

A SYNOPSIS OF THE GENUS *CLADRASTIS* (LEGUMINOSAE)

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ABSTRACT. The genus *Cladrastis* (*Sophora* group, Sophoreae, Papilionoideae, Leguminosae) occurs in the southeastern United States, China, and Japan, having an eastern North America–eastern Asia disjunct distributional pattern. It comprises trees with alternate, imparipinnate leaves with alternate leaflets, lateral buds enclosed in the base of the petiole, and white flowers in paniculate inflorescences that may be erect or pendulous. A phenetic analysis of morphological characters was conducted on a subset of the 600 herbarium specimens examined from 26 herbaria worldwide. The resulting phenogram of vegetative specimens showed 4 clusters of specimens. Further analysis using flowering specimens indicated two additional clusters. Comparing these clusters with type specimens resulted in recognition of six taxa: *Cladrastis platycarpa*, *C. kentukea*, *C. wilsonii*, *C. delavayi*, *C. shikokiana*, and one new species, *C. chingii*.

Key Words: *Cladrastis*, Fabaceae, legume, Leguminosae, Papilionoideae, *Sophora* group, Sophoreae

The genus *Cladrastis* Raf. is a member of the *Sophora* group, tribe Sophoreae, subfamily Papilionoideae of Leguminosae. The *Sophora* group contains 9 genera with 72–80 species (Polhill 1978); however, on the basis of wood anatomy (Fuji et al. 1994), pollen morphology (Chung and Lee 1990; Ferguson et al. 1994), and recent DNA studies (Doyle et al. 1997; Käss and Wink 1996) the group may not be monophyletic. *Cladrastis* comprises deciduous trees 10–20 m in height with smooth grayish bark and rounded crowns. Leaves are imparipinnate, with 5–15 leaflets on short petiolules. Flowers are typically white, in erect or pendulous panicles 25–50 cm long. The fruit is a narrowly oblong, compressed legume containing 1–8 seeds. *Cladrastis* is morphologically similar to both *Sophora* L. and *Maackia* Rupr. (Andrews 1996; Spongberg and Ma 1996); however, it differs from both in having alternate leaflets and petioles that enclose the lateral buds (*Sophora* and *Maackia* have opposite leaflets and *Maackia* has exposed lateral buds). In addition, it differs from *Maackia* in having paniculate inflorescences (those of *Maackia* are racemose), and from *Sophora* in having compressed seed pods (*Sophora* has cylindrical seed pods constricted between the seeds).

Cladrastis has an eastern North America and eastern Asia disjunct distribution pattern (Fernald 1931; Hu 1980). *Cladrastis kentukea*

(Dum.Cours.) Rudd is endemic to the central and southeastern United States (Pittillo 1963). All remaining taxa are Asian, with *C. delavayi* (Franch.) Prain, *C. wilsonii* Takeda, and *C. chingii* Duley & Vincent occurring only in China, and *C. shikokiana* (Makino) Makino occurring only in Japan; *C. platycarpa* (Maxim.) Makino is found in both China and Japan. *Cladrastis* may have been in North America as early as the Eocene, based on the fossil *C. eocenica* E. W. Berry, as reported from the Wilcox flora (Berry 1930; Cain 1943), and on fossil leaves and fruits from the southeastern United States (Herendeen 1992). Oligocene fossils of the genus have been found in Oregon (Manchester and Meyer 1987; Meyer and Manchester 1997). Miocene fossils of the genus have been reported from Alaska (Wolfe and Tanai 1980), Oregon [*C. oregonensis* (Knowlt. & Cockerell) R. W. Br.; Brown 1937], and Japan (*C. aniensis* Huzioka; Tanai et al. 1963).

In North America, *Cladrastis kentukea* occurs along cliffs above rivers, and in openings of mesophytic coves, where it appears to do best in the rich, coarse-textured soils. In China, *C. wilsonii* is common in moist woods of Hubei and as far west as the eastern reaches of the Red Basin of Sichuan province. *Cladrastis delavayi* occurs between 1500 and 2500 m in the forests of western Sichuan. *Cladrastis platycarpa* is reported from provinces along the southern and eastern borders of China and throughout Japan, whereas *C. shikokiana* is restricted to the southern provinces of Japan, below 500 m.

Used as an ornamental because of its large, showy, and fragrant inflorescences (Andrews 1999; Rehder 1927), *Cladrastis kentukea* makes a good shade tree with its rounded canopy and moderately dense silhouette (Gilman 1997). It should be noted, however, that *C. kentukea* flowers profusely only every two to three years (Spongberg 1990). Its yellowish heartwood has been used to make dyes and household items, such as bowls and paneling (Harlow et al. 1991), and the hard, dense wood was used by the American settlers to make gunstocks. Three of the Asian species, *C. platycarpa*, *C. wilsonii*, and *C. delavayi*, are also listed as garden trees (Griffiths 1994) because of their smooth, gray bark and showy inflorescences.

The name *Cladrastis* was first mentioned in 1822 by Rafinesque in the *Kentucky Gazette* (Rafinesque 1822), and then in a botanical garden catalog (Rafinesque 1824a), with the species name *C. fragrans*, but without a description. Rafinesque (1824b) subsequently described that genus and species in the *Cincinnati Literary Gazette*, based on a new tree he had reported earlier as *Virgilia alba* (Rafinesque 1822). Rafinesque (1824b) stated that he had now seen the tree in bloom and

it was not a *Virgilia* after all; therefore, he proposed the genus name *Cladrastis* (meaning “brittle branches”) for the tree and renamed the species *C. fragrans*.

Takeda (1913) separated the genus into subgenus *Eucladrastis* (*nom. inval.*, = subg. *Cladrastis*), including *Cladrastis sinensis* (= *C. delavayi*), *C. shikokiana*, and *C. lutea* (= *C. kentukea*), and subgenus *Platynosprion* containing *C. platycarpa*. Ma (1982) recognized two sections, *Cladrastis* and *Platynosprion*; section *Platynosprion* contained three species, *C. platycarpa*, *C. scandens*, and *C. parvifolia*, while section *Cladrastis* contained *C. lutea*, *C. sinensis* (= *delavayi*), *C. shikokiana*, and *C. wilsonii*. Murray (1985) also divided the genus into two subgenera, *Cladrastis* and *Platynosprion*. He further subdivided each subgenus into sections, subsections, series, and subseries. Murray's classification may be excessive for a genus to which he attributes only four species.

Several chemical compounds (mostly phenolics and flavonoids) have been isolated from the bark of *Cladrastis platycarpa*, *C. shikokiana*, and *C. kentukea* (Imamura et al. 1972, 1974, 1975; Ohashi et al. 1974, 1976; Ohashi, Goto, and Imamura 1977; Ohashi and Imamura 1978; Ohashi, Yamada, and Imamura 1977; Van Damme et al. 1995) but they have not proven useful for differentiation of species within the genus. The only published chromosome number for the genus, $2n = 28$, is for *C. kentukea* (as *C. lutea*; Atchison 1949; Berger et al. 1958; Smith 1988).

There has been no monograph published for *Cladrastis*. While Ma (1982) provided a key and descriptions of the species that he accepted, he did not reexamine type specimens, and he left many nomenclatural problems unresolved. The purpose of this study was to determine the number of species in the genus *Cladrastis* by morphological means, and answer the numerous nomenclatural questions after study of all available type material.

MATERIALS AND METHODS

Approximately 600 herbarium sheets were examined from the following herbaria: A, B, BM, CAS, DS, E, F, GH, HAST, ILL, ILLS, IND, K, KNK, KUN, KY, KYO, LL, MAK, MICH, MO, MU, NAS, NY, P, PE, PH, S, TEX, US, and WIS. In addition to specimens, photographs of some taxa were obtained from the Royal Botanical Gardens, Kew, England (K), and photocopies from Hong Kong (HK). Of these 600 specimens, 215 were selected for analysis, representing the range of morphological and geographical variation within the genus. Specimens were selected or rejected

Table 1. Characters measured for the analysis of the genus *Cladrastis*. Qualitative character state codes are in parenthesis. Characters marked with an asterisk (*) indicate those used in the final phenetic analysis.

Plant Part	Characters
VEGETATIVE CHARACTERS	
Leaf	1. Leaf length. 2*. Number of leaflets. 3. Petiole color: yellow (3), green (4), brown (6), yellow green (7). 4. Petiole pubescence: absent (0), sparse (1), dense (2). 5. Petiole pubescence color: white (1), rusty (2), yellow (3), green (4).
Terminal leaflet	6. Shape: ovate (1), obovate (2), elliptical (3), narrow elliptical (4). 7. Length. 8. Width. 9*. Apex: emarginate (0), rounded (1), acute (2), acuminate (3). 10*. Base: rounded (1), acute (2), cuneate (3), inequilateral (4). 11. Underside pubescence: absent (0), sparse (1), dense (2). 12. Underside pubescence color: white (1), rusty (2), yellow (3), green (4). 13. Underside midrib pubescence: absent (0), sparse (1), dense (2). 14. Underside midrib pubescence color: white (1), rusty (2), yellow (3), green (4). 15. Petiolule length. 16. Petiolule color: white (1), rusty (2), yellow (3), green (4), brown (6), yellow green (7). 17. Petiolule pubescence: absent (0), sparse (1), dense (2). 18. Petiolule pubescence color: white (1), rusty (2), yellow (3), green (4).
First leaflet	19. Shape: ovate (1), obovate (2), elliptical (3), narrow elliptical (4). 20. Length. 21. Width. 22. Apex: emarginate (0), rounded (1), acute (2), acuminate (3). 23. Base: rounded (1), acute (2), cuneate (3), inequilateral (4). 24. Underside pubescence: absent (0), sparse (1), dense (2). 25. Underside pubescence color: white (1), rusty (2), yellow (3), green (4). 26. Underside midrib pubescence: absent (0), sparse (1), dense (2). 27. Underside midrib pubescence color: white (1), rusty (2), yellow (3), green (4). 28. Petiolule length. 29. Petiolule color: white (1), rusty (2), yellow (3), green (4), brown (6), yellow green (7). 30. Petiolule pubescence: absent (0), sparse (1), dense (2). 31. Petiolule pubescence color: white (1), rusty (2), yellow (3), green (4).
Stipels	32*. Stipel type: absent (0), subulate (1), branched and multiple (2).
FLORAL CHARACTERS	
Inflorescence	33. Inflorescence length. 34. Peduncle color: yellow (3), green (4), brown (6), yellow green (7). 35*. Peduncle pubescence: absent (0), sparse (1), dense (2). 36*. Peduncle pubescence color: white (1), rusty (2), yellow (3), green (4).

Table 1. Continued.

Plant Part	Characters
Calyx	37. Tube width. 38. Tube length. 39. Upper lobe width. 40. Upper lobe length. 41*. Upper lobe shape: rounded (1), acute (2). 42. Lower lobe width. 43. Lower lobe length. 44. Lower lobe shape: rounded (1), acute (2). 45. Lateral lobe width. 46. Lateral lobe length. 47. Lateral lobe shape: rounded (1), acute (2). 48*. Pubescence color: white (1), rusty (2), yellow (3), green (4). 49. Pedicel pubescence color: white (1), rusty (2), yellow (3), green (4).
Corolla	50. Upper petal width. 51. Upper petal length. 52. Upper petal claw length. 53. Lateral petal width. 54. Lateral petal length. 55. Lateral petal claw length. 56. Lower petal width. 57. Lower petal length. 58. Lower petal claw length. 59. Anther width. 60. Anther length. 61. Ovary length. 62. Ovary width. 63*. Ovary pubescence color: white (1), rusty (2), yellow (3). 64. Style length.
Fruit	65*. Base shape: rounded (1), acute (2). 66*. Pod winged: yes (1), no (0).

based on whether they were complete for either vegetative or floral characters. The 215 herbarium sheets were assigned unique numeric codes and served as operational taxonomic units (OTUs), of which 66 vegetative/fruitleting and 13 floral sheets were used in the final phenetic analysis.

