



Systematic placement of *Elsholtzia griffithii* (Nepetoideae, Lamiaceae), a new record from China

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Abstract

Elsholtzia griffithii, the first record in Guangxi Province, China, is described and illustrated in detail. We provided the most updated phylogeny of *Elsholtzia* based on two nuclear ribosomal DNA regions (ITS, ETS) to resolve the phylogenetic placement of this species. Our study reveals that *E. griffithii* is most closely related to *E. cyprianii* but differs from it by having linear bracts ≥ 4 mm and distinctively longer than flowers (vs. bracts ≤ 3 mm in *E. cyprianii*) and calyx teeth unequal, two anterior lobes shorter than three posterior lobes (vs. five lobes equal in length). In addition, monophyly of *Elsholtzia* was strongly supported and three clades were recognized, whereas all sections and series were not recovered as monophyletic, indicating that reclassification is needed at higher taxonomic levels.

Keywords: Elsholtzieae, Lamiaceae, Nepetoideae, Molecular phylogeny

Introduction

Elsholtzia Willdenow (1790: 3) is a morphological diverse genus of herbs, shrubs, and small trees (Willdenow 1790; Wu & Li 1977) and comprises ca. 40 species (Li & Hedge 1994; Charkevich 1995; Lee 2000; Xiang & Liu 2012; Pu *et al.* 2012; Chang *et al.* 2014; Chen *et al.* 2016). The genus is distinguished from other members of its tribe (Elsholtzieae) by the combination of the following morphological characters: flowers forming a dense, cylindrical, sometimes secund, spiciform thyrse that is usually composed of several-flowered cymes or verticillasters; and bracts usually ovate or flabellate to minute (Li & Hedge 1994; Harley *et al.* 2004; Jeon *et al.* 2006, 2020; Jang *et al.* 2010). Most species of *Elsholtzia* have an affinity for xeric habitats in thickets, disturbed roadsides, and hot-dry ravines (Li & Hedge 1994).

Although *Elsholtzia* is widely distributed in Europe, North America, and East Asia, most species are restricted to East Asia (Harley *et al.* 2004) and species richness appears to be highest in southwest China (Li & Hedge 1994; Bongcheewin & Chantaranonthai 2008). In total, 31 species were recorded from China, of which 28 species are distributed in southwest China (Huang & Cheng 1978; Chen & Wu 1988; Li 1985, 1987, 1992; Li & Hedge 1994;

Hou 1996; Pu *et al.* 2012; Xiang & Liu 2012; Wu & Li 1977; Wu *et al.* 1977). In China, *Elsholtzia* has long been utilized throughout its range for medicinal and culinary purposes. For example, *E. rugulosa* Hemsley (1890: 278) is used routinely in traditional medicine to treat influenza and fever (Liu *et al.* 2008). In addition, this species is also an important nectar plant and widely used as herbal tea in southwest China (Liu *et al.* 2021; Yang *et al.* 2021). In total, at least 25 species are used as traditional herb in China (Peng & Xiang 2017).

Originally, Bentham (1832–1836) divided *Elsholtzia* into three sections (sect. *Aphanochilus* Bentham (1833: 161), sect. *Cyclostegia* Bentham (1832: 167), and sect. *Elsholtzia* Bentham (1833: 164)) based on the features of inflorescence, bract and corolla. Wu & Huang (1974) maintained the divisions proposed by Bentham (1832–1836), but further divided sect. *Aphanochilus* into two subsections based on the presence of narrowly lanceolate bracts, glossy nutlets vs. ovate-orbicular bracts and dull nutlets (i.e. *Stenelasmae* (Briq.) C.Y. Wu et S.C. Huang (1974: 337) and *Platyelasmae* (Briq.) C.Y. Wu et S.C. Huang (1974: 344)). Furthermore, they divided subsect. *Stenelasmae* into eight series based on habit and floral characters. The most recent infrageneric division of *Elsholtzia* was proposed by Press (1982) who recognized three sections. His infrageneric classification is generally similar with Wu & Huang's (1974), but included sect. *Cyclostegia* described by Bentham (1832–1836) in sect. *Elsholtzia*, and raised subsect. *Platyelasmae* erected by Wu & Huang (1974) to the rank of section.

Evolutionary relationships and infrageneric phylogeny of *Elsholtzia* are still not fully comprehended. Pu (2012) produced the most comprehensive samples of *Elsholtzia* which included 31 species. However, only three plastid DNA markers (*psbA*, *trnL-trnF*, and *rbcL*) and nrITS were used and most relationships were poorly resolved. In addition, Pu's (2012) study was reported only in a dissertation, not published in a broadly accessible form. In contrast, Chen *et al.* (2016) and Li *et al.* (2017) have focused on the whole tribe and did not sample *Elsholtzia* broadly. Recently, based on the karyological (Funamoto *et al.* 2012) and molecular data (Chen *et al.* 2016), Mayta-Anco *et al.* (2016) transferred two species of *Elsholtzia* (i.e. *E. flava* (Benth.) Benth. and *E. penduliflora* W.W. Smith) to the newly established genus, *Vuhuangia* Solomon Raju, Molinari and Mayta (2016: 1). However, the relationships between *Vuhuangia* and other genera within Elsholtzieae remain obscure, and the monophyly of most taxonomic units within *Elsholtzia* (i.e. sections, subsections and series) was never tested. Therefore, a comprehensive phylogenetic analysis is still needed for *Elsholtzia* classification.

