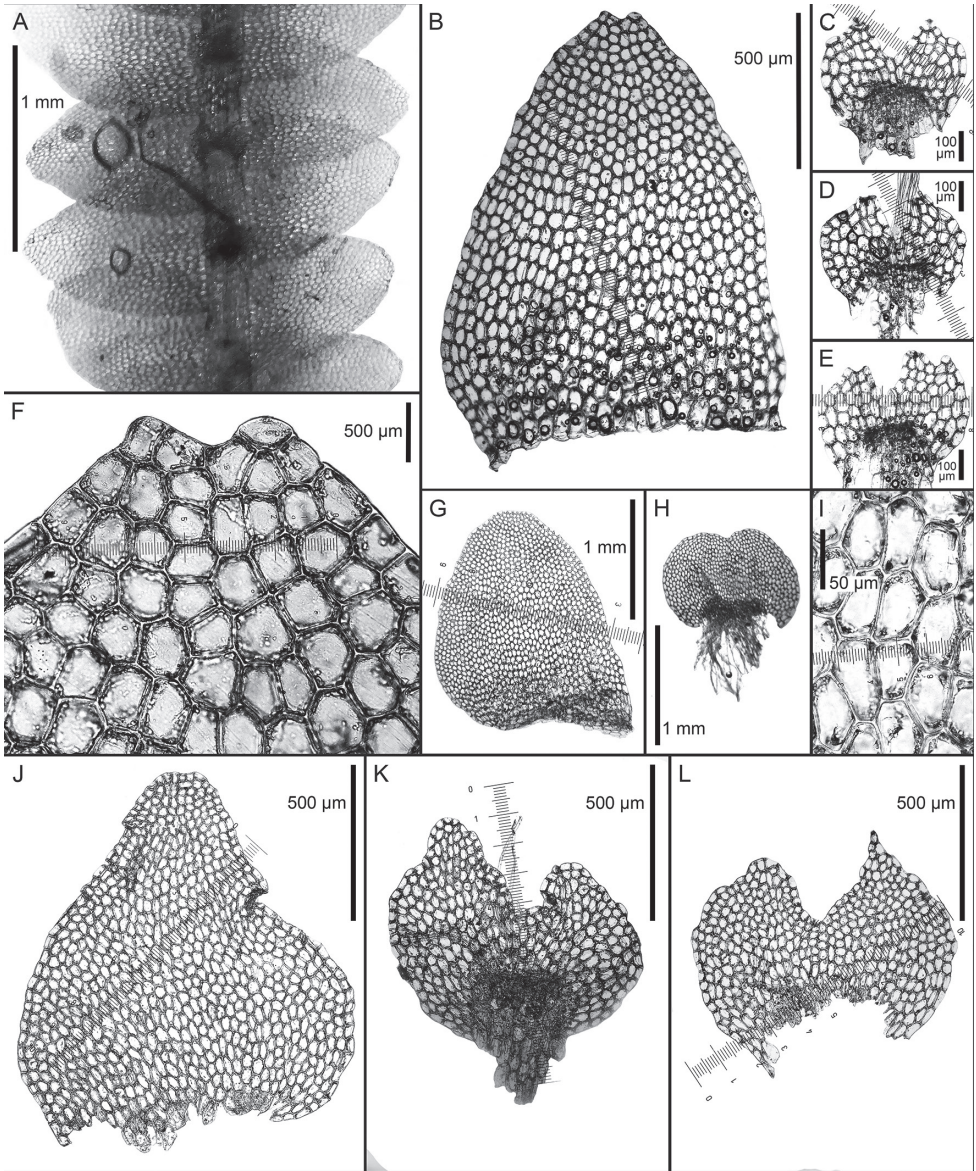


Figure 7. *Calypogeia cuspidata* (Steph.) Steph.: **A** plant habit, fragment, ventral view **B** leaf **C, D, E** underleaves **F** leaf apex cells *Calypogeia integristipula* Steph.: **G** leaf **H** underleaf **I** leaf middle cells *Calypogeia japonica* Steph. **J** leaf **K, L** underleaves. Scale bars: 1 mm (**A, G, H**); 500 µm (**B, F, J, L, K**); 100 µm (**C, D, E**); 50 µm (**I**). **A, B, C, D, E, F** from Lectotype of *C. hawaica* G00067698; **G, H, I** from Lectotype G00061108/26879; **J, K, L** Neotype G00047413/9720.

Calypogeia japonica was described by Stephani (1924) based on a specimen collected by U. Faurie. However, the collection in G contains the only specimen collected by Faurie (G00047412/9717!), which is from Quelpart Island (= Jeju-

do, Korea). Since Stephani sometimes treated Quelpart Island as part of mainland Japan (this was the reason for the geographic mistakes), this specimen might be regarded as a holotype. However, we agree with Furuki and Ota's (2001) neotypification since the neotype contains much better developed plants and is larger than the specimen from Korea, although the specimen from Japan (and two more, preserved in G) was collected by E. Uematsu, not by Faurie. Moreover, even Stephani annotated the specimen from Quelpart as 'spec. pessimum'; it would appear strange to regard this as of this type since other specimens in his herbarium provide more copious material.

The description based on the neotype is as follows: plants 1.8–2.0 mm wide, yellowish brownish, merely soft, loosely translucent; stem 220–280 μm wide, sparsely ventrally branched rhizoids common, but not numerous, in loose, obliquely to erect spreading fascicles or separated; leaves obliquely inserted and oriented, slightly concave-canaliculate, contiguous, to slightly overlapping above situated leaves, somewhat loosely crispate along margin, widely ovate-triangular, apex obtuse to narrowly rounded, 1000–1130 \times 1000–1250 μm ; underleaves obliquely spreading, decurrent for 1/3–2/3 of stem width, divided by V- to U-shaped sinus into two lobes without additional lateral teeth, undivided zone 4–6 cells high, 2.5–3.0 as wide as stem; midleaf cells 25–55 \times 25–35 μm , thin-walled, trigones small to very small, cuticle smooth.

***Calypogeia lunata* Mitt., J. Proc. Linn. Soc., Bot. 5 (18): 107. 1860 [1861].**

Figures 4L–S, 5G–J

Type. INDIA. Assam: Griffith (syntype: G [G00064229/5288!]).

Remarks. This is a broadly Sino-Himalayan endemic species that seems locally abundant in the eastern Sino-Himalaya. Mitten (1860) described *Calypogeia lunata* from Assam; later, Singh and Nath (2007a) recorded it from the East Khasi Hills and West Khasi Hills in India. Aside from India, the species was reported from eastern Nepal, Bhutan, Thailand and Yunnan Province in China (Mizutani 1979; Lai et al. 2008; Kitagawa 1988; Hattori 1975, Piippo 1990; Piippo et al. 1998; Long and Grolle 1990). The origin of the report of the species for Yunnan is unclear. Piippo (1990) mentioned *C. lunata* for Yunnan with reference to Grolle (1966), who does not, however, provide label data for this species in Yunnan, although it is also indicated in the review of the general distribution.

The description based on the isotype is as follows: plants brownish to blackish brownish in the herbarium, translucent, glistening, 1.5–2.2 mm width; stem 120–220 μm wide, branching not seen; rhizoids sparse to common in brownish grayish, erect to obliquely spreading loose fascicles; leaves overlapping \sim 1/4–1/3 of next leaf basal part, slightly convex, with apices somewhat turned to ventral side, obliquely inserted and oriented, ventrally clearly decurrent to 1.0 of stem width or less, widely tri-

angular-ovate, apex acute to obtuse (very rarely bilobed), 850–1200 × 770–1200 μm, margin entire to somewhat crispate; underleaves decurrent for (0.3–)0.5–1.0 of stem width, 1.5–3.5 as wide as stem, bisbifid or with each main lobe divided into three small lobes, or bisbifid with additional lateral tooth on each side; midleaf cells thin-walled, trigones vestigial, cuticle smooth, 30–38 × 20–33 μm (the cell measurements may be incorrect because of collapsed leaf cells).

The species is most morphologically similar to *Calypogeia goebelii* (Kitagawa 1988), from which, however, it differs in underleaf width and shape, long decurrency of underleaves, rarely shortly bifid leaves (versus underleaves commonly less than 2 times as wide as stem and leaves deeply incised). In contrast to mainly Malesian-Papuan *C. goebelii*, *C. lunata* is characterized by an eastern Sino-Himalayan distribution, where *C. goebelii* can hardly be expected. We hypothesize that the reports of *C. goebelii* from Thailand (Kitagawa 1988 and subsequent mentions based on this) represent the ill-developed modification (probably from dry habitats) of *C. lunata*. On the other hand, *C. lunata* seems to be very closely morphologically related to *C. latissima* (Philippines, see below), from which, however, it differs in its completely smooth cuticle and very rarely (as exclusion) bidentate leaves.

One more observation should be made on the type specimen identification. The specimen in JE marked as the possible type (JE-H2316 = JE04005930!) is actually not the type. The label means that the specimen was collected in “Khasia, Churra”, not in Upper Assam, as in the original description by Mitten (1860). The plants in the Jena ‘type’ are different from the typical *C. lunata* and rather resemble *C. tosana* or *C. goebelii*, although they differ from both in thickened leaf cell walls in dorsal half of leaves (especially in the external wall), V-shaped leaf sinus and 3–5 cells high undivided portion of underleaf. We speculate that the specimen may belong to an undescribed taxon, but we refrain from describing it here until fresh material suitable for DNA and oil body characteristics is obtained.

***Calypogeia sinensis* Bakalin & Buczk. PLoS ONE 13(10): e0204561 [13]. 2018.**

Type. CHINA. Guizhou Province: Duyun Municipality (26°22.383'N, 107°21.35'E), 1300 m alt., 22 Nov 2013, V.A. Bakalin China-56-77-13 (holotype: VBGI!; isotype: POZW!).

Remarks. The species was described in Guizhou Province, China, and confirmed in northern Vietnam (Buczkowska et al. 2018) but seems hardly restricted by known localities and is likely much more widely distributed. We (Buczkowska et al. 2018) expected its occurrence in the Meta-Himalaya, as well as in Hengduan, which is the area of occurrence of several Sino-Himalayan species of the group to which the present taxon should belong. Some of the records of *Calypogeia azurea* probably belong to this taxon (see doubtful records). The description and illustrations of the taxon were published recently, and no additional information seems required here.