The OTUs were divided into floral and vegetative/fruitleting subsets to eliminate age-related phenotypic variation (e.g., the underside of the terminal leaf is pubescent when the tree is in flower, but glabrous later in the growing season). Sheets were coded as floral if they contained flowers or if the collection date was prior to July, and as vegetative/fruitleting if they contained fruits or if the collection date was between July and October.

Fifty-one vegetative/fruitleting and fifty-one floral characters were scored for each OTU. Quantitative character states were coded as continuous data, and qualitative character states were coded as discrete values. The character states were coded as in Table 1. For a detailed explanation of how each character was measured, or to see the complete data matrix, see Duley (1998).

Data were entered into Excel (1997, Microsoft Corp., Redmond, WA) and then imported into NTSYS-pc 2.01 (Exeter Software, Setauket, NY) for computerized phenetic analysis. The default options were used to

standardize the data. This resulted in the typical standardization of a data matrix used in numerical taxonomy (Rohlf 1997). Distance coefficients were computed using the similarity interval command, SIMINT (correlation coefficient code, CORR). The sequential, agglomerative, hierarchical, and nested clustering method (SAHN) with the default, unweighted pair group method using arithmetic averaging (UPGMA), was used to construct a phenogram. To test how well the phenogram represented the original standardized data matrix, cophenetic values were computed, returning a cophenetic correlation coefficient r . These analyses were repeated for each subset of the data set and the phenograms were compared for variation. Principal Components Analyses (PCA) were also performed using NTSYS-pc 2.01 to help define the structure of these data sets.

RESULTS AND DISCUSSION

Based on the phenetic analysis of overall morphology, we recognize six species in the genus. The differences among the species do not warrant any infrageneric classification; previous authors (Ma 1982; Takeda 1913) subdivided the genus based on the presence or absence of winged fruits, and our analyses do not support this distinction. *Cladrastis kentukea* is endemic to central and southeastern United States. All remaining taxa are Asian, with *C. chingii*, *C. delavayi*, and *C. wilsonii* occurring only in China, and *C. shikokiana* restricted to Japan. *Cladrastis platycarpa* is found in both China and Japan.

The phenogram for the quantitative, vegetative data set (Figure 1) is used here to illustrate the most informative clustering result obtained. It also serves as a framework onto which other characters can be mapped to further illustrate interspecific differences. Figure 1 shows two major (A and B) and four minor (1–4) clusters. The first major cluster contains all of the North American specimens, representing *Cladrastis kentukea*, and a mix of Chinese and Japanese specimens, representing *C. wilsonii* and *C. shikokiana*. The second major cluster contains Chinese and Japanese specimens, representing *C. delavayi* and a complex of *C. platycarpa* and another taxon.

Within the first major cluster, several smaller clusters can be seen. However, it should be noted that the North American specimens tend to group together as do the Asian specimens. When qualitative characters such as leaf color, pubescence color, and geographical distribution are taken into consideration, a clear distinction between the North American species and the Asian species can be drawn. Observation of the

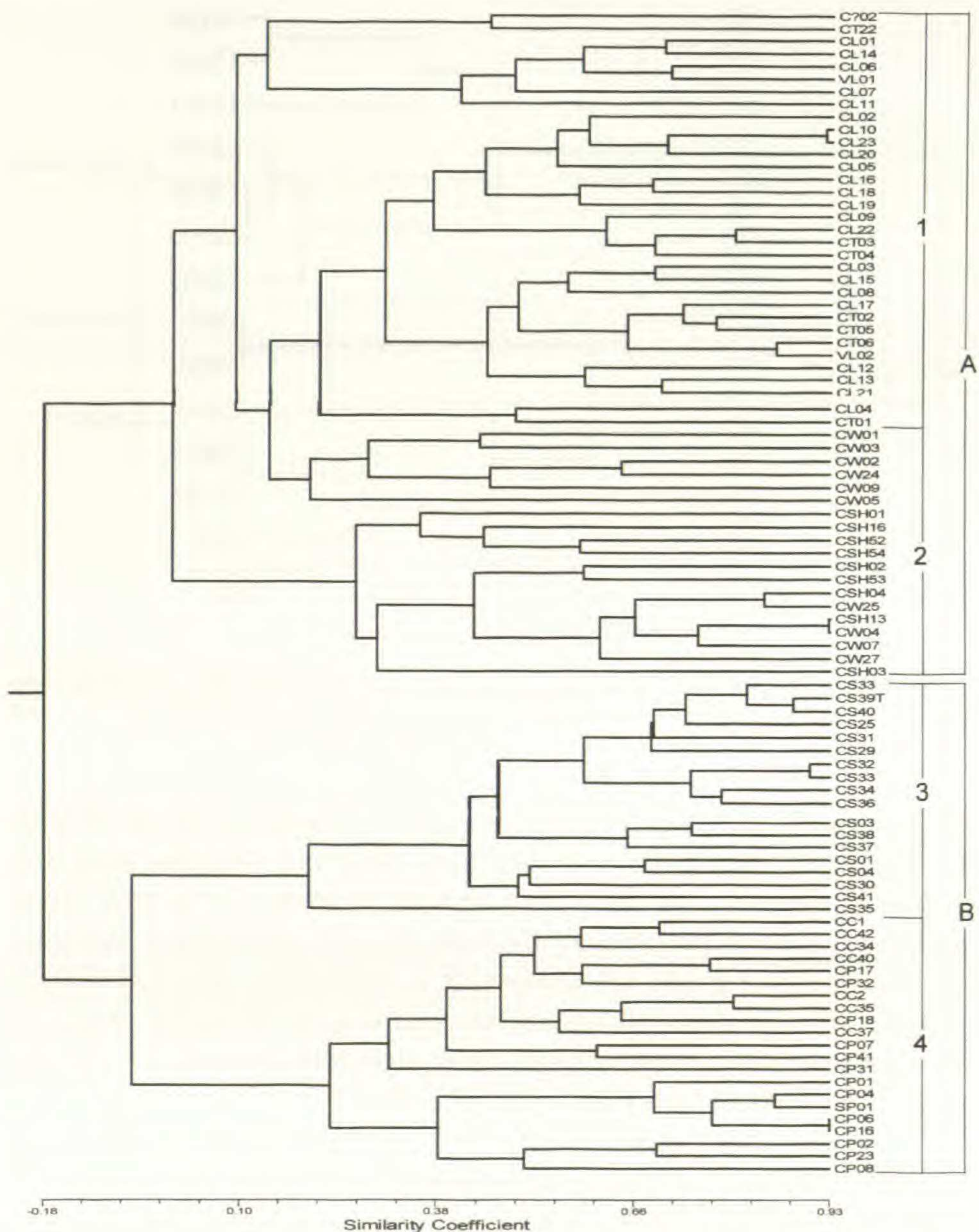


Figure 1. Phenogram derived from vegetative characters showing 2 major (A & B) and four minor (1–4) clusters. OTUs are identified as follows: CT, CL, VL, and C? = *Cladrastis kentukea*; CW = *C. wilsonii*; CSH = *C. shikokiana*; CS = *C. delavayi*; CC = *C. chingii*; CP, SP = *C. platycarpa*.

herbarium sheets suggested that OTUs CW01 through CW05 and CW09 should not be included with Cluster 1 (North American specimens) but with Cluster 2 (Asian specimens). Cluster 1 then contains all North American specimens of *Cladrastis kentukea*. Cluster 2 contains a mix of Chinese and Japanese specimens and represents the species *C. wilsonii*

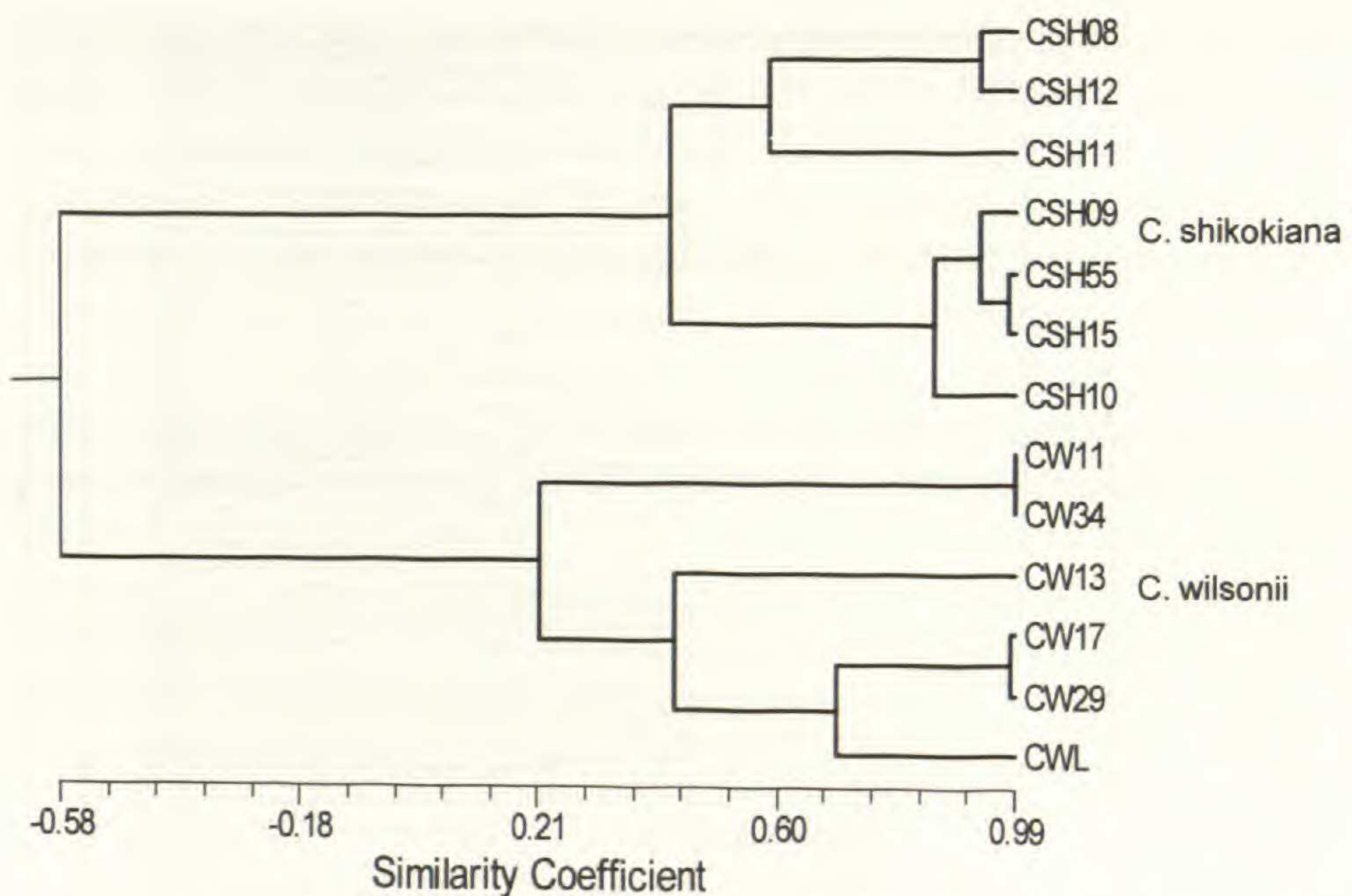


Figure 2. The top portion of the phenogram for the floral data set shows the separation of *Cladrastis wilsonii* and *C. shikokiana* into different clusters.

and *C. shikokiana*. *Cladrastis wilsonii* and *C. shikokiana* can be difficult to distinguish vegetatively. It had been observed that the best way to distinguish between these two species (Cluster 2) is with floral characters, such as the color of the pedicel/calyx pubescence: the hairs of *C. wilsonii* are green, while those of *C. shikokiana* are rusty brown. Analysis of other floral characters revealed overall clustering similar to the vegetative data set but showed clear separation between *C. wilsonii* and *C. shikokiana* (Figure 2).

