Ailuroglossum (Boraginaceae, Cynoglosseae), a New Genus Endemic to Southern China, and a New Species

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Abstract. A new genus, *Ailuroglossum* Sutorý (Boraginaceae), endemic to Sichuan and Yunnan provinces of southern China, is described. It includes two species: *A. triste* (Diels) Sutorý, formerly recognized as *Cynoglossum triste* Diels, and the newly described *A. breviglochidiatum* Sutorý. The genus is distinguished from *Cynoglossum* L. by a combination of characters, including a rhizome rather than a taproot, an almost flat gynobase, narrowly conical style, and discoid stigma, nutlets with perfect separation, without ventral attachment, and hourglass-shaped tricolporate pollen grains. The new species, *A. breviglochidiatum*, is distinguished by its more slender rhizomes with longer internodes, differently shaped leaves, and smaller nutlets with a denser indument of shorter glochids.

Key words: Boraginaceae, China, Cynoglosseae, *Cynoglossum*, endemism, new combination, Sichuan, Yunnan.

The problematics of the generic concept in the largest and taxonomically and morphologically most complex tribe of Boraginaceae, Cynoglosseae, and the position of the genus *Cynoglossum* L. in it are discussed in recent works by Hilger et al. (2015), Weigend et al. (2013), and Chacón et al. (2016). The phylogenies are unresolved. They support either a broad concept of *Cynoglossum*, including other genera such as *Adelocaryum* Brand, *Kuschakewiczia* Regel & M. Smirn., *Lindelofia* Lehm., *Mattiastrum* (Boiss.) Brand, *Paracaryum* (A. DC.) Boiss., *Rindera* Pall., *Solenanthus* Ledeb., and *Trachelanthus* Kunze, or the acceptance of a larger number of genera. There are still many taxa that have not yet been studied, and the construction of the exact limits of groups is not at all satisfying. However, it is evident that *Cynoglossum* as traditionally defined is not monophyletic. In the current author's opinion, a classification of Cynoglosseae recognizing a larger number of small, better-defined genera is preferable.

Eighteen species of *Cynoglossum* have been recognized in China (Zhu et al., 1995). Recent study of *C. triste* Diels, as well as a similar, previously unrecognized species, revealed characters that are inconsistent with placement in *Cynoglossum*. Likewise, none of the characteristics of these species are consistent with those of any recognized segregate genera of *Cynoglossum*. Therefore, a new genus, *Ailuroglossum* Sutorý, is proposed below. *Ailuroglossum* is distinguished by having a rhizome rather than a taproot; a flat gynobase with a narrowly conical style; large puberulous, trapeziform throat scales (fornices); nutlets with glochids primarily confined to the abaxial side, without a disk and lenticular to slightly depressed in lateral view; and perprolate, tricolporate, hourglass-shaped pollen grains in which the three colpori and alternating pori are connected with a transverse groove in the equatorial plane. Some of these characters are merely rare in *Cynoglossum*, while others are otherwise unknown, and their combination is unique within this group of genera. Further discussion is provided later for individual characters as appropriate.

In the Boraginaceae, a rhizome instead of a taproot can be found in the Chinese genera *Brachybotrys* Maxim. ex Oliv., *Mertensia* Roth, *Myosotis* L., *Trigonotis* Steven, and *Sinojohnstonia* H. H. Hu, the only endemic Chinese genus of Cynoglosseae. In descriptions of this tribe not much attention has been given to this character, but it is certainly not common. Brand (1921) mentions it only for *Omphalodes moupinensis* Franch. (≡ *Sinojohnstonia moupinensis* (Franch.) W. T. Wang ex Z. Y. Zhang) and *O. verna* Moench. In *Solenanthus* it is mentioned by Popov (1953) for *S. hirsutus* Regel (≡ *Cynoglossum regelii* Greuter & Stier), by Riedl (1972) for *S. micranthus* Riedl (= *Cynoglossum indecorum* Greuter & Stier), and by Czukavina (1984) for *S. albiflorus* Czukav. & Meling. Under *Cynoglossum* it is mentioned only for *C. hedbergiorum* Riedl (Riedl, 1985), but the generic placement of this species is doubtful (Hilger et al., 2015).

