



## The true identity of the *Gymnosphaera gigantea* (Cyatheaceae) in China

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### Abstract

The scaly tree fern widely accepted as *Gymnosphaera gigantea* in China is demonstrated to be a separate species, *G. henryi*. Our field observations show that *G. henryi* is a good species and is readily recognized by the combination of stipe bearing 2-rowed scales throughout, pinnae being sessile, and most or at least lower pinnae being opposite on rachis. However, *G. gigantea* is different in stipe without 2-rowed scales above the base and pinnae being more or less petiolate and mostly alternate on rachis. *Gymnosphaera henryi* is common in southern and southwestern China and Vietnam and is currently known also in Laos and Myanmar.

**Keywords:** misidentification, morphology, taxonomy, tree fern

### Introduction

The scaly tree fern *Gymnosphaera gigantea* (Wall. ex Hook.) S.Y. Dong (2019: 87) was originally described as *Alsophila gigantea* by Hooker (1844: 53) based on collections from Bangladesh and Nepal (*Wallich 321*, K). There are a dozen sheets of *Wallich 321* distributed in herbaria BM, K, L, LE, S, and UC, each containing fragments of fronds, such as a complete or incomplete pinna, a part of rachis with several basal parts of pinnae, or fragments of pinnae. These original materials do not show the stipe of this species, which was considered important to distinguish *G. gigantea* and related species in China (Xia 1989, Zhang 2004, Dong 2009, Zhang & Nishida 2013).

*Gymnosphaera gigantea* was first reported to occur in China (Hainan and Yunnan) by Holttum in 1965 when he revised *Cyathea* Sm. *s.l.* from Asia. Xia (1989) firstly revised Cyatheaceae in China and confirmed *G. gigantea* in southern and southwestern China (then using *Alsophila gigantea* Wall. ex Hook.), listing many specimens from Hainan and Yunnan. According to Xia (1989), the distinct character to recognize *G. gigantea* in China is the stipe and rachis bearing copious straight scales which are in two rows and spreading outwards. One of the present authors (Dong) had made extensive field surveys of Cyatheaceae in Hainan in 2000s and noticed that the characteristic stipe, namely stipe in its whole length bearing two rows of spreading scales, is very stable in Hainan populations of *G. gigantea*. Along with the scaly stipe, additional diagnostic features of *G. gigantea* in Hainan were found to be that all pinnae are sessile and at least the lower pinnae are always opposite on the rachis (Dong 2009). These characters were further confirmed to be correlated with each other and stable in *G. gigantea* during our field surveys of scaly tree ferns in Guangdong (Zuo *et al.* 2016), Yunnan, and Vietnam.

In recent years when trying to sort out the taxonomic confusion on *G. gigantea* in Southeast Asia, we realized that the *G. gigantea* in China may not be the true *G. gigantea*, because the conspicuous feature found in the *G. gigantea* from China and Vietnam, the stipe bearing two rows of spreading scales, was not used by Holttum (1965) in the key to species and, especially, the *G. gigantea* from either Thailand or Sri Lanka was not reported having scales on the upper part of stipe (Philcox 2006, Lindsay & Middleton 2012). Then in September 2019 we made a trip to Sylhet,

Bangladesh, the type locality of *G. gigantea*, and made sure that the true *G. gigantea* is a separate species from the one applied as *G. gigantea* in China.



**FIGURE 1.** Habitat and morphology of *Gymnosphaera henryi* (Baker) S.R. Ghosh from Yunnan, China (Voucher: *S.Y. Dong 4288* at IBSC). A, habitat. B, a frond, showing lateral pinnae being sessile and opposite on rachis. C, stipes, showing spreading scales regularly in two rows. D, part of two pinnules on a costa, showing V-shaped sori.



**FIGURE 2.** Habitat and morphology of *Gymnosphaera gigantea* (Wall. ex Hook.) S.Y. Dong from Sylhet, Bangladesh (Voucher: S.Y. Dong 5197 at IBSC). A, habitat. B, a frond, showing lateral pinnae being petiolate and alternate on rachis. C, stipes, showing no scales in two rows above the base. D, part of two pinnules, showing V-shaped sori.