Within the second major cluster, two additional smaller clusters can be seen. Cluster 3 contains only Chinese specimens and represents *Cladrastis delavayi*. Cluster 4 contains a mix of Chinese and Japanese specimens, and represents the *C. platycarpa* complex. Originally for specimens of the *C. platycarpa* complex, stipels were coded simply as being present or absent. However, there are two distinct types of stipels in this group, and stipel type appears to be linked to geography. All specimens from Japan had one awn-shaped stipel on either side of the base of the pulvinus of the leaflet. Those from China had stipels that were either like those of the Japanese specimens, or stipels that were multiple or branched on either side of the base of the pulvinus. A separate analysis performed on the OTUs in this cluster after recoding the stipel data as to type, not merely presence/absence (Figure 3),

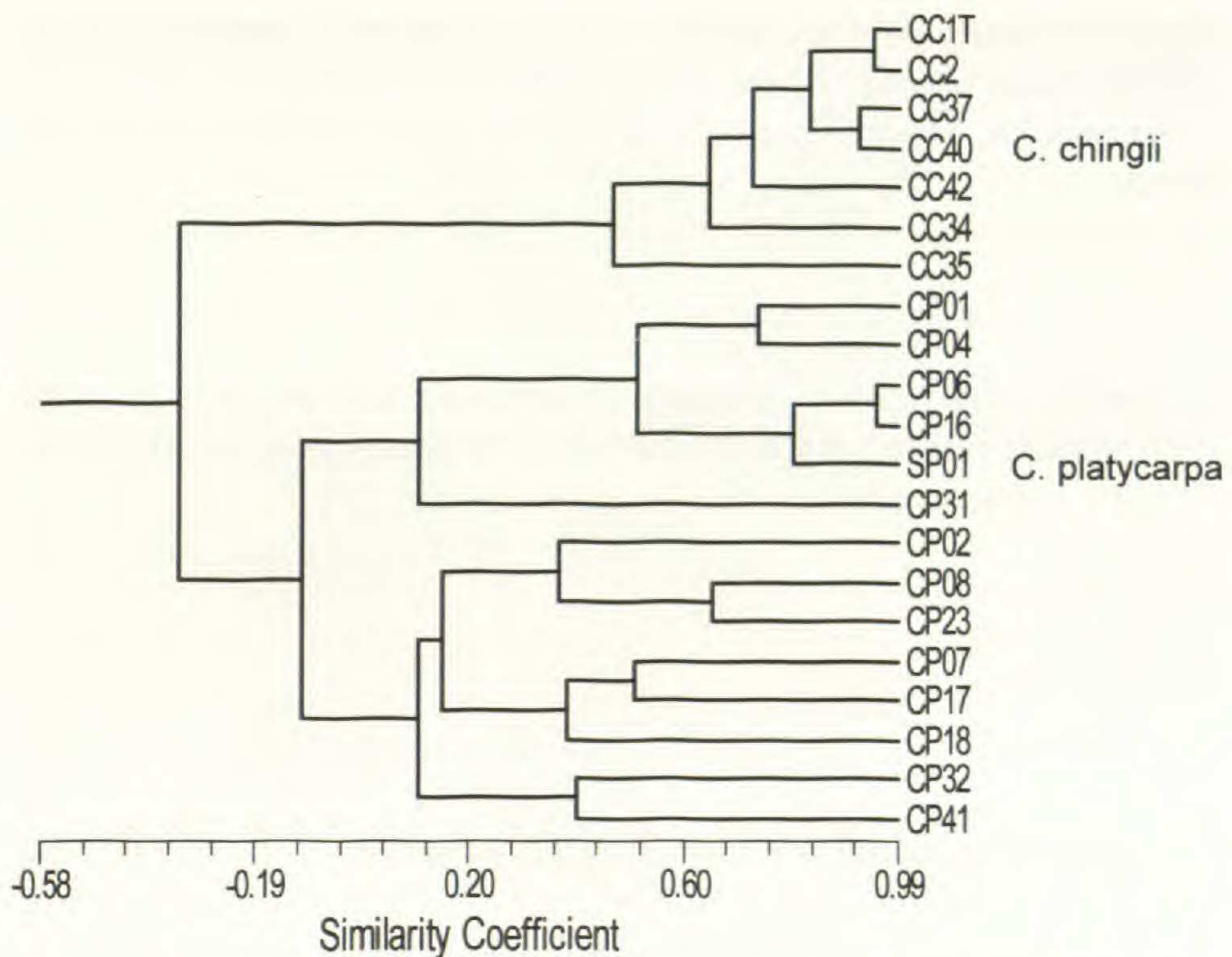


Figure 3. *Cladrastis chingii/platycarpa* complex after recoding stipel type. *Cladrastis chingii* has branched or multiple stipels; *C. platycarpa* has one pair of awn-shaped stipels.

resulted in a clear separation between *C. platycarpa* and another taxon, which we now recognize as *C. chingii*.

TAXONOMIC TREATMENT

Cladrastis Raf., Cincinnati Lit. Gaz. 1(8): 60. 1824. TYPE: *C. fragrans* Raf. *Platyosprion* (Maxim.) Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 22: 263. 1877. *Sophora* subgen. *Platyosprion* Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 18: 398. 1873.

Trees, deciduous; bark smooth, thin. Axillary buds enclosed in petiole base. Leaves alternate, odd-pinnately compound, estipulate; leaflets alternate, margins entire. Inflorescence terminal, paniculate, erect or pendulous. Flowers perfect, zygomorphic. Perianth hypogynous; calyx tubular, 5-lobed, fused basally for half its length; corolla white, sometimes pinkish, papilionoid. Stamens monadelphous, unequal, fused only slightly at base, anthers dorsifixed, dehiscence introrse via longitudinal slits. Ovary with 6–13 ovules, pubescent; style subulate;

stigma terminal, glabrous, minute. Fruit a compressed legume, with or without wings. Seeds oblong, compressed, testa brown.

Six species: temperate eastern Asia; central and southeastern United States.

KEY TO SPECIES OF *CLADRASTIS*

1. Leaflets with stipels at the base of pulvinus; fruit winged (2)
 2. Stipels simple, subulate, single on each side of pulvinus; fruit apex and base acute; leaves typically with 11 or more leaflets 1. *C. platycarpa*
 2. Stipels branched, and/or two or more on each side of pulvinus; fruit apex and base rounded; leaves typically with 9 or fewer leaflets 2. *C. chingii*
1. Leaflets without stipels at the base of pulvinus; fruit not winged (3)
 3. Leaves typically with 9 or fewer leaflets (4)
 4. Terminal leaflet nearly as wide as long; calyx pubescence white to yellow; lower calyx tooth acute, upper and lateral calyx teeth rounded 3. *C. kentukea*
 4. Terminal leaflet half as wide as long; calyx pubescence white to yellow to green; all calyx teeth acute 4. *C. wilsonii*
 3. Leaves typically with 11 or more leaflets (5)
 5. Terminal leaflet base rounded (rarely acute), apex emarginate; inflorescence erect 5. *C. delavayi*
 5. Terminal leaflet base acute, apex acuminate; inflorescence pendulous 6. *C. shikokiana*

1. *Cladrastis platycarpa* (Maxim.) Makino, Bot. Mag. (Tokyo) 15: 62. 1901. *Sophora platycarpa* Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg. 18: 398. 1873. *Platysprion platycarpum* (Maxim.) Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 22: 263. 1877. TYPE: JAPAN. Fudjiyama, 1864, *Tschonoski s.n.* (HOLOTYPE: LE; ISOTYPES: BM!, GH!, K!, P!, S!). Figure 4.

Cladrastis yungchunii Xiang-W. Li & G.-S. Fan, Bull. Bot. Res. Harbin 14(4): 347–348. 1994. TYPE: CHINA. Yunnan, Luxi, *Li Xiang-Wang 919028* (HOLOTYPE: SWFC). (*ex char.*)

Tree to 20 m. Leaves (17.4–) 24.4 (–31.7) cm; petiole (1.2–) 2.0 (–3.4) cm, green to greenish brown, glabrous to sparsely white pubescent;



Figure 4. Isotype of *Cladrastis platycarpa* (Tschonoski s.n., 1864, P). Inset shows awn-shaped stipels.

leaflets (7–) 13 (–15); first leaflet: pulvinus sparsely white to yellow to rusty pubescent; stipels simple, subulate, positioned singly on either side of the petiole base; lamina (2.5–) 4.9 (–9) \times (1.0–) 2.3 (–3.5) cm, ovate, base rounded, apex acute to acuminate, upper surface glabrous to sparsely white pubescent on veins, lower surface sparsely white pubescent near midrib; terminal leaflet: sparsely to densely white pubescent; stipels paired, subulate; lamina (4.6–) 6.8 (–8.7) \times (2.1–) 3.2 (–4.1) cm, elliptical to ovate, base acute, apex acuminate, upper surface glabrous to sparsely white pubescent on veins, lower surface glabrous to sparsely white pubescent on or near midrib. Inflorescence (9.6–) 18.6 (–27.7) cm, erect; peduncle (1.0–) 2.2 (–5.2) cm, green, glabrous or isolated white to rusty pubescent near stem; pedicel 0.7–1.1 cm, sparsely to densely rusty pubescent. Calyx (1.6–) 5.6 (–6.7) \times (9.1–) 9.5 (–12.0) mm, densely white to yellow pubescent, upper teeth (0.8–) 1.2 (–1.9) \times (1.6) 1.8 (–3.0) mm, rounded, lateral teeth (0.8–) 1.1 (–1.3) \times (1.3–) 1.8 (–2.4) mm, rounded to acute, lower tooth (1.1–) 1.3 (–1.6) \times (1.6–) 2.1 (–2.7) mm, acute. Corolla white with yellow spot in throat; banner petal (5.3–) 6.8 (–8.2) \times (5.3–) 6.3 (–8.5) mm, reflexed, orbicular, base acute to cuneate, claw (1.2–) 3.5 (4.8) mm; wing petals (5.9–) 7.5 (–9.3) \times (3.2–) 4.1 (–5.4) mm, lanceolate, base auriculate, claw (2.9–) 3.8 (–5.1) mm; keel petals (6.4–) 8.1 (–9.9) \times (3.5–) 4.6 (–5.9) mm, lanceolate, base auriculate, margins overlapping and folded together. Anthers (0.5–) 0.7 (–0.8) \times (0.3–) 0.5 (–0.8) mm. Ovary (4.5–) 5.4 (–6.4) \times (0.6–) 1.0 (–1.1) mm, densely white to yellow pubescent; style (2.6–) 3.3 (–4.8) mm; ovules 6–7. Fruit 5–8 cm, winged, apex and base acute; seeds 1–3.

