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ORIGINAL ARTICLE

Wood anatomy of major Bignoniaceae clades

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Abstract The circumscription of Bignoniaceae genera and tribes has undergone major changes following an increased understanding of phylogenetic relationships within the family. While DNA sequence data have repeatedly reconstructed major clades within the family, some of the clades recovered still lack diagnostic morpho-anatomical features, complicating their recognition. In this study we investigated the wood anatomy of all major lineages of Bignoniaceae (except Tourrettieae) in search for anatomical synapomorphies for clades. We sampled 158 species of Bignoniaceae, representing 67 out of the 82 genera currently recognized. Detailed descriptions of quantitative and qualitative wood anatomical features are presented for each clade and interpreted in the light of a molecular phylogeny for the family. Jacarandae are characterized by a paratracheal winged-aliform parenchyma, with the traditional subdivision of *Jacaranda* into sections *Monolobos* and *Dilobos* supported by the uniseriate and homocellular rays of *Monolobos* versus the wide and heterocellular rays of *Dilobos*. Tecomeae s.s. are characterized by scanty paratracheal parenchyma, septate fibers, and heterocellular rays, traits also found in *Delostoma*, a genus previously included in Tecomeae s.l., but recently shown to represent a separate lineage. Crescentiina includes two subclades, the *Tabebuia* alliance and the Paleotropical clade, which share abundant aliform parenchyma, short and mainly homocellular rays, less commonly with heterocellular rays with body procumbent and one row of marginal square cells. Members of the *Tabebuia* alliance and the Paleotropical clade can be distinguished from each other by the narrow vessels with a widespread storied structure found in members of the *Tabebuia* alliance, versus the vessels with medium to wide width and a non-storied structure found in members of the Paleotropical clade. Oroxyleae are characterized by a combination of simple and foraminate perforation plates and homocellular rays, while Catalpeae are characterized by scanty paratracheal parenchyma, abundant tyloses and vessel-ray pits simple to semi-bordered. Bignonieae differ from all other clades by a variant secondary growth and a typically lianoid wood anatomy. Overall, wood anatomical characters are not very labile within the family, being distributed across clades in a very predictive manner. Several anatomical characters represent good anatomical synapomorphies and provide further support to clades identified in molecular phylogenetic studies.

Keywords *Tabebuia* alliance · Coleeae · Bignonieae · Diversity · Liana · Secondary xylem · Neotropics · Paleotropics

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Introduction

Bignoniaceae are a family of woody plants with approximately 860 species and 82 genera (Lohmann and Ulloa 2006 onwards). Most species are trees and lianas, although some members are shrubs and herbs (Gentry 1980; Lohmann 2004; Fischer et al. 2004; Olmstead et al. 2009). The family is pantropical and centered in tropical South America (Lohmann 2004; Fischer et al. 2004; Olmstead et al. 2009; Olmstead 2013), with only a few genera reaching temperate climates (*Campsis*, *Catalpa*) or high mountains (*Argylia* in the Andes and *Incarvillea* in the Himalayas; Olmstead et al. 2009). Members of Bignoniaceae are generally recognizable by a woody habit, compound opposite leaves, tubular, zygomorphic and showy flowers, four didynamous stamens plus one staminode, and bi-valved dry capsular fruits (Gentry 1980; Lohmann 2004; Olmstead et al. 2009).

In the most recent angiosperm classifications, Bignoniaceae are placed in the order Lamiales (APG II 2003; APG III 2009), within which the family forms a well-supported lineage that is sister to a clade composed of Lamiaceae, Orobanchaceae, Rehmanniaceae, Paulowniaceae, Phrymaceae, Mazaceae, Verbenaceae, Thomandersiaceae, Lentibulariaceae and Schlegeliaceae (Refulio-Rodriguez and Olmstead 2014). Gentry (1980) recognized eight tribes in the family based on habit, fruit dehiscence, and geographical distribution: Bignonieae, Coleeae, Crescentieae, Eccremocarpeae, Oroxyleae, Tecomeae, Tourrettieae, and Schlegelieae (Gentry 1980, 1992; Fischer et al. 2004). However, Schlegelieae were shown to be distantly related from the rest of the family (Spangler and Olmstead 1999; Refulio-Rodriguez and Olmstead 2014) and were subsequently segregated into Schelegeliaceae Reveal. More recently, molecular phylogenetic studies (Spangler and Olmstead 1999; Zjhra et al. 2004; Olmstead et al. 2009) have indicated that some tribes were not monophyletic as traditionally circumscribed, suggesting that nine major clades should be recognized instead. Of these nine clades, two correspond to tribes previously recognized under Gentry's system (1980), i.e., Bignonieae and Oroxyleae. Two other tribes previously recognized under Gentry's system (1980), Crescentieae and Coleeae (minus *Kigelia*), also emerged as monophyletic but nested within more inclusive clades; Crescentieae emerged within the Neotropical *Tabebuia* alliance clade (Grose and Olmstead 2007a), and Coleeae emerged within the Paleotropical clade (Fig. 1; Zjhra et al. 2004; Olmstead et al. 2009). The large tribe Tecomeae, on the other hand, appeared scattered within six different clades: Catalpeae, the *Tabebuia* alliance, the Paleotropical clade, *Delostoma*, Tecomeae s.s., and Jacarandeae. While these clades are well supported by molecular characters, additional diagnostic morphological and anatomical traits are still desirable to characterize them. Indeed, Olmstead et al. (2009, page 1735) noted that: "Several of the large, prominent clades identified in this study lack evident diagnostic traits".

Stem anatomy is one of the most informative sources of diagnostic characters for Bignoniaceae. The wood anatomy of Bignoniaceae has been well studied, since the wood of several species are highly valuable, including that of *Handroanthus* (formerly included in a larger *Tabebuia*; Grose and Olmstead 2007a, b), *Tabebuia*, *Paratecoma*, and *Jacaranda* (Record and Hess 1943; Chudnoff 1984; Dos Santos and Miller 1992, 1997). In addition, the lianas have called the attention of researchers because of the presence of a conspicuous type of cambial variant in their stems, with the formation of four, or multiples of four, phloem wedges that furrow the xylem, giving the stem an unmistakable cross-like shape in transverse section (Schenck 1893; Dobbins 1971; Dos Santos 1995; Pace et al. 2009; Angyalossy et al. 2012). Systematic wood anatomical studies were also successful in sorting lineages within the family. In the large genus *Jacaranda*, wood anatomical studies found differences between *Jacaranda* section *Monolobos* and *Dilobos*, with *Jacaranda* section *Monolobos* exhibiting uniseriate, homocellular rays only and *Jacaranda* section *Dilobos* exhibiting wide, heterocellular rays (Dos Santos and Miller 1997). The recent division of *Tabebuia* into three different genera (Grose and Olmstead 2007a, b), *Handroanthus*, *Tabebuia*, and *Roseodendron* matches perfectly a division long known by wood anatomists that divided *Tabebuia* s.l. in different groups, those of light woods, those of heavy woods, and some species that did not fit in one of these two major groups (Record and Hess 1943; Chudnoff 1984; Dos Santos and Miller 1992). In fact, the light woods are now recognized as *Tabebuia s.s.*, the heavy woods with lapachol obstructing the vessels of the heartwood are now recognized as *Handroanthus*, and the wood anatomically unusual species are now recognized as *Roseodendron* (Grose and Olmstead 2007b). Given the importance of wood anatomical characters in the Bignoniaceae, our study aims to: i) describe the wood anatomy of all major woody clades of Bignoniaceae based in the new systematic arrangement of the family and, ii) search for commonalities on the wood anatomy and character that could represent anatomical synapomorphies of the clades delimited in phylogenetic studies of the family.

