



## *Begonia difformis* comb. & stat. nov. (Sect. *Platycentrum*, Begoniaceae), a new species segregated from *B. palmata* D. Don

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### Abstract

*Begonia palmata* D. Don is one of the most widely distributed and morphologically variable species of Asian Begoniaceae. Examinations of its morphological variation indicate that two of its seven varieties, *B. palmata* var. *difformis* and *B. palmata* var. *crassisetulosa*, both distributed in the Gaoligong Mountain areas of Yunnan, China are indistinguishable and yet distinct from other varieties. Phylogenetic analyses using ITS DNA sequences further reveals that samples identifiable to these two varieties are also distantly related to samples of typical *B. palmata*. Based on these observations, we combine and elevate these two varieties to the status of species, *Begonia difformis* (Irmsch.) W.C. Leong, C.I Peng & K.F Chung, comb. & stat. nov..

**Key Words:** *Begonia palmata* var. *crassisetulosa*, flora of China, ITS, Yunnan

### Introduction

*Begonia* Linnaeus (1753: 1056), comprising more than 1,700 species (Doorenbos *et al.* 1998, Golding & Wasshausen 2002, Hughes & Pullan 2007, Chung *et al.* 2014), is the 6<sup>th</sup> largest genus of flowering plants (Frodin, 2004). With relative few exceptions, most species of the genus are micro-endemic with restricted distribution (Kiew 2001, Tebbitt 2005, Chung *et al.* 2014). In Asia, *Begonia palmata* D. Don (1825: 223) is one of the most widespread *Begonia* species (Gu *et al.* 2007), occurring in forest understory from 100 to 3200 m in central to southern China (Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, Xizang, Yunnan), Taiwan, South Asia (Bangladesh, Bhutan, NE India, Nepal, and Sikkim), and Indochina (Myanmar, Laos, Thailand, and Vietnam). *Begonia palmata* is highly variable and seven varieties are recognized by Golding & Wasshausen (2002). The autonym *Begonia palmata* var. *palmata* is distributed in Yunnan (China), Himalayas, and northern Indochina. *Begonia palmata* var. *bowringiana* (Champ. ex Benthem 1852: 120–121) Golding & Karegeannes (1984: 494) is widespread in southern and central China (Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, Xizang, and Yunnan) and Taiwan. In the Flora of China (Gu *et al.* 2007), var. *bowringiana* was expanded to include *B. palmata* var. *principalis* (Irmscher 1939: 530) Golding & Karegeannes (1984: 495) that is distributed in Yunnan and Myanmar (Irmscher 1939). *Begonia palmata* var. *difformis* (Irmscher 1939: 531) Golding & Karegeannes (1984: 495) and *B. palmata* var. *crassisetulosa* (Irmscher 1939: 532) Golding & Karegeannes (1984: 495) are both distributed in Gaoligong Mountains, western Yunnan, China. *Begonia palmata* var. *khasiana* (Irmscher 1939: 529) Golding & Karegeannes (1984: 495) is found in the Himalayas. *Begonia palmata* var. *laevifolia* (Irmscher 1951: 43–44) Golding & Karegeannes (1984: 495) is only known from Hekou, southeastern Yunnan. These varieties are very similar on gross morphology, differed from one another mainly by the indumentum on stems, leaves, and flowers (Irmscher 1839, Gu *et al.* 2007); however, phylogenetic relationship among these varieties of *B. palmata* remains to be explored.

Among these varieties, *B. palmata* var. *difformis* and var. *crassisetulosa* are morphologically distinct in possessing red-minute setae on abaxial side of the tepals, while other varieties bearing brownish villous to tomentose hairs (Table 1). During our ongoing studies of Asian *Begonia* taxonomy and phylogenetics, field observation, greenhouse transplantation and specimen examination suggest that *B. palmata* var. *crassisetulosa* and var. *difformis* are hardly

distinguishable and should be combined. Molecular phylogenetic analysis further reveals that samples identifiable as *B. palmata* var. *difformis* (and var. *crassisetulosa*) formed a clade distantly related to samples attributable to other varieties of *B. palmata*. Based on these analyses, we combine the two varieties and elevate them to the status of species.

**TABLE 1.** Comparison of *Begonia difformis* and *B. palmata*.

Character\Species	<i>B. difformis</i>	<i>B. palmata</i>
Blade lobes	Usually divided to more than 1/3 of the leaf blade	Usually shallowly divided to less than 1/3 of the leaf blade
Blade indumentum	Adaxially hispidulous along veins	Adaxially hirsute, hispidulous
Outer tepals of staminate flower	Abaxially setulose	Abaxially villous or tomentose
Outer tepals of pistillate flower	Abaxially setulose of nearly glabrous	Abaxially villous or tomentose
Immature ovary	Setulose to nearly glabrous	Villous or tomentose to nearly glabrous

## Material and Methods

### Morphology

All plants studied were cultivated in the experimental greenhouse of Academia Sinica, Taipei for morphological observation and molecular analyses. Herbarium specimens (A, E, HAST, and MO) have also been examined for morphological comparison.