***Calypogeia tosana* (Steph.) Steph., Bull. Herb. Boissier (sér. 2) 8 (9): 678 (410). 1908.**

Figures 4AD–AH, 8F–I

= *Calypogeia granditexta* Steph. Species Hepaticarum 6: 448. 1924. Syn. nov. Type: Japan “Sendai” Uematsu 23 November 1907 (LECTOTYPE (designated here): G G00283130!; another syntype, G00283028!, contains rather typical *C. orientalis*).

Basionym. *Kantius tosanus* Steph., Hedwigia 34 (2): 54, 1895.

Type. JAPAN: Tosa Makino (LECTOTYPE (designated here): G [G00047274/26013, packet b]) The holotype should be in ‘herb. Polytechnicum Zurich’, but such specimen is absent in Zurich herbaria (<https://www.herbarien.uzh.ch/en/belegsuche.html>), therefore we were obliged to lectotypify the species by the specimen from G).

Remarks. This is a widely amphi-Pacific East Asian species whose area stretches from the southern Kurils and East Manchurian mountains in Russia via the Korean Peninsula and Japanese Archipelago to southeastern China, namely, Taiwan (Wang et al. 2011), Guangxi (Zhu and So 2003), Hong Kong (Zhang and Lin 1997), Anhui, Jiangsu, Guangdong, Hainan (Piippo 1990), and Guizhou (Bakalin et al. 2015; Buczkowska et al. 2018) and southward to northern Vietnam (Shu et al. 2017; Bakalin et al. 2018). This is one of the most common species in amphi-Pacific East Asia; however, it hardly penetrates into the Asian mainland. Admittedly, this species is quite morphologically polymorphous, although its polymorphism has probably been somewhat overestimated. Iwatsuki (2001) provides the key to *Calypogeia* in Japan, where the ‘races’(?) with both verruculose cuticle and smooth cuticle are identified as the single *C. tosana*. We hypothesize that these two ‘races’ may represent two different species. The type of *C. tosana* is characterized by a smooth leaf cuticle; this feature, although not mentioned in the original description under *Kantius tosanus* (Stephani 1895), was provided later when a new combination under *Calypogeia* was created (Stephani 1908). The concept of *C. tosana* is here accepted in the narrow sense closely following the type.

There is a problem with the type of plants in the type specimen due to mixture within. The type specimen (Makino 25, G), as correctly noted by T. Furuki *in litt.*, contains two intermixed species, with one belonging to true *C. tosana* (coinciding with the original description, packet b) and the other probably belonging to an undescribed taxon. We prefer not to describe this taxon here (it is also beyond the scope of the present account) since the re-collection of fresh material and the study of the ‘intravital’ character of the taxon (oil body characteristics) and DNA sequences should provide a much better understanding of the taxonomic position of the taxon than the study of poorly preserved sterile and old material in Stephani’s herbarium.

The brief description based on the plants belonging to *Calypogeia tosana* is as follows: plants translucent, glistening, brownish; leaves very shortly bilobed by U-shaped sinus; underleaves uniformly bisbifid (both small and larger) with undivided portion 1–3 cells high, cells in the midleaf thin-walled with small and concave trigones, 30–50 × 22–45 µm and smooth cuticle.

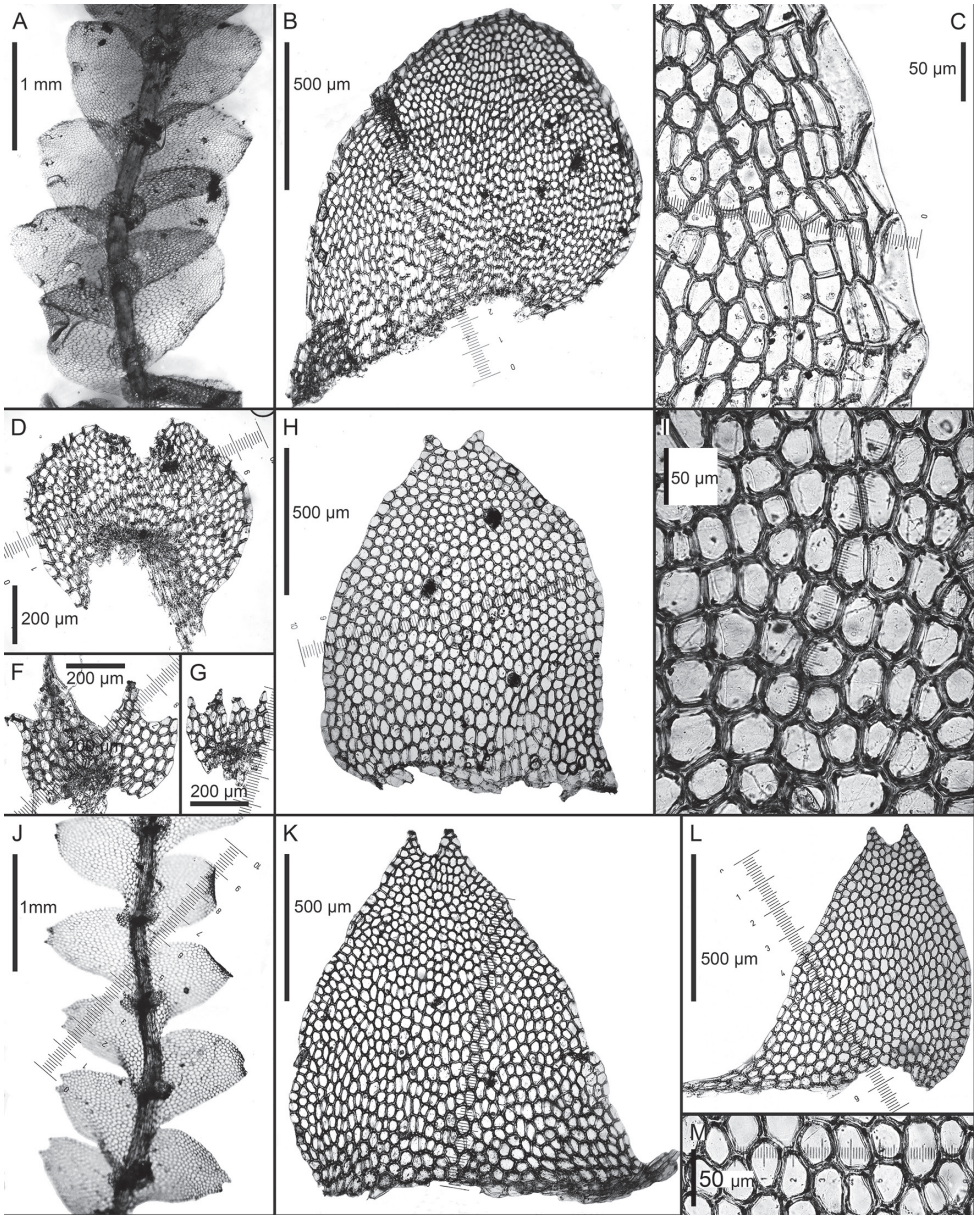


Figure 8. *Calypogeia marginella* Mitt.: **A** plant habit, fragment, ventral view **B** leaf **C** leaf margin cells **D** underleaf *Calypogeia tozana* (Steph.) Steph.: **F**, **G** underleaves **H** leaf **I** leaf middle cells *Calypogeia goebelii* (Schiffn.) Steph. **J** plant habit, fragment, ventral view **K**, **L** leaf **M** leaf middle cells Scale: 1 mm (**A**, **J**); 500 µm (**B**, **H**, **K**, **L**); 200 µm (**D**, **F**, **G**); 50 µm (**C**, **I**, **M**). **A**, **B**, **C**, **D** from Syntype G00113555/5289; **F**, **G**, **H**, **I** from Holotype G00047274/26013; **J**, **K**, **L**, **M** Syntype G00115804.

The plants in *Calypogeia granditexta* in G00283130 (lectotype) are very similar in their relatively narrow, shortly decurrent, uniformly bisbifid underleaves, shortly bifid leaves and smooth cuticle to *C. tozana*, and no differences of the species rank

were found. Before (Inoue 1974) *C. granditexta* was regarded as the synonym of *C. angusta*, from which, however, differs in incised (versus rounded) leaves and deeply bisbifid (versus bifid, although sometimes with additional lateral teeth in each side) underleaves. *Calypogeia granditexta* var. *anisophylla* S. Hatt *Journal of Japanese Botany* 20: 262. f. 45. isotype (Japan, “Fukushima County, Oze”, 1500 m a.s.l. 7 July 1941 S. Hattori, 451 (G00112334!)) contains fairly typical *Calypogeia integristipula* Steph. and has nothing to do with *Calypogeia tosana*. The holotype of var. *anisophylla* was not studied physically, although the photographs provided at TNS herbarium site (<http://www.type.kahaku.go.jp/TypeDB/bryophyta/41>) correspond well to *C. tosana*, but not to *C. angusta*, neither to *C. integristipula*.

***Calypogeia vietnamica* Bakalin et Vilnet *Herzogia* 32 (1): 225. 2019.**

Type. VIETNAM. Lao Cai Province: SaPa District, San Sa Ho Commune, Hoang Lien Range, Phan Xi Pang Peak area, *Rhododendron*-dominated forest with bamboo thickets and many rocky outcrops, moist cliffs in partial shade (22°18.45'N, 103°46.567'E), 2900 m alt., 20 April 2017, V.A. Bakalin & K.G. Klimova V-9-23-17 (holotype: VBGII!).

Remarks. This taxon was recently described in moist rocky outcrops at the highest elevation in Indochina – Phan Xi Pang Mt. – in the somewhat unique formation of a ‘mossy’ *Rhododendron* forest resembling mossy forests occurring in humid tropics, although different from the latter florogenetically (cf. Bakalin et al. 2019b). The species is characterized by blue oil bodies and noticeably large underleaves (only slightly smaller than the leaves) divided by a U-shaped sinus descending to 2/5–1/2 of underleaf length. The species may be expected in other areas of mountainous Indochina, if not spread more widely to the eastern Sino-Himalaya. The description and illustrations were published very recently, and it seems that no more information should be added here.

Doubtful records

***Calypogeia azurea* Stotler et Crotz, *Taxon* 32 (1): 74. 1983.**

Type. Not seen.