Materials and methods

Sampling

Altogether 158 species were sampled, belonging to 67 out of the 82 genera currently recognized in Bignoniaceae, and representing all major clades (Olmstead et al. 2009). Only Tourrettieae, a tribe of two monotypic genera of slender-stemmed vines from the Andes were not sampled. In most cases, two to three specimens were sampled per species. A complete list of species and specimens sampled, collecting numbers, and sampling localities are presented in "Appendix". Wood anatomical characters of the majority of arborescent and shrubby species were obtained from slides deposited at the Forest Products Laboratory Slide

Collection (MADw and SJRw; Madison, Wisconsin, USA), with additional species/specimens from Calvino Mainieri Wood Collection (BCTw; São Paulo, Brazil). Anatomical characters from lianas were obtained from our private slide collection, which was prepared from specimens collected in natural populations or from the living collection of Plantarum Institute and Botanical Garden (Appendix 1). Samples were fixed in FAA 50–70 (50–70 % ethanol-formaldehyde-acetic acid; Berlyn and Miksche 1976) for a week, and subsequently stored in a solution of 50 % ethanol.

Anatomical procedures

Section for our slide collection was prepared according to Barbosa et al. (2010), following double staining in Astra Blue and Safranine (Bukatsch 1972) and mounted in a synthetic resin to obtain permanent slides. Scanning electron microscopy was done with thick sections of wood (ca. 1 mm), submitted to dehydration with acetone, placed on aluminium stubs, sputter-coated with gold, and subsequently analysed in a scanning electron microscope.

Wood description

Anatomical descriptions followed the IAWA list of microscopic features (IAWA Committee 1989) as a starting point, adjusting to the specificities of the Bignoniaceae according to the wood anatomical diversity encountered. Measurements of vessel grouping followed Carlquist (2001). Semi-ring to ring-porous woods have their earlywood and latewood measured separately, since vessels in latewood usually had a different grouping arrangement. In woods with vessels of two width classes (lianas and plants with ring-porous or semi-ring porous woods), both the wide and the narrow vessels were measure and their values expressed separately. All characters and character states examined are presented in Table 1. Measurements were performed using the free software ImageJ (ver. 1.45 s; Rasband 2012), with a minimum of 30 repetitions per specimen. Parameters for all types of xylem cells were measured, including vessel and axial parenchyma frequency, vessel diameter, number of vessels per group, axial parenchyma area, intervessel pit size, ray width and height. Quantitative results are presented as averages accompanied by their standard deviations.

Results

Some wood anatomical traits are common to most, if not all, species of Bignoniaceae. Most arborescent

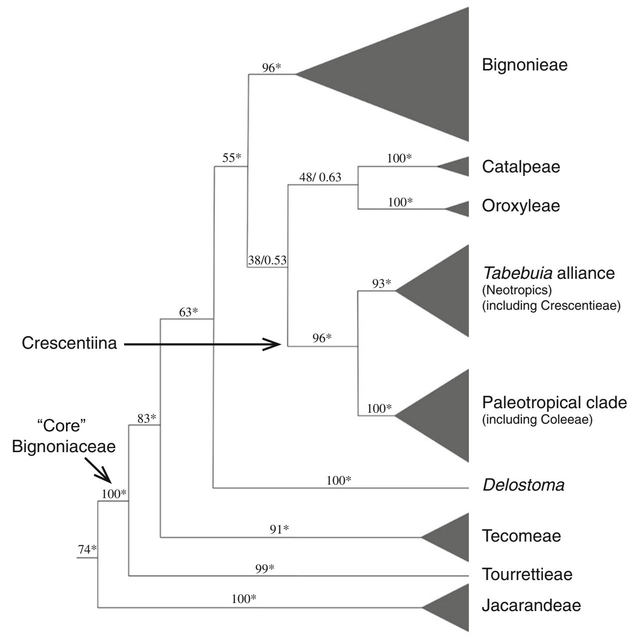

Fig. 1 Phylogenetic relationship of the nine major clades of Bignoniaceae as proposed by Olmstead et al. (2009). *Number above branches* represent bootstrap support, followed by posterior probabilities (recovered from Olmstead et al. 2009); *Asterisk* indicates 100 % posterior probabilities

Bignoniaceae have diffuse porous woods (Fig. 2a), except for the species growing in subtropical and temperate regions, which are semi-ring porous (Fig. 2b) to ring-porous. Most lianas, on the other hand, have semi-ring porous woods (Fig. 2c). Growth rings are typically delimited by a line or band of marginal parenchyma (Fig. 2a, b), thick-walled and radially flattened fibers (Fig. 2c) and occasionally ray dilatation at the limits of the growth rings (Fig. 2c). Many species also have very narrow vessels associated with the marginal parenchyma (Fig. 2a). Vessel dimorphism (the association of very wide and very narrow vessels) is widespread in the lianas (Fig. 2c). Tyloses on the heartwood are only rarely encountered, but common in Catalpaeae (Fig. 2b), *Spathodea campanulata*, and occasionally sparsely present in the woods of other species, including the lianas. Most Bignoniaceae have a straight grain (Fig. 2d), but the grain may sometimes be wavy (Fig. 2e) or interlocked (as in some specimens of *Handroanthus*). Axial parenchyma is paratracheal (Fig. 2a–c), varying from scarce (Fig. 2c) to abundant (Fig. 2b), with confluences forming bands. Crystals are common in the family and generally confined to ray cells (Fig. 2i), silica is absent (except in *Pachyptera kerere*). All qualitative and quantitative traits analyzed are presented in Table 1, while a summary of the most conspicuous features is given in Table 2. Below we characterize the wood anatomy of each major clade of the Bignoniaceae currently recognized (Olmstead et al. 2009; Fig. 1).

