

Lysimachia septemfida (Primulaceae), a new species from Yunnan, China



Ze-huan Wang^a, Xi-wen Li^a, En-de Liu^{a,*}, Fa-zhi Shangguan^a, Xue-ke Chang^b

^a Key Laboratory for Plant Diversity and Biogeography of East Asia, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, China

^b Nanjian Administration Bureau of Wuliangshan National Nature Reserve, Nanjian 675700, China

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ABSTRACT

A new species, *Lysimachia septemfida* (Primulaceae), from Yunnan (Southwest China) is described and illustrated. The new species exhibits several unusual characters in *Lysimachia* including lack of a corolla, 7-merous flowers, leaves in whorls of 3 and distinct multicellular nodiferous hairs, which make it readily distinguishable from all other species in this genus. The diagnostic differences between this new species and its suppositive allies are given. In addition, the systematic placement of this new species is also discussed based on an ITS molecular tree.

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1. Introduction

Lysimachia L. belongs to the tribe Lysimachieae Reich. and is commonly recognized as a primitive group of traditional Primulaceae (Chen and Hu, 1989; Fang, 2003). Based on the subsequent molecular phylogenetic analyses and morphological studies, *Lysimachia* and other genera of the tribe Lysimachieae have been transferred to the traditional family Myrsinaceae (Anderberg and Ståhl, 1995; Anderberg et al., 1998, 2002, 2007; Källersjö et al., 2000; Mast et al., 2001), and then moved back to Primulaceae but as members of subfamily Myrsinoideae (Stevens, 2016).

Lysimachia is the largest genus of the tribe Lysimachieae and contains approximately 140–200 species worldwide (Hu and Kelso, 1996; Ståhl and Anderberg, 2004; Heywood et al., 2007; Mabberley, 2008). China, as one of its famous diversity centers, has about 140 species (Chen and Hu, 1979, 1989; Hu and Kelso, 1996; Zhou et al., 2015). The paraphyly of traditional *Lysimachia* has been reported by several studies (Martins et al., 2003; Hao et al., 2004; Anderberg et al., 2007; Zhou et al., 2015). For monophyly, the other genera of the tribe Lysimachieae (i.e. *Glaux* L., *Trientalis* L., *Anagallis* L., *Asterolinon* Hoffmanns. & Link, *Pelletiera* A. St.-Hil.) need to be

merged in (Manns and Anderberg, 2009), leaving *Lysimachia* s.l. as the sole genus in this tribe.

During a plant survey of Nanjian Yi Autonomous country (Yunnan Province, China) in 2015, a distinct flowering population was found. The whole plant, especially the upper part of the stem and inflorescence, was coated with distinct multicellular nodiferous hairs. Moreover, several other characters made taxonomic assignment, even at the family level, extremely difficult. These characters include: leaves in whorls of 3, the terminal racemes, distinct bracts, 7-merous flowers, only one layer of half-divided tepals and long exerted stamens. Fortunately, we later found another two conspecific fruiting specimens collected in Xinping Yi Autonomous County (Yunnan) in 2009. These specimens indicate that they may belong to the family Primulaceae. Further studies of morphological characters and molecular phylogenetic relationships showed that the newly found population represented an undescribed species of *Lysimachia* s.l., which is described and illustrated below.

2. Materials and methods

The morphological description of the new species was based on careful examination of the types. The comparison between it and the two morphologically related species (*Lysimachia thyrsoflora* and *Glaux maritima*) was based on studies of the herbarium species in KUN.

* Corresponding author.

E-mail address: liuende@mail.kib.ac.cn (E.-d. Liu).

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The pollen grains and seeds were directly mounted on aluminum stubs coated with gold in a sputter coater and examined using scanning electron microscopy (SEM) as in Xiang et al. (2013). Pollen terminology follows Erdtman (1960), Bennell and Hu (1983). Seed terminology follows Oh et al. (2008).

Because the new species exhibited distinct morphological characters, we adopted a molecular approach to shed light on the position of *L. septemfida* within *Lysimachia* s.l. Bayesian and Maximum Likelihood analyses were used to construct a phylogenetic tree based on ITS sequences. GenBank sequences were selected to represent all the subgenus names of *Lysimachia* s.str., and cover all the three Chinese species of the other three genera (*Glaux*, *Trientalis*, *Analgalis*) of the tribe Lysimachieae. DNA extraction, PCR amplification, sequence alignment and phylogenetic reconstruction follow protocols detailed in Wang et al. (2013).