**FIGURE 3.** Comparison of *Gymnosphaera henryi* (Baker) S.R. Ghosh (A) with 2-rowed scales throughout stipe, lowest pinnae being sessile and opposite, and *G. gigantea* (Wall. ex Hook.) S.Y. Dong (B) without 2-rowed scales on stipe (A: *Rock 2032* at US, B: *Wallich 180* at K; both from Myanmar).

## Taxonomic treatment

*Gymnosphaera henryi* (Baker) S.R. Ghosh in Ghosh *et al.* (2004: 200), Figs. 1, 3A.

Basionym:—*Alsophila henryi* Baker (1898: 229).

≡ *Cyathea henryi* (Baker) Copeland (1909: 38).

Type:—CHINA. Yunnan: Mengtze, *A. Henry 11451* (lectotype, designated here, K-000061684!; isolectotypes: BM-001048268!, E-00385949!, GH-00020413!, K-000061683!, K-000061685!, MO-255953!, NY-00127893!, NY-00127894!, US-00055262!, US-00065495!).

Synonym:—*Cyathea pectinata* Ching & S.H. Wu in Ching & Wang (1964: 365). Type: CHINA. Hainan: Mt. Wuzhishan, *C. Wang 35217* (holotype, IBSC-0003121!).

Synonym:—*Cyathea petiolulata* Ching & S.H. Wu in Ching & Wang (1964: 365). Type: CHINA. Hainan: Lingshui, in forest of a valley, 16 November 1956, *L. Tang 3162* (holotype, IBSC-0003122!; isotypes: PE-01592997!, HITBC-054144!).

Synonym:—*Cyathea pseudogigantea* Ching & S.H. Wu in Ching & Wang (1964: 365). Type: CHINA. Hainan: Mt. Wuzhishan, in dense forest of hill-ridge, 800–900 m, 13 November 1954, *Hainan Bot. Exped. 692* (holotype, IBSC-0003123!; isotypes: CDBI-0000944!, IBK-00031970!, PE-01593000!).

Synonym:—*Cyathea tinganensis* Ching & S.H. Wu in Ching & Wang (1964: 366). Type: CHINA. Hainan: Ting-an, 9 January 1934, *H.Y. Liang 64353* (holotype, PE-01895877!).

Synonym:—*Cyathea gigantea* var. *polynervata* Miao (1980: 100), *Alsophila gigantea* var. *polynervata* (Miao) Q. Xia (1989: 11), *Gymnosphaera gigantea* var. *polynervata* (Miao) Y.K. Yang & J.K. Wu in Gong *et al.* (2002: 21). Type: CHINA. Hainan: Mt. Jianfengling, in dense forest of a valley, 800 m, May 1962, *P. Zeng 13132* (holotype, SYS!).

**Diagnostic characters:**—Low or semi-arboreal tree fern, rarely up to 3.5 m; scales marginate; stipe spineless, covered with copious scales throughout; some scales borne on abaxial side of scales, others on lateral sides on adaxial side and regularly spreading outside; lamina 2-pinnate-pinnatifid; pinnae sessile, at least lower pinnae opposite on rachis; costae and costules abaxially covered with minute lanceolate or scurfy scales; veins simple; sori in V-shape on pinnule-lobes; indusia lacking; 64 spores per sporangium.