As part of an ongoing taxonomic and floristic studies on Lamiaceae (e.g. Salimov *et al.*, 2018; Seyedipour *et al.* 2020; Bonsignore *et al.* 2021; Perrino *et al.* 2021; Bongcheewin *et al.* 2022; Turdiboev *et al.* 2022), especially in China (e.g. Xiang & Liu 2012; Chen *et al.* 2014, 2016, 2019; Xiang *et al.* 2016; Hu *et al.* 2017; Zhao *et al.* 2021), we collected some plants of an unknown *Elsholtzia* from Guangxi Province in 2021. After careful examination and morphological comparison between these specimens and other *Elsholtzia* species, and consultation of protologues for all published *Elsholtzia* names, we confirmed that the collected material from Guangxi is *Elsholtzia griffithii* Hooker (1885: 644), which is a new record for the flora of China. In addition, we have noticed that this species has never been included in any previous molecular phylogenetic studies (Pu 2012; Chen *et al.* 2016; Li *et al.* 2017). In order to clarify its systematic position within the genus *Elsholtzia*, we therefore performed an updated molecular phylogenetic study of the genus based on ETS and ITS nrDNA sequences.

Materials and methods

Taxonomic studies

The present study based on herbarium materials of *Elsholtzia* from herbaria BM, CSH, E, G, GXMG, GZTM, HITBC, IBK, IBSC, K, KB, KUN, L, MW, NAS, NY, P, PE, PEY, SZ, US and WUK (Herbarium acronyms follow Index Herbariorum; Thiers 2020). The description of *E. griffithii*, with the comparison of morphologically similar species was carried out based the observation, analyses, and collation of herbarium specimens, materials from our field work, and relevant literature (Wu & Li 1977; Huang & Cheng 1978; Li 1987; Li & Hedge 1994; Charkevicz 1995; Xiang & Liu 2012; Lee 2000; Pu *et al.* 2012; Choi *et al.* 2012; Chang *et al.* 2014). Measurements and morphological observations were made under a Leica DM2500 dissecting microscope (Leica Microsystems GmbH, Wetzlar, Germany). Terminology for the description of the newly recorded species followed Li & Hedge (1994).

Taxon sampling and DNA markers

Specimens of *Elsholtzia griffithii* were collected from Huanjiang County, Guangxi Province, SW China (Sun ZP & Xiao JF DC03). The phylogenetic position of *E. griffithii* was explored based on an ingroup sampling comprising

42 accessions representing 34 species of *Elsholtzia*, including two individuals of *E. griffithii*. Only five species, *E. amurensis* Probatova (1995: 374), *E. concinna* Vautier (1959: 43), *E. myosurus* Dunn (1913: 160), *E. pubescens* Benth (1833: 162) and *E. souliei* Léveillé (1911: 218), out of 39 recognized species were not included for analyses in the present study. Two species, *Keiskea japonica* (Miq.) Harley (1865: 105) and *Mosla chinensis* Maximowicz (1883: 805), were selected as outgroup based on previous studies (Chen *et al.* 2016; Li *et al.* 2017).

TABLE 1. The list of studied species information and GenBank accession numbers, new sequences are marked in “bold”.