3. Results

3.1. Taxonomic treatment

Lysimachia septemfida Z.H. Wang & E.D. Liu, **Sp.nov.** (Fig. 1) 七齿珍珠菜 (qī chí zhēn zhū cài).

Type: CHINA. Yunnan province, Nanjian Yi Autonomous county, Baohua town, Yongzheng village, Mt. Wuliang, peak of

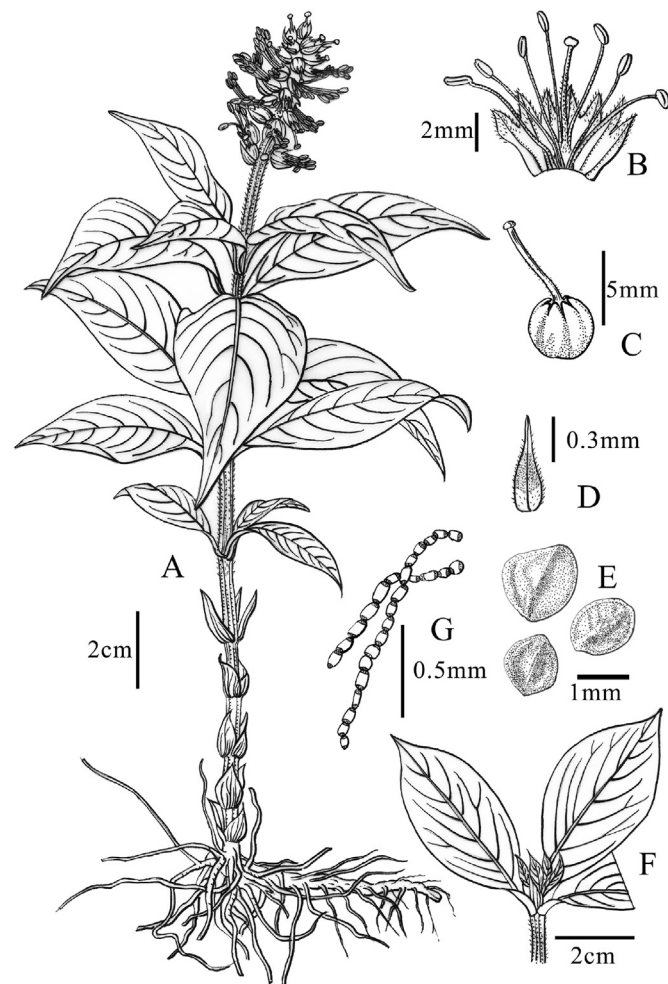


Fig. 1. *Lysimachia septemfida*. A. Flowering plant; B. Opened flower; C. Fruit with persistent style; D. Bract; E. Seeds; F. Leaves in whorls of 3; G. Multicellular nodiferous hairs.

Dazhongshan. 24°50'08.56"N, 100°25'17.90"E. Alt. 2790 m. 2015-06-28, Liu En-de et al. 4178 (holotype KUN; isotypes KUN, IBSC).

Perennial herbs or subshrubs, 25–150 cm tall, horizontal rhizomes densely with roots. Stems erect, usually simple, lower part glabrous, upper part densely with yellowish transparent multicellular nodiferous hairs. Leaves on lower part opposite, reduced to be scalelike, glabrous, and gradually become whorls of 3 and normal upwards. Leaves sessile, rarely indistinctly petiolate; leaf blade ovate-lanceolate to elliptic-lanceolate, 4–9 × 1.5–3.5 cm, with black glandular spots punctuated on both sides and yellowish transparent multicellular nodiferous hairs on the adaxial veins, lower part tapering toward semi-clasping base, apex acute to acuminate, margin entire. Racemes terminal, dense and floriferous, 2–3 cm long, elongating to 7 cm in fruit; peduncle 0.3–2 cm, with yellowish transparent multicellular nodiferous hairs; flowers sessile. Bracts ovate-lanceolate, 5–7 mm, with sparse yellowish glandular punctuate and marginal fringe-like multicellular nodiferous hairs abaxially. Calyx yellowish white, sub-transparent, shorter than bract; Calyx tube 3 mm; lobes 7, triangular, 1.5 mm, apex acuminate, sparsely with yellowish glandular spots outside and marginal fringe-like multicellular nodiferous hairs. Corolla absent. Stamens 7, long exerted, almost twice as long as calyx; anthers elliptic, dorsifixed, ca. 1–1.5 mm; pollen spheroidal, tricolporate, medium-sized [27.24 (24.28–29.29) × 23.04 (21.54–24.50) μm], P/E = 1.07 (Fig. 2A–D). Ovary and style both with yellowish transparent multicellular nodiferous hairs; style 4–5 mm in length, persistent. Capsule globose, ca. 3 mm in diam., dehiscent by valves. Seed dorsiventrally and laterally flattened (Fig. 2 E&G). Flowering in June, fruiting in September.