**Specimens examined:**—CHINA. **Guangdong:** Enping, 16 September 2017, *S.Y. Dong 4743* (IBSC); Foshan, 19 September 2017, *S.Y. Dong 4754* (IBSC); Gaozhou, 15 April 2016, *S.Y. Dong 4516* (IBSC); Huaiji, 11 November 1933, *W.T. Tsang 23157* (PE); Xinyi, 17 July 1931, *Y.K. Wang 30969* (PE); Yangchun, 18 April 2016, *S.Y. Dong 4531* (IBSC). **Guangxi:** Baise (Bako Shan), 18 September 1928, *R.C. Ching 7547* (PE); Cangwu, 27 July 1956, *S.H. Chen 10163* (PE); Dongxing, 02 August 2018, *S.Y. Dong 4997* (IBSC); Fangcheng, 16 January 2013, *S.J. Wei & Z.H. Dai 45060313011655LY* (GXMG); Jingxi, 03 August 2018, *S.Y. Dong 5005* (IBSC); Napo, 25 May 1989, *Huanan Exped. 1085* (PE); Lingyun, 15 September 1989, *Huanan Exped. 1588* (PE); Longlin, 14 September 2014, *K.W. Luo 121* (IBK); Ningming, 18 October 1958, *C.C. Chang 12387* (IBK); Tianlin, *Tianlin Exped. 451029130428013* (GXMI). **Hainan:** Baisha, 24 February 1936, *S.K. Lau 25438* (PE); Changjiang, 5 April 2002, *S.Y. Dong et al. 113* (PE); Ledong, 29 November 1984, *Q. Xia 5785* (PE); Lingshui, 16 November 1956, *L. Teng 3162* (PE); Tam (Danzhou), 16 May 1929, *W.T. Tsang et al. 192* (PE); Wuzhishan, 5 December 1921, *F.A. McClure 1836* (herb. no. 8344) (US); *ibid.*, 9 December 2005, *Wuzhishan Fern Survey 436* (PE). **Yunnan:** Guangnan, 3 January 1978, *Z.R. Wang 466* (PE); Hekou, 28 October 2017, *S.Y. Dong 4771* (IBSC); Jiangcheng, 23 December 1982, *W.M. Chu et al. 15791* (PE); Jinghong, 23 March 1997, *B.G. Li 9703115* (PE); Jinping, 29 October 2017, *S.Y. Dong 4783* (IBSC); Lüchun, 03 November 2017, *S.Y. Dong 4814* (IBSC); Menghai, July 1936, *C.W. Wang 76878* (PE); Mengla, 23 October 2015, *S.Y. Dong 4288* (IBSC); *ibid.*, 04 November 2017, *S.Y. Dong 4821* (IBSC); Mengzi, in 1893, *W. Hancock 169* (US); Pingbian, 26 October 2017, *S.Y. Dong 4758* (IBSC).

MYANMAR. **San State:** Keng Tung, 25–29 January 1922, *J.F. Rock 2032* (US), *2041* (P, US), & *2153* (P, US).

LAOS. **Champasak:** Bolaven Plateau, November 1938, *E. Poilane 28456* (P). **Khammouane:** Nakay Village, Phou Ar. (Dan Feuang), 31 October 2007, *S.K. Wu & J.Y. Xiang WS-157* (KUN). **Houaphan:** Sam Neua, 14 October 1920, *M. Poilane 2071* (P). Without locality, March 1877, *F.J. Harmand 1361* (P).

VIETNAM. **Ha Giang:** Du Gia Mun., Yen Minh Distr., 28 December 2004, *S.K. Wu et al. WP759* (KUN). **Hanoi:** Mt. Bavi, August 1887, *B. Balansa 1862* (P); *ibid.*, 7 November 1936, *Petelot 5768* (HNU). **Khanh Hoa:** Son Thai, Khanh Vinh, 25 December 2014, *C.W. Chen Wade4161* (TAIF). **Kon Tum:** Sa Son Mun., Sa Thay Distr., 15 November 2003, *S.K. Wu et al. WP024* (KUN). **Lao Cai:** Sa Pa, 17 November 2017, *S.Y. Dong 4839* (IBSC). **Quang Binh:** Hoa Son Comm., Minh Hoa Distr., 17 August 2011, *N.T. Hiep et al. CPC4394* (HNU). **Quang Tri:** Huong Lap Comm., Huong Hoa Distr., 05 May 2011, *L. Averyanov et al. CPC2790* (HNU). **Tuyen Quang:** Na Hang Nature Reserve, 20 November 2017, *S.Y. Dong 4856* (HNU, IBSC). **Thua Thien-Hue:** Huong Son Comm., Nam Dong Distr., 28 March 2005, *L. Averyanov et al. HAL7074* (HNU). **Vinh Phuc:** Tam Dao Nature Reserve, 22 November 2017, *S.Y. Dong 4869* (IBSC). **Yen Bai:** Con Voi, 24 March 1960, *Nguyen 4090* (HNU).