Species	Voucher	Collection Location	ITS	ETS
<i>E. angustifolia</i> (Loes.) Kitag.	Kim <i>et al.</i> KJS150051 (KB)	South Korea, Chungbuk	OL332712	OM302248
<i>E. argyi</i> H. Lévl.	Li P PNL120120255 (HZU)	China, Zhejiang, Linan	KY552491	KY552559
<i>E. beddomei</i> C.B. Clarke ex Hook. f.	Chamchumroon <i>et al.</i> s.n. (PBM)	Thailand, Chiang Mai	OL332718	OM302255
<i>E. blanda</i> (Benth.) Benth.	Li P PNL120120028-1 (HZU)	China, Yunnan, Yongde	KY552492	KY552560
<i>E. bodinieri</i> Vaniot	Li P PNL120120404-1 (HZU)	China, Yunnan, Fumin	KY552493	KY552561
<i>E. capituligera</i> C.Y. Wu	Li P PNL120120291-1 (HZU)	China, Yunnan, Shangri-La	KY552494	KY552562
<i>E. cephalantha</i> Hand.-Mazz.	Li P LP150610-1 (HZU)	China, Gansu, Kangle	KY552495	KY552563
<i>E. ciliata</i> (Thunb.) Hyland. 1	Li P PNL120120089 (HZU)	China, Heilongjiang, Yichun	KY552496	KY552564
<i>E. ciliata</i> (Thunb.) Hyland. 2	Kim <i>et al.</i> KJH19623 (KB)	South Korea, Incheon	OL332711	OM302247
<i>E. ciliata</i> (Thunb.) Hyland. 3	Lee J PNL120120474 (HZU)	South Korea, Jeju-do	KY552513	*KY552581
<i>E. ciliata</i> (Thunb.) Hyland. 4	Xiang CL <i>et al.</i> 1249 (KUN)	China, Sichuan, Mianning	OL332714	OM302250
<i>E. communis</i> (Coll. et Hemsl.) Diels	Li P PNL120130568-1 (HZU)	China, Shanghai, Firmenich Aromatics	KY552497	KY552565
<i>E. cyprianii</i> (Pavol.) C.Y. Wu & S. Chow	Li P PNL120120304 (HZU)	China, Yunnan, Yulong	KY552498	KY552566
<i>E. densa</i> Benth. 1	Li P LP150583-1 (HZU)	China, Gansu, Yuzhong	KY552502	KY552570
<i>E. densa</i> Benth. 2	Yuan YM YGY2012-034 (HZU)	China, Gansu, Yuzhong	KY552500	KY552568
<i>E. eriocalyx</i> C.Y. Wu & S.C. Huang	Li P PNL120120300 (HZU)	China, Yunnan, Yulong	KY552504	KY552572
<i>E. eriostachya</i> (Benth.) Benth. 1	Li P PNL120120227-1 (HZU)	China, Sichuan, Xiangcheng	KY552505	KY552573
<i>E. eriostachya</i> (Benth.) Benth. 2	Li P PNL120120227-2 (HZU)	China, Sichuan, Xiangcheng	KY552506	KY552574
<i>E. feddei</i> H. Lévl.	Li P PNL120120190 (HZU)	China, Sichuan, Yajiang	KY552507	KY552575
<i>E. fruticosa</i> (D. Don) Rehder	Li P PNL120120267 (HZU)	China, Yunnan, Eryuan	KY552511	KY552579
<i>E. glabra</i> C.Y. Wu & S.C. Huang	Li P PNL120120332-1 (HZU)	China, Yunnan, Yongsheng	KY552512	KY552580
<i>E. griffithii</i> Hook. f. 1	Sun ZP <i>et al.</i> DC03-1 (KUN)	China, Guangxi, Huanjiang	OL332716	OM302253
<i>E. griffithii</i> Hook. f. 2	Sun ZP <i>et al.</i> DC03-2 (KUN)	China, Guangxi, Huanjiang	OL332717	OM302254
<i>E. heterophylla</i> Diels	Chen YP <i>et al.</i> EM636 (KUN)	China, Sichuan, Xichang	OL332715	OM302251
<i>E. kachinensis</i> Prain	Li P PNL120120266 (HZU)	China, Yunnan, Eryuan	KY552514	KY552582
<i>E. lamprophylla</i> C.L. Xiang & E.D. Liu	Chen YP <i>et al.</i> EM1688 (KUN)	China, Sichuan, Xiangcheng	KY552515	OM302252
<i>E. litangensis</i> C.X. Pu & W.Y. Chen	Li P PNL120120220-1 (HZU)	China, Sichuan, Litang	KY552516	KY552583
<i>E. luteola</i> Diels	Li P PNL120120327-1 (HZU)	China, Yunnan, Yulong	KY552517	KY552584
<i>E. minima</i> Nakai	Lee J PNL120120473 (HZU)	South Korea, Jeju-do	KY552518	KY552585
<i>E. nipponica</i> Ohwi	Funamoto T s.n. *	Japan	OL332710	OM302246
<i>E. ochroleuca</i> Dunn	Li P PNL120120401 (HZU)	China, Yunnan, Fumin	KY552519	KY552586
<i>E. pilosa</i> (Benth.) Benth.	Li P PNL120120201-1 (HZU)	China, Sichuan, Yajiang	KY552523	KY552590
<i>E. pygmaea</i> W.W. Sm.	Sun ZP <i>et al.</i> SZP0039 (KUN)	China, Yunnan, Ninglang	OL332713	OM302249
<i>E. rugulosa</i> Hemsl.	Li P PNL120120005-1 (HZU)	China, Yunnan, Anning	KY552524	KY552591
<i>E. saxatilis</i> (Komarov) Nakai ex Kitagawa	Li P PNL120120060 (HZU)	China, Heilongjiang, Shangzhi	KY552525	KY552592
<i>E. splendens</i> Nakai ex F. Maek.	Li P PNL120120059 (HZU)	China, Heilongjiang, Shangzhi	KY552527	KY552594
<i>E. stachyodes</i> (Link) Raizada & H.O. Saxena	Li P PNL120120295-1 (HZU)	China, Yunnan, Shangri-La	KY552529	KY552596
<i>E. stauntonii</i> Benth.	Yuan YM YGY2012-026 (HZU)	China, Gansu, Dangchang	KY552530	KY552597
<i>E. strobilifera</i> (Benth.) Benth.	Li P PNL120120340 (HZU)	China, Yunnan, Ninglang	KY552531	KY552598
<i>E. winitiana</i> Craib	Li P PNL120120029-1 (HZU)	China, Yunnan, Yongde	KY552532	KY552599
<i>Keiskea japonica</i> Miq.	Tetsuo OT PNL120120049-1 (HZU)	Japan, Koishikawa Botanical Garden	KY552537	KY552605
<i>Mosla chinensis</i> Maxim.	Li P PNL120120245 (HZU)	China, Hangzhou, Zhejiang	KY552540	KY552609