Remarks. There are several records of this taxon in East and Southeast Asia. Singh and Nath (2007a) recorded it for the East Khasi Hills; Shu et al. (2017) reported it for northern Vietnam; Wang et al. (2011) mentioned it for Taiwan based on two records of ‘*Calypogeia trichomanis*’. Zhu and So (2003) recorded taxon for Guangxi Province. As shown by Buczkowska et al. (2018), the traditionally named *C. azurea* should be subdivided into at least three main lineages: ‘true’ *C. azurea* in Europe, a North American semicryptic and still validly not described taxon, and the taxon morphologically similar to European *C. azurea* but distributed in East Asia that was described as *C. orientalis* in l.c. Geography-correlated infraspecific variability was also observed within *C. orientalis*;

two subspecies may be maintained, both of which are distributed in temperate zone, with one restricted to continental mainland (Korean Peninsula, Russian Manchuria) and the other occurring in Japan. The occurrence of *C. orientalis* was not confirmed in China, although it is highly probable in the northeastern part of the country. Due to data in hand, *C. orientalis* is only known from Russian Manchuria, Sakhalin and Kuril Islands, Japan and the Korean Peninsula, being most common between 35 and 45°N (in cool temperate to hemiboreal zones). Thus, some records of *Calypogeia azurea* in Northeast China may actually belong to *C. orientalis*, but specimens from the Sino-Himalaya could hardly belong to this species. Another recently described taxon, *C. sinensis*, with exceedingly deep blue oil bodies (described based on material from northern Vietnam and Guizhou Province in China, where both specimens were preliminarily named *C. azurea*) may be the taxon previously misidentified as *C. azurea* in the aforementioned works. Bapna and Kachroo (2000) reported occurrences of *C. trichomanis* in Darjeeling and Nepal; what these reports mean is difficult to say, but some of them probably also belong to *C. sinensis*.

***Calypogeia fissa* (L.) Raddi, Jungermanniogr. Etrusca: 33. 1818.**

Basionym. *Mnium fissum* L., Sp. Pl. 1: 1114. 1753. nom. conserv. Original material: GREAT BRITAIN, Surrey, Dorking; not seen.

Remarks. *Calypogeia fissa* is one of the oldest names in *Calypogeia*, and several taxa were split from the original *C. fissa* s.l. The species seems to be restricted to Europe. Within North America and the northwestern amphi-Pacific (Commanders, Kamchatka, Kurils, Sakhalin), *C. fissa* is substituted by *C. neogaea* (R.M. Schust.) Bakalin. Stotler and Crandall-Stotler (2017: 591) noted that *C. fissa* “likely does not occur in North America and specimens identified as such likely belong to *C. neogaea*”. In an older time, *C. fissa* was recorded in Japan, although it was doubted as early as Hattori (1952) and then was never mentioned for the Japanese flora. The nearest morphological ally of *C. fissa* in temperate East Asia is *C. tosana*.

Nevertheless, *Calypogeia fissa* was several times recorded even at a relatively recent time for the East Asian mainland: Singh and Nath (2007a) recorded it for the East Khasi Hills and West Khasi Hills as well as (presumably based on other literature records, unfortunately not cited in l.c.) for Sikkim and Darjeeling. Bapna and Kachroo (2000) described its wide distribution in India. Wang et al. (2011) mentioned it for Taiwan; Fang et al. (1998), for Jiangxi. The records of the species for Yunnan and Hunan are based on Nicholson et al. (1930). Presumably, the vast majority of records of *C. fissa* may be based on misidentifications of *C. tosana* (if so, the latter is much more widely distributed on the Asian mainland than would be obvious if only available publications were taken into account). We hypothesize that ‘true’ *Calypogeia fissa* should be restricted to Europe from where the only accessions were confirmed by Buczkowska et al. (2018), and that the species should be excluded from the Sino-Himalayan *Calypogeia* flora. Moreover, even in Europe, *Calypogeia fissa* is represented by two genetically well-separated taxa (Buczkowska et al. 2011) that probably require taxonomic revision.

***Calypogeia goebelii* (Schiffn.) Steph., Bull. Herb. Boissier (sér. 2) 8 (9): 677 (409). 1908.**

Figures 6A–E, 8J–M

Basionym. *Kantius goebelii* Schiffn., Nova Acta Acad. Caes. Leop.-Carol. German. Nat. Cur. 60 (2): 260. 1893.

Type. Java. K. Goebel (syntype: G [G00115804!]).

Remarks. The species was described from Java based on K. Goebel specimen (Schiffner 1893) and is mostly Malesian-Papuan in distribution, probably reaching westward to northern Thailand (if the report by Kitagawa 1988 is correct) and spreading eastward to Samoa. We did not see the specimens of this species from northern Indochina. However, *Calypogeia lunata* is quite abundant, morphologically malleable and provides some modifications superficially resembling *C. goebelii* in northern Vietnam, although never having such distinctly lobed leaves as occur in ‘true’ *C. goebelii*, nor narrow underleaves (1.5–2.0 as wide as the stem, as commonly occurs in *C. goebelii*). Moreover, Kitagawa (1988) did not observe blue oil bodies in his specimens, and he provides a yellowish color for the plants, whereas the plants that have blue oil bodies commonly develop greenish-whitish to grayish pigmentation in the herbarium. Thus, it is an open question whether the specimens named *C. goebelii* by Kitagawa truly even belong to the blue-oil-bodied *Calypogeia* complex. The type of *C. goebelii* is actually similar to that of *C. tosana* in general outlook, and the differentiation from the latter in the absence of oil bodies is quite troublesome. Therefore, we are unable to confirm or reject this species from the northern Indochinese flora, although we doubt it.

The description based on the isotype is as follows: plants brownish, pellucid, glistening, 1.5–2.5 mm wide, 5–8 cm long; stem 150–200 μm wide, sparsely ventrally branched; rhizoids brownish, common to numerous, obliquely to erect spreading fascicles; leaves contiguous to somewhat distant, slightly convex, decurrent for 1–2 stem widths, 750–1250 \times 575–1050 μm , divided by U-shaped sinus into two acute lobes; underleaves, obliquely spreading, 1.5–2.5 as wide as stem, bisbifid, the undivided portion in the underleaf middle 2 cells high, arcuately inserted, not or barely decurrent; midleaf cells thin-walled, trigones very small, concave, 37.5–55.0 \times 25.0–37.5 μm .

***Calypogeia muelleriana* (Schiffn.) Müll.Frib., Beih. Bot. Centralbl. 10 (4/5): 217. 1901.**

Basionym. *Kantius muellerianus* Schiffn., Sitzungsber. deutsch. naturwiss.-med. Vereins Böhmen “Lotos” Prag 48: 342. 1900.

Original material. CZECH REPUBLIC, Bohemia, Schiffner; not seen.

Remarks. This boreal species was originally described from the border between the Czech Republic and German Bavaria (Bohemian Forest) and was found to have circumpolar distribution in the hemiarctic and boreal zones of the Northern Hemisphere. However, even in the hemiboreal zone of East Asia (e.g., in the southern Russian Far

East at 43–48°N), the species rarely occurs. *Calypogeia muelleriana* seems to be hardly possible even in Northeast China, as mentioned by Piippo (1990). Two recent reports from Guangxi and Jiangxi Provinces of China (Zhu and So 2003; Fang et al. 1998) may belong to other taxa, such as *C. apiculata*, *C. sinensis*, and *C. granulata*, whose distribution in the Sino-Himalaya is underestimated. The distinct differentiation features of *C. muelleriana* are highly undivided underleaf lamina (4–5 and more cells high), rounded to rarely obtuse leaf apices and grayish to colorless botryoidal oil bodies. The European materials of *Calypogeia muelleriana* are split into two different and perhaps cryptic taxa (Buczowska 2010, Buczowska and Bączkiewicz 2011).

***Calypogeia neesiana* (C. Massal. et Carestia) Müll.Frib., Verh. Bot. Vereins Prov. Brandenburg 47: 320. 1905.**

Basionym. *Kantius trichomanis* var. *neesianus* C. Massal. et Carestia, Nuovo Giorn. Bot. Ital. 12 (4): 351. 1880.

Original material. ITALIA, Rive Valsesia; not seen.

Remarks. The species was described from the Italian Alps (Massalongo and Carestia 1880) and later found as a sub-circumpolar (distinctly more common in amphi-oceanic areas) boreal and mainly montane species. The area of the taxon largely overlaps that of *C. integristipula*, although *C. neesiana* seems to be much rarer than the former, more inclined to inhabit decaying wood and slightly more southern in distribution (reaching to Japan and the Korean Peninsula; in both these sites, it is represented by *Calypogeia neesiana* subsp. *subalpina* (Inoue) Inoue). The species likely occurs in Northeast China; however, it has not been recorded there. The reports of the species from the southern half of China (Anhui, Jiangxi, Taiwan, and Yunnan, cf. Wang et al. 2011, Piippo et al. 1997, Fang et al. 1998; Piippo 1990) are at least partly based on *Calypogeia cordistipula* (synonymized with *C. neesiana* by Piippo et al. 1997) – another taxon accepted here with species status. Therefore, we doubt the occurrence of this species in the Sino-Himalaya and expect at least some of these records to be referred to *C. cordistipula*.

***Calypogeia sphagnicola* (Arnell et J.Perss.) Warnst. et Loeske, Verh. Bot. Vereins Prov. Brandenburg 47: 320. 1905.**

Basionym. *Kantius sphagnicola* Arnell et J.Perss., Rev. Bryol. 29 (2): 26. 1902.

Original material. SWEDEN, Dalarne; not seen.

Remarks. Buczowska et al. (2012a, 2012b) showed that *Calypogeia sphagnicola* is a complex of distanced taxa (at least three species should be recognized), where additional study is required to name all revealed entities. To date, this problem has not been resolved, and it is unclear what taxon is recorded for Guangxi Province in China (Zhu and So 2003). Within China, this species is also recorded for Jilin (Piippo 1990), but the specimen may belong to another species.