**Distribution and Habitat:**—Currently known in S & SW China, Myanmar, Laos, and Vietnam; terrestrial in lowland forest or montane forest, frequently occurring along streams in valleys, alt. 0–1500 m.

**Notes:**—*Alsophila henryi*, the basionym of *Gymnosphaera henryi*, was previously neglected or misinterpreted to be *G. gigantea* by authors who treated the taxonomy of scaly tree ferns from China (e.g., Xia 1989, Zhang 2004, Zhang 2006, Dong 2009, Zhang & Nishida 2013).

As mentioned above, *G. henryi* is strikingly different from *G. gigantea* in the stipe throughout bearing two rows of spreading scales, all pinnae being sessile, and at least lower pinnae opposite on rachis (Figs. 1, 3A). In contrast, in *G. gigantea* the scales are not regularly arranged on either side of stipe above the base, and the pinnae are all petiolate and are never stably opposite (Figs. 2, 3B). The type of *G. henryi* (*Henry 11451*), as well as that of *Cyathea gigantea* var. *polynervata* Miao (1980: 100), were from extraordinarily large fronds of this species, showing larger pinnules than normal size and thus having more (8–10 pairs) veins in ultimate lobes. Normally in this species there are 6–7 pairs of veins on pinnule-lobes and the cases of a lobe with 8–10 pairs are rare or occasional, which cannot be used to recognize species.

The types of *Cyathea pectinata* Ching & S.H. Wu, *C. petiolulata* Ching & S.H. Wu, *C. pseudogigantea* Ching & S.H. Wu, and *C. tinganensis* Ching & S.H. Wu were all from Hainan Island and apparently represent a single species (Xia 1989, Zhang 2004, Dong 2009, Zhang & Nishida 2013), as they are highly consistent in the stipe throughout bearing two rows of spreading scales, sessile and opposite pinnae, blackish stipe and rachis, and the characteristic V-shaped sori. Actually, the types of these four names are representatives of average-sized *G. henryi*, having slightly smaller pinnae and somewhat fewer veins (6–7 pairs) on ultimate lobes than the type of *G. henryi* (*Henry 11451*).

According to the examination of herbarium collections and our surveys in the wild, *G. henryi* is now known in southern and southwestern China, Laos, Myanmar, and Vietnam. Holttum (1965) tentatively identified two specimens from Sikkim as *C. henryi* (= *G. henryi*) and mentioned that those two specimens might belong to a distinct species. Just based on the two specimens from Sikkim and the comments by Holttum (1965), *Alsophila gammiei* was proposed as a distinct species by Dixit (1992). As the Sikkim specimens are currently not available to us, the distinctness of *A. gammiei* remains uncertain. The report of *Gymnosphaera henryi* in India (Ghosh *et al.* 2004) needs to be confirmed.

It is necessary to point out here that the samples of *G. gigantea* in the phylogenetic studies conducted by Dong & Zuo (2018) and Dong *et al.* (2019) are actually the samples of *G. henryi*, as the first author then did not confirm the distinctness of *G. henryi* from *G. gigantea*. These two studies, the Dong & Zuo (2018) based on plastid sequences while the Dong *et al.* (2019) based on nuclear sequences, supported *G. henryi* is closely related to *G. glabra* Blume (1828: 242), *G. andersonii* (J. Scott. ex Beddome 1866: 310) Ching & S.K. Wu in Wu (1983: 54), and *G. metteniana* (Hance 1868: 175) Tagawa (1951: 94). The samples named *G. glabra* in Dong & Zuo (2018) and Dong *et al.* (2019) might be correctly named *G. gigantea* (at least the samples from Vietnam should be corrected to be *G. gigantea*), because the present author (Dong) then did not confirm the misapplication of *G. gigantea* and thus identify the samples that resemble *G. gigantea* but lacking 2-rowed scales on stipe as *G. glabra*.