### Phylogenetic analyses

To test the monophyly of *Begonia palmata*, DNA sequences of the nuclear ribosomal internal transcribed spacer (ITS) of the 26 species in Clade PLA-SPH of Chung *et al.* (2014) were adopted. Nine samples of *B. palmata*, including four unambiguously identifiable to *Begonia palmata* var. *difformis* or var. *crassisetulosa* collected from Gaoligong Mountains, Yunnan, China were newly sequenced for ITS sequences. The 26 samples in Clade PLA-SPH include species of China, Taiwan, Himalayas, Indochina, Peninsular Malaysia, and Java (Table 2). Three tuberous deciduous species, *B. chingii* Irmscher (1939: 519), *B. fimbriatipula* Hance (1883: 202), and *B. ravenii* Peng & Chen (1988: 217), were chosen as outgroup taxa for they were placed in Grade DIP I sister to Clade PLA-SPH clade (Chung *et al.* 2014). The experimental procedures of DNA extraction, PCR amplification, and DNA sequencing described in Chung *et al.* (2014) were followed.

Multiple DNA sequence alignment was conducted by MUSCLE implemented in MEGA5.2 (Tamura *et al.*, 2011) with subsequently manual adjustments. Phylogenetic relationships were reconstructed based on Bayesian MCMC inference. The best nucleotide substitution models were determined by MrModeltest (Nylander, 2004). The model GTR+I+G was selected. For Bayesian MCMC inference, the consensus topology with posterior clade probability of each node was obtained by MrBayes 3.2.2 (Ronquist & Huelsenbeck, 2003) based on parameters setting as follows: random starting tree, 10,000,000 generation runs with sampling occurring every 1000 generations. Bayesian clade posterior probabilities and average branch lengths were calculated based on the sampled trees after the first 25% of the sampled trees were discarded as burn-in.

**TABLE 2.** Materials, voucher information and GenBank accession numbers.

Species	Section	Distribution	collector	GenBank Accession No.
<i>Begonia acetosella</i> Craib	Sphenanthera (SPH)	China		AY048976
<i>Begonia alpina</i> L.B.Sm. & Wassh.	Platycentrum (PLA)	Malaysia		AY753717

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TABLE 1. (Continued)

Species	Section	Distribution	collector	GenBank Accession No.
<i>Begonia alveolata</i> T. T. Yu	<i>Diploclinium</i> (DIP)	China, Yunnan	Peng 20421 (HAST)	AY048977
<i>Begonia augustinei</i> Hemsl.	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 20759 (HAST)	KF636421
<i>Begonia balansana</i> Gagnep.	<i>Sphenanthera</i> (SPH)	Viet Nam	Peng 21928 (HAST)	AF485091
<i>Begonia cathayana</i> Hemsl.	<i>Platycentrum</i> (PLA)	China, Guangxi	Peng 20288 (HAST)	AF280106
<i>Begonia ceratocarpa</i> S.H.Huang & Y.M.Shui	<i>Sphenanthera</i> (SPH)	China, Yunnan		AY048978
<i>Begonia chingii</i> Irmsch.	<i>Reichenheimia</i> (REI)	China, Guangxi	Peng 19733 (HAST)	KF636432
<i>Begonia difformis</i> (Irmsch.) W.-C. Leong, C.-I Peng & K.-F. Chung	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 23278* (HAST)	KP262496
<i>Begonia difformis</i> (Irmsch.) W.-C. Leong, C.-I Peng & K.-F. Chung	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 23252* (HAST)	KP262497
<i>Begonia difformis</i> (Irmsch.) W.-C. Leong, C.-I Peng & K.-F. Chung	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 23216* (HAST)	KP262498
<i>Begonia difformis</i> (Irmsch.) W.-C. Leong, C.-I Peng & K.-F. Chung	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 23253* (HAST)	KP262499
<i>Begonia decora</i> Stapf	<i>Platycentrum</i> (PLA)	Malaysia	Peng 20261 (HAST)	KF636435
<i>Begonia edulis</i> H. Lév.	<i>Platycentrum</i> (PLA)	China, Guangxi	Peng 18747 (HAST)	KF636437
<i>Begonia fimbriatipula</i> Hance	<i>Diploclinium</i> (DIP)	China, Guangxi	Leong 3673 (HAST)	KF636439
<i>Begonia hatacoa</i> Buch.-Ham. ex D. Don	<i>Platycentrum</i> (PLA)	Himalayas		AF485111
<i>Begonia hemsleyana</i> Hook. f.	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 17590 (HAST)	AF485099
<i>Begonia laminariae</i> Irmsch.	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 17447 (HAST)	KF636455
<i>Begonia longicarpa</i> K. Y. Guan & D. K. Tian	<i>Leprosae</i> (LEP)	China, Yunnan	Peng 18651 (HAST)	AY048985
<i>Begonia longifolia</i> Blume	<i>Sphenanthera</i> (SPH)	Taiwan	Peng 16795 (HAST)	AF485105
<i>Begonia multangula</i> Blume	<i>Sphenanthera</i> (SPH)	Java		AY753724
<i>Begonia nuwakotensis</i> S.Rajbh.	<i>Platycentrum</i> (PLA)	Nepal		HQ729061
<i>Begonia palmata</i> D. Don var. <i>bowringiana</i> (Champ. ex Benthem) Golding & Karegeannes	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 17658* (HAST)	KP262494
<i>Begonia palmata</i> D. Don var. <i>palmata</i>	<i>Platycentrum</i> (PLA)	Taiwan	Peng 15985* (HAST)	KP262491
<i>Begonia palmata</i> D. Don var. <i>palmata</i>	<i>Platycentrum</i> (PLA)	Taiwan	Peng 16670* (HAST)	KP262492
<i>Begonia palmata</i> D. Don var. <i>palmata</i>	<i>Platycentrum</i> (PLA)	China, Guangdong	Peng 19477* (HAST)	KP262493
<i>Begonia palmata</i> D. Don var. <i>palmata</i>	<i>Platycentrum</i> (PLA)	Taiwan, Chiayi	Peng 20903 (HAST)	KF636468
<i>Begonia palmata</i> D. Don var. <i>bowringiana</i> (Champ. ex Benthem) Golding & Karegeannes	<i>Platycentrum</i> (PLA)	China, Yunnan	Peng 23243* (HAST)	KP262495
<i>Begonia palmata</i> D. Don var. <i>cf.</i> <i>palmata</i>	<i>Platycentrum</i> (PLA)	China, Yunnan		AF485113
<i>Begonia panchtharensis</i> S.Rajbh.	<i>Platycentrum</i> (PLA)	Nepal		HQ729062