DISTRIBUTION AND PHENOLOGY. *Cladrastis platycarpa* was believed to be restricted to Japan (Brickell and Zuk 1996; Krüssmann 1976; Rehder 1927). However, it has been reported from China (Li and Fan 1994; Ma 1982) and several specimens were seen from the southern and southeastern provinces of China, including Zhejiang, Guangxi, and Guizhou (Figures 5 and 6).

Cladrastis platycarpa flowers in June after the leaves have emerged. Fruit set immediately follows flowering, and fruits remain on the tree through leaf drop.

Li and Fan (1994) published a new species, *Cladrastis yungchunii* Xiang-W. Li & G.-S. Fan, reporting it to be similar to *C. platycarpa*, with winged fruits, non-stipellate leaves, and glabrous leaflets and petiolules. The type specimen was not available for this study. Based on



Figure 5. Distribution of *Cladrastis* in China.

the winged fruit and the ephemeral nature of the stipels of *C. platycarpa*, *C. yungchunii* is tentatively placed in synonymy with *C. platycarpa*.

This species is most similar to *Cladrastis chingii*, but the leaves of *C. platycarpa* are thinner and more membranous in texture, and the stipels of *C. platycarpa* are awn-shaped and single on either side of the base of the pulvinus of the leaflet.

REPRESENTATIVE SPECIMENS: CHINA. Guizhou: Chengfeng, *Tsiang* 4452 (NY). Guangxi: Yanshan Park, *Guilin Team* 70123 (CAS). Zhejiang: Tung-yung hsien, *King* 929 (A).

JAPAN. Fukui: Ichi-no-tani Valley, *Ueda* 794 (A, K, MAK, MO, NY). Kagawa: *Wilson* 7522 (A). Kumamoto: *Wilson* 1653 (A). Nagano: Suwa City, *Mizushima* 17376 (S). Tokushima: *Makino* s.n. (CAS). Tokyo: Hachiou City, Mt. Takao, *Makino* s.n. (A). Yamanashi: *Togashi & Tateishi* s.n. (K).

2. ***Cladrastis chingii*** Duley & Vincent, *sp. nov.* TYPE: CHINA: Guangxi, Luchen, Tang Gior Poo, 23 May 1928, *R. C. Ching* 5230 (HOLOTYPE: NY!; ISOTYPE: A!). Figure 7.



Figure 6. Distribution of *Cladrastis* in Japan.

Species nova *Cladrastis platycarpae* proxima differt vero foliola crassiusculus paucibus (9 vice 13); stipellae ramosus vel plures (vice subulatus et singularis); legumen apex et base rotundatis.

Tree, ca. 13 m. Leaves (18.5–) 21.8 (–23.5) cm, petiole (2.4–) 3.4 (–4.3) cm, green to greenish brown, glabrous to sparsely white pubescent, leaflets 9 or fewer; first leaflet: pulvinus sparsely white to rusty pubescent; stipels branched and/or multiple; lamina (3.9–) 4.8 (–6.1) × (1.2–) 2.1 (–2.8) cm, ovate, base rounded, apex acuminate, upper

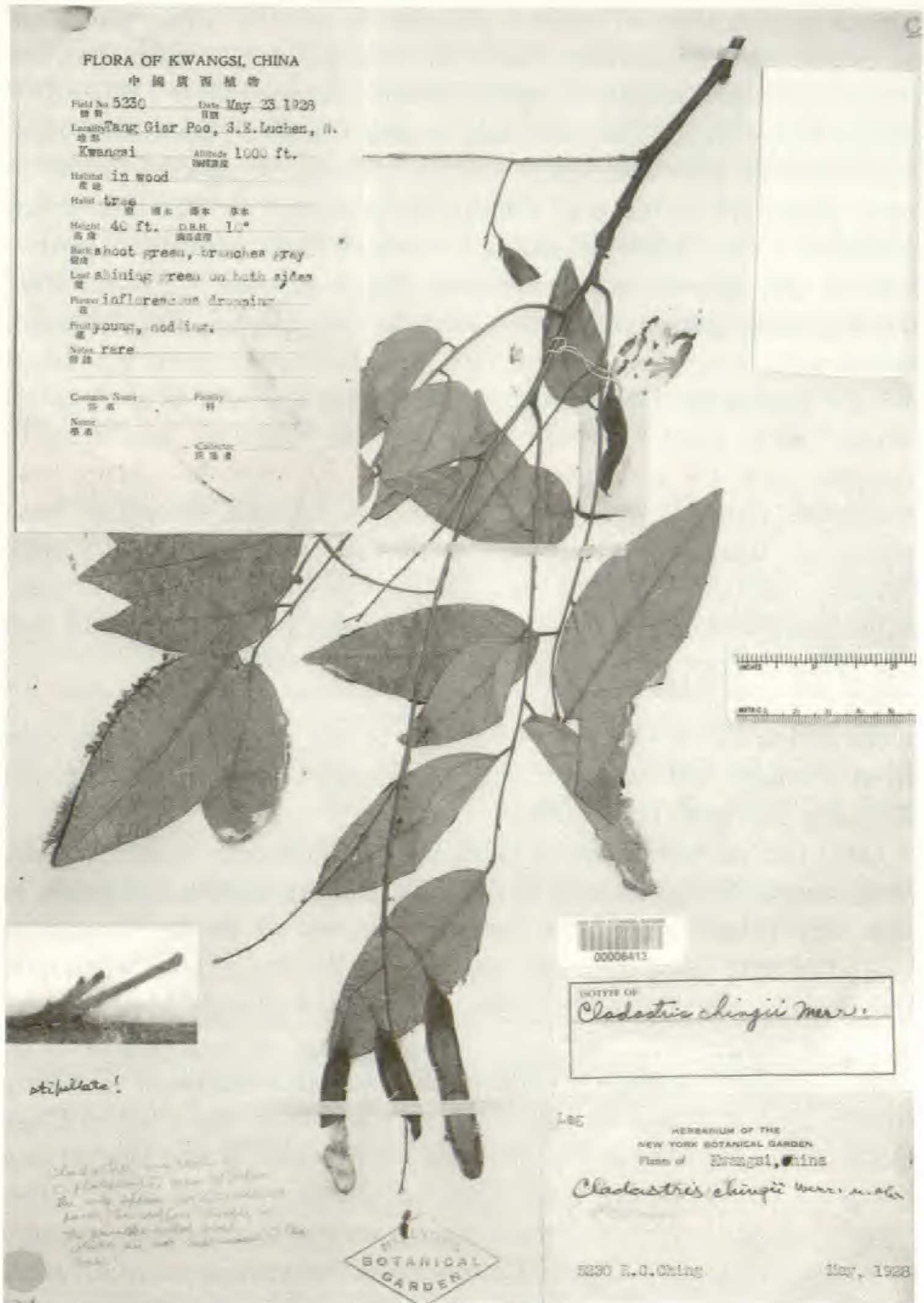


Figure 7. Holotype of *Cladrastis chingii* (Ching 5230, NY). Inset shows multiple/branched stipels characteristic of this species.

surface glabrous, lower surface glabrous to sparsely white pubescent on or near mid rib; terminal leaflet: pulvinus glabrous to sparsely white pubescent; stipels branched and/or multiple; lamina (5.3–) 7.0 (–7.8) × (2.5–) 3.1 (–3.5) cm, elliptical, base rounded to acute, apex acuminate, upper surface glabrous, lower surface glabrous to sparsely white to rusty pubescent on or near midrib. Inflorescence to 30.5 cm, erect; peduncle 3 cm, brown, glabrous to isolated rusty pubescent; pedicel 0.4–1.1 cm, densely rusty pubescent. Calyx 4.5–4.8 × 7.8–8.2 mm, densely rusty pubescent, upper teeth 1.3 × 1.0–1.8 mm, rounded, lateral teeth 1.1–1.4 × 1.9–2.1 mm, rounded, lower tooth 1.1–1.3 × 1.9–2.1 mm, acute. Corolla (data based on one available flower): petals white; banner petal 5.6 × 5.1 mm, reflexed, orbicular, base acute to cuneate, claw 1.4 mm; wing petals 6.2 × 3.4 mm, lanceolate, base auriculate, claw 1.8 mm; keel petals 6.1 × 3.4 mm, lanceolate, base auriculate, margins overlapping and folded together, claw 1.9 mm. Anthers 0.6–0.8 × 0.3–0.5 mm. Ovary 4.3–4.8 × 1.4 mm, densely white pubescent; style 2.1–2.6 mm, glabrous; ovules 3–6. Fruit 6–8 cm, winged, apex and base rounded to acute; seeds 1–3.

DISTRIBUTION AND PHENOLOGY. Specimens of this species have been seen from southern and eastern China in Guangxi, Hunan, Yunnan, and Zhejiang provinces (Figure 5).

Only two herbarium sheets of flowering specimens were available. Both were collected in early to mid-May and the flowers had begun to lose their petals. In addition, herbarium sheets of fruiting specimens examined were dated from late May through the end of June. Therefore, it is probable that flowering occurs in late April or early May.

NOTES. *Cladrastis chingii* is named in honor of its collector, R. C. Ching (Ching 1988; Ching et al. 1999). The type specimen was cited by Chun (1934) as *C. platycarpa*. The specimen at Harvard (A) was labeled as a duplicate distributed by the Lingnan University herbarium in 1954, which had been previously distributed from the Metropolitan Museum of Natural History, Nanking. There may be isotypes in those herbaria, as well.

Vegetatively, this species is very similar to *Cladrastis platycarpa* except for the stipel type and leaf texture. *Cladrastis chingii* has a very distinctive stipel that is branched, or, if unbranched, there are multiple stipels on either side of the base of the pulvinus. Leaves of *C. chingii* are thicker and more coriaceous than those of *C. platycarpa*. In addition, the base of the terminal leaf showed variation from rounded to acute, while

the terminal leaf base in *C. platycarpa* is typically acute with very little variation. There are also major differences between this species and *C. platycarpa* regarding fruit characteristics. The pod is 5–8 cm long for both species; however, the fruit of *C. chingii* is 4–5 times longer than wide with a more rounded apex and base, while that of *C. platycarpa* is 2–3 times longer than wide with an acute apex and base.

Ten collections were available of this species, only two of which were flowering.

PARATYPES: CHINA. Guangxi: *Chen* 62–66 (MU), *Li Lin* F349 (MU). Hunan: *Liang Baohan* 83155 (MO). Guangdong: *Tso* 20959 (A), *Gao Xipeng* 52588 (MO), *Tan Peixiang* 59058 (MO, MU). Yunnan: *Feng* 12608 (KUN). Zhejiang: *King* 923 (A), *Yu* 29203 (MO).