***Gymnosphaera gigantea*** (Wall. ex Hook.) S.Y. Dong (2019: 87), Figs. 2, 3B.

Basionym:—*Alsophila gigantea* Wall. ex Hooker (1844: 53).

≡ *Cyathea gigantea* (Wall. ex Hook.) Holttum (1935: 318).

Type:—BANGLADESH (Sylhet) or NEPAL, *N. Wallich 321* (lectotype, selected by Holttum [1963: 124], K-001044558!).

Synonym:—*Alsophila umbrosa* Wall. ex Ridley (1926: 6). Type: MALAYSIA. Penang, *N. Wallich 336* (lectotype, designated here, K-000636525!; isolectotypes, K-000636526!, K-001109846!, K-001109847!).

**Diagnostic characters:**—Low or semi-arboreal tree fern, trunks rarely up to 1 m; scales marginate; stipe spineless, with copious scales on the basal part, without 2-rowed scales above the base; lamina 2-pinnate, with pinnules shallowly or lobed half way to costules; pinnae mostly shortly petiolate, rarely sessile, alternate or rarely lower 1–2 pairs opposite; costae and costules abaxially bearing scurfy scales; veins simple; sori in V-shape; indusia lacking; 64 spores per sporangium.

**Specimens examined:**—BANGLADESH. **Bandarban:** Ruma, 24 January 2017, *K.K. Islam 915* (DACB); **Chittagong:** Chittagong Hill Tracks, in 1876, *J.L. Lister s.n.* (P); Mirrersharai, Chittagong, 22 December 1996, *M.K. Pasha 37* (DACB); Tankaboti, Cox's Bazar, 21 October 1996, *M.K. Pasha 55* (DACB). **Moulvibazar:** Adampur, Kamalgang, 20 September 2011, *S.N. Uddin 4717* (DACB); Amampur, Sreemangal, 22 September 2019, *S.Y. Dong 5183, 5184 & 5191* (IBSC); Lowachera, Sreemangal, 1 February 1986, *M.S. Khan & M.M.K. Mia 7572* (DACB); *ibid.*, 9 June 2000, *M.S. Khan & M.M.K. Mia 10758* (DACB); *ibid.*, 8 May 1997, *A.M. Huq & A.I. 10510* (DACB). **Rangamati:** Farua Chara, 17 April 2009, *M.M. Mirza 958* (DACB). **Sylhet:** on the way from BTRI to Lowachera, 19 May 2005, *M.M. Mirza 563* (DACB); Khadimnagar National Park, 23 September 2019, *S.Y. Dong 5197* (IBSC).

MYANMAR.—**Mon State:** Kyain, Moulmein (Mawlamyine), February 1938, 30–150 m, *F.G. Dickason 6854 & 6860* (US). **Kachin State:** Putao, 27°43'35"N, 98°52'19"E, 870–1050 m, 14–17 March 2009, *X.F. Gao et al. 2142 & 2484* (IBSC), *Xia et al. 1711* (IBSC); Myitkyina, 12 January 1958, 150 m, *H.S. McKee 6036* (US). **Tanintharyi:** without precise locality, in 1827, *N. Wallich* Num. List 180 (K); Kambauk, 125 m, 17 October 1998, *J.F. Maxwell 98-1161* (L).

INDIA.—**Kerala:** Ponmudi, Trivandrum, 17 March 2007, *C.R. Fraser-Jenkins FN59* (TAIF). **Meghalaya:** Mawmluh, E Khasi Hills Distr., 21 November 2008, *C.R. Fraser-Jenkins FN180* (TAIF). **Assam:** in 1834, *Griffith s.n.* (P-01349766). **Sikkim:** in 1859, *J.D. Hooker s.n.* (P).