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TABLE 1. (Continued)

Species	Section	Distribution	collector	GenBank Accession No.
<i>Begonia pavonina</i> Ridl.	<i>Platycentrum</i> (PLA)	Malaysia	Peng 20239 (HAST)	KF636472
<i>Begonia pedatifida</i> H. Lév.	<i>Platycentrum</i> (PLA)	China, Guizhou	Peng 18779 (HAST)	KF636473
<i>Begonia ravenii</i> C.-I Peng & Y.-K. Chen	<i>Diploclinium</i> (DIP)	Taiwan	Peng 14855 (HAST)	KF636479
<i>Begonia robusta</i> Blume	<i>Sphenanthera</i> (SPH)	Java		AY753729
<i>Begonia ruboides</i> C. M. Hu ex C. Y. Wu & T. C. Ku	<i>Diploclinium</i> (DIP)	China, Yunnan	Peng 18705 (HAST)	KF636481
<i>Begonia sikkimensis</i> A. DC.	<i>Platycentrum</i> (PLA)	China, Tibet	Peng 20848 (HAST)	KF636485
<i>Begonia versicolor</i> Irmsch.	<i>Platycentrum</i> (PLA)	China, Yunnan		AF485090
<i>Begonia xanthina</i> Hook.	<i>Platycentrum</i> (PLA)	Himalayas		AY753733

## Results and Discussion

### Morphology

*Begonia difformis* resembles *B. palmata* in being hairy and palmatifid leaf, differing by the leaf shape and the indumentum on leaves and flowers. *Begonia difformis* has palmate leaves usually divided to more than 1/3 of total leaf length, whereas *B. palmata* possesses shallowly lobed leaf blades which are usually divided to less than 1/3 of total length. While adaxial surfaces of leaf blades of *B. difformis* are hispidulous only along veins, *B. palmata* is hirsute or hispidulous on the whole surfaces. Compared to the villous or tomentose flower of *B. palmata*, *B. difformis* has red-minute setae flowers. Detail comparison of *B. difformis* and *B. palmata* is provided in Table 1.

Irmscher (1939) suggested *B. palmata* var. *crassisetulosa* and var. *difformis* are both having sparsely-hairy leaves but tepals of the former variety has thick bristles (setae) to 2 mm long, in which the later one has no such indumentum. In our observation, the tepal indumentum can be very sparse (sometimes nearly glabrous) and could be difficult to observe on dry specimen. Density of tepal indumentum can be different between flowers within the same individual.

### Phylogenetic Analyses

The aligned data matrix included 728 aligned positions. The Bayesian 50% majority rule consensus tree with mean branch length and posterior probability (PP) is depicted in Fig. 1. Samples identified to *Begonia palmata* (PP: 100) and *B. difformis* (PP: 100) were grouped into two highly supported monophyletic groups distantly related to one another. The clade composed of *Begonia difformis* was nested within a clade with six species from China, five species from Himalayas and two species share by the two regions (PP: 82), whereas the *B. palmata* clade resided in another clade with two species from Java and 3 species from Peninsular Malaysia (PP: 100). This result strongly supports that *B. difformis* is a distinct species.