Ailuroglossum has nutlets with glochids dispersed primarily on the abaxial side, while the adaxial side and the area around the cicatrice are glabrous (Fig. 1A–D). There is no indication of a disk as is often seen in *Cynoglossum*, in which glochids are borne on both sides (abaxial and adaxial) running up close to the cicatrice. The nutlets of *Ailuroglossum* are lenticular in lateral view (*A. triste* (Diels) Sutorý, similar to the Mexican genus *Oncaglossum* Sutorý) or only slightly depressed (*A. breviglochidiatum* Sutorý, similar to the American genera *Adelinia* J. I. Cohen and *Andersonglossum* J. I. Cohen).

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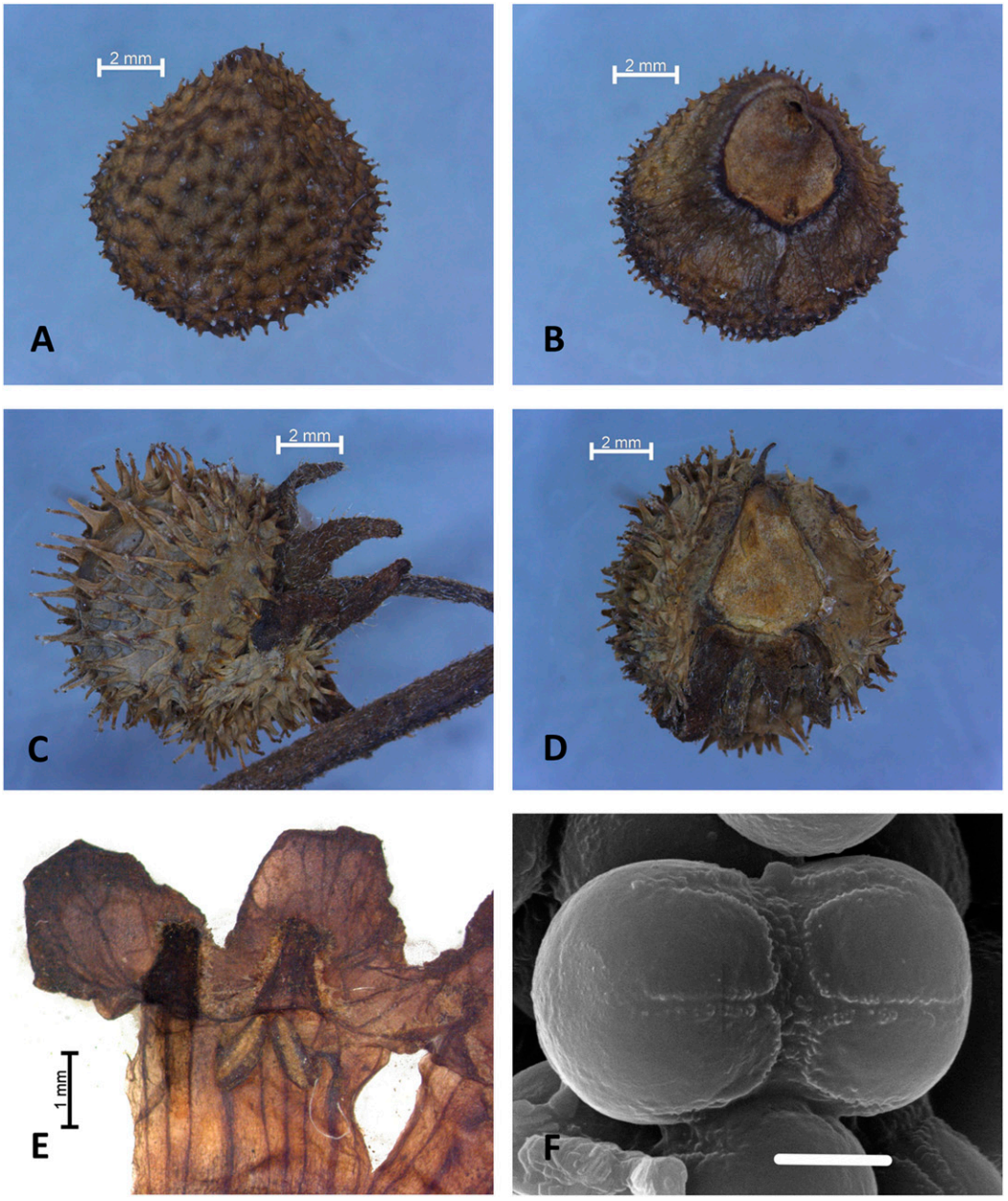