Table 1 Analyzed species, habit, xylem characters and climate of occurrence

Tribe or clade	Species	Habit	Porosity	Growth ring marker: parenchyma	Growth ring marker:dilated rays	Growth ring marker: flattened fibers	Vessel arrangement	Vessel grouping	Vessels/group	Vessel dimorphism	Vessel frequency (per mm2)	Vessel diameter mean		Tyloses	Perforation plate	Intervessel pit size (µm)	Helical thickening	Patratracheal parenchyma	Confluence	Axial parenchyma frequency	Axial parenchyma cell mean area (µm2)	Diffuse parenchyma	Parenchyma strands	Storied structure	Ray width		Ray height	Rays: cellular composition	Vessel-ray pitting	Septate fibers	Perforated ray cells	Crystals	Type of cambial variant	Climate of occurrence
												Wide vessels (µm)	Narrow vessels (µm)												In µm	In number of cells								
JACARANDEAE	*Digomphia densicoma*	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	2.11 ± 1.22	-	?	?	NA	-	Simple	?	-	Aliform	Short	?	?	-	Four (3-4) cells per strand	-	?	2 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Tropical
	Jacaranda brasiliana	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.64 ± 0.29	-	10 ± 8	68 ± 7	NA	-	Simple	7.2 ± 2	-	Aliform	Long, forming bands	10%	313 ± 152	-	Four (3-4) cells per strand	-	20 ± 5	1 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Jacaranda copaia	Tree	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	1.23 ± 0.23	-	3 ± 5	300 ± 40	NA	-	Simple	8.4 ± 4	-	Aliform	Long, forming bands	9%	685 ± 133	-	Eight (5-8) cells per strand	-	30 ± 4	3 ± 1	Short <1 mm	Homocellular to slightly heterocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Jacaranda obtusifolia	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.37 ± 0.30	-	?	?	NA	-	Simple	10.9 ± 2	-	Aliform	Long, forming bands	?	?	-	Four (3-4) cells per strand	-	?	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Jacaranda puberula	Tree	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	2.09 ± 0.20	-	21 ± 10	75 ± 8	NA	-	Simple	10.3 ± 2	-	Aliform	Short	5%	278 ± 77	-	Four (3-4) cells per strand	-	24 ± 4	3 ± 1	Short <1 mm	Heterocellular with 2-4 square/upright marginal cells	Similar to intervessel pits	-	-	-	NA	Tropical
	Jacaranda ulei	Tree	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	10.2 ± 3	-	Aliform	Short	?	?	-	Four (3-4) cells per strand	-	?	3 ± 0	Short <1 mm	Heterocellular with 2-4 square/upright marginal cells	Similar to intervessel pits	-	-	-	NA	Tropical
TECOMEAE	*Campsis radicans*	Liana	Porous	-	-	+	Diffuse	Solitary to multiples of 2-3	5.32 ± 0.51	+	320 ± 91	158 ± 36	26 ± 6	-	Simple	8.2 ± 1	+	Scanty	Absent	2%	192 ± 87	-	Four (3-4) cells per strand	-	26 ± 6	3 ± 1	Short <1 mm	Heterocellular with 2-4 square/upright marginal cells	Similar to intervessel pits	+	+	-	Perimedullar phloem	Temperate
	Deplanchea bancana	Tree	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	1.34 ± 0.35	-	6 ± 5	125 ± 42	NA	-	Reticulate or foraminate plate present	9.4 ± 3	-	Aliform	Long, forming bands	4%	351 ± 113	-	Four (3-4) cells per strand	-	27 ± 6	2 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-+	-	-	NA	Tropical
	Pandorea jasminoides	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	2.22 ± 0.58	+	165 ± 17	83 ± 14	14 ± 5	-	Simple	?	-	Scanty	Absent	3%	80 ± 32	-	Eight (5-8) cells per strand	-	32 ± 9	3 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	?	-	NA	Tropical
	Podranea ricasoliana	Liana	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	2.64 ± 0.35	+	126 ± 20	66 ± 18	19 ± 7	-	Simple	6.2 ± 3	-	Scanty	Absent	4%	103 ± 38	-	Eight (5-8) cells per strand	-	19 ± 4	2 ± 0	Short <1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	NA	Tropical
	Tecoma cochabambensis	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	+	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	2 ± 0	Short <1 mm	Heterocellular with 2-4 square/upright marginal cells	Similar to intervessel pits	-	-	-	NA	Subtropical (Montane)
	Tecoma fulva	Tree	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	+	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	2 ± 1	Short <1 mm	Heterocellular with 2-4 square/upright marginal cells	Similar to intervessel pits	-	-	-	NA	Subtropical (Montane)
	Tecoma stans	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	2.08 ± 0.53	-	28 ± 11	73 ± 13	NA	+	Simple	4.3 ± 1	+	Vasicentric	At short sectors	7%	338 ± 132	-	Four (3-4) cells per strand	-	21 ± 7	2 ± 0	Short <1 mm	Heterocellular with 2-4 square/upright marginal cells	Similar to intervessel pits	+	-	Present in rays	NA	Temperate (Montane)
	Tecomanthe dendrophila	Liana	Diffuse	?	?	?	Diffuse	Solitary to multiples of 2-3	?	+	?	?	NA	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	?	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	?	Present in rays	NA	Tropical
	Tecomaria capensis	Shrub/Liana	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-4 or more, radially disposed	1.93 ± 0.40	-	142 ± 38	30 ± 4	NA	-	Simple	5.6 ± 4	-	Scanty	Absent	0.5%	106 ± 40	-	Four (3-4) cells per strand	-	21 ± 3	2 ± 0	Short <1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	NA	Subtropical
	Tecomella undulata	Tree	Semi-ring porous	+	+	+	Tangential bands	Solitary to multiples of 2-3	2.26 ± 0.65	-	28 ± 11	70 ± 23	NA	-	Simple	9.0 ± 2	-	Vasicentric	Long, forming bands	7%	374 ± 114	-	Four (3-4) cells per strand	-	33 ± 7	3 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
DELOSTOMA	*Delostoma integrifolia*	Tree	Diffuse	+	-	-	Radial pattern	Solitary to multiples of 2-3 & Radial multiples	2.93 ± 1.21	-	46 ± 20	70 ± 12	NA	-	Simple	4.0 ± 1	-	Scanty	Absent	1%	268 ± 62	-	Four (3-4) cells per strand	-	33 ± 8	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	+	-	Present in rays	NA	Subtropical
OROXYLEAE	*Millingtonia hortensis*	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.94 ± 0.30	-	27 ± 8	80 ± 26	NA	-	Reticulate or foraminate plate present	3.1 ± 3	-	Vasicentric	Short	8%	221 ± 105	-	Four (3-4) cells per strand	-	34 ± 6	3 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Oroxylum indicum	Tree	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	1.24 ± 0.31	-	4 ± 4	179 ± 18	NA	-	Reticulate or foraminate plate present	5.3 ± 2	-	Aliform	Short	10%	359 ± 44	-	Four (3-4) cells per strand	-	30 ± 6	3 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	+	-	-	NA	Tropical
CATALPEAE	*Catalpa bignonioides*	Tree	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	EW 1.40 ± 0.22 LW 13.90 ± 3.18	-	10 ± 3	204 ± 17	32 ± 8	+	Simple	11.1 ± 3	-	Scanty	Absent	2%	246 ± 65	-	Four (3-4) cells per strand	-	26 ± 3	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Simple to semi-bordered	-	-	-	NA	Temperate
	Catalpa longissima	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.56 ± 0.36	-	6 ± 4	131 ± 10	NA	+	Simple	6.3 ± 4	-	Aliform	Short	7%	388 ± 231	-	Four (3-4) cells per strand	-	32 ± 6	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Simple to semi-bordered	+	-	Present in rays	NA	Subtropical
	Catalpa speciosa	Tree	Semi-ring porous	-	-	+	Diffuse	Solitary to multiples of 2-3	EW 1.33 ± 0.18 LW 24.63 ± 9.68	-	14 ± 11	200 ± 36	26 ± 7	+	Simple	7.3 ± 2	+	Vasicentric	Absent	7%	557 ± 311	-	Four (3-4) cells per strand	-	25 ± 5	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Simple to semi-bordered	-	-	-	NA	Temperate
	Chilopsis linearis	Small tree	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	EW 2.00 ± 0.75 LW 4.69 ± 2.43	-	34 ± 10	142 ± 16	31 ± 7	+	Simple	4.1 ± 1	+	Scanty	Absent	14%	354 ± 161	-	Four (3-4) cells per strand	-	35 ± 5	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Simple to semi-bordered	+	-	-	NA	Subtropical (arid)