3. *Cladrastis kentukea* (Dum.Cours.) Rudd, *Phytologia* 21: 327. 1971. (as “*C. kentuckea*”). *Sophora kentukea* Dum.Cours., *Bot. Cult.* (ed. 2) 6: 56. 1811. *Virgilia dumontii* Raf., *Kentucky Gaz.*, Vol. 36 (new series 45(1): 2, Thursday, 7 November). 1822. *Virgilia kentukea* (Dum.Cours.) Raf., *Neogenyton* 1. 1825 (as “*V. kentukensis*”). *Cladrastis kentukea* (Dum.Cours.) Raf. ex B. D. Jacks., *Index Kew.* 1: 552. 1893 (as “*C. kentukensis*”; *pro. syn.*, *nom. inval.* Art. 34.1c). TYPE: North Carolina: Jackson County, 16 May 1999, *K. D. Heafner & J. F. Barcelona s.n.* (NEOTYPE here designated: MU!; ISONEOTYPES: K!, MO!, US!). Figure 8.

Virgilia lutea Michx. f., *Hist. Arbr. Forest.* 3: 266, pl. 3. 1813. *Cladrastis lutea* (Michx. f.) K. Koch, *Dendrologie* 1: 6. 1869. TYPE: A. *Michaux s.n.* (HOLOTYPE: P; ISOTYPE: P!).

Virgilia fragilis Raf., *Kentucky Gaz.*, Vol. 36 (new series 45(1): 2, Thursday, 7 November). 1822. TYPE: Kentucky: 1842, *C. W. Short s.n.* (NEOTYPE here designated: NY!; ISONEOTYPES: NY!, NY!).

Virgilia alba Raf., *Kentucky Gaz.* 1822, *fide* Raf. *Cincinnati Lit. Gaz.* 1(8): 60. 1824. TYPE: Kentucky: banks of Kentucky River, May 1833, *R. Peter s.n.* (NEOTYPE here designated: NY!; ISONEOTYPE: NY!).

Cladrastis fragrans Raf., *Cincinnati Lit. Gaz.* 1(8): 60. 1824. TYPE: Kentucky: 1831, *Rafinesque s.n.* (NEOTYPE here designated: NY!).

Cladrastis tinctoria Raf., *Neogenyton* 1. 1825. *Cladrastis albiflora* Raf., *New Fl. (Rafinesque)* 3: 83. 1838. (*pro syn.*). TYPE: Kentucky: Kentucky River, Cumberland, *s.d.*, *Rafinesque s.n.* (NEOTYPE here designated: PH!).

Cladrastis lutea f. *tomentosa* Steyerm., *Rhodora* 40: 487. 1938. *C. kentukea* f. *tomentosa* (Steyerm.) Spongberg in Spongberg and J. Ma, *Int. Dendrol. Soc. Year. Book* (1996): 29. 1996. TYPE: Alabama: Tuscaloosa Co., *E. J. Palmer* 35387 (HOLOTYPE: FI; ISOTYPE: US!).

Tree 10–20 m, canopy broad, rounded, to 16 m wide. Bark gray to gray-brown, on new stems reddish brown. Buds rusty-pubescent. Leaves

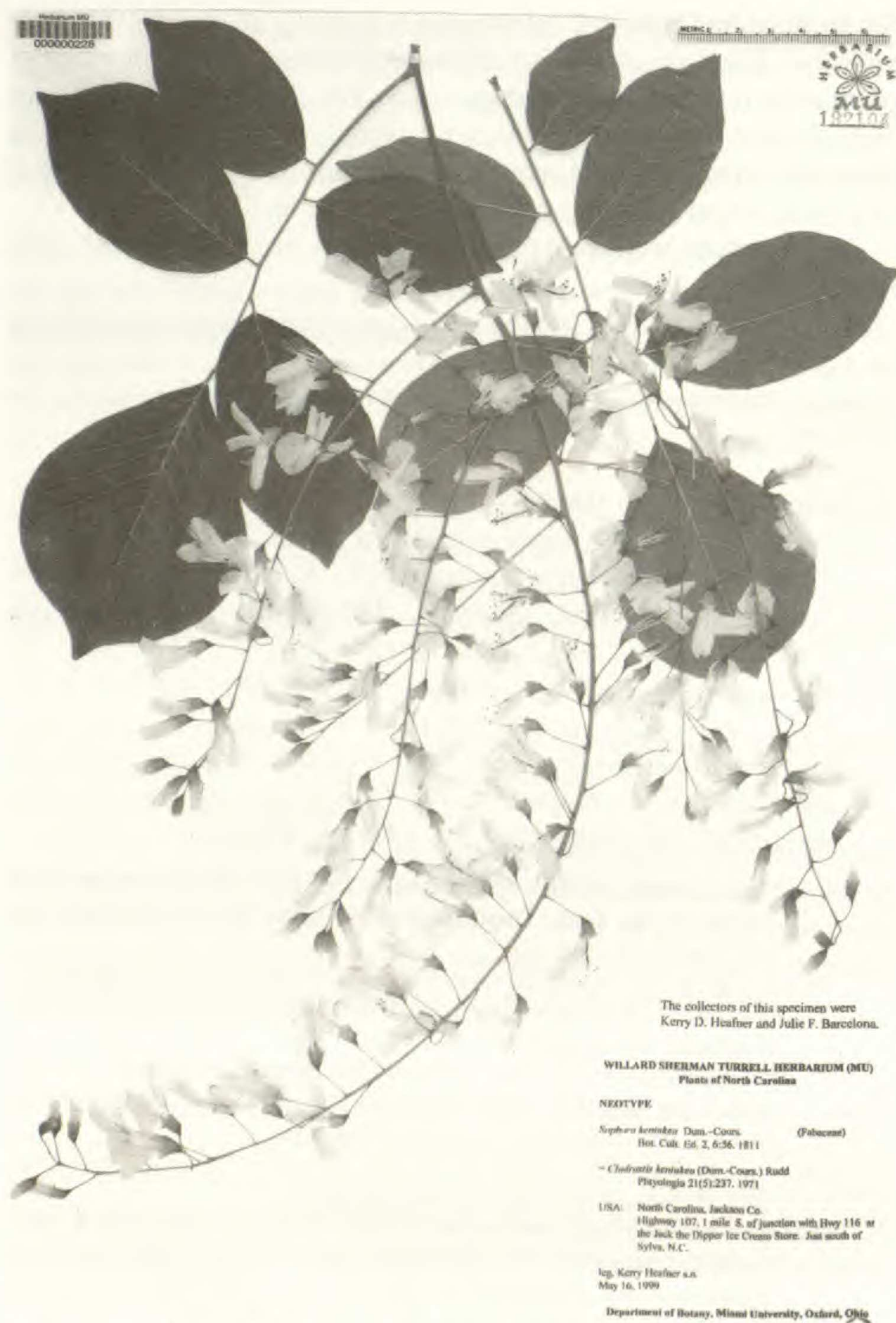


Figure 8. Neotype of *Sophora kentukea* (= *Cladrastis kentukea*; Heafner & Barcelona s.n., MU).

(17–) 26 (–34) cm, petiole (1.0–) 3.3 (–5.0) cm, green to greenish brown, glabrous, leaflets (5–) 7 (–9); first leaflet: pulvinus sparsely yellow to rusty pubescent; stipels absent; lamina (3.0–) 6.0 (–9.5) × (2.5–) 3.9 (–6.0) cm, ovate, base rounded, apex acuminate, upper surface glabrous, lower surface sparsely to densely white pubescent at base near midrib; terminal leaflet: pulvinus glabrous to sparsely yellow to rusty pubescent, stipels absent, lamina (6.0–) 7.0 (–17.0) × (5.0–) 7.2 (–11.0) cm, obovate to ovate to elliptical to broadly elliptical, base acute, apex acuminate, upper surface glabrous, lower surface glabrous to sparsely white pubescent on or near midrib. Inflorescence (20–) 25 (–50) × 7–22 cm, pendulous; peduncle (1.5–) 2.8 (–8.0) cm, green, glabrous or sparsely yellow to rusty pubescent proximally; pedicel 1–2 cm, sparsely to densely white to yellow pubescent. Calyx (7.2–) 7.4 (–11.2) × (9.6–) 12.5 (–14.9) mm, densely white to yellow pubescent; upper teeth (1.0–) 1.5 (–2.4) × (2.4–) 3.8 (–6.7) mm, rounded; lateral teeth (1.1–) 1.6 (–2.5) × (2.2–) 2.7 (–3.2) mm, rounded; lower tooth (0.4–) 1.5 (–2.4) × (0.9–) 1.9 (–2.7) mm, acute. Corolla white (rarely pink); banner petal (12.3–) 15.9 (–18.3) × (10.0–) 13.0 (–15.7) mm, reflexed, orbicular, base acute to cuneate, claw 4–7 mm; wing petals (12.0–) 15.3 (–18.9) × (5.1–) 6.4 (–7.7) mm, lanceolate, base auriculate, claw 5–8 mm; keel petals (10.7–) 14.2 (–18.2) × (6.1–) 6.8 (–9.0) mm, lanceolate, base auriculate, margins overlapping and folded together. Anthers (0.8–) 1.3 (–1.6) × (.5–) 0.9 (–1.3) mm. Ovary (3.8–) 7.2 (–9.4) × (0.6–) 0.9 (–1.3) mm, densely white to yellow pubescent; style (3.5–) 4.0 (–4.8) mm; ovules 8–13. Fruit 7–8 cm, not winged, apex and base acute; seeds 5–8. Chromosome number $2n = 28$ (Atchison 1949).

DISTRIBUTION AND HABITAT. *Cladrastis kentukea* is endemic to North America (Figure 9). It is found in two separate geographic areas in the United States: 1) North and South Carolina, Tennessee, Kentucky, Alabama, and Georgia, and 2) Illinois, Indiana, Missouri, Arkansas, and Oklahoma (Pittillo 1963). Populations in Brown County State Park in Brown County, Indiana, and the Yellowwood State Forest in Indiana are the northernmost occurrences of the species (Huffman 1986). Spongberg and Ma (1996) reported *Cladrastis* from Brown County, Ohio, though Cooperrider et al. (2001) considered it as introduced in that state.