Figure 1. A, B. *Ailuroglossum breviglochidiatum* Sutorý (PE01336928), nutlets. —A. Abaxial view. —B. Adaxial view. C, D. *Ailuroglossum triste* (Diels) Sutorý (KUN0307130), nutlets. —C. Abaxial view. —D. Adaxial view. —E. *Ailuroglossum breviglochidiatum* (PE01336904), detail of corolla. —F. *Ailuroglossum breviglochidiatum*, pollen grains. Scale bar = 25 μm (PE01133053).

Nutlets in *Cynoglossum* are flattened, their upper part more or less planar. The nutlets of *Ailuroglossum* are perfectly separated (not connected to the style by an apical connection or "awn" as in all species of *Cynoglossum* s. str.). Perfect separation is mentioned as typical of *Cynoglossum* sect. *Eleutherostylum* Brand, in which 15 species from Asia, tropical Africa, and the western Americas were accommodated (Brand, 1921). Riedl (1962), in his recognition of that group at the subgeneric level (*Cynoglossum* subg. *Eleutherostylum* (Brand) Riedl), listed 13 species. This character has implications for the character of the style.

Ailuroglossum has a flat gynobase (not conical or pyramidal as in *Cynoglossum*), with a narrowly conical style, not quadrangular in cross section, and a discoid (not capitate) stigma.

Throat scales (fornices) in the corolla tube of *Ailuroglossum* are large (1.5 mm high and 1 mm wide), trapeziform, and conspicuously puberulous (Fig. 1E). Riedl (1962) placed the species of *Cynoglossum* with this character in *Cynoglossum* subg. *Papilligera* Riedl. All these species, in total five, occur in China and Central Asia. The similar North American genera *Adelinia*, *Andersonglossum*, and *Oncaglossum* have glabrous scales. The rich variability of scales in Cynoglosseae is well described in Brand (1921).

Pollen grains of *Ailuroglossum* are hourglass-shaped, perprolate, and tricolporate (three compound apertures, colpori, alternating with three simple apertures, pori). Colpori and pori in the equatorial plane are connected with a transverse groove; a polar pseudoaperture is present in one species and missing in the other (Fig. 1F). Similar apertures in the polar region are known within the Boraginaceae, but only from the Amsinckiinae (former Eritrichieae), namely in *Cryptantha intermedia* (A. Gray) Greene (Hargrove & Simpson, 2003), in species of *Hackelia* Opiz (Gentry & Carr, 1976), in Rochelieae, and finally in *Oncaglossum* (Sutorý, 2010). For *Cynoglossum triste* the pollen morphology was first reported by Liu et al. (2001). Liu et al. studied pollen on acetolyzed material, a different method that likely influenced their measurements, which were slightly different from mine, and measured with an SEM (10.7×8.3 μm vs. $10.0–11.0 \times 6.5$ μm, respectively). According to Sahay (1979), Liu et al. (2001), and my personal observations, a similar type of grain (tricolporate, hourglass-shaped) occurs in a group of *Cynoglossum* (s. str.) taxa from West Africa to South Asia (*C. amabile* Stapf & J. R. Drumm., *C. borbonicum* Bory, *C. glochidiatum* Benth., *C. lanceolatum* Forssk., and *C. wallichii* G. Don). Other *Cynoglossum* species (and also *Pardoglossum* Barbier & Mathez, *Solenanthus*, *Adelinia*, etc.) differ in an ovate to prolate shape of pollen grains (Avetisyan, 1956; Barbier & Mathez, 1973; Sahay, 1979; Liu et al., 2001).