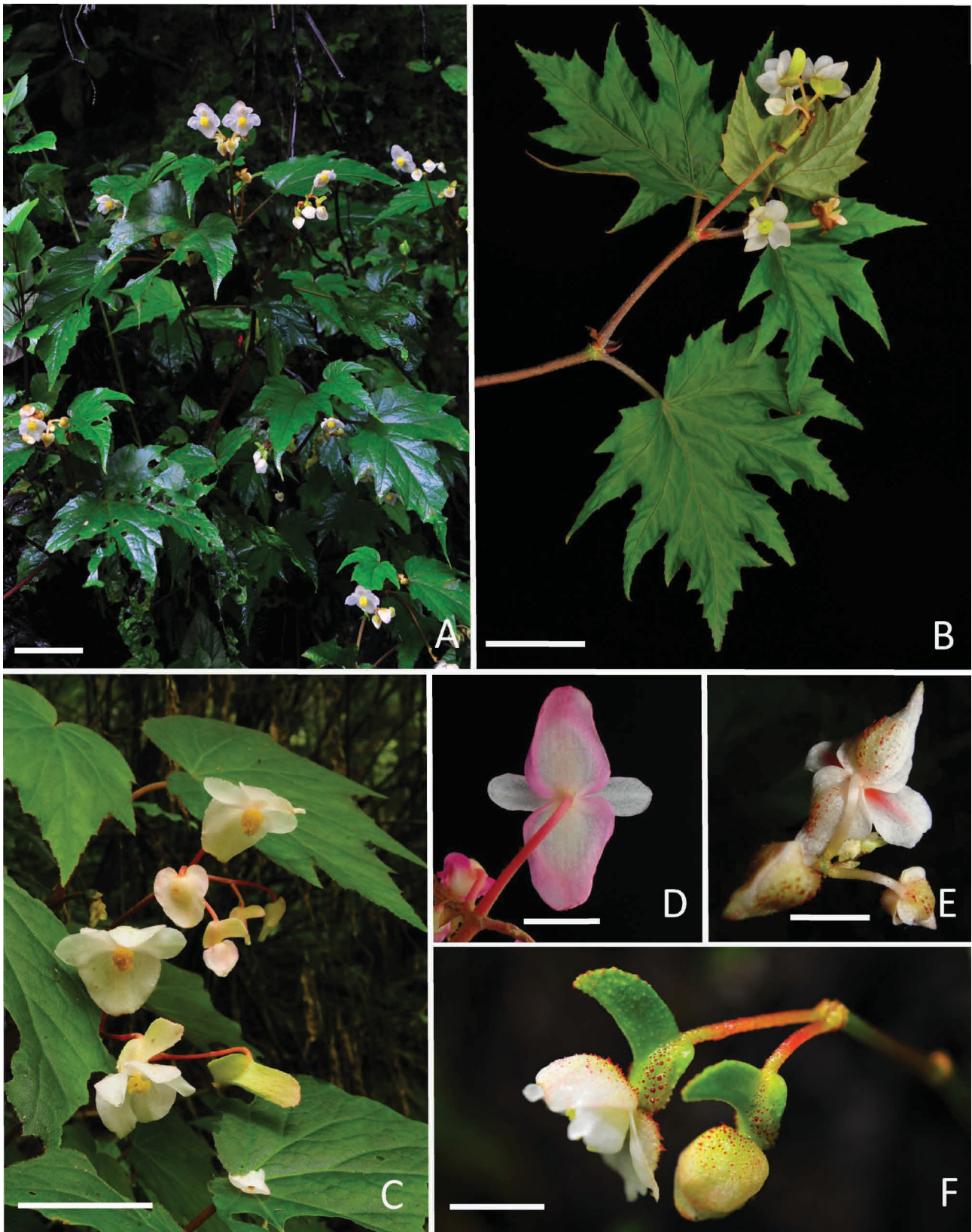
### Taxonomic treatment

*Begonia difformis* (Irmsch.) W.C. Leong, C.I Peng & K.F Chung, *comb. & stat. nov.* (Fig. 1)