3.1.1. Diagnosis

The new species shares most characters with *Glaux* (*G. maritima*) and *Lysimachia* subgen. *Naumburgia* (*L. thyrsoiflora*) (Table 1). It is probably related to *G. maritima* by their apetalous flowers (i.e. corolla absent, calyx half divided, persistent and surrounded the capsule), but differs from the latter by its 7-merous flowers, leaves in whorls of 3 and the distinct multicellular nodiferous hairs. Otherwise, given their shared characters of non-5-merous flowers and furry fells, it is probably related to *L. thyrsoiflora*, but the absent corolla, terminal raceme and the arrangement of leaves in whorls of 3 makes it readily distinguishable from the latter (Chen and Hu, 1989; Hu and Kelso, 1996; Fang, 2003).

3.1.2. Other specimens examined

CHINA. Yunnan province, Xiping Yi Autonomous county, Gasa town, Mt. Ailao, Yuenanjin. 23°59'59"N, 101°33'36"E. Alt. 2400 m, 2009-09-14, Wang Jia-he XPALSC518 (KUN, Paratype).

3.1.3. Distribution and habitat

Lysimachia septemfida is currently known from two separate localities in Yunnan, China (Fig. 3). It grows among shrubs on the peaks of mountains (Fig. 4) or in mountain valleys.

3.1.4. Etymology

The specific epithet "septemfida" is derived from the 7-merous flowers of the new species, indicating the calyx is 7-lobed. The "septem-" is a Latin prefix, which means "seven"; the "-fidus" is a Latin suffix, which means "half lobated".

3.1.5. Conservation status

To date, *Lysimachia septemfida* has only been collected from two separate locations in Yunnan, China. Its distribution range still needs further investigation to assess whether it is endangered. It is, therefore, classified as Data Deficient (DD) in the IUCN Red List (IUCN Standards and Petition Subcommittee, 2014).