The habitat of *Cladrastis kentukea* is variable across its range, but it is typically found along river bluffs and in openings in mesophytic cove forests in association with major drainage areas (Huffman 1986; Pittillo 1963). Sargent (1949) reported that *Cladrastis* only grew in limestone soils but other researchers have reported it in areas where the parent

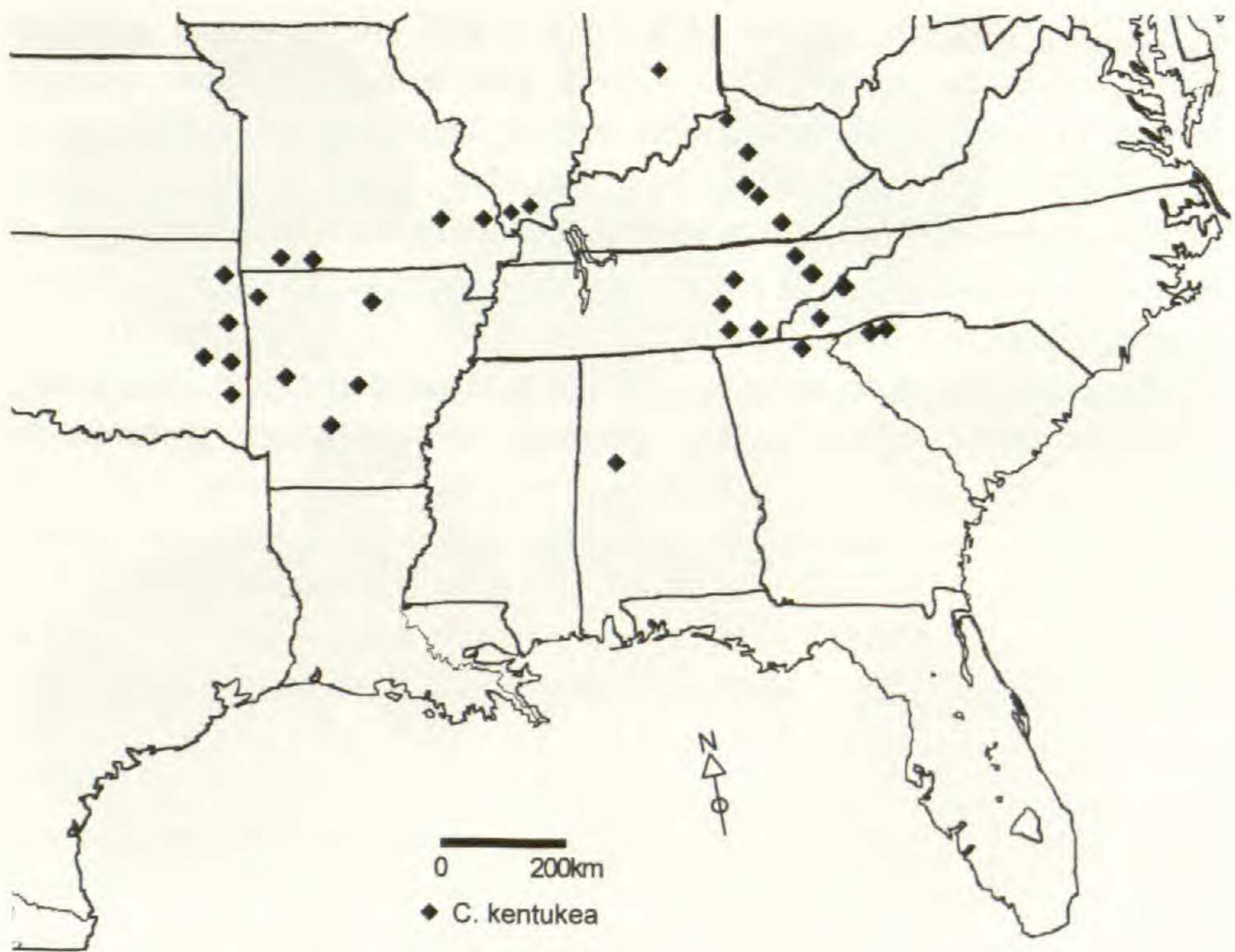


Figure 9. Distribution of *Cladrastis kentukea* in the United States.

material is other than limestone, such as shale (Palmer and Steyermark 1935).

PHENOLOGY. Flowering commences in mid-May, after the leaves have emerged, and is generally finished by the end of May. Trees become fertile after 6–8 years and generally flower every two to three years (Hershey 1977). Fruit set immediately follows flowering and the fruits remain on the trees through leaf drop (Robertson 1977).

NOTES. The specimen designated as the neotype for *Cladrastis fragrans*, Rafinesque *s.n.* 1831 (NY), has been determined by R. L. Stuckey to be a Rafinesque specimen. It is believed to be one of only two surviving *Cladrastis* specimens from Rafinesque's herbarium (Stuckey 1971a, b). We have chosen the other specimen, labeled "*Cladrastis riparia*" (an unpublished name) in Rafinesque's script, as neotype of *Cladrastis tinctoria*; the specimen is mounted on the upper right corner of a sheet with a collection by C. W. Short.

Cladrastis kentukea is not a common tree in the wild but it can be propagated by root cuttings or from seed (Robertson 1977) and it is widely cultivated (Gilman 1997; Griffiths 1994; Hershey 1977;

Krüssmann 1976). However, unlike many other species in the subfamily Papilionoideae, *C. kentukea* does not fix nitrogen with rhizobia (Graves and van de Poll 1992) so those wishing to grow this species should not rely on rhizobia to provide the plant with nitrogen. A pink-flowered tree is on the grounds of the Perkins School for the Blind in Watertown, Massachusetts. The origin of this tree is unknown; however, cuttings have been successfully cultivated by the Arnold Arboretum; Brimfield Nurseries in Connecticut; The Barnes Foundation in Marion, PA; the Dawes Arboretum in Newark, OH; and the Morton Arboretum in Lisle, IL (Hershey 1977; Robertson 1977). Specimens of the pink-flowered form are sold by nurseries under the horticultural name 'Rosea.' A pubescent form was described by Steyermark (1938). However, the type is of a young flowering plant, and since *Cladrastis* is somewhat pubescent early and becomes glabrous later in the season, the form name is not warranted.

Rafinesque published seven names for this taxon, and this has resulted in much confusion. The first mention he made of this plant was in the *Kentucky Gazette* (Rafinesque 1822), in a note in which he distinguished *Virgilia lutea* Michx. from *V. fragilis* (found in Kentucky) and from *V. dumonti* (also found in Kentucky). He proposed the latter name as a replacement for *Sophora kentukea* Dum.Cours. In *Neogenyton*, Rafinesque (1825) used the name *Cladrastis tinctoria* (replacing *C. fragrans*) as a synonym for both *V. lutea* Michx. and *V. kentukensis* Dum.Cours. It is thought that Rafinesque meant Dumont de Courset's *S. kentukea* instead of *V. kentukensis*, since *V. kentukensis* had apparently never been published. In his *New Sylva*, Rafinesque (1838) equated *C. albiflora* with *C. tinctoria*. Koch (1869) made the combination *C. lutea*. Finally, Rudd (1971) made the combination *C. kentuckea* [sic] based on a note in the 1893 Index Kewensis that *S. kentukea* and *V. kentukensis* were synonyms. The name *C. kentukea* (Dum.Cours.) Raf. ex B. D. Jackson (Index Kew. 1: 552. 1893; as "C. kentukensis") is not validly published as per Art. 34.1c of the 2000 International Code of Botanical Nomenclature and therefore does not have priority over *C. kentukea* (Dum.Cours.) Rudd. The original description of Dumont de Courset's *S. kentukea* clearly represents this taxon; the spelling of the epithet should be *kentukea*, not the incorrect spelling *kentuckea*.

Of the thirteen names associated with this species, only two, *Virgilia lutea* Michx. f. and *Cladrastis lutea* forma *tomentosa* Steyermark had holotypes specified in the protologues. Neotypes for *Sophora kentukea* and *C. fragrans* are designated here, as no original material is known to

exist for either epithet. The Rafinesque specimen is designated neotype rather than lectotype because there is no date on the specimen and it is impossible to ascertain when and where it was collected. The specimen was labeled, in Rafinesque's script, as *Cladrastis*. The need for neotypification of many of Rafinesque's names is borne out by the fact that very few of his specimens still exist, and much of his botanical collection was destroyed or sold as waste paper after his death (Call 1895; Stuckey 1971a, b).

REPRESENTATIVE SPECIMENS: UNITED STATES. Alabama: Tuscaloosa Co., Warrior River near lock 14, *Palmer 35387* (A, MO, PH). Arkansas: Benton Co., *Demaree 6613* (A, F, MO, NY, TEX). Georgia: Towns Co., 1.5 mi. E, 10° S of Titus, Hightower Bald region, *Duncan 7644* (B, GH, KY, LL, MO, NY, PENN, TEX, US). Illinois: Alexander Co., NW slope of Wolf Creek Hill, SE 1/4 sec. 17, T14S, R2W, Thebes quad, SW of Diswood, *Busar 5420* (ILL). Indiana: Brown Co., Brown Co. State Game Preserve, *Deam 54279* (A, F, GH, IND, MO, PH, NY, US). Kentucky: Along Kentucky River, *Short s.n.* (E, GH, NY). Missouri: Taney Co., Forsyth, common on rocky bluffs, *Bush 84* (F, GH, IND, MO, NY, US). North Carolina: Haywood Co., Pigeon River Gorge, 2.1 km E of TN state line on I-40, *Pittillo 5120* (BM, GH, KY, NY, TEX). Oklahoma: Cherokee, Wooded base of Keyough Bluffs, 2 mi. N of Ft. Gibson, *Wallis 6896* (GH, TEX). South Carolina: Greenville Co., Saluda River valley between reservoir and Benfield, *Hill 25031* (GH, MO, NY, TEX). Tennessee: Davidson Co., Hills around Nashville, *Gattinger 703* (BM, F, GH, K, MO, NY, PA).

4. *Cladrastis wilsonii* Takeda, Notes Roy. Bot. Gard. Edinburgh 8(37): 103. 1913. [LECTOTYPE here designated: CHINA. Patung Hsien woodlands, alt. 1500–1600 m, Jul and Sep 1907, *E. H. Wilson 1102* in part (A!)]. Figure 10.

C. lichuanensis Q. W. Yao & G. G. Tang in G. G. Tang, Bull Bot. Res. Harbin 8(3): 157. 1988. *C. lichuanensis* Q. W. Yao & G. G. Tang, Chinese Trees and Wood 2: 1335–1336. 1985, *nom. nud.* TYPE: CHINA. Hupeh, Lichuanxian Shindoshan, *s.d.*, *G.G. Tang & X. H. Song 633* (HOLOTYPE: Nanjing Forestry University Herbarium).

Tree 4–16 m. Bark gray to yellowish gray, on new stems reddish gray. Leaves (20.4–) 26.4 (–34.6) cm, petiole (1.4–) 2.4 (–3.9) cm, green to greenish brown, glabrous, leaflets (8–) 9 (–11); first leaflet: pulvinus glabrous to sparsely white to yellow pubescent; stipels absent; lamina (3.5–) 6.2 (–8.7) × (1.8–) 2.8 (–3.7) cm, ovate, base rounded, apex acuminate, upper surface glabrous; lower surface glabrous; terminal leaflet: pulvinus glabrous; stipels absent; lamina (6.0–) 9.3 (–14.3) × (2.7–) 4.6 (–6.5) cm, elliptical to ovate, base acute, apex acuminate, upper surface glabrous, lower surface glabrous when mature, (early leaves sparsely white pubescent on or near midrib). Inflorescence (13.3–) 22.3 (–28.4) cm, pendulous; peduncle (1.5–) 2.2 (–4.3) cm, green to



Figure 10. Lectotype of *Cladrastis wilsonii* (Wilson 1102, in part, A).

brown, glabrous to sparsely white to yellow pubescent; pedicel (0.5–) 0.8 (–1.1) cm, sparsely to densely white to yellow to pale green pubescent. Calyx (7.2–) 7.7 (–8.0) × (10.4–) 12.3 (–14.4) mm, densely white to yellow to pale green pubescent; upper teeth (1.3–) 1.9 (–2.8) × (1.9–) 2.3 (–2.7) mm, acute; lateral teeth (1.9–) 2.2 (–2.6) × (2.1–) 2.7 (–3.2) mm, acute; lower tooth (1.6–) 2.1 (–2.7) × (1.6–) 2.2 (–2.9) mm, acute. Corolla white; banner petal (9.3–) 12.9 (–15.2) mm × (9.6–) 11.6 (–13.4) mm, reflexed, orbicular, base acute to cuneate, claw (2.3–) 3.6 (–5.1) mm; wing petals (9.3–) 13.4 (–14.4) × (3.8–) 5.7 (6.7) mm, lanceolate, base auriculate, claw (4.0–) 5.0 (–5.9) mm; keel petals (8.8–) 14.0 (–14.9) × (4.8–) 6.0 (–7.2) mm, lanceolate, base auriculate, margins overlapping and folded together. Anthers (0.8–) 1.1 (–1.6) × (0.6–) 0.7 (–1.0) mm. Ovary (5.0–) 7.9 (–8.0) × (1.1–) 1.4 (–1.6) mm, densely white to yellow pubescent; style (3.2–) 5.1 (–7.2) mm; ovules (1–) 3 (–5). Fruit 4.5 cm, apex and base acute; seeds 1–5.