***Calypogeia trichomanis* (L.) Corda Naturalientausch 12 [Opiz, Beitr. Naturgesch.]: 653. 1829. Rejected name, Art. 56, Szechzen Code**

Remarks. There are several records of this rejected name. *Calypogeia trichomanis* was treated very broadly in former times. Mitten (1860) reported it from the Sikkim and Khasia Mountains, and Noguchi et al. (1966) recorded it for eastern Nepal. Piippo (1990) indicated it for Jilin, Anhui and Taiwan in China. Bapna and Kachroo (2000) reported several occurrences in India. In Europe, this species was sometimes estimated as the current *Calypogeia azurea* taxon, which is not present in East Asia (Buczowska et al. 2018). The understanding of “*C. trichomanis*” in East Asia is additionally complicated by synonymization of other names with ‘*C. trichomanis*’; e.g., Hattori (1952) synonymized *C. angusta* under *C. trichomanis* and created additional confusion.

Taxa that are not recorded but may be expected

***Calypogeia asakawana* S. Hatt. ex Inoue, J. Jap. Bot. 39 (4): 107. 1964.**

Figure 9A–D

= *Calypogeia okamurana* Steph. ex Bonner, Index Hepaticarum 3: 501, 1963 (nom. inval., Art. 38.1(a), no description). Authentic material: Japan. Iyo: Tokonabe Mt., 30 March 1913, S. Okamura no. 383 (original material, probably scheduled as the type: G [G00067726!], the specimen in all ways is similar to *C. asakawana*).

Type. JAPAN. Tokyo: Asakawa Experimental forest, 12 June 1954, U. Mizushima, no. 5 (holotype: TNS [TNS-174359!]; isotype NICH [NICH-55582!]).

Remarks. The species is regarded as Japanese endemic (known in Honshu only, cf. Yamada and Iwatsuki 2006) and is characterized morphologically by small, deeply divided, bifid and spreading underleaves (slightly wider than stem) and rounded leaf apices.

The description based on the holotype is as follows: plants pale brownish in herbarium, prostrate, translucent, slightly glistening, 1.1–1.5 mm wide and 8–20 mm long, forming loose mats; rhizoids rather numerous, originating as several unclear fascicles near underleaf bases and obliquely to erect spreading, attaching plants to the substratum; stem brownish (in the herbarium), 100–160 µm in diameter, branching not seen; leaves subhorizontally inserted, dorsally insertion line subtransverse to loosely arcuate, ventrally decurrent for 1/2–2/3 of stem width, obliquely lingulate, to obliquely ovate-lingulate, slightly convex to planar, slightly undulate along margin, laterally spreading, 650–700 × 400–550 µm, leaf apex rounded; underleaves loosely sinuately to transversely inserted, shortly decurrent (up 1/3 of stem width), 120–170 × 200–220 µm, bilobed by U-shaped sinus descending to 2/3 of leaf length, undivided zone 1–2 cells, lobes in the base 3–5 cells wide, midleaf cells

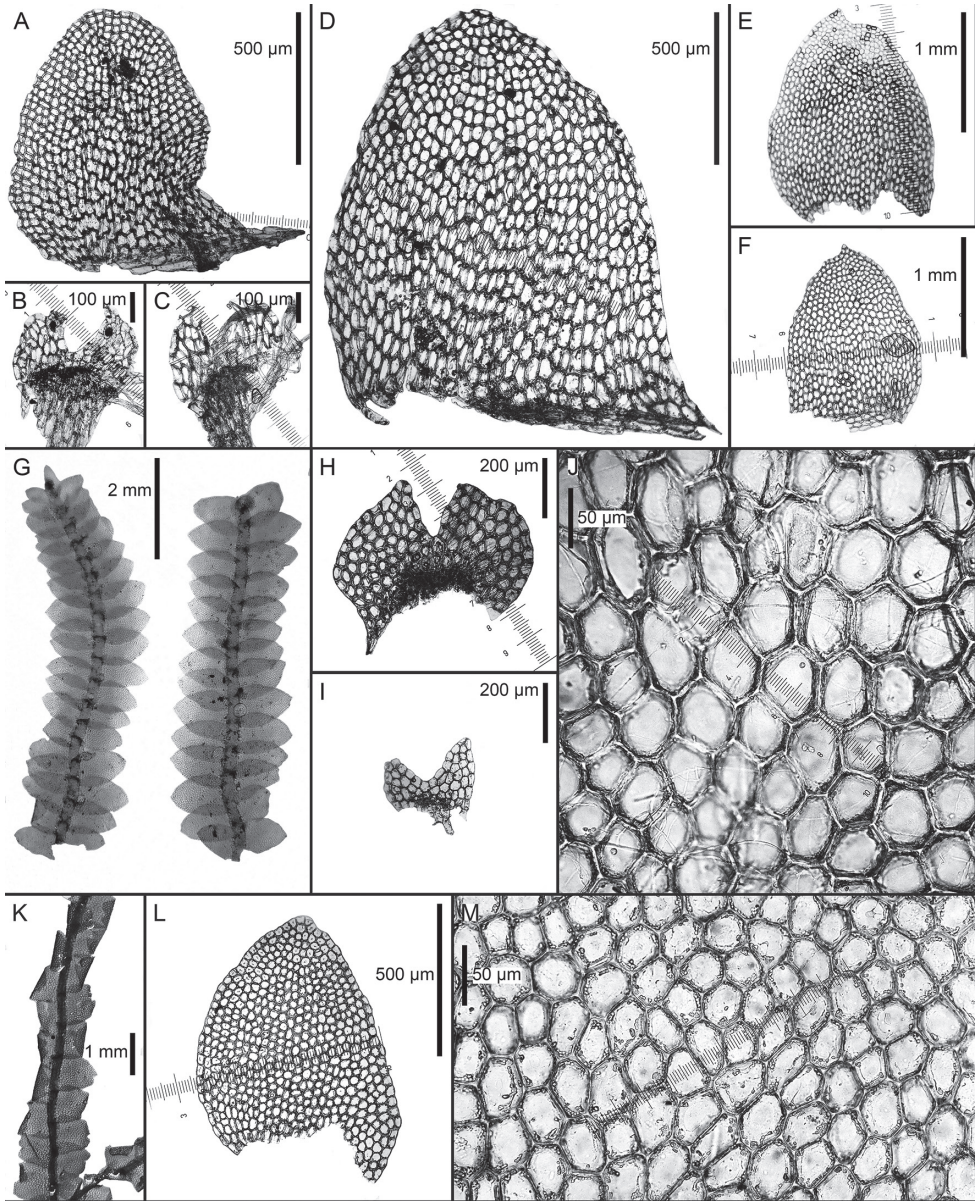


Figure 9. *Calypogeia asakawana* S.Hatt. ex Inoue: **A** plant habit, fragment, ventral view **B, C** underleaves **D** Leaf *Calypogeia ceylanica* S.Hatt. et Mizut.: **E, F** leaves **H** underleaf **J** leaf middle cells *Calypogeia cuspidata* (Steph.) Steph. **G** plant habit, fragment, ventral view **I** underleaf **L** leaf **M** leaf middle cells *Calypogeia decurrens* (Steph.) Steph.: **K** plant habit, fragment, ventral view. Scale bars: 2 mm (**G**); 1 mm (**E, F, K**); 500 µm (**A, D, L**); 200 µm (**H, I**); 100 µm (**B, C**); 50 µm (**J, M**). **A** from Holotype TNS-174359; **B, C, D** from authentic material of *C. okamurana* Steph. nom. herb., G00067726; **E, F, H, J** Isotype G00064248, **G, I, L, M** from Lectotype G00069713; **K** from Isotype G00060745.

oblong, thin-walled, $32\text{--}62 \times 20\text{--}33 \mu\text{m}$, trigones vestigial, cuticle virtually smooth; cells along leaf margin subquadrate to oblong, $20\text{--}38 \mu\text{m}$, thin-walled, with very small concave trigones, cuticle smooth.

***Calypogeia ceylanica* S. Hatt. et Mizut., *Candollea* 23: 288. 1968.**

Figures 6F–M, 9E–J

Type. SRI LANKA. Central Province: Nuwara-Eliya, 1950 m a.s.l., 24–27 February 1954, F. Schmid 10334 (isotype: G [G00064248!]).

Remarks. *Calypogeia ceylanica* is known as a taxon restricted to Ceylon (Sri Lanka) and was never recorded for the Sino-Himalaya, although it may be expected in Sikkim, Assam, or even farther. Moreover, some reports of *C. muelleriana* may actually be based on *C. ceylanica*. *Calypogeia ceylanica* differs from *C. muelleriana* in more deeply divided and narrower underleaves and apiculate to shortly bidentate leaf apices (a feature that very rarely occurs in *C. muelleriana*).

The description based on isotype plants is as follows: plants yellowish brownish in herbarium, glistening, translucent, 2.2–3.5 mm wide 3–5 cm long; stem $370\text{--}450 \mu\text{m}$ wide, branching not seen; rhizoids in loose colorless to brownish fascicles, sparse to numerous; leaves obliquely inserted, slightly concave or convex, somewhat turned to ventral side, not or barely decurrent ventrally, obliquely ovate, well developed $560\text{--}670 \times 450\text{--}550 \mu\text{m}$, apex acute to (rarely) unclear and very shortly bidentate; underleaves obliquely spreading, 1.1–1.3 as wide as stem, decurrent for $\frac{1}{4}\text{--}\frac{1}{3}$ of stem width, divided by V- to U-shaped sinus into two lobes, lateral teeth absent or present and unclear, undivided portion 2–3 cells high; midleaf cells thin-walled, trigones very small to vestigial, $35\text{--}80 \times 35\text{--}58 \mu\text{m}$, cuticle smooth.

***Calypogeia cuspidata* (Steph.) Steph., *Bull. Herb. Boissier* (sér. 2) 8 (9): 669 (401). 1908.**

Figures 6N–Q, 7A–F, 9G–M

= *Calypogeia confertifolia* Steph. *Species Hepaticarum* 6: 447. 1924. Type: HAWAII. 330 m a.s.l. (1000 ft. on the label) (Lectotype (designated here): G [G00067701!] there is no other known authentic materials for this taxon in G).

= *Calypogeia hawaica* Steph. *Bull. Herb. Boissier*, sér. 2, 8(9): 663. 1908. Type: HAWAII, Baldwin (Lectotype, designated here: G [G00067698]). The cited specimen should be selected as the lectotype (there are several specimens in the sheet, all collected by Baldwin in Hawaii) because this specimen label bears only measurements handwritten by Stephani. G00282642 contains plants similar to *C. tosana* (as also annotated by H. Miller) with constantly bifid leaves and bisbifid underleaves. G00282641 is the same as G00282642. G00282640 is the transi-

tional variant between G00282642 and the lectotype. G00282598 is the same as G00282640.