Table 1 continued

Tribe or clade	Species	Habit	Porosity	Growth ring marker: parenchyma	Growth ring marker:dilated rays	Growth ring marker: flattened fibers	Vessel arrangement	Vessel grouping	Vessels/group	Vessel dimorphism	Vessel frequency (per mm2)	Vessel diameter mean: Wide vessels (µm)	Vessel diameter mean: Narrow vessels (µm)	Tyloses	Perforation plate	Intervessel pit size (µm)	Helical thickening	Patratracheal parenchyma	Confluence	Axial parenchyma frequency	Axial parenchyma cell mean area (µm2)	Diffuse parenchyma	Parenchyma strands	Storied structure	Ray width: In µm	Ray width: In number of cells	Ray height	Rays: cellular composition	Vessel-ray pitting	Septate fibers	Perforated ray cells	Crystals	Type of cambial variant	Climate of occurrence
	Adenocalymma bracteatum	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	?	?	3 ± 1	High >1 mm	Heterocellular mixed	Simple to semi-bordered	+	+	-	Four phloem wedges	Tropical
	Adenocalymma comosum	Liana	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	1.52 ± 0.28	+	45 ± 10	137 ± 28	26 ± 10	-	Simple	11.2 ± 3	-	Scanty	Absent	4%	171 ± 53	-	Four (3-4) cells per strand	-	41 ± 11	3 ± 1	High >1 mm	Heterocellular mixed	Simple to semi-bordered	+	+	-	Four phloem wedges	Tropical
	Adenocalymma divaricatum	Liana	Semi-ring porous	+	+	+	Diffuse	Solitary to multiples of 2-3	1.37 ± 0.47	+	236 ± 32	70 ± 15	12 ± 4	-	Simple	6.4 ± 1	-	Scanty	Absent	1%	62 ± 22	-	Four (3-4) cells per strand	-	30 ± 6	4 ± 1	High >1 mm	Heterocellular mixed	Simple to semi-bordered	-	?	Present in rays	Multiple of four phloem wedges	Tropical
	Adenocalymma flaviflorum	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	3 ± 1	High >1 mm	Heterocellular mixed	Simple to semi-bordered	+	+	+	Four phloem wedges	Tropical
	Adenocalymma neoflavidum	Shrub	Diffuse	-	-	-	Diffuse	Solitary to multiples of 2-3	?	-	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	2 ± 1	High >1 mm	Heterocellular mixed	Simple to semi-bordered	?	?	-	Four phloem wedges	Tropical
	Adenocalymma nodosum	Shrub	Diffuse	-	-	-	Diffuse	Solitary to multiples of 2-3	?	-	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	?	-	?	?	?	?	Simple to semi-bordered	?	?	?	Four phloem wedges	Tropical
	Adenocalymma peregrinum	Shrub	Diffuse	-	-	-	Diffuse	Solitary to multiples of 2-3	?	-	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	2 ± 1	High >1 mm	Heterocellular mixed	Simple to semi-bordered	?	?	-	Four phloem wedges	Tropical
	Adenocalymma salmoneum	Liana	Semi-ring porous	+	+	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	4 ± 1	High >1 mm	Heterocellular mixed	Simple to semi-bordered	+	+	-	Four phloem wedges	Tropical
	Amphilophium crucigerum	Liana	Semi-ring porous	+	+	+	Diffuse	Solitary (wide vessels)	4.73 ± 3.25	+	98 ± 36	293 ± 60	33 ± 9	-	Simple	5.2 ± 2	-	Scanty	Absent	6%	185 ± 65	-	Four (3-4) cells per strand	+	42 ± 3	9 ± 3	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Included phloem wedges	Tropical
	Amphilophium elongatum	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	+	?	6 ± 2	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Included phloem wedges	Tropical
	Amphilophium magnoliifolium	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	+	?	?	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Included phloem wedges	Tropical
BIGNONIEAE	*Amphilophium paniculatum*	Liana	Growth ring absent	NA	NA	NA	Diffuse	Solitary (wide vessels)	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	+	?	5 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Included phloem wedges	Tropical
	Amphilophium pulverulentum	Liana	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.55 ± 0.59	+	?	?	?	-	Simple	?	-	Scanty to vasicentric	Absent	?	?	-	Four (3-4) cells per strand	+	?	8 ± 2	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Included phloem wedges	Tropical
	Anemopaegma chamberlaynii	Liana	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	2.46 ± 1.06	+	122 ± 61	106 ± 16	19 ± 8	-	Simple	5.2 ± 2	-	Scanty	Absent	3%	111 ± 44	-	Eight (5-8) cells per strand	-	20 ± 9	2 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	?	-	Multiple of four phloem wedges	Tropical
	Bignonia campanulata	Liana	Diffuse	-	-	?	Diffuse	Solitary to multiples of 2-3	2.31 ± 0.25	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	5 ± 3	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Bignonia capreolata	Liana	Porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	+	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	4 ± 1	Short <1 mm	Heterocellular mixed	Similar to intervessel pits	?	+	?	Multiple of four phloem wedges	Temperate
	Bignonia magnifica	Liana	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	3.55 ± 0.44	+	131 ± 22	137 ± 15	28 ± 8	-	Simple	5.6 ± 3	-	Scanty	Absent	2%	200 ± 66	-	Four (3-4) cells per strand	-	19 ± 5	3 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Bignonia prieurei	Liana	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	2.40 ± 0.87	+	48 ± 25	156 ± 29	27 ± 8	-	Simple	7.2 ±1	-	Scanty	Absent	1%	155 ± 35	-	Four (3-4) cells per strand	-	?	4 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Callichlamys latifolia	Liana	Diffuse	+	-	+	Diffuse	Solitary (wide vessels)	1.90 ± 0.56	+	?	?	?	-	Simple	?	-	Vasicentric	Short	?	?	-	Four (3-4) cells per strand	-	?	4 ± 1	Short <1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Cuspidaria pulchra	Shrub	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.80 ± 0.31	-	28 ± 17	45 ± 10	NA	-	Simple	4.2 ± 1	-	Scanty	Absent	1%	113 ± 37	-	Four (3-4) cells per strand	-	18 ± 3	1 ± 0	Short <1 mm	Heterocellular mixed	Simple to semi-bordered	+	-	-	Four phloem wedges	Tropical
	Cuspidaria convoluta	Liana	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	?	+	?	74 ± 22	19 ± 6	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	4 ± 1	?	Heterocellular mixed	Simple to semi-bordered	-	+	-	Four phloem wedges	Tropical
	Dolichandra unguis-cati	Liana	Diffuse	+	-	+	Diffuse	Solitary (wide vessels)	2.13 ± 0.52	+	140 ± 47	111 ± 23	16 ± 9	-	Simple	5.3 ± 2	-	Scanty	Absent	4%	128 ± 21	-	Four (3-4) cells per strand	+	20 ± 5	1 ± 0	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	+	+	-	Multiple dissected phloem wedges	Tropical
	Dolichandra quadrivalvis	Liana	Diffuse	+	-	+	Diffuse	Solitary (wide vessels)	1.32 ± 0.25	+	-	-	-	-	Simple	-	-	Scanty	Absent	-	-	-	Four (3-4) cells per strand	+		-	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	+	+	-	Multiple dissected phloem wedges	Tropical