**Basionym:**—*Begonia laciniata* Roxb. subsp. *difformis* Irmsch. (1939: 531).

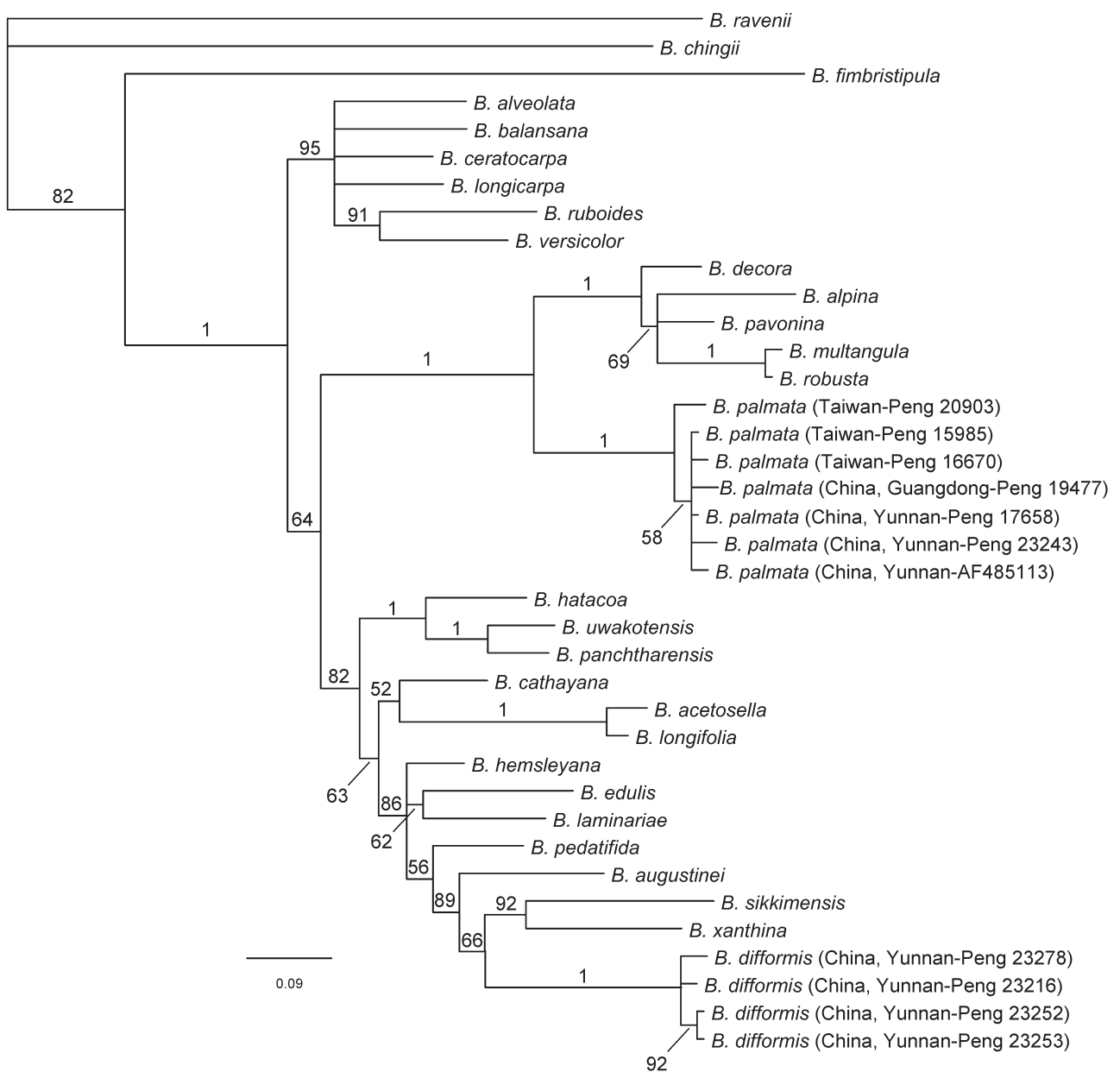
**Lectotype** (verified by Irmscher 1956/designated here):—CHINA. Yunnan, September 1912, *G. Forrest 16098* (E!), Shweli-Salwin Divide, Sep. 1924, *G. Forrest 25207* (paratype, E!). See Note.

*Heterotypic synonyms*:—*Begonia laciniata* Roxb. subsp. *crassisetulosa* Irmsch. (1939: 532). *Begonia palmata* D. Don var. *crassisetulosa* (Irmsch.) Golding & Kareg. (1984: 495). Lectotype (verified by Irmscher 1956/designated here):—CHINA. Yunnan: Hills east to Tengyueh, July 1912, *G. Forrest* 8673 (E!).



**FIGURE 1.** *Begonia difformis* (A, B, E, F) and *B. palmata* (C, D). A. Habitat. B. Habit. C. Male and female flowers. D, E. Abaxial surface of staminate flower, note the red-m on tepals of *B. difformis* (E). F. Pistillate flower. Scale bars A–C. 4 cm. D–F. 1 cm.

Evergreen herbs, 20–80 cm tall. Rhizomes elongate, to 2 cm in diam.; aerial stems erect, hirsute when young. Leaves bearing on rhizomes and aerial stems; stipules caducous, narrowly ovate or ovate, to 3 cm long, 2 cm wide, margin minutely dentate, apex cuspidate; petioles 10–28 cm long, hirsute or sparsely so; blade asymmetric, ovate or obovate-orbicular, 7–17 cm × 5–11 cm, adaxial surface hispidulous along veins, abaxial surface hirsute, base oblique, slightly cordate or cordate, margin remotely and shallowly denticulate, usually divided to 1/3 of the blade or more, lobes 3–7(–9), subtriangular, 2.5–5 cm long, apex acuminate to long-acuminate; venation palmate, 5–10-nerved. Inflorescences tomentose; bracts caducous, ovate, 1–1.5 × 0.5–0.8 cm, abaxial surface sparingly hispidulous to nearly glabrous, apex acute, margin ciliate. Staminate flowers: Pedicels 1–2 cm long; tepals 4, white or pink, outer two obovate to orbicular, 1.2–2.3 × 0.8–2.0 cm, abaxial surface red-setulose or sparsely so, inner two oblanceolate to narrowly obovate, 0.7–2.3 × 0.6–1.0 cm, glabrous; stamens ca. 80–200; filaments 0.8–2.4 mm long; anthers narrowly obovate, 1.9–2.3 mm long, acute or round at apex. Pistillate flowers: Pedicels 1–2 cm long; tepals 5, unequal, oblanceolate to orbicular, the largest 1.1–2.4 × 0.8–2.1 cm, abaxially red-setulose or nearly glabrous, the smallest 0.8–2.1 × 0.4–0.9 cm wide; ovary green, red-setulose or nearly glabrous, 2-locular; placentae axile, bilamellate; styles fused at base; stigmas 2-cleft, spiralled. Capsule nodding, obovoid, 1.5–1.7 × 0.8–1.0 cm wide, unequally 3-winged, abaxial wing obliquely oblong or narrowly so, 1.2–2.9 cm long, lateral wings much shorter.