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The nuclear ribosomal internal and external transcribed spacers (nrITS and ETS) were selected for the phylogenetic reconstruction of *Elsholtzia*, which were used in previous phylogenetic studies of the tribe Elsholtzieae (Chen *et al.* 2016; Li *et al.* 2017) and have more informative sites than plastid DNA markers. Voucher information for newly sequenced taxa and GenBank accession numbers for all sequences used in this study are provided in Table 1.

DNA extraction and amplification

Total DNA was extracted from silica-gel-dried leaf material or herbarium samples using the modified CTAB method (Doyle & Doyle 1987). The primer pairs ETS-B (Beardsley & Olmstead 2002) and 18S-IGS (Baldwin & Markos 1998) were used for the amplification of ETS (see also Xiang *et al.* 2013), and 17SE and 26SE (Sun *et al.* 1994) were used for the amplification of ITS. The conditions of the Polymerase chain reaction (PCR) procedure were followed as described by Chen *et al.* (2016).

Sequence alignment and phylogenetic analysis

Sequences were assembled by Geneious v.11.0.4 (Kearse *et al.* 2012), and then aligned using MAFFT (Kato & Standley 2013), and manually adjusted using PhyDE-1 (Müller *et al.* 2010) when necessary.

Bayesian Inference (BI) method was used for phylogenetic reconstruction on the Cyberinfrastructure for Phylogenetic Research Science (CIPRES) Gateway (<http://www.phylo.org/>; Miller *et al.* 2010), using MrBayes v.3.2.6 (Ronquist *et al.* 2012). Detailed settings and parameters for BI analyses followed those described in our previous study (Chen *et al.* 2019). The best-fit nucleotide substitution models were selected under the Akaike Information Criterion (AIC) using jModelTest v.3.7 (Posada 2008) and the model GTR+I+G was selected. The trees were visualized and edited using FigTree v1.4.3 (Rambaut 2016), and posterior probability (PP) values were annotated above or near branches. Supported values for strongly, moderately and weakly supported were defined as Chen *et al.* (2019).

Results

In total, 84 nrDNA sequences were included in phylogenetic analyses and 19 sequences were newly sequenced in the present study (Table 1). The aligned nrDNA data matrix was 1044 nucleotides in length (ITS, 643 bp; ETS, 401 bp).

All *Elsholtzia* samples were recovered as a well-supported clade (1.00), and three strongly supported clades were recovered (Fig. 1). Clade I consisted of three taxa from *E.* sect. *Aphanochilus*. Within this clade, *E. eriostachya* (Benth.) Bentham (1833: 163) was sister to *E. cephalantha* Handel-Mazzetti (1934: 90) and *E. densa* Bentham (1835: 714). Clade II was composed of 10 species from *E.* sect. *Aphanochlus*. All species in this clade were members of *E.* sect. *Aphanochlus*. Within this clade, *E. rugulosa* is the first branch, then subsequently followed by a subclade (1.00) composed of *E. blanda* (Benth.) Bentham (1833: 162), *E. beddomei* C.B. Clarke ex Hooker (1885: 643), *E. winitiana* Craib (1918: 368) and a subclade (1.00) consisting of *E. capituligera* C.Y. Wu (1959: 49), *E. stachyodes* (Link) C.Y. Wu (1974: 340), *E. pilosa* (Benth.) Bentham (1833: 63), *E. communis* (Coll. et Hemsl.) Diels (1912: 47), *E. cyprianii* (Pavol.) C.Y. Wu & S. Chow (1974: 343), and the focal species of this study, *E. griffithii*. Clade III was the largest clade consisting three primary subclades, two of which consisted of species of distinctly different habit type. Subclade III-i (1.00) consisted of *E. heterophylla* Diels (1912: 231) and *E. bodinieri* Vaniot (1904: 176), which are perennial herbs, subclade III-ii (1.00) consisted of seven species that are shrubs, and subclade III-iii (1.00) consisted of 13 species that are annual herbs.

Discussion

As currently defined (Cantino 1992; Chen *et al.* 2016; Mayta-Anco *et al.* 2016; Zhao *et al.* 2021), eight genera (*Collinsonia* L., *Elsholtzia* Willd., *Keiskea* Miq., *Mosla* (Benth.) Buch.-Ham. ex Maxim., *Ombrocharis* Hand.-Mazz., *Perilla* L., *Perillula* Maxim., and *Vuhuangia* Solomon Raju, Molinari and Mayta) were placed within Elsholtzieae, of which *Elsholtzia* is the largest genus within the tribe (Zhao *et al.* 2021). We used two nuclear DNA regions to provide the most comprehensive phylogenetic reconstruction of *Elsholtzia*, which represents over 90% of the genus and all sections *sensu* Wu & Huang (1974).