DISTRIBUTION AND PHENOLOGY. *Cladrastis wilsonii* is found throughout central China (Figure 5). It is fairly common in the moist woods of western Hubei province (Takeda 1914) and is known from Yunnan province in the south, north through Guangxi and Hunan, east to the Jiangxi, Fujian, and Zhejiang provinces, and as far north as Anhui province. The eastern edge of the Red Basin in Sichuan province appears to be the western limit of the range of *C. wilsonii*.

Cladrastis wilsonii flowers in mid-May in the southern extent of its range with flowering time moving into mid-July in Hubei and Sichuan provinces farther north. Flowering is preceded by the emergence of the leaves, and seed set immediately follows. The fruits remain on the trees through leaf drop in September and October.

NOTES. The designation “Wilson 1102” appears to have been a field number for the species, rather than an actual collection number, since many different dates and localities are listed on different sheets with this number on them. *Cladrastis wilsonii* is cultivated, although the inflorescences are not as large as nor as showy as those of either *C. delavayi* or *C. kentukea*. The species may be susceptible to frost damage when young (Krüssmann 1976). The leaves of *C. wilsonii* are similar to those of *C. shikokiana*; however, the underside of the young leaves of *C. wilsonii* are sparsely white to yellowish pubescent when young, becoming glabrous, whereas the underside of the leaves of *C. shikokiana* are brown pubescent. *Cladrastis wilsonii* is sympatric on the western edge of its range with *C. delavayi*. *Cladrastis delavayi* differs from

C. wilsonii by its larger number of leaflets that are narrower with rounded bases and emarginate apices. The leaves of *C. delavayi* are also a darker green and may be slightly glaucous underneath.

Tang (1988) reported a new species, *Cladrastis lichuanensis* Q. W. Yao & G. G. Tang, as similar to *C. wilsonii* but differing in the underside of the leaflet being a paler green, and the petiole, leaf rachis, and legume densely rusty pubescent (all characters of *C. delavayi*). Examination of the type specimen, *Tang & Song 633*, located in the Nanjing Forestry University, was not possible. However, when we read the original article, it became clear that two different species, *C. delavayi* and *C. wilsonii*, were inadvertently used in writing the species' description. The illustration given with the protologue is of *C. wilsonii*, and at least one of the paratypes (*C. T. Hwa 417, A!*) is *C. delavayi*.

REPRESENTATIVE SPECIMENS: CHINA. Anhui: Wang shan, *Ching 2958* (A, K, S). Zhejiang: King Yuan, *Ching 2535* (BM, E, GH, NY). Hubei: *Wilson 1102* (BM, E, F, A, K, MO, P, US). Hunan: Wukang, *Handel-Mazzetti 702* (A). Jiangxi: *Wilson 1535* (A); Kuling, 1 Aug 1907, *Wilson 1535* (A, syntype). Guangxi: *Steward & Cheo 375* (BM, GH, NY, P, S). Sichuan: *Cheng 2885* (BM, E). Yunnan: *s.d., McLaren s.n.*, (K); Changyang Hsien woods, alt. 1600–200. m, 19 May 1907, *Wilson 1102* in part (*n.v.*, syntype). Fang Hsien woodlands, alt. 2000 m, 19 May 1907, *Wilson 1102* in part (A, syntype); Changlo Hsien, woods, alt. 1600–2000 m, Jul 1907, *Wilson 1102* in part (A, syntype); Wushan Hsien woods, alt. 1600–2000 m, Oct 1907, *Wilson 1102*, in part (A, BM, MO, syntypes).

5. *Cladrastis delavayi* (Franch.) Prain, Ann. Roy. Bot. Gard. (Calcutta). 10(1): 109. 1904. *Dalbergia delavayi* Franch., Pl. Delav. (1): 186–187. 1888. TYPE: CHINA: Yunnan Province: Pou-sy, Pien-kio, 16 Jul 1888, *P. J. M. Delavay s.n.* (HOLOTYPE: P!). Figure 11.

Cladrastis sinensis Hemsl., J. Linn. Soc., Bot. 29: 304. 1892. TYPE: CHINA. Szechuan: Tachienlu, *s.d.*, *A. E. Pratt 129* (HOLOTYPE: K!; ISOTYPES: BM!, E!, GH!, K!, P!).

Tree to 15 m. Bark grayish. Leaves (15–) 23 (–33) cm, petiole (1.2–) 2.5 (–3.0) cm, yellow to green to greenish brown, glabrous to sparsely yellow pubescent, leaflets (9–) 11 (–13); first leaflet: pulvinus densely yellow pubescent; stipels absent; lamina (3.9–) 5.1 (–6.6) × (1.7–) 2.2 (–2.8) cm, ovate, base rounded, apex emarginate, upper surface glabrous, lower surface glabrous to sparsely white to yellow pubescent near midrib; terminal leaflet: pulvinus glabrous to sparsely yellow to rusty pubescent; stipels absent; lamina (5.6–) 7.6 (–11.3) × (2.2–) 3.2 (–3.8) cm, elliptical to narrowly elliptical, base rounded (rarely acute), apex emarginate, upper surface glabrous, lower surface glabrous to sparsely white pubescent on or near midrib. Inflorescence (11.8–) 21.9 (–29.3)



Figure 11. Holotype of *Cladrastis delavayi* (Delavay s.n., P).

cm, erect; peduncle (1.1–) 2.7 (–5.3) cm, green to brown, sparsely rusty pubescent proximally; pedicel (0.4–) 0.6 (–0.8) cm, densely rusty pubescent. Calyx (4.6–) 5.9 (–6.9) × (7.7–) 9.5 (–10.9) mm, densely white to rusty pubescent; upper teeth (0.8–) 1.7 (–1.8) × (1.4–) 2.0 (–2.6) mm, acute; lateral teeth (0.6–) 1.4 (–2.1) × (1.6–) 2.1 (–2.7) mm, acute; lower tooth (0.8–) 1.4 (–1.9) × (1.4–) 1.8 (–2.4) mm, acute. Corolla white (rarely pink); banner petal (6.4–) 9.0 (–14.4) × (5.4–) 7.3 (–9.3) mm, reflexed, orbicular, base acute to cuneate, claw (0.6–) 2.4 (–3.2) mm; wing petals (6.4–) 8.3 (–9.6) × (3.0–) 3.9 (–4.8) mm, lanceolate, base auriculate, claw (2.1–) 3.2 (–4.0) mm; keel petals (6.2–) 9.3 (–10.5) × (3.8–) 4.8 (–5.6) mm, lanceolate, base auriculate, margins overlapping and folded together. Anthers (0.5–) 0.8 (–1.1) × (0.3–) 0.6 (–0.8) mm. Ovary (4.0–) 5.5 (–7.2) × (0.8–) 0.7 (–1.3) mm, densely white to yellow pubescent; style (1.1–) 2.8 (–3.5) mm; ovules (7–) 10 (–15). Fruit 3–6 cm, apex and base acute; seeds 1–3.

DISTRIBUTION AND PHENOLOGY. *Cladrastis delavayi* occurs in western and central China (Figure 5). It is found in western Sichuan, Yunnan, Hunan, and Hubei provinces primarily in wooded habitats between 1500 and 2500 m.

Flowering begins mid-June, after the leaves have emerged, and is generally finished by mid- to late July. Fruit set immediately follows flowering and the fruits remain on the trees through leaf drop.

NOTES. *Cladrastis delavayi* has been cultivated in the United States and Europe (Cullen 1995) and, like *C. kentukea*, has a pink-flowered horticultural form, 'Rosea.' In China, the range of *C. delavayi* overlaps somewhat with another Chinese species, *C. wilsonii*. In the field, the two species can be easily distinguished when they are in flower, since *C. delavayi* has an erect inflorescence, whereas the inflorescence of *C. wilsonii* is pendulous. In addition, *C. delavayi* is the only *Cladrastis* species with an emarginate leaflet apex.

All references seen cite the name *Cladrastis sinensis* Hemsl. as the correct name for this species. However, Franchet (1889) reported a new species as *Dalbergia delavayi* and cited a Delavay specimen collected 16 July 1888 as the type. Prain (1904) excluded *D. delavayi* from his *Dalbergia* treatment and correctly placed it in *Cladrastis*. Takeda (1913) stated he had not seen the specimen but, according to the description, he believed it was not a *Cladrastis* and placed *C. delavayi* in his excluded species. The specimen Franchet cited as the holotype represents the same species as *C. sinensis* Hemsl. According to the International Code of Botanical Nomenclature, *delavayi*, as the older specific epithet, has

priority over *sinensis*. Therefore, the correct name is *C. delavayi* (Franch.) Prain.

REPRESENTATIVE SPECIMENS: CHINA. Hubei: *Wilson* 2398 (A, NY); Hubei/Sichuan border near *Metasequoia* area, *Hwa* 417 (A). Hunan: *Henry* 10784 (A, E, MO, S). Sichuan: *Forrest* 7827 (A, E). Yunnan: *Maire* 686 (E).

6. *Cladrastis shikokiana* (Makino) Makino, Bot. Mag. (Tokyo) 15: 62. 1901. *Sophora shikokiana* Makino, Bot. Mag. (Tokyo) 14: 34–35. 1900. *Sophora shikokiana* Makino, Bot. Mag. (Tokyo) 6: 53. 1892. *nom. nud.* (LECTOTYPE here designated: MAK 133710!). Figure 12.

Tree, 15 m. Leaves (19.8–) 24.7 (–34.8) cm, petiole (2.0–) 2.7 (–4.2) cm, green to greenish brown, glabrous, leaflets (9–) 11 (–13); first leaflet: pulvinus glabrous to isolated yellow pubescent; stipels absent; lamina (4.2–) 5.7 (–6.9) × (1.6–) 2.6 (–3.3) cm, ovate, base rounded, apex acuminate, upper surface glabrous, lower surface glabrous to sparsely white to yellow pubescent at base near midrib; terminal leaflet: pulvinus glabrous; stipels absent; lamina (5.3–) 9.2 (–12.4) × (2.5–) 4.2 (–5.3) cm, elliptical, base acute, apex acuminate, upper surface glabrous, lower surface glabrous. Inflorescence (14.0–) 19.4 (–27.2) cm, pendulous; peduncle (1.7–) 2.6 (–4.6) cm, green, glabrous; pedicel, densely rusty pubescent. Calyx (7.4–) 8.5 (–9.6) × (11.5–) 12.9 (–14.9) mm in circumference, densely rusty pubescent; upper teeth (1.6–) 1.8 (–1.9) × (1.9–) 2.6 (–3.2) mm, acute; lateral teeth (1.9–) 2.2 (–2.4) × (2.4–) 2.7 (–3.2) mm, acute; lower tooth (1.9–) 2.1 (–2.6) × (2.1–) 2.5 (–3.2) mm, acute. Corolla white; banner petal (9.3–) 12.7 (–14.4) × (10.2–) 11.0 (–12.0) mm, reflexed, orbicular, base acute to cuneate, claw (2.9–) 3.7 (–4.0) mm; wing petals (9.3–) 12.2 (–14.4) × (3.8–) 5.7 (–6.7) mm, lanceolate, base auriculate, claw (4.0–) 5.3 (–5.6) mm; keel petals (8.8–) 12.2 (–14.4) × (4.8–) 5.9 (–7.2) mm, lanceolate, base auriculate, margins overlapping and folded together. Anthers (0.8–) 1.2 (–1.6) × (0.6–) 0.7 (–0.9) mm. Ovary (4.8–) 6.7 (–7.2) × (1.1–) 1.4 (–1.6) mm; densely white to yellow pubescent; style (3.2–) 4.9 (–6.4) mm; ovules 11–14. Fruit 6–7 cm, not winged, apex and base acute; seeds 4–6.