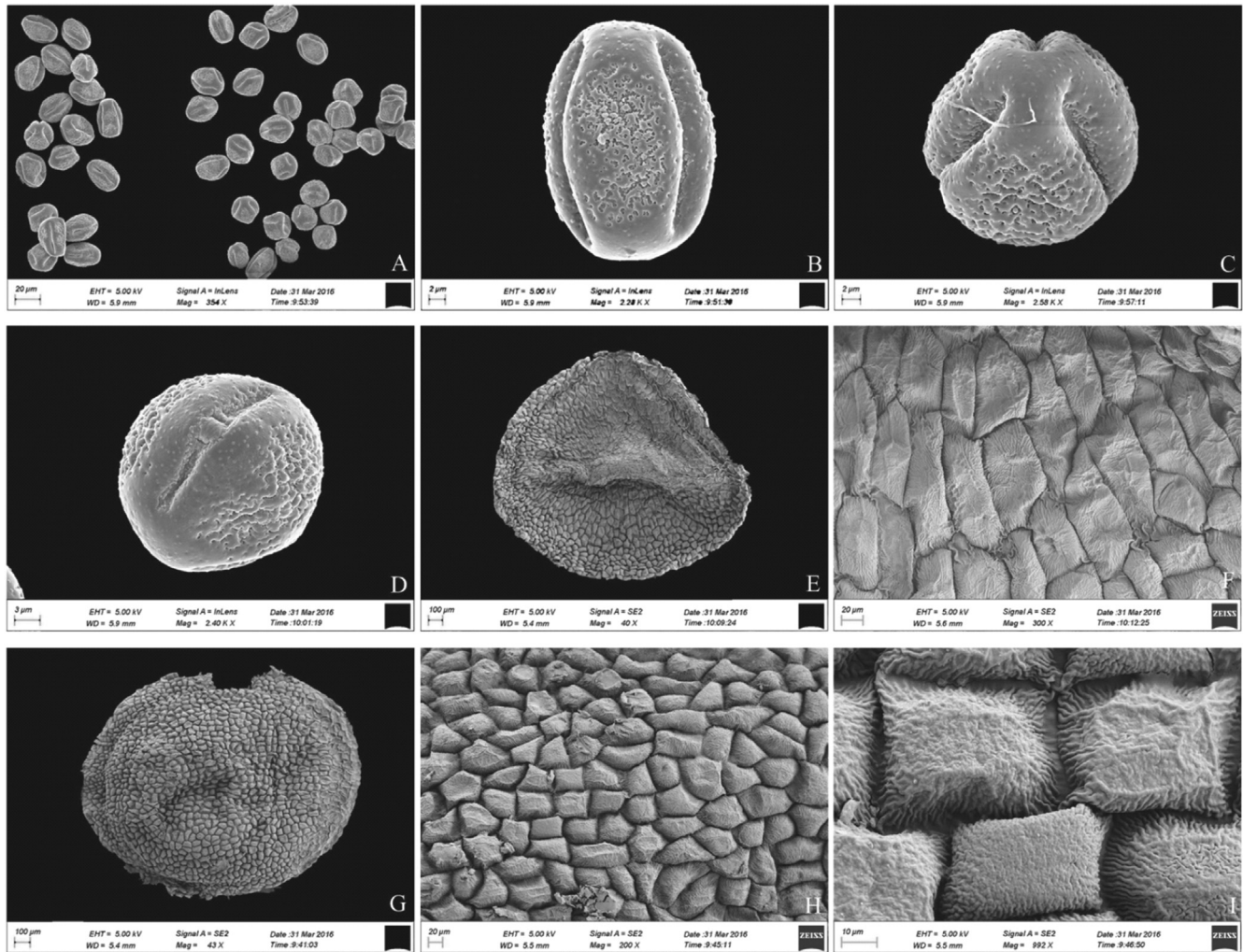


Fig. 2. Scanning electron microscope (SEM) images of *Lysimachia septemfida*. A–D: Pollen grain (A. Overall view; B. Equatorial view; C. Polar view; D. Aperture). E–I: Seed (E. Ventral view; F. Ornamentation of ventral side; G. Dorsal view; H&I. Ornamentation of dorsal side).

Table 1

Characters comparison between the new species and the genera of the tribe Lysimachieae. The new species shares most characters with *Glaux* (*G. maritima*) and *Lysimachia* subgen. *Naumburgia* (*L. thysiflora*), and their shared characters are bolded.

Taxa (NO. of species in China)	Stem ¹	Phyllotaxy ²	Inflorescence ³	Flower merous	Pedicel	Calyx ⁴	Corolla	S/C ⁵
<i>Anagallis</i> (1)	(+)	O, W	S	5	Obvious	Green, B	Present	–1
<i>Glaux</i> (1)	0	A, O	S	5	Almost absent	White/Pink, M	Absent	0
<i>Lysimachia</i> Subgen. <i>Idiophyton</i> (38)	(+)	A, O, W	S, TR, AR	5	Obvious	Green, B	Present	–1
Subgen. <i>Lysimachia</i> (56)	(+)/+	A, O, W	S, TR	5	Obvious	Green, B	Present	–1
Subgen. <i>Palladia</i> (36)	(+)/+	A, O, W	TR	5	Obvious	Green, B	Present	0
Subgen. <i>Heterostylandra</i> (1)	0	R	TR	5	Obvious	Green, B	Present	0
Subgen. <i>Naumburgia</i> (1)	+	O, basal scalelike	AR	6–7	Almost absent	Green, B	Present	+1
<i>Trientalis</i> (1)	0	F	S	7	Obvious	Green, B	Present	0
<i>Lysimachia septemfida</i> (1)	+	W, basal scalelike	TR	7	Almost absent	Yellowish white, M	Absent	+1