Basionym. *Kantius cuspidatus* Steph., Bull. Herb. Boissier 5 (10): 846. 1897.

Type. Hawaii, Heller 2308 (LECTOTYPE (designated here): G [G00069713!]; there are no other known authentic materials for this taxon in G).

Remarks. The species was described from Hawaii and is somewhat morphologically similar to Indochinese-Malesian *C. apiculata*, especially in comparatively small and only shortly decurrent underleaves. It is questionable whether the species may occur in the Sino-Himalaya and Meta-Himalaya, although similar forms, regarded by us as the only forms of *C. apiculata*, were observed in Vietnam. The description from the lectotype of *C. cuspidata* is as follows: plants greenish to brownish greenish, 1.5–2.3 mm wide 2–4 cm long; stem 180–210 μm wide; rhizoids virtually absent or in erect spreading fascicles, rarely occur; leaves contiguous to overlapping for 2/5 of leaf width in the basal part, loosely concave-canaliculate, obliquely ovate, not decurrent, well developed 700–1100 \times 550–900 μm , merely acute to obtuse, rarely narrowly rounded; underleaves 1.1–1.4 as wide as stem, arcuately inserted, not or for 1/4 of stem width decurrent, divided by U-shaped sinus, undivided portion 2(–3) cells high, lateral teeth absent; midleaf cells thin-walled, trigones very small, concave, 35–53 \times 30–40 μm ; cuticle smooth.

Calypogeia cuspidata differs from *C. apiculata* in not or shortly decurrent underleaves, more densely inserted leaves, wider underleaves with longer lobes, divided by U-shaped sinus and smooth leaf cuticle.

The status of *Calypogeia confertifolia*, synonymized with *C. cuspidata* (Miller et al. 1983, also <https://bryophyteportal.org/frullania/taxa/index.php?tid=164252#>), is questionable. The description from the lectotype of *C. confertifolia* is as follows: plants greenish brownish, slightly glistening, barely translucent, 1250–2200 μm wide; stem 250–300 μm wide; rhizoids sparse to numerous, in brownish, obliquely to erect spreading fascicles; leaves subimbricate (overlapping to 1/2 of the next leaf), convex, obliquely inserted and oriented, apical thirds turned to ventral side, not or barely decurrent, obliquely ovate to subrotundate, apex acute to obtuse or rounded, well-developed 800–1000 \times 800–1000 μm ; underleaves appressed to the stem or very narrowly spreading, 1.5–2.0 as wide as stem, divided by V- to U-shaped sinus into two triangular lobes, without lateral teeth, not decurrent or decurrent to 1/3 of stem width, undivided portion 2–3 cells high; cells in the midleaf thin-walled, 35–55 \times 30–45 μm , trigones very small to vestigial, concave; cuticle smooth.

Due to plant features in the type specimen *Calypogeia confertifolia*, it differs from the *C. cuspidata* type in leaf shape, which is convex in *C. confertifolia* but concave-canaliculate in *C. cuspidata*, as well as in wider leaves and thicker stems. Due to limited material available, we still maintain the synonymy of these names.

Another possible synonym of *Calypogeia cuspidata* is *C. hawaica*. The description based on the lectotype is as follows: plants yellowish brownish, merely translucent, more or less soft, 2.0–3.1 mm wide, branching not seen; stem 210–320 μm wide;

rhizoids sparse, in some underleaves only, in obliquely spreading brownish fascicles; leaves contiguous to overlapping to 1/3 of the next leaf in the base, nearly planar to very loosely canaliculate-concave, ventrally not decurrent, 800–1400 × 700–1150 µm, obliquely ovate, apiculate, or rarer, apex obtuse or very shortly bidentate (commonly larger leaves); underleaves obliquely spreading, decurrent for 1/3–1/2 of stem width, 1.0–1.2 as wide as stem, divided by V-shaped sinus into two lobes, undivided portion 2–3 cells high, with smooth or without blunt tooth or very shortly bisbifid; cells in the midleaf 37–75 × 37–45 µm, thin-walled, trigones vestigial, cuticle virtually smooth.

Calypogeia hawaica may be compared with *C. tosana*, *C. apiculata* and *C. cuspidata*. It is different from *C. apiculata* through its not decurrent leaves and smooth cuticle; from typical *C. cuspidata* in sometimes briefly bifid, narrower and longer decurrent underleaves and sometimes bisbifid leaves; from *C. tosana*, it differs in almost uniformly bifid leaves and bisbifid underleaves (underleaves are wider in *C. tosana*), and more translucent and glistening appearance. The closest morphological relations are to *C. cuspidata*, but this question needs further consideration.

***Calypogeia decurrens* (Steph.) Steph., Bull. Herb. Boissier (sér. 2) 8 (9): 675 (407). 1908.**

Figure 9K

Basionym. *Kantius decurrens* Steph., *Hedwigia* 34 (2): 52. 1895.

Type. INDONESIA, Sumatra, Kehding (isotype: G [G00060745!]).

Remarks. The species status is seriously doubted by Söderström et al. (2016), probably due to supposed close morphological relations to *C. arguta*. However, the taxon is different from *C. arguta* in narrow (not U-shaped, as common in *C. arguta*) leaf sinus and smooth cuticle (versus distinctly papillose) and especially in brown pigmentation of herbarium plants (*C. arguta* is pale even in the very old type in STR). To attract some attention to this very poorly known species (and to stimulate the search for similar forms in the Meta-Himalaya), we include this Indonesian taxon in the key.

***Calypogeia formosana* Horik., J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 2: 186. 1934.**

Type. TAIWAN (Formosa). Mt. Morrison, August 1932, Y. Horikawa, no. 9124; not seen.

Remarks. This is a Taiwan endemic species (Horikawa 1934) that may be expected in the eastern Meta-Himalaya. The taxon has unclear relationships (placed into “incertae sedis” in Söderström et al. 2016), and by morphology (as it could be estimated from the description and illustration) it is related to *Calypogeia integristipula*, from which, however, it differs in acute leaves. Acute leaves are also similar to many other *Calypogeia* that are recorded or may be expected in the Sino-Himalaya, but all of them have more deeply (more than 1/2) divided underleaves, versus only short and

lunate sinus in *C. formosana* underleaves. Another possible morphological relative of *C. formosana* is *C. neesiana* ssp. *subalpina*, which is characterized by orbicular and shortly divided underleaves. The two taxa, however, differ in their leaf apex features.

***Calypogeia goebelii* var. *siamensis* N.Kitag., Beih. Nova Hedwigia 90: 165. 1988.**

Type. THAILAND. Nakawn Sritamarat: Mt. Khao Luang, M. Tagawa & N. Kitagawa (holotype: KYO [T4737]); not seen.

Remarks. The taxon is known only from the type that is from southern Thailand (Kitagawa 1988) and was never recorded for the Sino-Himalaya. This taxon is indeed different from true *C. goebelii* due to considerably larger leaf cells, more deeply bilobed leaves and fragile apical leaf teeth. This taxon may belong to a species not yet described, but to draw any conclusions, new collections that are suitable for molecular analysis and/or for study of oil body characteristics are needed.

***Calypogeia integristipula* Steph., Bull. Herb. Boissier (sér. 2) 8 (9): 662 (394). 1908.**

Figure 7G–I

Type. GERMANY. Saxonia: July 1888, F. Stephani (lectotype, designated by Bonner (1963) and followed by Grolle (1976): G [G00061108/26879!]).

Remarks. This is a generally boreal circumpolar species widely spreading to hemiarctic and hemiboreal zones and southward in corresponding belts in the mountains (especially in Japan, although surprisingly not known in China and the Korean Peninsula). The description based on the lectotype is as follows: plants 2.2–3.0 mm wide, soft, greenish to yellowish greenish, loosely translucent; stem 200–300 µm wide, freely ventrally branched with 1–2 branches from one underleaf sinus; rhizoids common, in obliquely spreading brownish fascicles; leaves very obliquely inserted, not or barely decurrent ventrally, contiguous to overlapping 1/4 of above situated leaf in the leaf base, slightly convex to nearly planar, ovate to obliquely ovate, 1200–1900 × 1000–1500 µm, with rounded apex; underleaves appressed to the stem, retuse to emarginate at apex, 1.7–2.5 as wide as stem; midleaf cells thin-walled, trigones vestigial, cuticle smooth to very finely verruculose, 37.5–70.5 × 32.5–55.0 µm.

***Calypogeia khasiana* Ajit P. Singh et V. Nath, Taiwania 52 (4): 320. 2007.**

Type. INDIA. Meghalaya: East Khasi Hills, Langkyrdum–Dawki Road, 07 Nov 1998, V. Nath et al. (holotype: LWG [206109-A]; not seen).