DISTRIBUTION AND PHENOLOGY. *Cladrastis shikokiana* is restricted to the southern half of Japan (Figure 6), from as far south as Hondo in the Kumamoto prefecture on the island of Kyushu, north to Ehime prefecture on the island of Shikoku, and then the southern half of the island of Honshu. There, it is found in Shimane, Hyogo, Kyoto, Wakayama, Shiga, Aichi, and Yamanashi prefectures, and as far north as

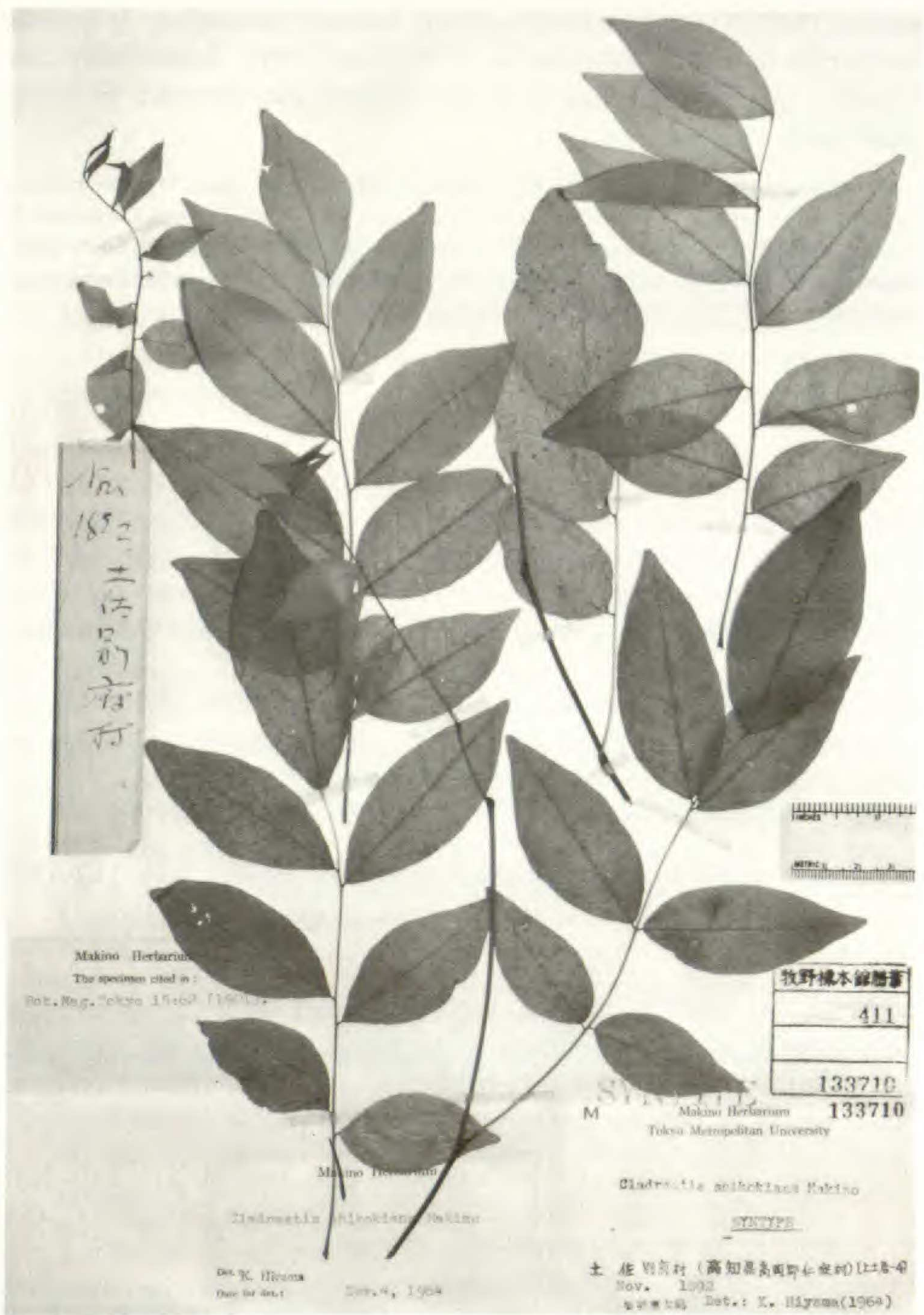


Figure 12. Lectotype of *Cladrastis shikokiana* (MAK 133710).

Tokyo prefecture. In all instances, it appears to be found at elevations of less than 500 m.

Cladrastis shikokiana flowers between May and June, after the emergence of the leaves.

NOTES. There is very little written about *Cladrastis shikokiana*. It appears to be rare in occurrence (Makino 1901; Ohwi 1965; Satake 1989), its distribution is limited, and it is not listed in the literature as being cultivated.

REPRESENTATIVE SPECIMENS: JAPAN. Ehime: *Yamanaka s.n.* (MO). Hyogo: Harima province, *Faruse s.n.* (NY). Kumamoto: *Kobayashi 14293* (s). Kyoto: *Tsugarwu & Sawada 19101* (A, MO). Shiga: W side of Mt. Hira san, *Tateishi & Hoshi 9149* (MO). Shimane: *Oka 990* (P, NY). Wakayama: Mt. Keya, *Makino s.n.* (A, MO). Yamanashi: near junction of Taba & Komuro rivers, *Tateishi & Hoshi 8701* (MO).

QUESTIONABLE TAXA

Ma (1982) reported two new *Cladrastis* species, *C. scandens* and *C. parvifolia*, in China. The type specimens of these two species were repeatedly requested from the herbaria cited in the protologue, with no response. It was subsequently discovered that the types were not at the herbaria indicated in the protologue (C. Y. Ma, pers. comm.). According to Dr. Ma, the type of *C. scandens* Ma is in the Herbarium, Institute of Botany, Academia Sinica, Beijing (PE), and the type of *C. parvifolia* Ma is in the Herbarium, Department of Taxonomy, South China Institute of Botany, Academia Sinica, Guangzhou (IBSC). We were unable to obtain these specimens on loan.

Cladrastis scandens C. Y. Ma, Bull. Bot. Res., Harbin 2(1): 112–113. 1982. TYPE: CHINA. Guizhou, Anlong, Renli, May 1960, Y. T. Chang & Z. S. Chang 3547 (HOLOTYPE: PE, n.v.). (ex char.)

From the description, it is highly probable that *C. scandens* is synonymous with *C. platycarpa*. Ma stated that the only difference between the two is the scandent habit of *C. scandens*. There is no clear indication as to how the habit was determined.

Cladrastis parvifolia C. Y. Ma, Bull. Bot. Res., Harbin 2(1): 110–111. 1982. TYPE: CHINA. Guangxi: Linggui, Chaotian Tangjiacun, Oct 1950, C. H. Tsoong 808659 (HOLOTYPE: IBSC, n.v.). (ex char.)

Without having seen the type of *C. parvifolia*, it is impossible to ascertain if it belongs in the genus *Cladrastis*. Information on the axillary bud location (whether or not it is enclosed by the petiole) is missing (Ma 1994). The smaller size of the leaflets, 2–4 × <2 cm versus (2.5–) 4.9 (–9) × (1–) 2.3 (–3.5) cm in other *Cladrastis* species, the smaller inflorescence length, 5–10 cm versus (9.6–) 18.6 (–27.7) cm in other *Cladrastis*, and the fact that it flowers in October rather than in

the spring suggest it may not belong in this genus. Based on the descriptions of *C. parvifolia* and *Maackia fauriei* (Takeda 1913), *C. parvifolia* may be synonymous with *M. fauriei*.

EXCLUDED TAXA

Cladrastis amurensis (Rupr.) Benth. ex Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 18: 400. 1873. ≡ *Maackia amurensis* Rupr., Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Pétersbourg 15: 128, 143. 1856. TYPE: CHINA. Manchuria: *s.d.*, *R. Maack s.n.* (HOLOTYPE: LE; ISOTYPE: K!, P!).

Cladrastis australis Dunn, Bull. Misc. Inform. 10: 86–87. 1912. ≡ *Maackia australis* (Dunn) Takeda, Notes Roy. Bot. Gard. Edinburgh 8: 102. 1913. TYPE: CHINA. “*Sophora* from China, Hort. Soc. Hort. London.” 1838, *Millett s.n.* (SYNTYPE: K!).

Cladrastis buergeri (Maxim.) Kom., Trudy Imp. S.-Petersburgsk. Bot. Sada 22: 571. 1904. *Amorpha fruticosa* Thunb., Fl. Jap. 278. 1784. *Buergeria floribunda* Miq., Ann. Mus. Bot. Lugduno-Batavi 3: 53. 1867. *Cladrastis amurensis* var. *buergeri* Maxim., Bull. Acad. Imp. Sci. Saint-Pétersbourg 18: 400. 1873. *Maackia amurensis* var. *buergeri* (Maxim.) C. K. Schneider, Ill. Handb. Laubh. 2: 16. 1907. *Maackia buergeri* (Maxim.) Tatew., Trans. Sapporo Nat. Hist. Soc. 16: 4. 1939. *Maackia amurensis* subsp. *buergeri* (Maxim.) Kitam., Acta Phytotax. Geobot. 25(2–3): 44. 1972. (*ex char.*)

Based on the descriptions, *C. buergeri* (Maxim.) Kom. should be placed in *Maackia*, not *Cladrastis*. It is not possible to say whether it merits specific rank without a complete revision of the genus *Maackia*.

Cladrastis fauriei H. Lev., Repert. Spec. Nov. Regni Veg. 7: 230. 1909. ≡ *Maackia fauriei* (H. Lev.) Takeda, Notes Roy. Bot. Gard. Edinburgh 8: 101. 1913. TYPE: KOREA: Hallaisan, Quelpaert, Aug 1907, *U. Faurie 1692* (HOLOTYPE: E!).

Cladrastis secundiflora (Ortega) Raf., Neogenyton Sect. 1: 1. 1825. ≡ *Sophora secundiflora* (Ortega) DC., Cat. Pl. Horti Monsp. 148. 1813. (Isely 1998).

Cladrastis tashiroi Yatabe, Bot. Mag. (Tokyo) 6: 345. 1892. ≡ *Maackia tashiroi* (Yatabe) Makino, Bot. Mag. (Tokyo) 16: 34. 1902. TYPE: JAPAN. Osumi, Oshima Island, Sep 1887, *Y. Tashiro s.n.* (*n.v.*). (*ex char.*)

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