Note: 1. Stem: “0” completely glabrous; “(+)” generally glabrous; “+” with multicellular nodiferous hairs. 2. Phyllotaxy: “A” alternate; “O” opposite; “W” whorl; “F” fasciated; “R” rosulate. 3. Inflorescence: “S” solitary; “TR” terminal raceme; “AR” axillary raceme. 4. Calyx: “B” split to the base; “M” almost half lobated. 5. S/C = Comparison of stamen and corolla length: “–1” stamen obviously shorter than corolla; “0” stamens almost equal to corolla; “+1” stamen obviously longer than corolla.

3.2. Phylogenetic reconstruction

Both Bayesian and Maximum Likelihood analysis generated congruent results and the Bayesian 50% consensus tree is shown in Fig. 5. The new species is deeply nested in *Lysimachia* s.str., clustering with *Glaux maritima* and one subclade of *L.* subgen. *Lysimachia* (Clade C2), with weak support value (ML < 50; BI = 0.9).

4. Discussion

4.1. Paraphyly of *Lysimachia* s.str. and its subgenus classification

Our present data confirmed the paraphyly of both *Lysimachia* s.str. and its present subgenus classification, which is in accordance with previous studies based on both morphology and molecular

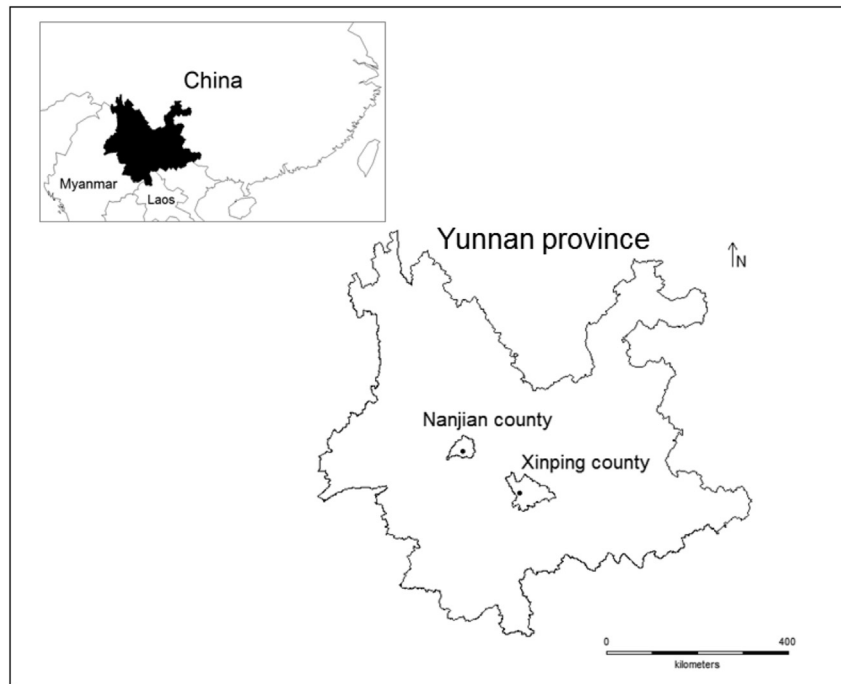


Fig. 3. Distribution map of *Lysimachia septemfida*.



Fig. 4. *Lysimachia septemfida* in the wild (Mt. Wuliang, Nanjian Yi Autonomous county, Yunnan province, China), photographed by SHANGGUAN Fa-zhi. A: microhabitat; B: plant; C: inflorescens.

data (Anderberg and Ståhl, 1995; Källersjö et al., 2000; Hao and Hu, 2001; Martins et al., 2003; Hao et al., 2004; Anderberg et al., 2007; Zhou et al., 2015).