Table 1 continued

Tribe or clade	Species	Habit	Porosity	Growth ring marker: parenchyma	Growth ring marker:dilated rays	Growth ring marker: flattened fibers	Vessel arrangement	Vessel grouping	Vessels/group	Vessel dimorphism	Vessel frequency (per mm2)	Vessel diameter mean: Wide vessels (µm)	Vessel diameter mean: Narrow vessels (µm)	Tyloses	Perforation plate	Intervessel pit size (µm)	Helical thickening	Patratracheal parenchyma	Confluence	Axial parenchyma frequency	Axial parenchyma cell mean area (µm2)	Diffuse parenchyma	Parenchyma strands	Storied structure	Ray width: In µm	Ray width: In number of cells	Ray height	Rays: cellular composition	Vessel-ray pitting	Septate fibers	Perforated ray cells	Crystals	Type of cambial variant	Climate of occurrence
	Fridericia chica	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	4 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Fridericia conjugata	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	2.92 ± 1.01	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	2 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	?	Four phloem wedges	Tropical
	Fridericia platyphylla	Shrub	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.31 ± 0.26	-	14 ± 5	72 ± 20	NA	-	Simple	6.1 ± 3	-	Scanty	Absent	1%	171 ± 72	-	Eight (5-8) cells per strand	-	18 ± 5	1 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	-	-	-	Four phloem wedges	Tropical
	Fridericia samydoides	Liana	Semi-ring porous	+	+	+	Diffuse	Solitary (wide vessels)	?	+	?	?	?	-	Simple	?	-	Vasicentric	Short	?	?	-	Eight (5-8) cells per strand	-	?	3 ± 1	Short <1 mm	Heterocellular mixed	Simple to semi-bordered	+	+	-	Four phloem wedges	Tropical
	Fridericia speciosa	Liana	Diffuse	-	-	+	Diffuse	Solitary (wide vessels)	3.01 ± 1.03	+	118 ± 36	133 ± 37	20 ± 11	-	Simple	9.0 ± 1	-	Vasicentric	Short	7%	89 ± 23	-	Four (3-4) cells per strand	-	34 ± 5	3 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Lundia damazii	Liana	Diffuse	-	+	+	Diffuse to tangential	Solitary (wide vessels)	3.69 ± 1.48	+	101 ± 30	232 ± 57	20 ± 9	-	Simple	9.4 ± 1	-	Vasicentric	Short	14%	212 ± 140	-	Four (3-4) cells per strand	-	33 ± 8	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Lundia glazioviana	Liana	Semi-ring porous	+	?	+	Diffuse to tangential	Solitary (wide vessels)	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	3 ± 1	High >1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Lundia longa	Liana	Semi-ring porous	+	+	+	Diffuse	Solitary (wide vessels)	?	+	?	?	?	-	Simple	?	-	Vasicentric	Absent	?	?	-	Four (3-4) cells per strand	-	?	3 ± 1	High >1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Manaosella cordifolia	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	2.12 ± 0.59	+	33 ± 20	216 ± 43	23 ± 6	-	Simple	12.4 ± 2	-	Vasicentric	Short	1%	167 ± 60	-	Four (3-4) cells per strand	-	15 ± 5	2 ± 1	Short <1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Mansoa difficilis	Liana	Diffuse	-	+	+	Diffuse	Solitary to multiples of 2-3	2.80 ± 0.33	+	109 ± 14	139 ± 25	22 ± 9	-	Simple	6.0 ± 1	-	Scanty	Absent	1%	154 ± 45	-	Four (3-4) cells per strand	-	57 ± 18	4 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Mansoa onohualcoides	Liana	Diffuse	-	+	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	?	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Mansoa standley	Liana	Diffuse	-	+	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	3 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Martinella obovata	Liana	Diffuse	+	-	+	Radial pattern	Radial multiples of 4 or more common	3.76 ± 1.33	+	97 ± 19	192 ± 32	35 ± 11	-	Simple	7.0 ± 4	-	Scanty	Absent	2%	244 ± 78	-	Four (3-4) cells per strand	-	50 ± 8	3 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
BIGNONIEAE	*Neojobertia mirabilis*	Liana	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	?	+	-	-	-	(+)	Simple	-	-	Scanty	Absent	-	-	-	Four (3-4) cells per strand	-	-	-	Short <1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	Present in rays	Four phloem wedges	Tropical
	Neojobertia sp.nov.	Liana	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	2.83 ± 0.65	+	100 ± 7	109 ± 25	16 ± 5	-	Simple	7.6 ± 2	-	Scanty	Absent	3%	127 ± 45	-	Four (3-4) cells per strand	-	29 ± 5	3 ± 0	Short <1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	Present in rays	Four phloem wedges	Tropical
	Pachyptera kerere	Liana	Diffuse	-	-	+	Radial pattern	Solitary to multiples of 2-3 and small vessels in radial multiples	2.41 ± 0.57	+	35 ± 12	118 ± 28	24 ± 7	-	Simple	8.8 ± 3	-	Scanty	Absent	1%	113 ± 50	-	Eight (5-8) cells per strand	-	?	2 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	Present in rays	Four phloem wedges	Tropical
	Perianthomega vellozoi	Liana	Semi-ring porous	-	+	+	Diffuse	Solitary to multiples of 2-3	2.25 ± 0.62	+	100 ± 17	112 ± 15	23 ± 8	-	Simple	8.4 ± 1	-	Scanty	Absent	4%	116 ± 52	-	Eight (5-8) cells per strand	-	30 ± 8	3 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem arcs	Tropical
	Pleonotoma melioides	Liana	Diffuse	-	+	+	Diffuse	Solitary to multiples of 2-3	3.31 ± 0.85	+	88 ± 27	167 ± 25	15 ± 5	-	Simple	8.3 ± 2	-	Scanty	Absent	1%	100 ± 55	-	Four (3-4) cells per strand	-	13 ± 4	1 ± 0	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Pleonotoma stichadenia	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	?	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Pleonotoma tetraqueta	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty to vasicentric	Absent	?	?	-	Four (3-4) cells per strand	-	?	4 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Pyrostegia venusta	Liana	Semi-ring porous	+	+	+	Diffuse	Solitary to multiples of 2-3	2.03 ± 0.37	+	75 ± 18	138 ± 26	29 ± 9	-	Simple	9.6 ± 2	-	Scanty	Absent	1%	165 ± 32	-	Four (3-4) cells per strand	-	52 ± 5	4 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Multiple of four phloem wedges	Tropical
	Stizophyllum riparium	Liana	Diffuse	+	+	+	Diffuse	Solitary (wide vessels)	2.29 ± 0.82	+	52 ± 19	190 ± 30	14 ± 3	-	Simple	6.9 ± 3	-	Scanty	Absent	2%	103 ± 28	-	Four (3-4) cells per strand	-	25 ± 3	2 ± 1	Short <1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Tanaecium bilabiatum	Liana	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	3 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Tanaecium duckei	Liana	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	4.63 ± 1.77	+	?	?	?	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	?	High >1 mm	Heterocellular mixed	Similar to intervessel pits				Four phloem wedges	
	Tanaecium pyramidatum	Liana	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	60 ± 40	290 ± 54	21 ± 7	-	Simple	10.3 ± 2	-	Vasicentric	Absent	5%	185 ± 44	-	Four (3-4) cells per strand	-	53 ± 18	3 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Tynanthus cognatus	Liana	Semi-ring porous	+	-	+	Diffuse	Solitary (wide vessels)	3.00 ± 0.41	+	47 ± 25	208 ± 37	17 ± 6	-	Simple	8.3 ± 3	-	Aliform	Short	7%	123 ± 55	-	Four (3-4) cells per strand	-	31 ± 10	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Xylophragma myrianthum	Liana	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	+	?	?	?	-	Simple	?	-	Aliform	Short	?	?	-	Four (3-4) cells per strand	-	?	?	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical
	Xylophragma pratense	Liana	Semi-ring porous	+	+	-	Diffuse	Solitary to multiples of 2-3	2.48 ± 0.69	+	20 ± 15	265 ± 65	15 ± 5	-	Simple	1.6 ± 1	-	Aliform	Absent	9%	276 ± 53	-	Four (3-4) cells per strand	-	63 ± 20	5 ± 1	High >1 mm	Heterocellular mixed	Similar to intervessel pits	+	+	-	Four phloem wedges	Tropical