The creation of a new genus is supported by the conclusion of Weigend et al. (2013: 604) that the "complex of nutlet characters (e.g., characters of the gynobase and cicatrix together with nutlet orientation and sculpturing) tends to circumscribe natural units," which fully corresponds with our case. Although several of the above-mentioned characters can appear in related genera, their combination in the proposed genus *Ailuroglossum* is unique. The morphologically closest genera to *Ailuroglossum*, previously also classified in the genus *Cynoglossum* (having a similar shape of nutlets, which are perfectly separated), occur in North America. *Adelinia*, *Andersonglossum*, and *Oncaglossum*, at that time partially not yet with these names, were already mentioned in Weigend et al. (2013) as being different and not fitting even in the broadly circumscribed concept of the genus *Cynoglossum*. In the latest contribution by Chacón et al. (2016), North American taxa of "*Cynoglossum*" are included in the morphologically heterogeneous subtribe Amsinckiinae Brand in tribe Cynoglosseae. Due to distinct morphological differences, the creation of a new subtribe could be considered. This action would be supported by the position of North American genera on phylogenetic trees published by Cohen (2015), Chacón et al. (2016), and Otero et al. (2019). However, a proposal to do so would require more phylogenetic results. The relationship of the discussed material from China must be affirmed by molecular data.

The recognition of the new genus *Ailuroglossum* is supported not only by its unique and conspicuous morphological characters, but also by its isolated geographical position and occurrence in an area (China, Sichuan and Yunnan provinces) with a high degree of endemism (Huang et al., 2011) in the core part of the Hengduan Mountain ranges, one of the world's biodiversity hotspots (Boufford & Dijk, 2000). The distribution of these morphologically similar genera represents another example of the biogeographic disjunction between eastern Asia and North America (Graham, 1972; Wen, 1999). Otero et al. (2019) provide particular data on this topic for the Cynoglossoideae in their study. The emergence of this disjunction in this subfamily is supposed to have happened in the Oligocene. North America was the first direction in the spread of this group from the "central and north east Palearctic" and was represented by the Amsinckiinae tribe.

Materials and Methods

Specimens from herbaria KUN, PE, W, and WU were examined using traditional taxonomic methods. This material was supplemented using databases of the Royal Botanic Garden, Edinburgh (E), and the Muséum national d'Histoire naturelle, Paris (P).

Pollen grains were measured on photographs. SEM microphotographs were produced using a TESCAN MIRA3 LMU electron microscope (TESCAN, Brno, Czech Republic). Material was sputter-coated in vacuum with gold (SCD 040; Oerlikon Balzers, Balzer, Liechtenstein). Other microphotographs were taken with a Zeiss Stemi 2000 microscope (Zeiss, Göttingen, Germany) using an AxioCam ERc5s microscope camera (Zeiss).

Citations are provided of photographs of living plants identified as "*Cynoglossum triste*" on publicly available websites that well depict the overall appearance of the two species, especially their flower colors.

Taxonomic Treatment

Ailuroglossum Sutorý, gen. nov. TYPE: *Ailuroglossum triste* (Diels) Sutorý [≡ *Cynoglossum triste* Diels].

Diagnosis. The combination of the following characters distinguishes *Ailuroglossum* Sutorý from other genera of Cynoglosseae: presence of a rhizome (not a taproot); large puberulous throat scales; an almost flat gynobase, narrowly conical style, and discoid stigma; nutlets with perfect separation, without ventral attachment; and hourglass-shaped tricolporate pollen grains.

Perennial herbs, rhizomatous. Basal leaves broadly ovate to narrowly lanceolate, bases cordate or cuneate. Cymes terminal, ebracteate. Flowers pedicellate; calyx 5-parted to base; corolla 5-parted, infundibuliform, throat scales trapeziform, large (1.5 mm high and 1 mm wide), puberulous; stamens 5, included, inserted on short filaments in upper part of tube; gynobase flat, style terete, narrowly conical, not exserted, stigma discoid. Nutlets 4 or fewer by abortion, subglobose, slightly adaxially depressed, with perfect separation, covered by glochids on abaxial side only, subapical attachment scar (cicatrice) broadly ovate (4.5–5 × 4 mm), occupying upper half of adaxial side of nutlet. Pollen grains perprolate, hourglass-shaped, tricolporate with 3 compound apertures (colpori) alternating with 3 simple apertures (pori), colpori and pori in equatorial plane connected with transverse groove, polar pseudoaperture present or missing.