Remarks. Singh and Nath (2007b) described *Calypogeia khasiana* from Khasia Mt. The species is somewhat similar to *C. ceylanica*, which differs in smaller cells and acute (not incised) leaf apex. The differences from *C. lunata* are less clear. Singh and

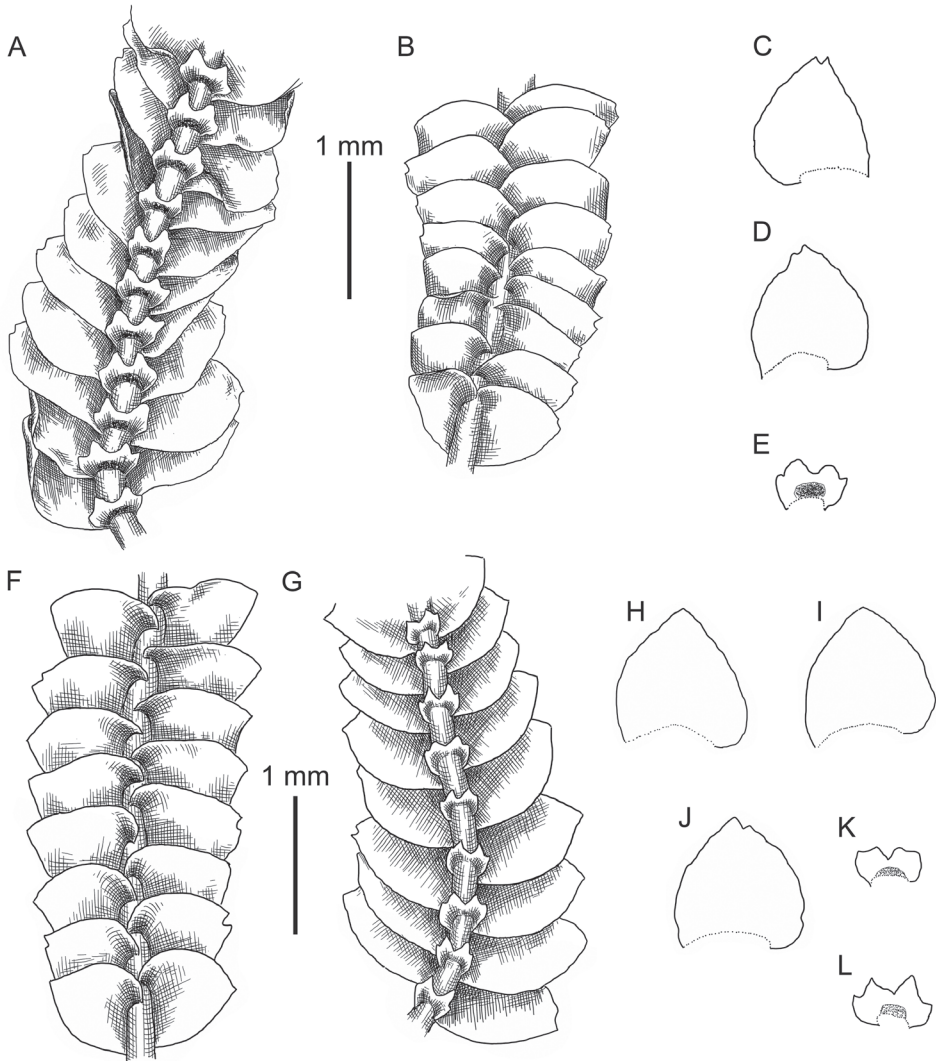


Figure 10. *Calypogeia latissima* Steph. **A** plant habit, fragment, ventral view **B** plant habit, fragment, dorsal view **C, D** leaves **E** underleaf *Calypogeia yoshinagana* Steph. **F** plant habit, fragment, dorsal view **G** plant habit, fragment, ventral view **H, I, J** leaves **K, L** underleaves. **A–E** from Lectotype G00061102; **F–L** Lectotype G00067733.

Nath (2007b: 322) noted “*C. lunata* Mitt. differs from *C. khasiana* in having yellow brown color, stem 9–10 cells across and $0.25\text{--}0.26 \times 0.36\text{--}0.38$ mm in diameter, leaves obliquely ovate, apex narrowed, obtuse to subacute, bidentate, sinus less broad, acute to obtuse, lobes 2 cells long, underleaves bisbifid, lobes divergent, shallowly and irregularly notched, forming acute-obtuse dentitions”. This list of features is untenable, for instance, because *C. lunata* is not yellowish in the herbarium and has similar (and greatly variable) leaf apex, and the same should be noted about underleaf shape. In our opinion, *C. khasiana* may be only a *C. lunata* habitat modification. The possible

difference is in underleaves that are not or barely decurrent in *C. khasiana* (the feature is observed in the picture in the original paper, but no information on this feature is provided in the description), whereas commonly 1/2–1 of stem width decurrent in *C. lunata*. We include it in the key with some doubts, at the same couplets with *C. lunata*.

***Calypogeia latissima* Steph., Sp. Hepat. (Stephani) 6: 449. 1924.**

Figures 10A–E, 11A, B, D

Type. PHILIPPINES. LUZON, Merrill (LECTOTYPE (designated here): G [G00061102!]).

Remarks. The species was described from the Philippines (“Luzon”) and is very similar to the Meta-Himalayan *C. lunata*. Moreover, the translucent nature of plants and pale coloration may suggest the presence of blue oil bodies in living cells. Whether the difference in distribution is associated with the gap in genetics is not known. Currently, only the geographic concept may demonstrate the species status of the taxon.

There are two original specimens of the species in G. Both represent the parts of one original specimen (one was probably scheduled to be preserved in the Stephani herbarium, and the other should be returned to the collector) of which we prefer to select G00061102 as the lectotype because the second one (G00061101) has no original label (and is probable a duplicate).

The description from the lectotype is as follows: plants pale brownish (perhaps were bluish green when fresh), glistening and translucent, 1.5–2.0 mm wide; stem 180–230 µm wide, branching not seen; rhizoids common to numerous in brownish, loose, obliquely spreading fascicles; leaves contiguous or overlapping to 1/2 of leaf width, obliquely inserted and oriented, slightly convex, with apex commonly turned to ventral side, not decurrent, 800–1000 × 800–1000 µm, widely triangular-ovate, shortly bifid at the apex; underleaves obliquely spreading, decurrent for 1/3–1/2 of stem width, 1.2–2.2 as wide as stem, mostly bisbifid or with lateral tooth on one or on both sides, rarely bifid; cells in the midleaf 30–40 × 25–35 µm; nearly thin-walled, trigones small, cuticle nearly smooth in the leaf middle to very finely verruculose near leaf apices.

***Calypogeia marginella* Mitt., J. Proc. Linn. Soc., Bot. 5 (18): 106. 1860 [1861].**

Figures 4T–Z, AA–AC, 8A–D

Type. INDIA. Khasia 1849 Hooker, no. 1339 (syntype: JE [JE-04005904, =JE-H4084!]; syntype: G [G00113555/5289!]).

Remarks. *Calypogeia marginella* is a distinct narrow endemic taxon with a range probably restricted to the Khasia Hills. The species was described by Mitten (1860) from the Khasia Mountains (Hills). Singh and Nath (2007a) recorded it for the West Khasi

* There are three specimens in G. The largest one is G00113555/5289, and another – G00113557/5291 – is part of the same specimen; the third specimen, G00113556/5290, is the possible syntype of the taxon, but the collection number is absent on the label.

Hills and East Khasi Hills. However, it is worth noting that the treatment of the taxon in Singh and Nath (2007a) should be incorrect because authors do not show in the figures nor mention in the description exceedingly large cells along leaf margin that are distinctly characteristic of the taxon. Which species they discussed under *C. marginella* is not clear to us.

The description based on the syntype G00113555/5289 is as follows: plants brownish to greenish brownish, slightly translucent and glistening, 2.0–2.5 mm wide; stem 140–200 μm wide, sparsely ventrally branched; rhizoids virtually absent or solitary, obliquely spreading; leaves contiguous to overlapping 1/3–1/2 of the leaf base of the next leaf, nearly planar to slightly convex, subhorizontally inserted and oriented, shortly or up to 1/2 of stem width decurrent, widely obliquely ovate to rounded-lingulate, with rounded apex, 1100–1300 \times 1000–1300 μm ; underleaves appressed to the stem, decurrent for 1/2–2/3 of stem width, divided mostly by very narrow V-shaped sinus into two lobes without additional lateral teeth or shortly bisbifid, with rounded to obtuse lobes, undivided portion 3–6 cell high; midleaf cells 30–65 \times 17–37 μm , thin-walled, trigones small, cuticle smooth; marginal cells considerable larger and elongate along leaf margin, 70–80 μm long, with thickened external wall.

Calypogeia marginella is a very distinct species due to the elongated cells along the leaf margin, wide leaves and transversely elliptic but not deeply divided underleaves.

***Calypogeia nasuensis* Inoue, Bull. Natl. Sci. Mus. Tokyo, n.s. 12: 653. 1969.**

Figure 11E, G, H

Type. JAPAN. Tochigi Prefecture: Nasu, 700 m a.s.l., August 1968, Empress Nagako (holotype: TNS: TNS-174632!]; isotype: G [G00064238!]).

Remarks. The taxon is currently known from Japan only (Honshu). It was recently synonymized with *C. asakawana* (Isono et al. 2006), which is similar in relatively small underleaves and leaves with commonly rounded apices. However, we think these taxa are different due to the finely asperulose leaf cuticle, sometimes bisbifid underleaves and leaf apex not only rounded but also truncate and even shortly bifid, which are characteristic of *C. nasuensis* and dissimilar to the smooth cuticle, bifid underleaves, rounded leaf apex and less than 1/3 of stem width decurrent underleaves of *C. asakawana*.

The description based on the holotype is as follows: plants merely soft, glistening and translucent, greenish, 1.2–1.6 mm wide; stem 150–200 μm wide, sparsely ventrally branched; rhizoids numerous, in short, divaricate, grayish, erect spreading fascicles; leaves obliquely inserted and oriented, slightly concave-canaliculate or slightly convex (then apex somewhat turned to ventral side), ventrally decurrent for 1/2 of stem width or farther, 750–900 \times 750–800 μm , with rounded or truncate apex; underleaves obliquely spreading, 1.0–1.5 as wide as stem, decurrent for 1/3–1/2 of stem width, deeply divided by U-shaped sinus into two lobes, entire at margin or with blunt tooth on one or each lateral side or very shortly bisbifid cells in the midleaf thin-walled, trigones vestigial to nearly absent, 35–52 \times 25–40 μm , cuticle finely but distinctly papillose.