Table 1 continued

Tribe or clade	Species	Habit	Porosity	Growth ring marker: parenchyma	Growth ring marker:dilated rays	Growth ring marker: flattened fibers	Vessel arrangement	Vessel grouping	Vessels/group	Vessel dimorphism	Vessel frequency (per mm2)	Vessel diameter mean		Tyloses	Perforation plate	Intervessel pit size (µm)	Helical thickening	Patratracheal parenchyma	Confluence	Axial parenchyma frequency	Axial parenchyma cell mean area (µm2)	Diffuse parenchyma	Parenchyma strands	Storied structure	Ray width		Ray height	Rays: cellular composition	Vessel-ray pitting	Septate fibers	Perforated ray cells	Crystals	Type of cambial variant	Climate of occurrence
												Wide vessels (µm)	Narrow vessels (µm)												In µm	In number of cells								
	Amphitecna latifolia	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.55 ± 0.25	-	9 ± 7	69 ± 25	NA	-	Simple	?	-	Aliform	Long, forming bands	29%	501 ± 136	-	Two cells per strand	+	17 ± 4	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays and axial parenchyma	NA	Tropical
	Amphitecna regalis	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.24 ± 0.30	-	11 ± 6	63 ± 8	NA	-	Simple	4.3 ± 3	-	Aliform	Long, forming bands	6%	811 ± 448	-	Two cells per strand	+	16 ± 6	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
TABEBUIA ALLIANCE (CRESCENTIEAE)	*Crescentia alata*	Small tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.34 ± 0.31	-	31 ± 7	55 ± 11	NA	-	Reticulate or foraminate plate present	5.4 ± 2	-	Aliform	Short & Long, forming bands	11%	187 ± 49	-	Four (3-4) cells per strand	+	15 ± 6	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays and axial parenchyma	NA	Tropical
	Crescentia cujete	Small tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.38 ± 0.32	-	16 ± 4	59 ± 9	NA	-	Simple	?	-	Aliform	Long, forming bands	45%	539 ± 140	-	Four (3-4) cells per strand	+	19 ± 7	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Parmentiera macrophylla	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.58 ± 0.37	-	47 ± 10	44 ± 6	NA	-	Reticulate or foraminate plate present	4.3 ± 2	-	Aliform	Short & Long, forming bands	12%	165 ± 45	+	Four (3-4) cells per strand	-	20 ± 4	2 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-+	-	-	NA	Tropical
	Cybistax antisyphilitica	Tree	Diffuse	+	-	-	Tangential bands	Solitary to multiples of 2-3	2.08 ± 0.36	-	43 ± 4	45 ± 6	NA	-	Simple	3.1 ± 0.8	-	Aliform	Long, forming bands	19%	321 ± 106	-	Four (3-4) cells per strand	+	21 ± 4	2 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Ekmanianthe actinophylla	Tree	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	1.51 ± 0.31	-	13 ± 6	107 ± 29	NA	-	Simple	6.5 ± 3	-	Vasicentric	Short	4%	277 ± 114	-	Four (3-4) cells per strand	-	32 ± 5	3 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Ekmanianthe longiflora	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Scanty	Absent	?	?	-	Two cells per strand & Four (3-4) cells per strand	+	?	2 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Godmania aesculifolia	Tree	Semi-ring porous	+	-	-	Tangential bands	Solitary to multiples of 2-3	2.22 ± 0.71	-	26 ± 16	42 ± 8	NA	-	Simple	5.3 ± 2	-	Vasicentric	Short	18%	504 ± 110	-	Four (3-4) cells per strand	+	25 ± 5	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Handroanthus albus	Tree	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	11.2 ± 4	-	Aliform	Short	?	?	-	Two cells per strand	+	?	3 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Handroanthus barbatus	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.20 ± 0.24	-	?	?	NA	-	Simple	12.4 ± 2	-	Aliform	Short	?	?	-	Two cells per strand	+	?	3 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Handroanthus chrysotrichus	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.40 ± 0.25	-	25 ± 9	97 ± 11	NA	-	Simple	19.1 ± 3	-	Aliform	Long, forming bands	34%	492 ± 115	-	Two cells per strand	+	21 ± 7	2 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Handroanthus impetiginosus	Tree	Diffuse	-	+	+	Diffuse	Solitary to multiples of 2-3	1.49 ± 0.30	-	12 ± 5	125 ± 2	NA	-	Simple	12.2 ± 2	-	Aliform	Short	5%	257 ± 96	-	Four (3-4) cells per strand	+	28 ± 6	3 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Handroanthus serratifolius	Tree	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	1.43 ± 0.23	-	?	?	NA	-	Simple	11.3 ± 2	-	Aliform	Short	?	?	-	Two cells per strand	+	?	2 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Paratecoma peroba	Tree	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	1.84 ± 0.33	-	?	?	NA	-	Simple	?	-	Vasicentric	Absent	?	?	-	Two cells per strand & Four (3-4) cells per strand	+-	?	2 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Roseodendron donnell-smithii	Tree	Diffuse&Semi-ring	+	-	+	Diffuse	Solitary to multiples of 2-3	1.20 ± 0.19	-	12 ± 5	97 ± 25	NA	+	Simple	5.1 ± 1	-	Vasicentric	Short	3%	206 ± 28	-	Four (3-4) cells per strand	+	35 ± 4	3 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Sparattosperma leucanthum	Tree	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	1.83 ± 0.45	-	51 ± 18	83 ± 18	NA	-	Simple	2.5 ± 1	-	Vasicentric	Short	13%	279 ± 64	-	Four (3-4) cells per strand	+	30 ± 7	2 ± 0	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Tropical
TABEBUIA ALLIANCE																																		
	Spirotecoma spiralis	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.74 ± 0.31	-	60 ± 19	50 ± 11	NA	-	Reticulate or foraminate plate present	6.3 ± 1	-	Aliform	Short	4%	86 ± 42	-	Four (3-4) cells per strand	+	32 ± 3	2 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Tabebuia aurea	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Reticulate or foraminate plate present	5.2 ± 2	-	Aliform	Short	?	?	-	Four (3-4) cells per strand	+	?	2 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Tabebuia cassinoides	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.47 ± 0.36	-	14 ± 10	66 ± 15	NA	-	Simple	4.3 ± 1	-	Aliform	Long, forming bands	26%	505 ± 268	-	Four (3-4) cells per strand	+	24 ± 7	2 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Tabebuia fluvialitis	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.74 ± 0.40	-	27 ± 7	54 ± 12	NA	+	Simple	8.3 ± 2	-	Aliform	Short & Long, forming bands	27%	366 ± 118	-	Four (3-4) cells per strand	+	12 ± 3	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Tabebuia heterophylla	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	Short & Long, forming bands	?	?	-	Four (3-4) cells per strand	+	?	2 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Tabebuia obtusifolia	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	Short & Long, forming bands	?	?	-	Four (3-4) cells per strand	(+)	?	2 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Tabebuia rigida	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	Short & Long, forming bands	?	?	-	Two cells per strand	+	?	2 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Tabebuia roseoalba	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	At short sectors	?	?	-	Four (3-4) cells per strand	+	?	1 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Zeyheria montana	Tree	Semi-ring porous	+	-	-	Diffuse	Solitary to multiples of 2-3	1.85 ± 0.40	-	30 ± 16	59 ± 13	NA	-	Reticulate or foraminate plate present	6.7 ± 2	-	Vasicentric	Long, forming bands	14%	291 ± 121	-	Four (3-4) cells per strand	+	40 ± 8	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Tropical
	Zeyheria tuberculosa	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.37 ± 0.32	-	?	?	NA	-	Simple	6.3 ± 1	-	Vasicentric	Long, forming bands	?	?	-	Four (3-4) cells per strand	+	?	2 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Tropical