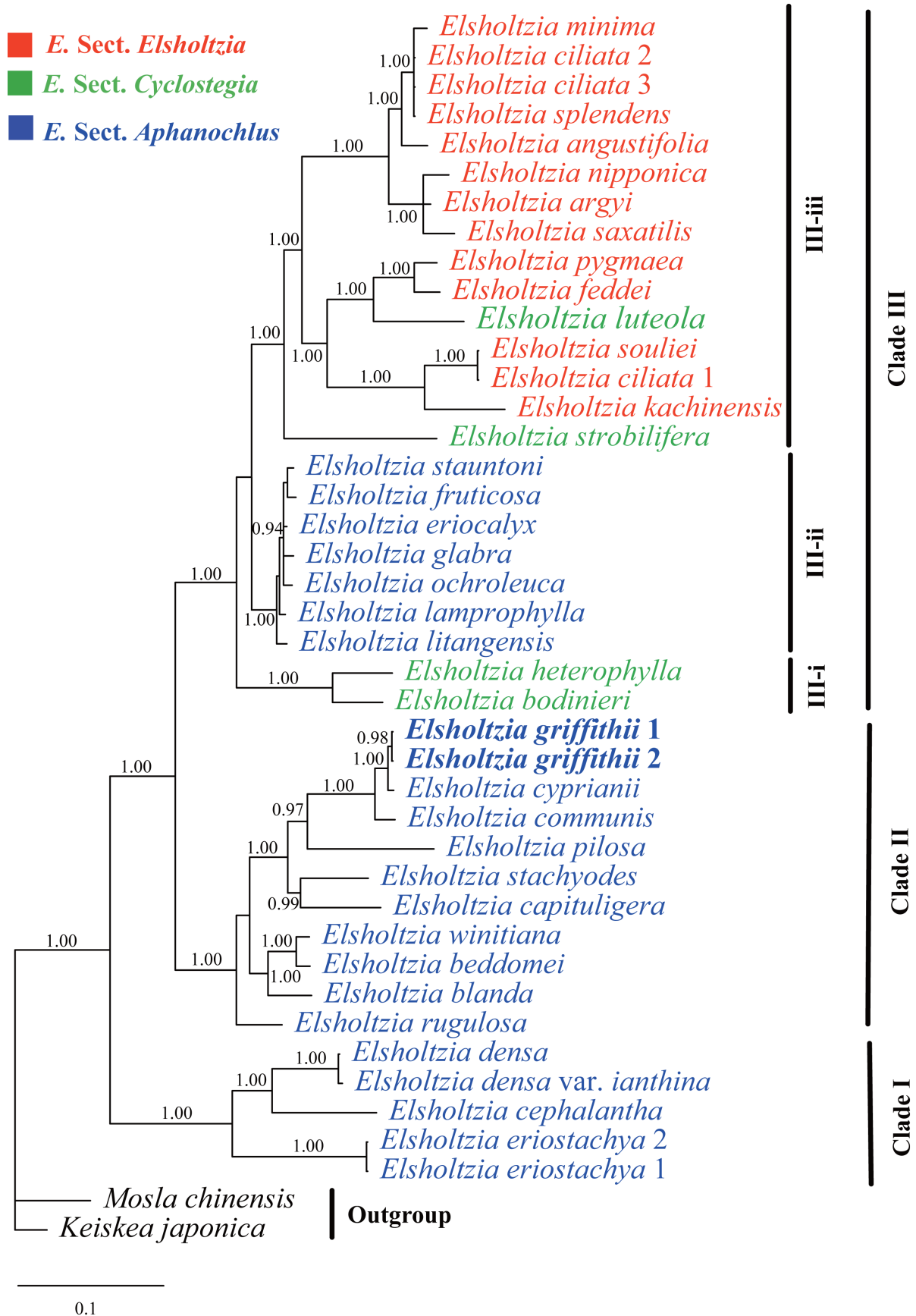


FIGURE 1. Bayesian 50% majority-rule consensus tree of *Elsholtzia* based on combined nuclear (ITS and ETS) dataset. Scale bar denotes the expected number of substitutions per site in Bayesian analysis. Support values < 0.90 PP are not displayed.

Elsholtzia is monophyletic and structured as three clades, which has similarly been reported by previous studies (Chen *et al.* 2016; Li *et al.* 2017; Zhao *et al.* 2021). Using five chloroplast (*rbcL*, *matK*, *trnL-F*, *ycf1*, *ycf1-rps15*) and two nuclear DNA regions (ETS, ITS), Li *et al.* (2017) carried out a phylogenetic study of the tribe Elsholtzieae, and the topology of *Elsholtzia* is overall comparable to our study. They recognized four subclades for the genus *Elsholtzia* (subclades I, II, III, IV), but we identified three major clades (Fig. 1). Subclades I and II in their study were identified as two subclades separately within Clade III (Fig. 1) in the present study. The major difference is that *E. bodinieri* was placed in subclade I in the study of Li *et al.* (2017). Whereas, we found that *E. bodinieri* and *E. heterophylla* are recovered as one subclade in this study (i.e. subclade III-i; Fig. 1). The possible reason for this difference in placement is that we included more species (35 species of *Elsholtzia*), especially the morphologically distinct species, *E. heterophylla*, which was not included for analyses in Li *et al.*'s (2017) study. In contrast, our previous study (Chen *et al.* 2016) also found that *E. heterophylla* and *E. bodinieri* consistently grouped together in all analyses.