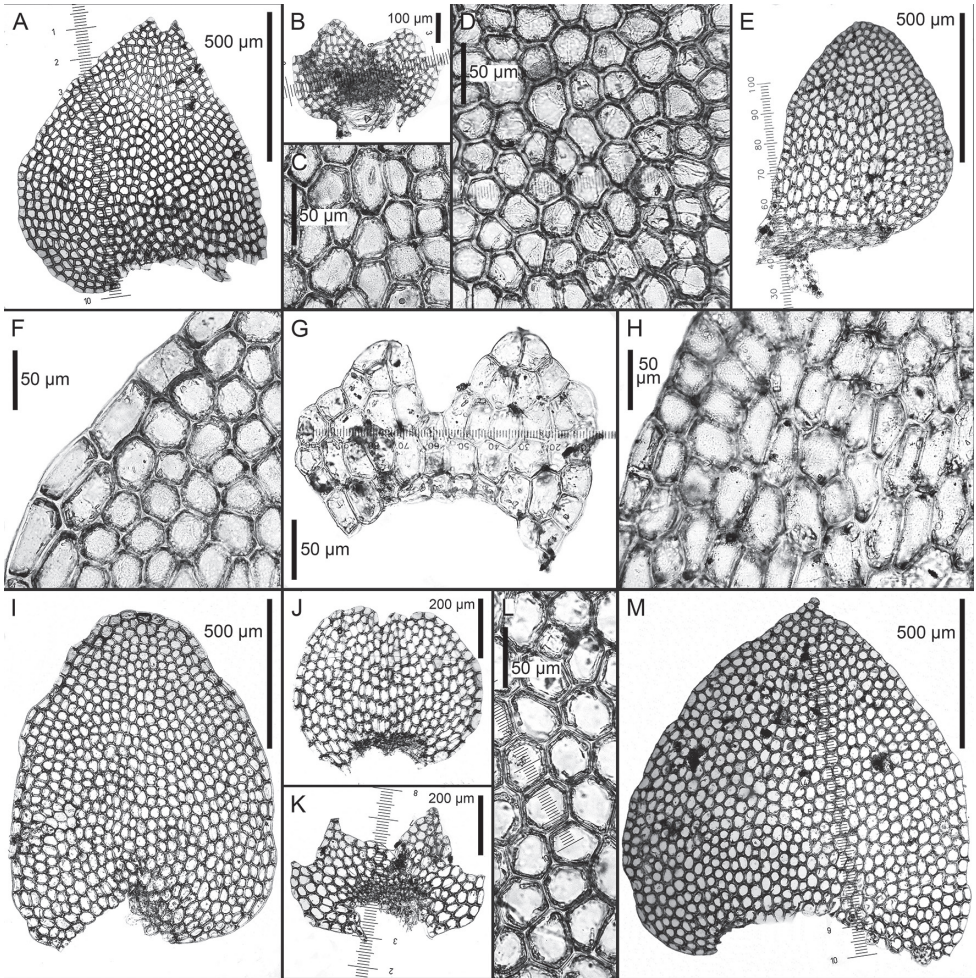


Figure 11. *Calypogeia latissima* Steph.: **A** leaf **B** underleaf **D** leaf middle cells *Calypogeia nasuensis* Inoue: **E** leaf **G** underleaf **H** leaf margin cells *Calypogeia neesiana* subsp. *subalpina* (Inoue) Inoue **F** leaf margin cells **I** leaf **J** underleaf *Calypogeia yoshinagana* Steph. **K** underleaf **L** leaf middle cells **M** leaf. Scale bars: 1 mm (**A, G, H**); 500 μ m (**B, F, J, L, K**); 100 μ m (**C, D, E**); 50 μ m (**I**). **A, B, D** from Lectotype G00061102; **E, G, H** from Holotype TNS-174632; **F, I, J** holotype NICH-49950; **K, L, M** from Lectotype G00067733.

Calypogeia neesiana subsp. *subalpina* (Inoue) Inoue, Mem. Natl. Sci. Mus. (Tokyo) 4: 58. 1971.

Figure 11F–J

Basionym. *Calypogeia subalpina* Inoue, J. Jap. Bot. 37 (4): 103. 1962.

Type. JAPAN, Toyama Prefecture, Tateyama Mt., between Shishindake and Ryodake, 2600–2800 m a.s.l., on humus beneath *Pinus pumila* shrub, 15 August 1959, H. Inoue, no. 8733 (holotype: NICH [NICH-49950!]).

Remarks. Unlike *Calypogeia neesiana* s. str., its subsp. *subalpina* may be expected in the eastern Sino-Himalaya. It differs from *C. neesiana* s. str. in larger marginal leaf cells (not only longer, as is typical for *C. neesiana*, but also wider, which is somewhat like marginal cells in *C. marginella*) and orbicular underleaves (versus underleaves transversely ellipsoidal).

The description based on the holotype is as follows: plants prostrate to loosely ascending, pale brownish in herbarium, forming loose mats, 1.1–2.0 mm wide and 5–10 mm long; rhizoids sparse to virtually absent, in several bundles obliquely to erect spreading or spreading up by the underleaf surface, from each underleaf base (if rhizoids developed), brownish to nearly colorless; stem brownish, 140–200 μm in diameter; leaves obliquely to subhorizontally inserted, dorsally insertion line transverse to arcuate, ventrally shortly decurrent, contiguous to subimbricate, ovate to obliquely ovate, 925–1075 \times 625–875 μm ; underleaves appressed to the stem, hyaline, 450–550 \times 550–650 μm , nearly orbicular; midleaf cells subsodiametric to slightly oblong, ~25–40 μm in diameter, cells 5–6-gonal, thin-walled, with small and concave but distinct trigones, cuticle loosely verruculose; along margin 37–75 μm , with walls slightly thickened, trigones moderate in size, sometimes confluent on tangential side, concave; cells in underleaf middle mostly thin-walled with small to vestigial, concave trigones, along margin thin-walled, with small concave trigones.

***Calypogeia udarii* Sudipa Das et D.K. Singh, *Nelumbo* 53: 194. 2011.**

Type. INDIA. Eastern Himalaya: Arunachal Pradesh, Lower Dibang Valley district, Mehao Wildlife Sanctuary, Mayodia top, ~2850 m, 18 Nov 2000, D.K. Singh 98225 (holotype: BSD); not seen.

Remarks. The species is known only from the type locality cited by Das and Singh (2011). The species is morphologically similar to *C. vietnamica*, although different in underleaves and leaf apices (oil body characteristics are not known in *C. udarii*), as discussed previously (Bakalin et al. 2019b).

***Calypogeia yoshinagana* Steph. *Bull. Herb. Boissier, sér. 2* 8(9): 670. 1908.**

Figures 10F–L, 11K–M

Type. JAPAN. Mt. Yokogura, May 1901, T. Yoshinaga no. 38 (LECTOTYPE (designated here): G [G00067733!], another, poor specimen [G00282608!] is lectotype duplicate. This species was founded on the gatherings by T. Yoshinaga and U. Faurie, however only Yoshinaga's collections are now present in G. Both reviewed specimens contain plants fully corresponding to the original description).

Remarks. Hattori (1966) synonymized this species with *Calypogeia tosana*, regarding *C. yoshinagana* as only an environmentally induced modification. We, however, believe these are separate species. *Calypogeia yoshinagana* differs from *C. tosana* in acute

leaves (very rarely bidentate and, if bidentate, the ‘lobes’ are distinctly unequal), more or less rigid texture, dull coloration (plants are not glistening). Attention to this species is needed in the eastern Meta-Himalayan flora where it may be revealed.

The description based on the lectotype is as follows: plants greenish brownish to dirty greenish, 1.8–2.2 mm wide, 2–3 cm long, relatively rigid; stem 200–250 µm wide, branching not seen; rhizoids sparse to common, in brownish, erect spreading fascicles; leaves obliquely inserted and oriented, slightly concave-caliculate, leaves not decurrent ventrally, triangular-ovate, with acute or rarely obtuse or bidentate apices, 900–1100 × 1000–1200 µm; underleaves 1.5–2.5 as wide as stem, decurrent for 1/3–2/3 of stem width, clearly bisbifid, undivided area 2(–3) cells high; midleaf cells subisodiametric 30–50 × 27–40 µm, thin-walled, trigones small to very small, cuticle smooth.

Key to *Calypogeia* taxa recorded for the Sino-Himalaya and eastern Meta-Himalaya or possibly expected there

- 1 Leaf apex mostly rounded 2
- Leaf apex acute to incised or distinctly bilobed 12
- 2 Underleaves shortly bilobed, emarginate or rounded at the apex 3
- Underleaves distinctly bilobed, at least for 2/5 of the length 5
- 3 Underleaves as large as leaves or slightly smaller, leaves distinctly curved to ventral side, plants distinctly bluish when fresh due to blue (grading to purple!) oil bodies *C. aeruginosa*
- Underleaves much smaller than leaves, leaves not curved to ventral side, plants greenish to bluish greenish, oil bodies colorless to grayish 4
- 4 Cells along leaf margin elongate and distinctly wider than cells of intramarginal row *C. neesiana* ssp. *subalpina*
- Cells along leaf margin nearly isodiametric, smaller than in intramarginal row *C. integristipula*
- 5 Cells along leaf margin distinctly swollen *C. marginella*
- Cells along leaf margin not different from intramarginal cell row 6
- 6 Underleaves bifid 7
- Underleaves bisbifid or bifid with blunt tooth on each lateral side 11
- 7 Oil bodies biconcentric, with large central eye *C. japonica*
- Oil bodies never biconcentric 8
- 8 Leaves with mostly acute apex, only some leaves on some shoots narrowly rounded 10
- Leaves with uniformly rounded apex 9
- 9 Underleaves decurrent for 1/3–1/2 of stem width, blunt teeth on lateral sides commonly present or underleaves bisbifid *C. nasuensis*
- Underleaves not or shortly decurrent (to 1/3 of stem width), without or rarely with additional blunt tooth on one side *C. asakawana*