Distribution. *Ailuroglossum* is endemic to southwestern Sichuan and northwestern Yunnan in China.

Etymology. The new genus is named after Styan's red panda, *Ailurus styani* (Thomas, 1902), which occurs in Sichuan and Yunnan provinces in China and in northern Myanmar.

Notes. Study of the material of *Cynoglossum triste* from China, herein transferred to *Ailuroglossum* as its type, revealed that it is not homogenous and that two separate species can be distinguished. The best characters to use for the delimitation of these two taxa are the rhizome morphology and the shape of the nutlets. One form has short, thick rhizomes and nutlets with glochids 1–2 mm long, while the other has slender rhizomes with long internodes and nutlets with short, 0.5-mm glochids. Basal leaf shape of mature plants is also variable.

Cynoglossum triste was described in 1912 based on material collected in the region of Lijiang in northwest Yunnan in China in 1906 by G. Forrest, "collector for A.K. Bulley of Ness, Neston, Neshire," as *Forrest 2235*. The type specimens have spent flowers but do not yet have fruits. Brand (1921: 148), monographer of the tribe, apparently only saw *Forrest 2235* and classified this species as "incertae sedis" because of missing fruits. Only specimens with long glochids on the nutlets have been seen from the area of collection of the type (see below), but Diels wrote in the protologue "nuculae valde complanatae, minute tuberculate" (Diels, 1912: 169). I assume that Diels inserted information about the fruits in the text after seeing another specimen of a fruiting plant or nutlets separately collected elsewhere at another locality. In Edinburgh another specimen (E 00840564) collected by Forrest (s.n.) in 1910 is deposited, which Diels might have seen before the publication of the name. It was collected at a locality close to that of the type and also lacks ripe fruits. Nutlets with long glochids are mentioned in this species, e.g., by Zhu et al. (1995). Though the type of *A. triste* does not have mature nutlets, its geographic origin in the region where only plants with long glochids were found and the shape of the basal leaves lead to the conclusion that it would have belonged to the species with long glochids. Hence, the name *A. triste* (s. str.) must apply to that species.

Key to the Species of *Ailuroglossum*

1. Rhizome stout (to 1.5 cm diam.) with short internodes; basal leaf apices acuminate, bases deeply cordate; corolla black-purple; nutlets with glochids 1–2 mm long . . . . . *A. triste* (Diels) Sutorý
1′. Rhizome slender (ca. 0.5 cm diam.) with long internodes; basal leaf apices acute, bases cuneate or slightly cordate; corolla dark crimson; nutlets with glochids 0.5 mm long . . . . . *A. breviglochidiatum* Sutorý

1. Ailuroglossum breviglochidiatum Sutorý, sp. nov. TYPE: China. Yunnan: Zhongdian [= Xiangelila], 3300 m, 13 Aug. 1962, *J. Cheng 755* (holotype, PE [PE01336908]!; isotype, PE [PE01336909]!).

Diagnosis. *Ailuroglossum breviglochidiatum* Sutorý is distinguished from *A. triste* (Diels) Sutorý by slightly flattened nutlets up to 0.9 × 0.9 mm with glochids only 0.5 mm long, a slender rhizome, and a dark crimson corolla.

Rhizome slender, ca. 0.5 cm thick, nodes rather widely spaced. Stem 40–60 cm, sparsely pubescent. Leaves: basal leaves thick-textured, blade broadly ovate or ovate, at maximum size up to 10–14 × 7–8 cm, base cuneate or slightly cordate, apex acute, petiole 5–12(–16) cm; upper leaves at least shortly petiolate, lowest small leaves sometimes rounded, ca. 3 cm in diam., inflorescence bracts often distinctly separated from leaves; abaxial leaf surface lighter green than adaxial, with scattered 1-mm trichomes. Inflorescences with flowers clustered on branches, mature branches not elongated; pedicels 6–9 mm. Sepals in flower lanceolate, 4–5 × 1.5 mm, in fruit up to 7 mm; corolla dark crimson, infundibuliform, ca. 5 mm, tube and limb both 2.5 mm or tube slightly longer; anthers 1 mm; style 2–2.5 mm. Nutlets rounded, slightly flattened, up to 0.9 × 0.9 mm, glochids 0.5 mm, distributed densely over abaxial surface. Pollen grains hourglass-shaped,

tricolporate, in equatorial plane connected by transverse groove, polar pseudoaperture missing.