In comparison with Li *et al.*'s (2017) study, the difference of the placement of *E. bodinieri* might be caused by the topological incongruence between cpDNA and nuclear trees. Besides two nuclear DNA regions (nrITS, ETS), Li *et al.* (2017) also used five chloroplast DNA markers, but the phylogeny were reconstructed based on the combined data. Actually, Li *et al.* (2017) have detected significant incongruences between cpDNA and nrDNA datasets using ILD test, however, no separate phylogenetic trees were provided therein. Using the same DNA regions (*ycf1*, *rps15-ycf1*, *trnL-F*, *rpl32-trnL*, nrITS, ETS) for the phylogeny reconstruction of the tribe Elsholtzieae, we have (Chen *et al.* 2016) also found topological incongruence between plastid tree and nuclear phylogenies. Therefore, future studies involving next-generation sequencing and increased taxon sampling are needed to provide insights into the complex evolutionary history of this group.

The reconstructed phylogeny based on nuclear DNA sequence data coincided with no infrageneric entities based on gross morphology. Wu & Huang (1974) divided *Elsholtzia* into three sections based primarily on characteristics of habit, leaf shape, and bract morphology. However, none of the sections traditionally defined by morphology are monophyletic (Fig. 1), and species of each section were scattered through the phylogeny and appeared in three clades. Species in Clades I and II are members of the section *Aphanochlus*, while Clade III is composed of species from all three sections. Thus, the infrageneric classification of *Elsholtzia* should be revised on the basis of a robust phylogenetic reconstruction inferred from additional molecular data and more complete samplings, as well as morphological and ecological characters.

In our phylogenetic analyses, two individuals of *E. griffithii* are deeply nested within Clade II. All species in this clade have linear or lanceolate bracts, and glossy mericarps. Species in Clade I usually have ovate or orbicular bracts, and puberulent mericarps. As mentioned above, Clade III is the largest group within *Elsholtzia* and species have diversified morphological characters. For example, *E. heterophylla* and *E. bodinieri* in subclade III-i have broadly flabellate bracts that are densely overlapping, but bracts of species in subclade III-ii are (broadly) ovate (*E. kachinensis* Prain (1904: 206), *E. ciliata* (Thunb.) Hylander (1941: 129), *E. pygmaea* W.W. Smith (1920: 204), *E. saxatilis* (Komarov) Nakai ex Kitagawa (1937: 266), and *E. nipponica* Ohwi (1936: 180)), circular (*E. feddei* Diels (1911: 218), *E. argyi* Léveillé (1910: 425), *E. angustifolia* (Loes.) Kitagawa (1937: 265), and *E. splendens* Nakai ex F. Maekawa (1934: 50)), and united into a shallow cup and densely overlapping (*E. strobilifera* Benth (1833: 163), *E. luteola* Diels (1912: 232)). Further studies are required to clarify character evolutionary trend in this group.

Because all sections are non-monophyletic, and based on our phylogenetic study, we can conclude that *E. griffithii* is most closely related to *E. cyprianii*. This connection is also supported by some morphological features, including annual herbs, cylindrical inflorescence, dense cover of glandular trichomes on the abaxial leaf surface (Fig. 2). Because *E. griffithii* is a new record species in China, we provide a morphological description of this species and updated data on its distribution.

Taxonomic treatment

Elsholtzia griffithii Hooker (1885: 644, Fig. 2).

Type:—East Bengal, the late East India Company, *Griffith W.*, 3975 (holotype: K!; isotype: P!).

Diagnostic characters:—*Elsholtzia griffithii* Hook. f. is morphologically similar to *E. cyprianii* (Pavol.) S. Chow ex Hsu, but can be distinguished from the former by its lanceolate bracts exceeding the flowers, 3.0–4.0 mm long; five calyx-lobes unequal, of which anterior two lobes shorter than three posterior lobes (vs. bracts up to 3.0 mm, generally shorter than flowers, calyx teeth equal in *E. cyprianii*).