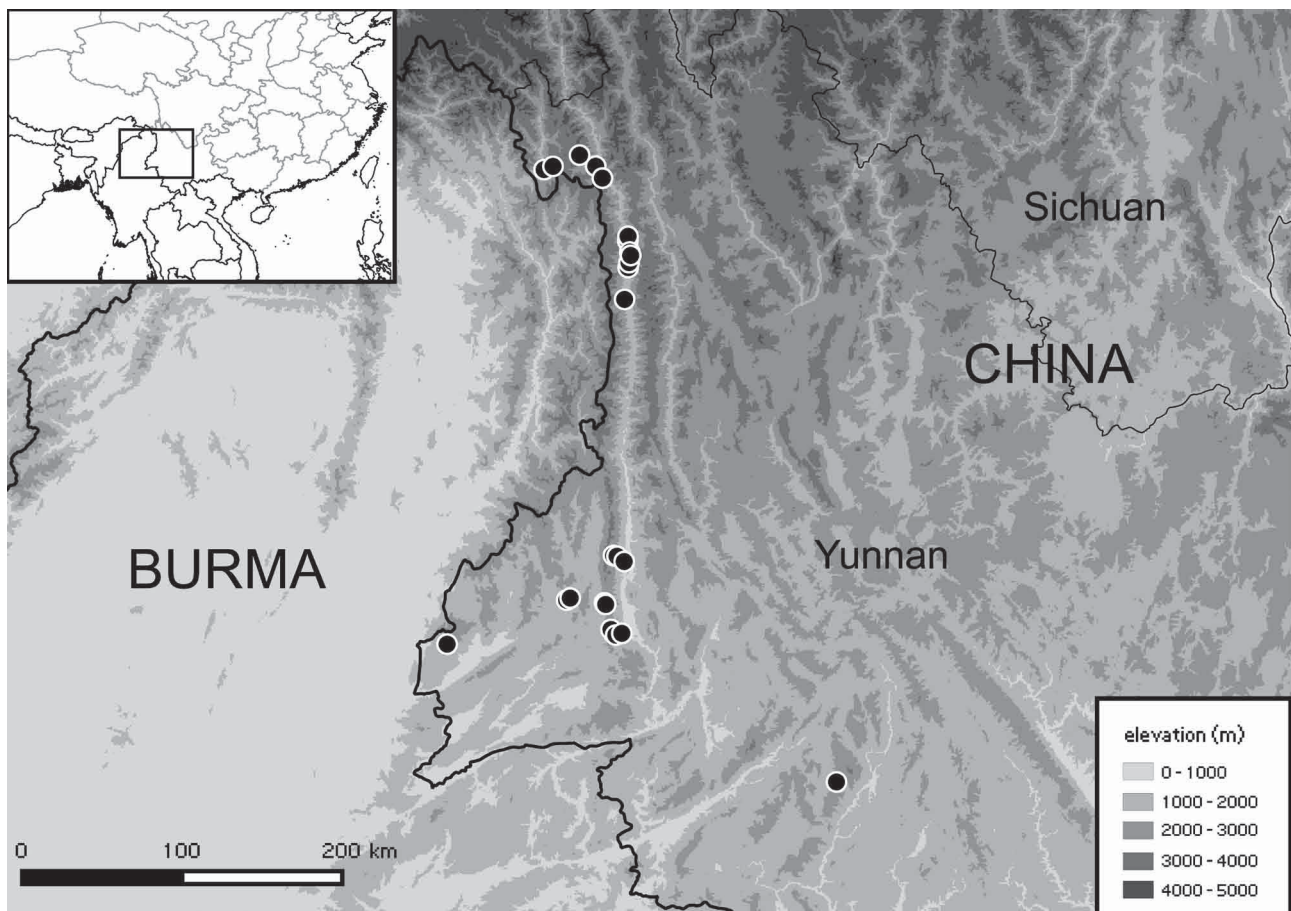
**FIGURE 2.** Bayesian 50% majority rule consensus tree base on nrITS DNA sequence. Numbers adjacent to the branches are posterior probabilities.

**Distribution & habitat:**—*Begonia difformis* occurs at the elevation at 1500–3200 m in western and southwestern Yunnan (Fig. 3), commonly found on sandstone rock crevices of the moist environments by streams or on mountain slopes under evergreen broadleaved forests or coniferous forests.

**Phenology:**—*Flowering* June–October; *Fruiting* August–November.

**Chinese name:** 刺毛紅孩兒.

**Note:**—Both *Begonia laciniata* subsp. *difformis* and subsp. *crassisetulosa* were both described without types (Irmscher 1939). In the *Global Plant* database of JSTOR, *Forrest 8673* (E), which bears a *determinavit* slip with Irmscher's identification in 1956, was noted as the 'Type' of *B. laciniata* var. *crassisetulosa* ('Verified by E. Irmscher, 1956/7/1'; <http://plants.jstor.org/stable/10.5555/al.ap.specimen.e00299206>). Irmscher's *determinavit* slips of *B. laciniata* subsp. *difformis* were also seen on two specimens at E: *Forrest 16098* ('det. E. Irmscher 1958') and *Forrest 25207* ('det. E. Irmscher 1956'). *Forrest 16098* was noted as 'Lecotype' of *B. laciniata* subsp. *difformis* ('Verified by E. Irmscher, 1956/7/1'; <http://plants.jstor.org/stable/10.5555/al.ap.specimen.e00299196>), while *Forrest 25207* as 'Syntype' ('Verified by E. Irmscher, 1956/07/01'; <http://plants.jstor.org/stable/10.5555/al.ap.specimen.e00299194>). Because both taxa were described by Irmscher, his verifications as noted in JSTOR are followed.