INDONESIA.—**Java:** Central Java: Kampung Baru, 11 March 1894, *V. Schiffuer 8256* (BO); West Java: Calobak Bunung Salak, Bogor, 24 December 2019, *S.Y. Dong 5213* (IBSC); Sukamantri, Bogor, 29 December 1923, *R.C. Bakhuizen 3121 & 6274* (BO). **Sumatra:** Atjeh, N Sumatra, 4 September 1971, *K. Iwatsuki et al. s-1693* (BO).

MALAYSIA.—**Penang:** Penang, 1 May 1925, *R.E. Holttum 19340* (BO).

NEPAL.—**Gorkha:** Aanbu Khairani, 18 September 2004, *C.R. Fraser-Jenkins 30791* (TAIF); Deurali, 9 October 2008, *C.R. Fraser-Jenkins FN224* (TAIF).

SRI LANKA.—**Nuwara Eliya:** Ramboda, 25 October 2005, *Janssen 3027* (P); *ibid.*, 17 December 1950, *G. Ballard 1153* (P). District unknown: New Peradeniya to Gadawela road, 28 October 1967, *P.L. Comanor 508* (P).

THAILAND.—**Chanthaburi**: Khlong Khruie Wai Wildlife Sanctuary, 11 January 2009, *D.J. Middleton et al.* 4683 (P).

VIETNAM.—**Dak Lak**: Nam Kar Nature Reserve, 27 November 2017, *S.Y. Dong* 4883 (HNU, IBSC). **Dak Nong**: Dak Mil, *Schmid* 158 (P); Nam Nung Nature Reserve, 28 November 2017, *S.Y. Dong* 4893 (IBSC).

**Distribution**:—Bangladesh, Bhutan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Nepal, Sri Lanka, Thailand, and Vietnam.

**Notes**:—*Gymnosphaera gigantea* is mentioned to be very similar to *G. glabra*, a species recorded in Borneo, Java, Malay Peninsula, and Sumatra (Holttum 1963: 120). After examining herbarium specimens of *G. gigantea* across its whole range (from NE India to Java Island) and all specimens identified as *G. glabra* by Holttum in BO, the present author (Dong) did not find a morphological character which can distinguish *G. gigantea* from *G. glabra*. Holttum had used several different characters to distinguish these two species in different articles, such as 1) pinnules being stalked or sessile and the number of veins (3–5 versus 5–6 pairs) (Holttum 1935: 299); 2) costal scales bearing lateral setae or not, the shape of ultimate segments of lamina (round and subentire vs. deltoid and toothed), the distribution of sori (extending to apices of segments or not), and the arising of the basal basicopic vein (from costule vs. costa) (Holttum 1963: 116); and 3) the cutting depth of pinnules (less than halfway vs. halfway to costa), the arrangement of sori on segments (not V-shaped vs. V-shaped), and the arising of the basal basicopic vein (from costule vs. costa) (Holttum 1965: 6). However, these characters (or their states) are generally continuous instead of clearly discrete and are less reliable for species recognition, except for the costal scales bearing setae and the arising of the basal basicopic vein. The scales bearing lateral setae or not seems to be a good character, however, Holttum (1963: 120) just described the scales on costae as “few, ...often bearing a few dark setae for *Cyathea glabra* (= *G. glabra*) and two years later he no longer mentioned this character when distinguishing *G. glabra* from *G. gigantea* (Holttum 1965). The report of the setae on costal scales seems questionable. The present author (Dong) did not find any clear lateral setae on costal scales when checking the specimens identified as *G. glabra* by Holttum in BO. As for the position from which the basal basicopic veins arise, according to my extensive observations in Southeast Asia and the description of *G. gigantea* in Nepal, they may arise either from the pinnule costa (costule) or from the lobe-midrib (Fraser-Jenkins *et al.* 2015: 151). This character is variable in *G. gigantea* and thus cannot be used to recognize species in *Gymnosphaera*. Further studies, especially the observations in the field of Java and nearby areas, are needed to decide whether *G. glabra* is conspecific with *G. gigantea*.

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