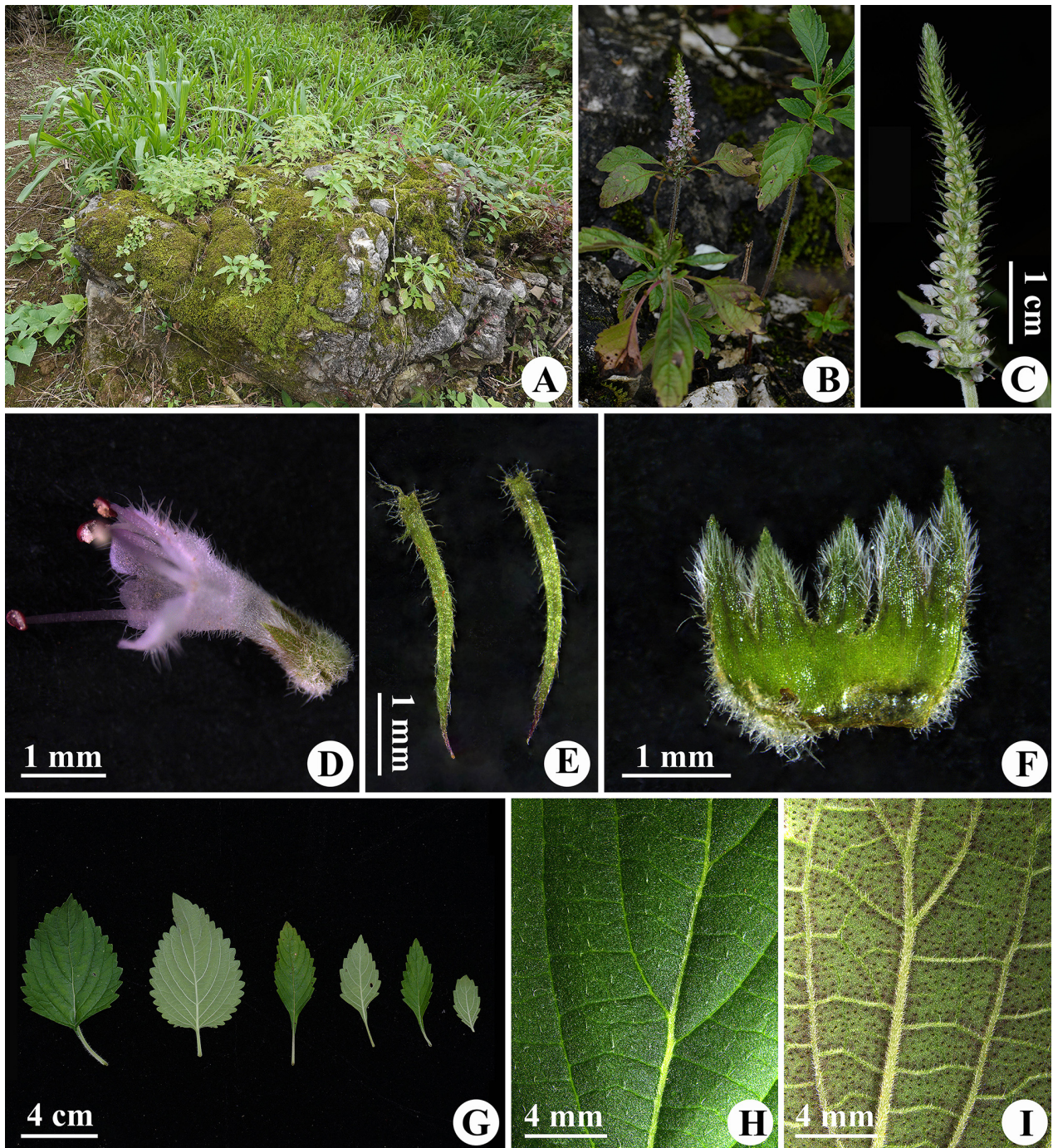


FIGURE 2. *Elsholtzia griffithii*. **A.** Habitat; **B.** Plant; **C.** Inflorescence; **D.** Flower; **E.** Bracts; **F.** Calyx; **G.** Leaves; **H.** Adaxially leaf; **I.** Abaxially leaf. B-C and G, photographed by J.F. Xiao; A, D-F, H-I, photographed by Z.P. Sun.

Herbs annual, 15–60 cm tall. Stems simple, erect, 4-angled, densely retrorse pubescent or villous. Leaves opposite; petiole 0.5–2.0 cm; leaf blade oblong to ovate-oblong, 2.0–8.0 cm × 1.0–2.5 cm, herbaceous, adaxially dark green, puberulent, abaxially densely pubescent, glandular, base broadly cuneate, decurrent, midrib prominent abaxially, lateral veins 4–6 paired, margin crenate-serrate to coarsely serrate, apex acute. Spikes cylindrical, 8–15 × 0.5–1.0 cm, terminal, retrorse white pubescent; verticillasters compact; bracts lanceolate, 3.5–4.0 mm long, exceeding the flowers; pedicel nearly absent. Calyx green, tubular-campanulate, ca. 1.8 mm, densely white pubescent outside, teeth 5, lanceolate, ca. 0.8 mm long, anterior 2 calyx lobes shorten, and the posterior frontal lobe is longer than two lateral lobes. Corolla reddish or white, 2–2.5 mm, pubescent and glandular outside, glabrous inside; 2-lipped, upper lip entire or emarginate, middle lobe of lower lip circular, lateral lobes semicircular, margin entire. Stamens 4, straight, exserted from upper lip of corolla, 2 anterior stamens much longer, 3.0–3.5 mm long, filaments filiform, glabrous. Style much exserted, 2.5–3.0 mm as long as posterior pair of stamens, apex equally two-cleft.