**FIGURE 3.** Distribution map of *Begonia difformis*.

**Additional selected specimen examined:**—CHINA. Yunnan: Baoshan, Gangdang, Baihualing, 2000 m, 10 August 2011, *Peng 23252* (HAST), *Peng 23253* (HAST); Baoshan, Longling, Zhenan Zhen, Lishuzhai, on the east side of Gaoligong Shan, 24°48'09" N, 98°47'41" E, 1930 m, 21 October 1998, *Li 10756* (HAST); Baoshan, Longling, Zhenan Zhen, Xiaoshui He, on the west side of Gaoligong Shan, 24°50'16" N, 98°45'53" E, 2170 m, 22 October 1998, *Li 10782* (HAST); Baoshan, Longling, Zhenan Zhen, Vicinity of Hupa village, east side of Gaoligong Shan, 24°48'48" N, 98°49'58" E, 1530 m, 23 August 2003, *Gaoligong Shan Biodiversity Survey 17621* (HAST); Baoshan, Longling, Lujiang, Vicinity of Nankang village, east side of Gaoligong Shan, 1908 m, 24°48'47" N, 98°46'59" E, 25 August 2003, *Gaoligong Shan Biodiversity Survey 17820* (HAST); Baoshan, Longling, Mangkuan, Baihualing Cun, east side of Gaoligong Shan, 25°18'00" N, 98°46'51" E, 2220 m, 8 September 2003, *Gaoligong Shan Biodiversity Survey 18866* (HAST); Baoshan, Longling, Mangkuan, Vicinity of Hanlong, Baihualing Cun, east side of the Gaoligong Shan, 25°17'44" N, 98°48'09" E, 1777 m, 2 June 2005, *Gaoligong Shan Biodiversity Survey 25364* (HAST); Baoshan,

Longling, Sanyun, Qiaojie Cun, in vicinity of Henghe village, west side of Gaoligong Shan, 24°59'38" N, 98°43'55" E, 1980 m, 1 September 2003, *Gaoligong Shan Biodiversity Survey 18323* (HAST); Baoshan, Tengchong, 1550 m, 6 August 2011, *Peng 23216* (HAST); Baoshan, Tengchong, Sanyun, Chuanlong Cun, on the west side of Gaoligong Shan, 25°00'13" N, 98°43'29" E, 1740 m, 4 November 1998, *Li 11477* (HAST); Chih-tse-lo, 2500 m, 7 September 1933, *Tsai 54180* (A), 3200 m, 11 September 1934, *Tsai 58473* (A), *Tsai 58488* (A); Dehong, Yingjiang, Xima, Qincaidagou, 24°44'44" N, 97°44'27" E, 1730 m, 3 November 2002, *Peng 19152* (HAST); Lincang, Fengxiang Zhen, 23°53'09" N, 100°10'28" E, 2100 m, 7 November 2002, *Peng 19192* (HAST); Nujiang, Fugong, Lishadi, Mi'eluo Cun, east side of Gaoligong Shan, 27°15'56" N, 98°52'14" E, 1500 m, 12 August 2005, *Gaoligong Shan Biodiversity Survey 27354* (HAST); Nujiang, Fugong, Lishadi, Ziguduo Cun, east side of Gaoligong Shan, 27°11'45" N, 98°52'57" E, 1610 m, 14 August 2005, *Gaoligong Shan Biodiversity Survey 27531* (HAST); Nujiang, Fugong, Maji, along the west side of the Nujiang River, east side of Gaoligong Shan, 27°17'40" N, 98°52'18" E, 1320 m, 19 August 2005, *Gaoligong Shan Biodiversity Survey 27882* (HAST); Nujiang, Fugong, Lumadeng, west side of the Nujiang River, 27°05'56" N, 98°52'21" E, 1225 m, 9 May 2004, *Gaoligong Shan Biodiversity Survey 19739* (HAST); Nujiang, Fugong, Lumadeng, Yaduo Cun, east side of Gaoligong Shan, 27°07'48" N, 98°52'40" E, 1090 m, 22 August 2005, *Gaoligong Shan Biodiversity Survey 28901* (HAST); Nujiang, Fugong, Yueliangshi, 1600 m, 13 August, 2011, *Peng 23278* (HAST); Nujiang, Gongshan, 27°48'05" N, 98°34'07" E, 1900 m, 18 September 1997, *Li 9240* (MO), *Li 9241* (MO); 1800-2000 m, 19 September 1997, *Li 9276* (MO); Nujiang, Fugong, 26°54' N, 98°51' E, 1600-1700 m, 30 September 1997, *Li 9784* (MO); Nujiang, Gongshan, Cikai Zhen, east side of the Gaoligong Shan, 1600 m, 20 July 2000, *Li 12974* (HAST); Nujiang, Gongshan, Dulongjiang, on the east side of the Dulong Jiang River, 27°42'40" N, 98°20'50" E, 1460 m, 30 October 2004, *Gaoligong Shan Biodiversity Survey 21127* (HAST); Nujiang, Gongshan, Dulongjiang, on the west side of Gaoligong Shan, 2340 m, 27°43'53" N, 98°24'10" E, 2 November 2004, *Gaoligong Shan Biodiversity Survey 22113* (HAST); Nujiang, Gongshan, Cikai, Vicinity of Yimaluo Cun, east side of Gaoligong Shan, 27°39'28.5" N, 98°42'41.5" E, 1520 m, 14 August 2006, *Gaoligong Shan Biodiversity Survey 33333* (HAST); Shang-pa Hsien, 2100 m, 25 September 1933, *Tsai 56624* (A); Shang-pa Hsien, 1600 m, 2 October 1933, *Tsai 54748* (A), 2200 m, 17 September 1933, *Tsai 54261* (A), 2800 m, 10 October 1934, *Tsai 58684* (A), 2000 m, 30 October 1934, *Tsai 59105* (A).