- 10 Stem $\sim 1/5$ – $1/6$ of shoot width, underleaf lobes 8–10 cells in the base, underleaves 1.5–2.0 of stem width..... *C. confertifolia*
- Stem $\sim 1/7$ – $1/8$ of shoot width, underleaf lobes 3–5 cells width in the base, underleaves 1.1–1.4 of stem width..... *C. cuspidata*
- 11 Stem relatively narrow, $\sim 1/8$ of plant width, leaves nearly planar.....
..... *C. nasuensis*
- Stem relatively wide, $\sim 1/4$ of plant with, leaves distinctly turned to dorsal side *C. angusta*
- 12 Leaf apex acute 13
- Leaf apex incised (sometimes shortly so) to distinctly bilobed 25
- 13 Leaf cuticle smooth, underleaves mostly distinctly wider than stem 14
- Leaf cuticle very finely verruculose, underleaves as wide as stem or slightly wider *C. apiculata*
- 14 Underleaves 1.1–1.5 as wide as the stem 15
- Underleaves 1.5–3.5 as wide as the stem 18
- 15 Underleaf lobes 3–5 cells wide in the base, no additional lateral tooth on each side, leaves uniformly acute..... *C. cuspidata*
- Underleaf lobes more than 6–8 cells wide in the base, additional lateral teeth commonly present on one or both sides, leaves commonly shortly incised, rarely acute (at least some admixture of incised leaves present) 16
- 16 Underleaves commonly bisbifid, rarely with obtuse lateral teeth on both sides, oil bodies brownish blue to brownish, finely granulate..... *C. granulata*
- Underleaves commonly bifid with blunt (sometimes very smoothed) teeth on one or both sides, oil bodies not known..... 17
- 17 Underleaves decurrent for $1/3$ – $1/2$ of stem width, Hawaii
..... *C. cuspidata* [*C. hawaica*' phase]
- Underleaves decurrent for $1/4$ – $1/3$ of stem width, Sri Lanka *C. ceylanica*
- 18 Undivided portion of underleaf 2–3 cells high 19
- Undivided portion of underleaf more than 4 cells high 21
- 19 Oil bodies colorless to grayish 20
- Oil bodies deep blue to blue brown, coarsely granulate *C. sinensis*
- 20 Underleaves commonly bisbifid *C. yoshinagana*
- Underleaves without lateral teeth *C. confertifolia*
- 21 Underleaves bisbifid..... 22
- Underleaves bifid 23
- 22 Underleaves decurrent for 0.5–1.0 of stem width, oil bodies blue, leaves sometimes shortly incised *C. lunata*
- Underleaves not or barely decurrent, oil bodies not known, leaves only acute
..... *C. khasiana*
- 23 Underleaf lobes obtuse, underleaves 1.8–2.5 times wider than stem..... 24
- Underleaf lobes prominently acute, with 2–3 celled uniseriate ends, underleaves 3–4 times wider than stem *C. vietnamica*

- 24 Underleaves divided by semicrescentic to U-shaped sinus, descending less than 1/7 of underleaf length *C. formosana*
- Underleaves divided by V- to U-shaped sinus descending for 1/3–2/5 of underleaf length (undivided portion of underleaves 3–5 cells high).....
..... *C. cordistipula*
- 25 Midleaf cell surface finely verruculose26
- Midleaf cell surface smooth.....27
- 26 Leaves constantly incised, cells in the leaf middle 40–80 × 30–60 µm, underleaves bisbifid.....*C. arguta*
- Leaves rarely incised, commonly apiculate, cells in the leaf middle 37–58 ×25–35 µm, underleaves bifid..... *C. apiculata*
- 27 Underleaves bifid or with obscure additional teeth on one or both sides ...28
- Underleaves constantly bisbifid or with distinct and prominent additional lateral teeth on one or both sides.....31
- 28 Underleaves 0.8–1.3 as wide as stem, its undivided portion 1–3 cells high29
- Underleaves 2.8–3.5 times as wide as stem, its undivided portion more than 5 cells high..... *C. udarii*
- 29 Leaves apiculate to shortly incised into two strongly unequal or rarely nearly equal (sinus depth 2–3 cells) lobes30
- Leaves shortly bilobed, for two subequal lobes, leaf sinus depth 4–6 cells.....
..... *C. decurrens*
- 30 Leaf apex commonly obliquely truncate, unequally and very shortly bilobed, underleaves decurrent for 1/3 of stem width or less..... *C. ceylanica*
- Leaf apex mostly acute to obtuse, underleaves decurrent for 1/3–1/2 of stem width..... *C. cuspidata* [*C. hawaica*' phase]
- 31 Undivided portion of underleaves 2–3 cells high, oil bodies blue to grayish, brown and colorless32
- Undivided portion of underleaves 4–5 and more cells high, oil bodies blue ..
..... *C. lunata*
- 32 Underleaves 1.1–1.3 as wide as stem, commonly bifid, with obscure additional lateral teeth on each side *C. ceylanica* [see also couplet 30]
- Underleaves commonly more than 1.5 as wide as stem, almost constantly bisbifid.....33
- 33 Leaves commonly acute, rarely incised (predominantly acute!).....34
- Leaves commonly with incised apex, rarely acute35
- 34 Oil bodies coarsely granulate, deep blue to blue-brown, plants merely soft, somewhat glistening, commonly wider 2.2 mm wide, leaves somewhat undulate at margins, commonly turned to ventral side..... *C. sinensis*
- Oil bodies not known, plants more or less rigid, not glistening, commonly less than 2.2 mm wide, leaves planar at margins, not turned to ventral side.....
..... *C. yoshinagana*

- 35 Oil bodies brownish to brown, blue and blue brown, botryoidal to granulate (in *C. latissima* not known but suspected as blue), leaves commonly incised at apex, sinus commonly V-shaped **36**
- Oil bodies colorless to grayish, botryoidal, leaves with almost constantly shortly divided apex by U-shaped sinus..... ***C. tosana***
- 36 Oil bodies blue to deep blue botryoidal or not known **37**
- Oil bodies brownish to brownish blue, finely granulate..... ***C. granulata***
- 37 Underleaves decurrent for 1/3–1/2 of stem width, oil bodies not known, leaves distinctly bilobed at apex (sinus depth 2–3 cells), leaves subimbricate ***C. latissima***
- Underleaves not or barely decurrent, oil bodies presumably deep blue, leaves distinctly bilobed at apex (sinus depth 3–5 or more cells), leaves contiguous to distant ***C. goebelii***

Phytogeographic speculations

The vertical movements of the Himalaya, Tibetan Plateau and Hengduan Mts. have influenced the speciation of various groups of biota, not only that of liverworts (Luo et al. 2014; Zhuo et al. 2013). These movements have additionally complicated the relationships within various groups and resulted in several phytogeographic boundaries crossing the eastern Sino-Himalaya. One of the most pronounced phytogeographic lines recognized today is the “Ward line” in the Salween-Mekong watershed (Luo et al. 2017). The robust differences between adjacent plant floras were formed due to uplift of the Qinghai-Tibetan Plateau and changes in river courses and correlated with increasing numbers and diversification of ecological niches (Clark et al. 2004; Shi et al. 1998). Niche diversification was associated with speciation. The same patterns were observed not only in plants but also in other groups of living organisms, e.g., birds (Cai et al. 2018). Moreover, the taxonomical diversity of taxa with narrow ranges in mountains could be explained by topography and evolutionary history, including geographic isolation rather than by the climate alone (Fjeldså and Rahbek 2006; Fjeldså et al. 2012; Jetz et al. 2004; Rahbek et al. 2007).

The eastern part of the Sino-Himalaya and the eastward adjacent Meta-Himalaya, as identified in this work, are valuable biodiversity hotspots on Earth (Myers et al. 2000; Luo et al. 2017). This general trend is also observed in *Calypogeia*, whose diversity is quite high in two respects: taxonomical and morphological. The data on the occurrence of *Calypogeia* taxa in the study area and nearby are placed in Fig. 1. The map indicates only reports where the geographic position of the collection might be identified with the deviations less than 400–500 km. In total, 11 taxa are known in the study area, and one more taxon (*Calypogeia marginella*) is found at a rather distant locality in the western Himalaya but may be expected in the study area. Two regularities in distribution are prominent: 1) all records in the study area and nearby are above 1000 m a.s.l., and 2) the annual amounts of precipitation in the collecting localities are between 1000 and 2000 mm per year. The exclusions are rare and belong mostly to *C. arguta* – a rather ‘weedy’ species of roadsides and other sites with disturbed veg-

etation cover. The third peculiarity has a presumptive character – this feature is the complete absence of taxa known and abundant in the boreal and hemiboreal Holarctic, including *C. integristipula*, *C. muelleriana*, *C. sphagnicola*, *C. orientalis*, etc. Although it is impossible to be absolutely sure that these taxa are absent from the Sino-Himalaya, the probability of occurrence of these species converges to zero.

Although 11 *Calypogeia* taxa are known within the study area, there are only three taxa restricted to this land: *C. cordistipula*, *C. sinensis* and *C. vietnamica*. However, for *C. aeruginosa* and *C. lunata*, the eastern Sino-Himalaya and eastern Meta-Himalaya are the area cores. *Calypogeia aeruginosa* is also known in southern Japan and Taiwan, where it is a possible relict. *Calypogeia lunata* spreads slightly southward of treated area, to northern Thailand. Other taxa are also distributed in the insular parts of East Asia, such as Japan and Taiwan (*C. angusta* and *C. granulata*), or slightly wider, in amphipacific East Asia (*C. tosana* and *C. japonica*). Only *C. arguta*, as mentioned above, is a much more widely distributed taxon. The tight connection of amphipacific floras with the Sino-Himalaya and Meta-Himalaya regions also implies that other taxa of *Calypogeia* presently known in insular and peninsular parts of East Asia and Southeast Asia and probably some other taxa known in South Asia may be expected in treated area.

In a broader context, taking into account the distribution of Calypogeiaceae in the Sino-Himalaya, the patterns can be found to be somewhat similar: Calypogeiaceae includes 5 genera (Söderström et al. 2016), of which the northern amphipacific *Eocalypogeia* and Southeast Asian tropical *Mizutania* do not occur in the Sino-Himalaya and Meta-Himalaya. The merely speciose and antipodal *Mnioloma* has one species (and the only extratropical East Asian representative) distributed in northern Guizhou Province, China (Bakalin et al. 2015; Liu et al. 2013). *Metacalypogeia* has two species: the hemiboreal to cool-temperate Pacific-East Asian *Metacalypogeia cordifolia* (Steph.) Inoue and the mostly Sino-Himalayan *Metacalypogeia alternifolia* (Nees) Grolle that also reaches insular parts of East Asia.

Conclusion

Calypogeia in the eastern Sino-Himalaya and Meta-Himalaya is still poorly understood taxonomically. The first attempt to summarize the information reveals that there are only a few data points based on a limited number of specimens. Moreover, many recorded taxa are poorly known, have questionable status or are presumably based on mistaken identifications. The taxa widely distributed in the North Holarctic (boreal zone and northward) are hardly possible in the study area, while the occurrence of some taxa from the south temperate zone of mountainous areas in southern Japan, Taiwan and the southeastern China mainland is quite probable. It seems that all, or nearly all, *Calypogeia* taxa of the Sino-Himalaya deeply penetrate to the eastern Meta-Himalaya and together form a highly peculiar pool of taxa reflecting the specificity of the Sino-Himalaya admitted in many biota groups. The identification key provided here is an attempt to increase research on and knowledge of *Calypogeia* in East Asia and should be further supplemented with exhaustive studies of living collections of the genus.

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