Phenology:—Flowering from May to August, fruiting from August to October.

Distribution and Habitat:—Bangladesh, China (Guangxi), India, Korea, Myanmar, Nepal, Thailand (Bongcheewin & Chantaranothai 2008; Hong *et al.* 2021). *Elsholtzia griffithii* is currently known from Huanjiang County of Guangxi Province in southern China. It grows on the rocks of field or on the roadside at an altitude of 264–314 m, together with *Bidens pilosa* Linnaeus (1753: 832), *Acalypha australis* Linnaeus (1753: 1004), *Oxalis corniculata* Linnaeus (1753: 435), *Cayratia japonica* (Thunb.) Gagnepain (1911: 349) etc. *Elsholtzia griffithii* is known only in two locations in Huanjiang County, Guangxi, further exploration may result in the discovery of additional localities for this species.

Common name (assigned here):—Chang Bao Xiang Ru (长苞香薷; Chinese name).

Additional specimens examined of *Elsholtzia griffithii*:—CHINA. Guangxi Province: Huanjiang County, Chuanshan, near the ancient road of Xiazhai village, 25°8'39.53"N, 108°3'5.43"E, on the rock of field, alt. 264 m, 18 May 2021, *Sun ZP and Xiao JF DC03* (KUN); Huanjiang County, Chuanshan, on the way from Shangbaidan village to Mulun Nature Reserve, roadside, alt. 314 m, 19 Jun. 2021, *Sun ZP and Xiao JF DC06* (KUN).

Additional specimens examined of *Elsholtzia cypranii*:—CHINA. Guangxi Province: Jingxi County, Sanhe, Damengtun village, alt. 980 m, 27 Sep. 2010, *Huang et al. LYJX0786* (IBK); Jingxi County, Tongling large barranca, alt. 390 m, 8 Dec. 2015, *Zhang et al. s.n.* (PE); Tianlin County, Langping, Nongyang village, alt. 1300 m, 30 Nov. 2012, *Tian Lin Exped. 451029121130030* (GXMG). Jiangxi Province: Xiushui County, Dachun, near Yangjinyunkeng village, alt. 689 m, 28 Oct. 2014, *Tan et al. 2125* (KUN). Sichuan Province: Mianning County, alt. 1820 m, 30 Oct. 1993, *Zhao ZC 5345* (PE). Yunnan Province: Eryuan County, Dengchuan to Eeyuan on the way, alt. 2050 m, 10 Oct. 2012, *Xiang CL 521* (KUN); Kunming City, Panlong District, Xiaoshao village, alt. 2350 m, 19 Oct. 2019, *Sun ZP and Zhang BY SZP0006* (KUN); Nanjian County, Gonglang, near Luodihe hydroelectric dam, alt. 1210 m, 30 Dec. 2015, *Liu et al. 4627* (KUN); Yangbi County, Shangpingpo, alt. 1854 m, 29 Nov. 2007, *Pu CX and Chen WY 2007157* (KUN); Wenshan City, near Wenshanzhuli street, 1404 m, 5 Nov. 2007, *Chen WY, Ji YH and Pu CX 2007105* (KUN); Yingjiang County, near Pugahe bridge, alt. 710 m, 14 Dec. 2012, *Guo et al. 12CS5292* (KUN); Dali City, Jizu mountain, alt. 2231 m, 28 Nov. 2007, *Pu CX and Chen WY 2007154* (KUN).

Additional specimens examined of *Elsholtzia communis*:—CHINA. Yunnan Province: Honghe City, Lvchun County, Pinghe, alt. 990 m, 15 Feb. 2008, *Li R and Zhang HX DZL-253* (KUN); Menghai County, Jingpozuzhai village, alt. 1600 m, 18 Dec. 1986, *Huang ZX 38948* (KUN); Mengla County, alt. 590 m, 27 Nov. 1957, *Cai XT 80429* (KUN, PE).

Additional specimens examined of *Elsholtzia pilosa*:—CHINA. Yunnan Province: Eryuan County, Jiulong village, alt. 2100 m, 11 Oct. 2012, *Xiang CL et al. 537* (KUN); Heqing County, Maer mountain, alt. 2546 m, 5 Oct. 2010, *Sun et al. SunH-07ZX-3153* (PE); Kunming City, Panlong District, Xiaoshao village, alt. 2350 m, 19 Oct. 2019, *Sun ZP and Zhang BY SZP0005* (KUN); Shilin County, Shidulin, alt. 2300 m, 12 Sep. 1958, *Wang WC 226* (KUN); Songming County, alt. 2200 m, 9 Oct. 1940, *Zhang YB 0017* (IBSC). Tibet: Jilong County, Jipu village, 2745 m, 15 Sep. 2019, *Chen et al. EM1208* (KUN); Medog County, alt. 2250 m, 24 Sep. 1982, *Li BS and Chen SJ 01045* (PE); Baxoi County, on the way from Ranwu to Zayü, alt. 2702 m, 14 Sep. 2012, *Hu et al. 1209064* (KUN).

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