Notes. Nutlets, rhizomes, and color of flowers are not always available on herbarium specimens, and other characters are not so unequivocal and are variable and thus not so easy to use. This is probably one of the reasons why this taxon has previously not been recognized as distinct.

Iconography. <http://www.asianflora.com/Boraginaceae/Cynoglossum-triste.htm>

Paratypes. CHINA. **Sichuan:** Muli, around Muli, Juni 1930, *G. Forrest 28440* (E, PE); western slopes of Mt. Mitzuga, May–June 1932, *J. F. Rock 24538* (E); Ye-tze, 12 June 1937, *T. T. Yü 7024* (PE); Mt. Mitxuga, 23 May 1937, *T. T. Yü 5660* (PE); Yan Yuan xian, 9 June 1960, *Sh. Nan & D. Bei 5893* (PE [2 sheets]); Gaoshan song mulin, 11 Sep. 1983, *Z. D. Qing 13923* (PE); Yazui Lichang, Linchang, 19 Aug. 1983, *Z. D. Qing 13101* (PE). **Yunnan:** Chungtien plateau [Zhongdian = Xianggelila], Sep. 1913, *G. Forrest 11253* (E, PE); 1 June 1937, *T. T. Yü 11478* (PE [2 sheets]); 16 June 1937, *T. T. Yü 11614* (PE [2 sheets]); 25 Aug. 1959, *G. Zhong, X. Ke, Zh. W. Juan, J. S. Yan, M. Kun & Z. Z. Jong 23239* (PE); 22 June 1960, *Sh. Nan & D. Bei 10132* (PE); 21 July 1963, *Zhongdian Expedition 63-3682* (KUN); 5 Aug. 1981, *J. Huan & Sh. L. Yun 81-1494* (PE); 12 June 1981, *Z. D. Qing 894* (PE [2 sheets]); 26 May 2009, *Sh. S. Zhou 6156* (PE); 27 May 2009, *Sh. S. Zhou 6219* (PE); 19 May 2009, *Sh. S. Zhou 5901* (PE); 12 May 2009, *Sh. S. Zhou 5530* (PE); 24 May 2012, *X. F. Jin 0043* (PE).

2. Ailuroglossum triste (Diels) Sutorý, comb. nov. Basionym: *Cynoglossum triste* Diels, Notes Roy. Bot. Gard. Edinburgh 5: 169. 1912. TYPE: China. Yunnan: moist, shady situations in pine forests on eastern flank of the Lichiang Range, lat. 27°12′N, 10–11,000 ft., June 1906, *G. Forrest 2235* (lectotype, designated here, E [E00284595]!; isolectotype, P [P03525301]!).

Rhizome stout, up to ca. 1.5 cm in diam., its yearly growth short and nodes close together. Stem 30–40(–90) cm, sparsely pubescent. Leaves: basal leaves often membranaceous, ovate to broadly ovate, at maximum size up to 13–14 × 8–12 cm, base often deeply cordate, apex acuminate, petiole 5–15 cm; upper leaves at least shortly petiolate, blade broadly ovate, gradually passing into descending inflorescence bracts; abaxial leaf surfaces lighter green than adaxial, covered by ± dense indument, trichomes not stiff, about 1 mm, laxly appressed. Inflorescences with mature branches elongated; pedicels ca. 5 mm, inflexed in fruit. Sepals in flower lanceolate, 4–5 × 1.5 mm, in fruit up to 7 mm; corolla black-purple, infundibuliform, ca. 5 mm, tube and limb both 2.5 mm or tube slightly shorter; anthers 1 mm; style 2–2.5 mm. Nutlets rounded, up to 1.4 × 1.1 mm, glochids 1–2 mm, regularly but not densely dispersed on abaxial side. Pollen grains hourglass-shaped, tricolporate, in equatorial plane connected with transverse groove, polar pseudoaperture present.