The Chinese *Lysimachieae* contains four genera (i.e. *Lysimachia* s.str., *Glaux*, *Trientalis* and *Anagallis*), with the latter three being monotypic (Chen and Hu, 1989; Hu and Kelso, 1996). The largest *Lysimachia* s.str. can be divided into 5 subgenera, i.e. *L.* subgen. *Idiophyton* Hand.-Mazz., *L.* subgen. *Lysimachia*, *L.* subgen. *Palladia* (Moench) Hand.-Mazz., *L.* subgen. *Heterostylandra* (Hand.-Mazz.) Chen et C. M. Hu and *L.* subgen. *Naumburgia* (Moench) Hand.-Mazz (Chen and Hu, 1989; Fang, 2003). Our molecular phylogenetic study based on ITS sequence (Fig. 5) shows that *Lysimachia* s.str. is mixed with *Anagallis*, *Trientalis* and *Glaux* and it could be divided into four

clades (Clade A–D). *Anagallis* and *Trientalis* form one small clade with weak support values (Fig. 5; ML < 50; BI = 0.93), which is sister to all *Lysimachia* s.str. except the small clade A. The two sequences of *Glaux maritima* form a well-supported subclade (ML = 100; BI = 1), which is deeply nested in *Lysimachia* Clade C and groups with the taxa of *L.* subgen. *Lysimachia* (Clade C2), with weak support values (ML < 50; BI = 0.9). For the subgenus classification, our present data do not corroborate the current subgenus classification of *Lysimachia* s.str., especially *L.* subgen. *Lysimachia*, which was revealed as a heterogeneous assembly of at least five lineages: part of the clade A and B, part of the subclade C2 and the whole subclade C3, conforming its polyphyletic status to previous studies (Hao et al., 2004; Anderberg et al., 2007; Zhou et al., 2015).