Table 1 continued

Tribe or clade	Species	Habit	Porosity	Growth ring marker: parenchyma	Growth ring marker:dilated rays	Growth ring marker: flattened fibers	Vessel arrangement	Vessel grouping	Vessels/group	Vessel dimorphism	Vessel frequency (per mm2)	Vessel diameter mean		Tyloses	Perforation plate	Intervessel pit size (μm)	Helical thickening	Patratracheal parenchyma	Confluence	Axial parenchyma frequency	Axial parenchyma cell mean area (μm2)	Diffuse parenchyma	Parenchyma strands	Storied structure	Ray width		Ray height	Rays: cellular composition	Vessel-ray pitting	Septate fibers	Perforated ray cells	Crystals	Type of cambial variant	Climate of occurrence
												Wide vessels (μm)	Narrow vessels (μm)												In μm	In number of cells								
	Catophractes alexandrii	Shrub	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	Short	?	?	-	Two cells per strand & Four (3-4) cells per strand	-	?	2 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Subtropical (arid)
	Colea gentryi	Treelet	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3 and some clusters	1.97 ± 0.24	-	?	?	NA	-	Simple	?	-	Vasicentric	Short	?	?	+	Two cells per strand	-	?	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Colea resupinata	Treelet	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	Short	?	?	+	Two cells per strand	-	?	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Dolichandrone atrovirens	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	2.29 ± 1.02	-	10 ± 9	72 ± 22	NA	-	Reticulate or foraminate plate present	6.1 ± 1	-	Aliform	Short & Long, forming bands	7%	310 ± 109	-	Four (3-4) cells per strand	-	15 ± 4	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Dolichandrone spathacea	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Reticulate or foraminate plate present	?	-	Aliform	Short & Long, forming bands	?	?	-	Four (3-4) cells per strand	-	?	1 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Tropical
	Fernandoa adenophylla	Tree	Diffuse	+	+	+	Diffuse	Solitary to multiples of 2-3	2.58 ± 1.64	-	73 ± 21	92 ± 19	NA	-	Simple	5.2 ± 1	-	Aliform	Absent	23%	300 ± 95	-	Four (3-4) cells per strand	-	41 ± 7	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Tropical
	Fernandoa magnifica	Tree	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	1.50 ± 0.23	-	?	?	NA	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	2 ± 0	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Heterophragma quadriloculare	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.29 ± 0.17	-	14 ± 6	112 ± 26	NA	-	Simple	8.3 ± 3	-	Aliform	Short	13%	494 ± 141	-	Four (3-4) cells per strand	-	40 ± 7	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Simple to semi-bordered	+	-	?	NA	Tropical
	Heterophragma sulfureum	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.28 ± 0.20	-	?	?	NA	-	Simple	?	-	Scanty	Absent	?	?	-	Four (3-4) cells per strand	-	?	2 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Simple to semi-bordered	+	-	Present in rays	NA	Tropical
	Kigelia africana	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.12 ± 0.12	-	6 ± 4	137 ± 26	NA	-	Simple	7.2 ± 2	-	Aliform	Long, forming bands	27%	499 ± 144	-	Four (3-4) cells per strand	-	31 ± 9	2 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Markhamia lutea	Tree	Semi-ring porous	+	+	+	Diffuse	Solitary to multiples of 2-3	1.15 ± 0.19	-	49 ± 29	96 ± 34	NA	-	Simple	5.2 ± 3	-	Aliform	Short	9%	213 ± 91	-	Four (3-4) cells per strand	-	18 ± 5	2 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	Present in rays	NA	Subtropical
	Markhamia stipulata	Small tree	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Reticulate or foraminate plate present	?	-	Aliform	Short	?	?	-	Four (3-4) cells per strand	-	?	2 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	Present in rays	NA	Subtropical
PALEOTROPICAL CLADE	*Newbouldia laevis*	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.60 ± 0.36	-	11 ± 5	133 ± 19	NA	-	Reticulate or foraminate plate present	4.7 ± 2	-	Aliform	Long, forming bands	38%	1198 ± 529	-	Four (3-4) cells per strand	-	41 ± 8	2 ± 0	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Tropical
	Ophiocolea floribunda	Tree	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	1.68 ± 0.33	-	21 ± 12	68 ± 14	NA	-	Simple	2.2 ± 1	-	Aliform	Short	16%	356 ± 97	+	Four (3-4) cells per strand	-	21 ± 5	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Pajanelia longifolia	Tree	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	1.25 ± 0.47	-	?	?	NA	(+)	Simple	?	-	Aliform	Short	?	?	-	Four (3-4) cells per strand	-	?	3 ± 0	Short <1 mm	Homo and hetero with 1 row of square cells	Simple to semi-bordered	(+)	-	-	NA	Tropical
	Phyllarthron bojeranum	Tree	Diffuse	-	-	+	Diffuse	Solitary to multiples of 2-3	1.61 ± 0.17	-	39 ± 14	51 ± 13	NA	-	Simple	7.5 ± 2	-	Aliform	Short	5%	126 ± 65	+	Four (3-4) cells per strand	-	12 ± 2	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Radermachera ignea	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	Long, forming bands	?	?	-	Four (3-4) cells per strand	-	?	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	(+)	-	-	NA	Tropical
	Radermachera gigantea	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	Short	?	?	-	Four (3-4) cells per strand	-	?	3 ± 0	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	(+)	-	-	NA	Tropical
	Radermachera glandulosa	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.29 ± 0.18	-	24 ± 9	74 ± 9	NA	-	Reticulate or foraminate plate present	4.3 ± 2	-	Aliform	Short	10%	278 ± 80	-	Four (3-4) cells per strand	-	35 ± 5	3 ± 0	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	(+)	-	Present in rays	NA	Tropical
	Radermachera pinnata	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Vasicentric	Short	?	?	-	Four (3-4) cells per strand	-	?	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	(+)	-	-	NA	Tropical
	Radermachera sinica	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Vasicentric	Short	?	?	-	Four (3-4) cells per strand	-	?	3 ± 0	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	(+)	-	-	NA	Tropical
	Rhodocolea multiflora	Treelet	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	?	-	?	?	NA	-	Simple	?	-	Aliform	Short	?	?	+	Four (3-4) cells per strand	-	?	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical
	Rhodocolea nycteriphilla	Treelet	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3 and some clusters	?	-	?	?	NA	-	Simple	?	-	Aliform	Short	?	?	+	Four (3-4) cells per strand	-	?	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Rhodocolea telfarii	Tree	Diffuse	+	-	+	Diffuse	Solitary to multiples of 2-3	1.81 ± 0.36	-	34 ± 8	77 ± 14	NA	-	Simple	2.2 ± 1	+	Vasicentric	Short	14%	259 ± 124	+	Four (3-4) cells per strand	-	14 ± 2	1 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	Present in rays	NA	Tropical
	Spathodea campanulata	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.30 ± 0.28	-	8 ± 5	136 ± 34	NA	+	Simple	7.8 ± 2	-	Aliform	Long, forming bands	18%	371 ± 126	-	Two cells per strand	-	39 ± 12	3 ± 1	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	-	NA	Tropical
	Stereospermum chelonoides	Tree	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	1.08 ± 0.09	-	9 ± 10	158 ± 56	NA	-	Simple	10.7 ± 1	-	Aliform	Short	22%	577 ± 236	-	Four (3-4) cells per strand	-	39 ± 8	3 ± 1	Short <1 mm	Homocellular	Similar to intervessel pits	+	-	-	NA	Tropical
	Tecomella undulata	Tree	Semi-ring porous	+	+	+	Tangential bands	Solitary to multiples of 2-3		-	28 ± 11	70 ± 23	NA	-	Simple	9.0 ± 2	-	Vasicentric	Long, forming bands	7%	374 ± 114	-	Four (3-4) cells per strand	-	33 ± 7	3 ± 0	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	-	NA	Tropical

Key: + present, – absent, *?* unsampled, *()* present, but rare or inconspicuous, *NA* not applicable, *EW* earlywood, *LW* latewood