Notes. Duplicates of the collection cited in the protologue (*Forrest 2235*) are preserved in two herbaria. The specimen at E is more complete as it includes the important basal leaves and so is selected as lectotype.

Iconography. <http://www.fpcn.net/a/yeshenghuahui/20130718/Cynoglossum_triste.html>

Specimens examined. CHINA. **s. loc.:** Les bois de Kou-Touri ou depus de Mo-So-Yn. ["haud procul Lan Kong, supra Che ngay teou"], 24 May 1889, *Delavay 3722* [leg. *Y. T. Trang*], (P [3 sheets]). **Sichuan:** Mu-li, Ku-ma-tian, 26 May 1937, *Yü 5838* (PE); Ha-chin Yunnanpu, 29 June 1937, *Yü 6596* (PE); *Qiinghai-Xizang Expedition 13081*, 9 Aug. 1983 (KUN [2 sheets], PE); Yan Yuan, 26 July 1983, *Qiinghai-Xizang Expedition 12500* (KUN [2 sheets], PE [3 sheets]); in declivibus siccis regionis temperatae jugi Daörlbi medii inter Yenyüen et Yungning, 2900–3600 m, 13 June 1914, *Handel-Mazzeti 543a* (WU). **Yunnan:** Li Chiang [Lichiang, Li jiang, Li-kiang], Lichiang Range, 1910, *Forrest 5614* (E, P, PE, W); Lichiang Range, June 1913, *Forrest* (PE) [duplicate from Edinburgh]; Yangtze watershed, eastern slopes of Likiang Snow Range, May 1922, *Rock 3588* (P, W); Li-kiang Hsien, July 1935, *Wang 70848* (PE); Li jiang, Xiu song cui, 7 June 1937, *Yü 15126* (PE); Lijiang, Liyejiao, 18 Sep. 1939, *Ching 30619* (KUN [3 sheets]); Lijiang, Snow Mtn., 15 July 1940, *Ching 30865* (KUN [3 sheets], PE); Lijiang, Yulongshan, 12 July 1956, *Yunnan University Expedition Team 00372* (KUN); 2 Aug. 1960, Yu long Shan, *Jiang 6328* (PE); Lijiang, Yulong Shan, Xianji Yan, 20 June 1962, *Lijiang Botanical Garden 100309* (KUN [3 sheets]); Lijiang, Yulong Shan, 4 May 1971, *Anonymous 71-14* (KUN); Lijiang, Yulong Shan, Lehus, 29 May 1985, *Kunming-Edinburgh Yulong Shan Exp. 1985* (E); Lijiang, Yulongshan, Ganhaizi, 4 June 1985, *Sino-British Expedition Team 85-517* (KUN); Lijiang, Yulong Shan, Lehua, 3250 m, 29 May 1985, *Kunming-Edinburgh, Yulong Shan Expedition* (E); Lijiang Co., Yulong Shan, near Sandaowan, 25 May 1987, *Chamberlain, Gray-Wilson, Li, McBeath, Schilling, Xu & Yuan* (E); in montium ad septentrionis Urbis Lidjang ("Likiang") … in via Yungning ducente, copiose in bambusetis et aperturis, 27°30–34′, 3500–3700 m, 13 July 1915, *Handel-Mazzeti 1257* (W, WU); Diqing Prefecture, Jiulong, 14 June 1993, *Aldén, Alexander, Long, McBeath, Noltie & Watson 1276* (E); Di qing xiang Nanbohai, 16 July 2008, *Jang & Yuan 1859* (PE); Dali Prefecture, Jianchun Xian, Luoping Shan, s.d., *R. C. Ching 23093* (KUN [2 sheets], PE); Heqing Xian, Songgui, s.d., *Ching 24181*, (KUN [3 sheets], PE); Xiaohuadianba [Xiaohuangjia??], above farm, 18 May 1981, *Sino-British Cangshan Expedition 0759* (E); Ninglang, Ning lang xian, 14 July 1981, *Han, Denk & Chen 81-1220* (PE); Ning lang cui Yilichang, 10 July 1981, *Han & Deng 81-1124* (PE).

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