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## References

- Bentham, G. (1852) *Florula Hongkongensis: an enumeration of the plants collected in the Island of Hong-Kong. Hooker's Journal of Botany and Kew Garden Miscellany* 4: 116–123.
- Chung, K.-F., Leong, W.-C., Rubite, R., Repin, R., Kiew, R., Liu, Y. & Peng, C.-I. (2014) Phylogenetic analyses of *Begonia* sect. *Coelocentrum* and allied limestone species of China shed light on the evolution of Sino-Vietnamese karst flora. *Botanical Studies* 55: e1.  
<http://dx.doi.org/10.1186/1999-3110-55-1>
- Don, D. (1825) *Prodromus florae Nepalensis*. J. Gale Press, London, 256 pp.
- Doorenbos, J., Sosef, M.S.M. & Wilde, J.J.F.E. de (1998) The sections of *Begonia* including descriptions, keys and species lists (Studies in Begoniaceae VI). *Wageningen Agricultural University Paper* 98 (2): 1–266.
- Frodin, D.G. (2004) History and concepts of big plant genera. *Taxon* 53: 753–776.  
<http://dx.doi.org/10.2307/4135449>
- Golding, J. & Karegeannes, C.E. (1984) *Begonia* nomenclature notes 7. *Phytologia* 54: 493–499.
- Golding, J. & Wasshausen, D.C. (2002) *Begoniaceae*, Edition. Part 1: Annotated species list; Part II: Illustrated key, abridgement and supplement. *Contributions from the United States National Herbarium* 43: 1–289.
- Gu, C.-Z., Peng, C.-I. & Turland, N.J. (2007) *Begoniaceae*. In: Wu, Z.-Y., Raven, P.H. & Hong, D.-Y. (Eds.) *Flora of China*, vol.13 (*Clusiaceae through Araliaceae*). Science Press & Missouri Botanical Garden, Beijing & St. Louis, Missouri, pp. 153–207.



- Hance, H.F. (1883) Three new Chinese begonias. *Journal of Botany, British and Foreign* 21: 202–203.
- Hughes, M. & Pullan, M. (2007) Southeast Asian *Begonia* database. Electronic publication. Available from: <http://elmer.rbge.org.uk/begonia/> (accessed 7 September 2015)
- Irmscher, E. (1939) Die Begoniaceen Chinas und ihre Bedeutung für die Frage der Formbildung in polymorphen Sippen. *Mitteilungen aus dem Institut für Allgemeine Botanik in Hamburg* 10: 431–557.
- Irmscher, E. (1951) Some new Chinese species of *Begonia*. *Notes from the Royal Botanic Garden Edinburgh* 21: 35–45.
- Kiew, R. (2001) The limestone begonias of Sabah, Borneo—Flagship species for conservation. *Gardens' Bulletin Singapore* 53: 241–286.
- Linnaeus, C. (1753) *Species plantarum, exhibentes plantas rite cognitatas, ad genera relatas, cum differentiis specificis, nominibus trivialibus, synonymis selectis, locis natalibus, secundum systema sexuale digestas*, vol. 1. Salvius, Stockholm, 1200 pp.  
<http://dx.doi.org/10.5962/bhl.title.59734>
- Nylander, J.A.A. (2004) MrModeltest v2.3 Program distributed by the author. Evolutionary Biology Centre, Uppsala University.
- Peng, C.-I., Chen, Y.-K. & Yen, H.-F. (1988) *Begonia ravenii* (Begoniaceae), a new species from Taiwan. *Botanical Bulletin of Academia Sinica* 29: 217–222.
- Ronquist, F. & Huelsenbeck, J. P. (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models, version 3.1. 2. *Bioinformatics* 19: 1572–1574.  
<http://dx.doi.org/10.1093/bioinformatics/btg180>
- Tamura, K., Peterson, D., Peterson, N., Stecher, G., Nei, M. & Kumar, S. (2011) MEGA5: molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. *Molecular Biology and Evolution* 28: 2731–2739.  
<http://dx.doi.org/10.1093/molbev/msr121>
- Tebbitt, M.C. (2005) *Begonias: cultivation, identification and natural history*. Timber Press, Portland, 336 pp.
- Zuur, A.F., Ieno, E.N. & Elphick, C.S. (2010) A protocol for data exploration to avoid common statistical problems. *Methods in Ecology and Evolution* 1: 3–14.  
<http://dx.doi.org/10.1111/j.2041-210X.2009.00001.x>