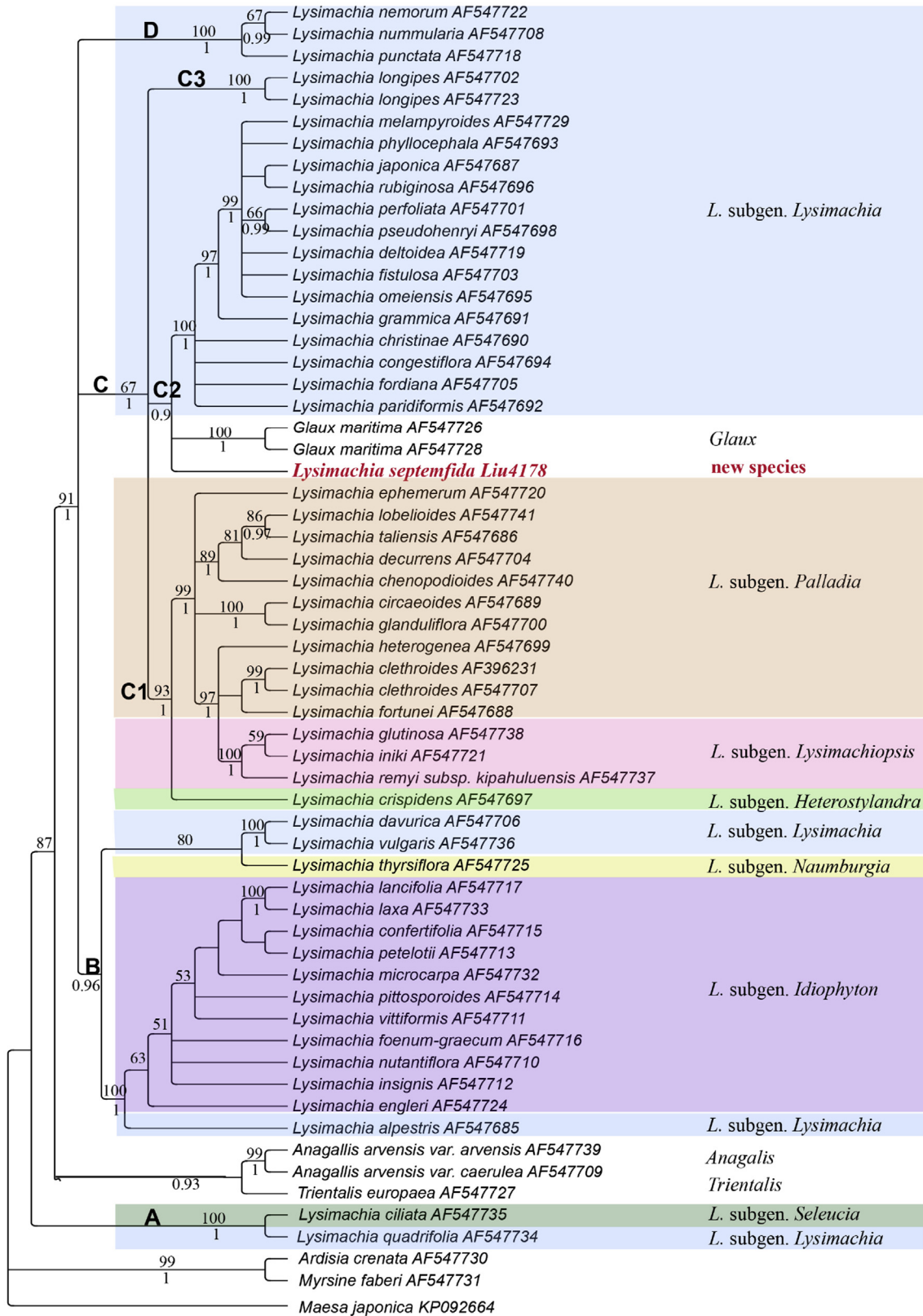


Fig. 5. The Bayesian consensus tree of *Lysimachia* s.l. based on the ITS region. The Bayesian posterior probabilities are shown below the branches and Maximum Likelihood (ML) bootstrap values above. The subgenera of *Lysimachia* s.str. (Hao et al., 2004) are labeled on the right side with different color bar. All the sequences downloaded from the GenBank have species names followed by their accession number.

Further efforts are needed to improve the infrageneric classification of *Lysimachia* s.l.

4.2. Systematic position of the new species

Molecular phylogenetic study based on ITS sequence shows that the new species is deeply nested within the *Lysimachia* s.str. Clade C and groups with *Glaux maritima* and the taxa of *L.* subgen. *Lysimachia* (Clade C2), but with weak support values (Fig. 5; ML < 50; BI = 0.9).

Lysimachia s.str. pollen morphology has previously been reported (Huynh, 1970, 1971; Bennell and Hu, 1983; Ren et al., 1994; Shao and Zhang, 2005). Bennell and Hu (1983) recognized ten major pollen-types and four subtypes. We found that *L. septemfida* pollen is spheroidal, tricolporate, tectum imperforate, and medium-sized [$27.24 (24.28–29.29) \times 23.04 (21.54–24.50) \mu\text{m}$, $P/E = 1.07$]. Furthermore, the pollen morphology of *L. septemfida* is most similar to that of *Glaux maritima* (Halbritter, 2010), which suggests the two species are closely related. Our phylogenetic analysis (Fig. 5) and comparative morphological studies (Table 1) support the close relationship between the two species.

Two seed microfeature types were first recognized for Chinese *Lysimachia* s.str. by Shao et al. (2006) using light microscopy (LM) and scanning electron microscopy (SEM). Oh et al. (2008) investigated the seed morphology of *Lysimachia* s.l. systematically and included 34 species of *Lysimachia* s.str. and 14 species and 2 subspecies of its six related genera (*Anagallis*, *Ardisiandra*, *Asterolinon*, *Glaux*, *Pelletiera*, *Trientalis*), identifying three types of seed shape and six types of seed surface pattern. The sectoroid seed shape is the most common type in *Lysimachia* s.str., which has also been found in *Anagallis*, *Glaux maritima*, and *Asterolinon adoense*. *L. septemfida* seed shape is dorsiventrally and laterally compressed, which is similar to the sectoroid type, but much thinner and more flattened. The seed surface sculpturing of the new species may belong to the colliculate type, which is very rare and has only been found in *L. insignis* thus far. However, *L. septemfida* differs from *L. insignis* in that its seed top surface is much flatter.

Based on the above discussion, we can only preliminarily conclude that *Lysimachia septemfida* is closely related to *Glaux maritima* and some species of *L.* subgen. *Lysimachia*. Due to the incorporation of *Glaux*, *Trientalis*, *Anagallis*, *Asterolinon* and *Pelletiera*, the relationships within *Lysimachia* s.l. remain unresolved. The combination of several distinct characters (Table 1) of *L. septemfida* bar it from being assigned to current subgenera or sections of *Lysimachia* s.str. Therefore, further studies are needed to unveil the systematic position of the new species in *Lysimachia*.

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