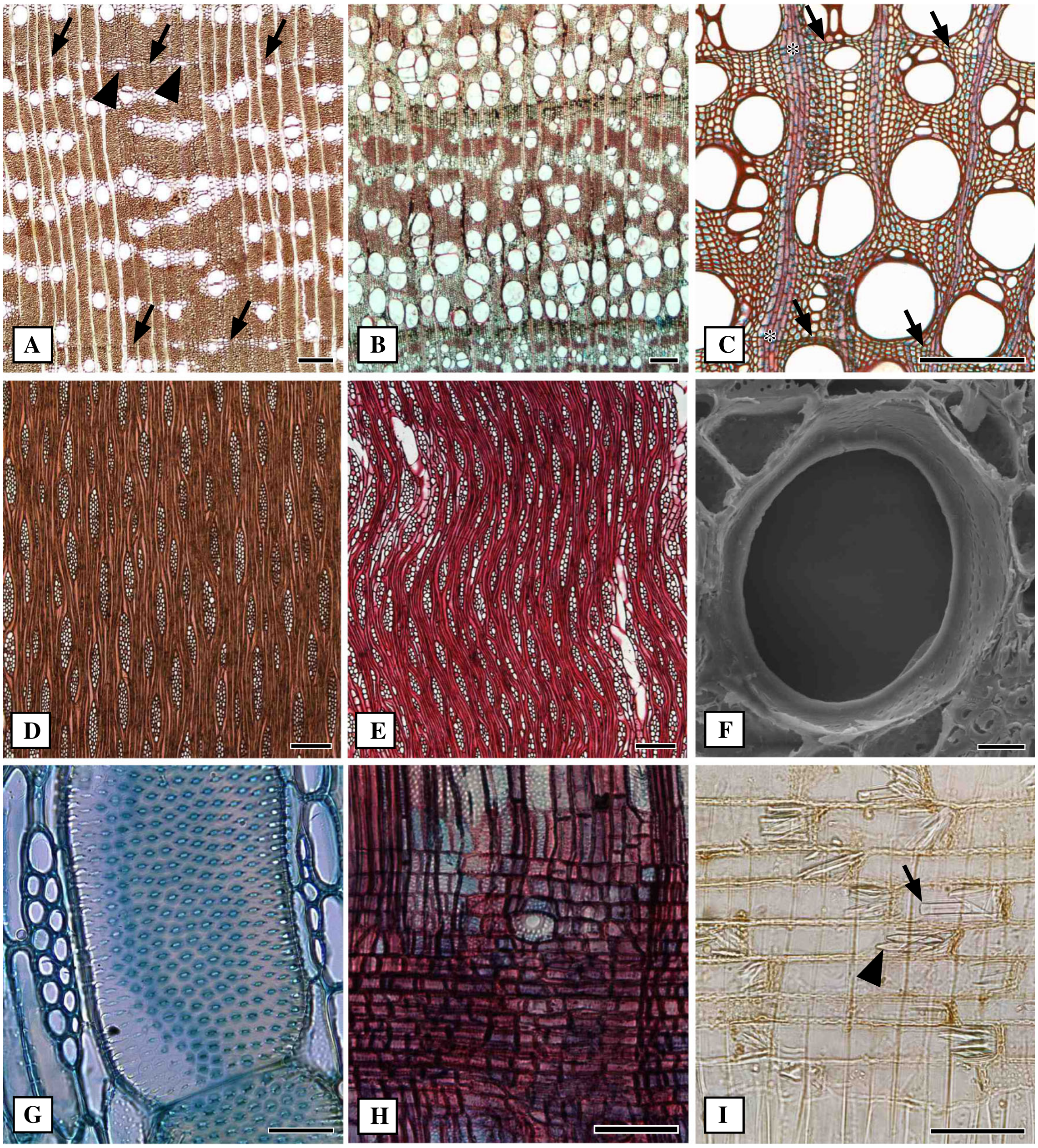

Fig. 2 General wood anatomical features of Bignoniaceae. **a** *Tabebuia rigida*, transverse section (TS), diffuse porous wood with aliform parenchyma with short confluences and growth rings delimited by a line of marginal parenchyma (*arrows*) associated with very narrow vessels (*arrowheads*). **b** *Chilopsis linearis*, TS, semi-ring porous wood, growth rings marked by a band of marginal parenchyma and radially flattened fibers, tyloses common. **c** *Mansoa difficilis*, TS, scanty paratracheal parenchyma, growth rings marked by radially flattened fibers (*arrows*) and dilated rays (*asterisks*). **d** *Roseodendron donnell-smithii*, longitudinal tangential section (LT), straight grain, multiseriate non-storied rays. **e** *Dolichandrone atrovirens*, LT, wavy grain, multiseriate non-storied rays. **f** *Tabebuia aurea*, TS, scanning electron microscopy of simple perforation plate. **g** *Handroanthus barbatus*, LT, intervessel pits alternate. **h** *Campsis radicans*, longitudinal radial section (LR), perforated ray cell **i** *Radermachera glandulosa*, LR, prismatic (*arrow*) and navicular (*arrowhead*) crystals in rays. *Scale bars* **a**, **c**, **d**, **e** 200 µm, **b** 400 µm, **f** 20 µm, **g**, **i** 50 µm, **h** 100 µm

Jacarandeae

We sampled six of the 51 species representing both genera, *Digomphia* (one of three species) and *Jacaranda* (five of 49 species), currently included in the tribe (Lohmann and Ulloa 2006 onwards). Representatives of both *Jacaranda* sections *Monolobos* (*J. copaia*, *J. brasiliana* and *J. obtusifolia*) and *Dilobos* (*J. puberula* and *J. ulei*) were sampled.

Table 2 Synopsis of the wood features and habits by tribe/clade

Tribe or clade	Habit	Porosity	Growth ring marker: parenchyma	Growth ring marker:dilated rays	Growth ring marker: flattened fibers	Vessel arrangement	Vessel grouping	Vessel dimorphism	Tyloses	Perforation plate	Helical thickening	Patratracheal parenchyma	Confluence	Diffuse parenchyma	Parenchyma strands	Storied structure	Ray height	Rays: cellular composition	Vessel-ray pitting	Septate fibers	Perforated ray cells	Crystals
JACARANDEAE	Trees, and a few subshrubs in arid zones	Diffuse	+	±	+	Diffuse	Solitary to multiples of 2-3	-	-	Simple	-	Aliform	Short to long	-	Four (3-4) cells per strand	-	Short <1 mm	Homocellular in *Jacaranda* Monolobos and heterocellular in *Jacaranda* Dilobos	Similar to intervessel pits	-	-	Present in the rays of some species
TECOMEAE	Mostly lianas, with few trees and shrubs	Diffuse to ring-porous	±	-	+	Diffuse	Solitary to multiples of 2-3	+ in lianas	-	Simple	+ in species ring-porous	Scanty to vasicentric	Absent from present	-	Mostly four (3-4) cells per strand	-	Short <1 mm and hight > 1mm in lianas	Heterocellular	Similar to intervessel pits	+	+ in lianas	Present in the rays of some species
DELOSTOMA	Trees	Diffuse	+	-	-	Radial pattern	Solitary to multiples of 2-3 & Radial multiples	-	-	Simple	-	Scanty	Absent	-	Four (3-4) cells per strand	-	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	+	-	Present in rays
OROXYLEAE	Trees, a few lianas	Diffuse	+	±	+	Diffuse	Solitary to multiples of 2-3	-	-	Reticulate, foraminate and simple	-	Vasicentric to aliform	Short	-	Four (3-4) cells per strand	-	Short <1 mm	Homocellular	Similar to intervessel pits	±	-	-
CATALPEAE	Trees	Semi-ring porous	+	-	+	Diffuse	Solitary to multiples of 2-3	-	+	Simple	+ in species semi-ring porous	Scanty to aliform	Absent to short	-	Four (3-4) cells per strand	-	Short <1 mm	Homo and hetero with 1 row of square cells	Simple to semi-bordered	±	-	Present in the rays of some species
BIGNONIEAE	Liana, a few shrubs	Diffuse to semi-ring porous	+	+	+	Diffuse	Solitary to multiples of 2-3	+	-	Simple	-	Scanty to aliform	Absent	-	Four (3-4) cells per strand	-, present in but a few species	Generally high >1 mm	Heterocellular mixed	Predominantly similar to intervessel pits	+	+	Present in the rays of some species
TABEBUIA ALLIANCE	Trees	Diffuse	+	-	-	Diffuse	Solitary to multiples of 2-3	-	-	Mostly Simple	-	Aliform	Generally long, forming bands	-	2-4 cells per strand	+	Short <1 mm	Homocellular	Similar to intervessel pits	-	-	When present, in both rays and axial parenchyma
PALEOTROPICAL CLADE	Trees and shrubs	Diffuse	+	±	±	Diffuse	Solitary to multiples of 2-3	-	-	Mostly Simple	-	Aliform	Short to long	+ in Coleeae	Four (3-4) cells per strand	-	Short <1 mm	Homo and hetero with 1 row of square cells	Similar to intervessel pits	-	-	Present in the rays of some species

Key: + present, − absent, *?* unsampled

Diagnostic features

Jacarandeae have a unique combination of winged-aliform axial parenchyma, with short to long confluences, non-storied structure, and non-septate fibers.

Detailed description

Growth rings are distinct to indistinct, delimited by thick-walled and radially flattened fibers associated with narrow vessels (Fig. 3a), sometimes with dilated rays (e.g., *Jacaranda puberula*, *J. ulei*) and a line of marginal parenchyma (Fig. 3d). *Porosity* diffuse. *Vessels* solitary (Fig. 3a) or in multiples, predominantly of 2–3 (Fig. 3b–d), 1.68 ± 0.40 vessels/group, narrow, 70 ± 8 µm in diameter (*Jacaranda copaia*, very wide 300 µm), and 17 ± 10/mm^2 in frequency (*J. copaia* 3 ± 5). *Perforation plates* are simple. *Intervessel pits* are medium (7–10 µm in diameter). *Vessel-ray pits* are similar in size and shape to the intervessel pits. *Fibers* are non-septate, thin (Fig. 3a) to thick-walled (Fig. 3b), with simple to minutely bordered pits. *Parenchyma* is winged-aliform (Fig. 3a), lozenge to winged-aliform in *Digomphia* (Fig. 3b), with short (Fig. 3a–b) to long confluences (Fig. 3c–d) sometimes forming lines that vary from 1 to 4 cells; and marginal parenchyma forming lines of 1–2 cells (Fig. 3d). Parenchyma strands are mostly of 4 cells, except from *J. copaia*, which has 5–8 cells per strand. *Rays* are non-storied, with a contrasting composition between sections *Monolobos* and *Dilobos*. In *Jacaranda* section *Monolobos* rays are uniseriate and homocellular (*J. brasiliana* and *J. obtusifolia*; Fig. 3e, f), except from *J. copaia* (species atypical within section *Monolobos*), with 2–4-seriate homocellular to slightly heterocellular rays (with one row of marginal square cells). In *Jacaranda* section *Dilobos* rays are biseriate and heterocellular, with 2–4 marginal upright to square cells (*J. puberula* and *J. ulei*; Fig. 3g, h). In *Digomphia*, rays are biseriate, homo and heterocellular with one row of marginal square cells.

Tecomeae

We sampled nine of the 52 species currently included in Tecomeae s.s. (Lohmann and Ulloa 2006 onwards). Our sampling included members of eight of the 11 genera currently recognized in the tribe; only *Campsidium*, a monotypic genus from Chile and Argentina, *Incarvillea*, an herbaceous genus from the Himalayas, and *Lamiodendron*, a monotypic genus from Papua New Guinea, were not sampled. We sampled: *Campsis radicans* (1 of 2 species), *Deplanchea bancana* (1 of 5 species), *Pandorea jasminoides* (1 of 6 species), *Podranea ricasoliana* (monotypic), *Tecoma cochabambensis*, *T. fulva* and *T. stans* (3 of 12 species), *Tecomanthe dendrophila* (1 of 5 species), and *Tecomaria capensis* (1 of 2 species).

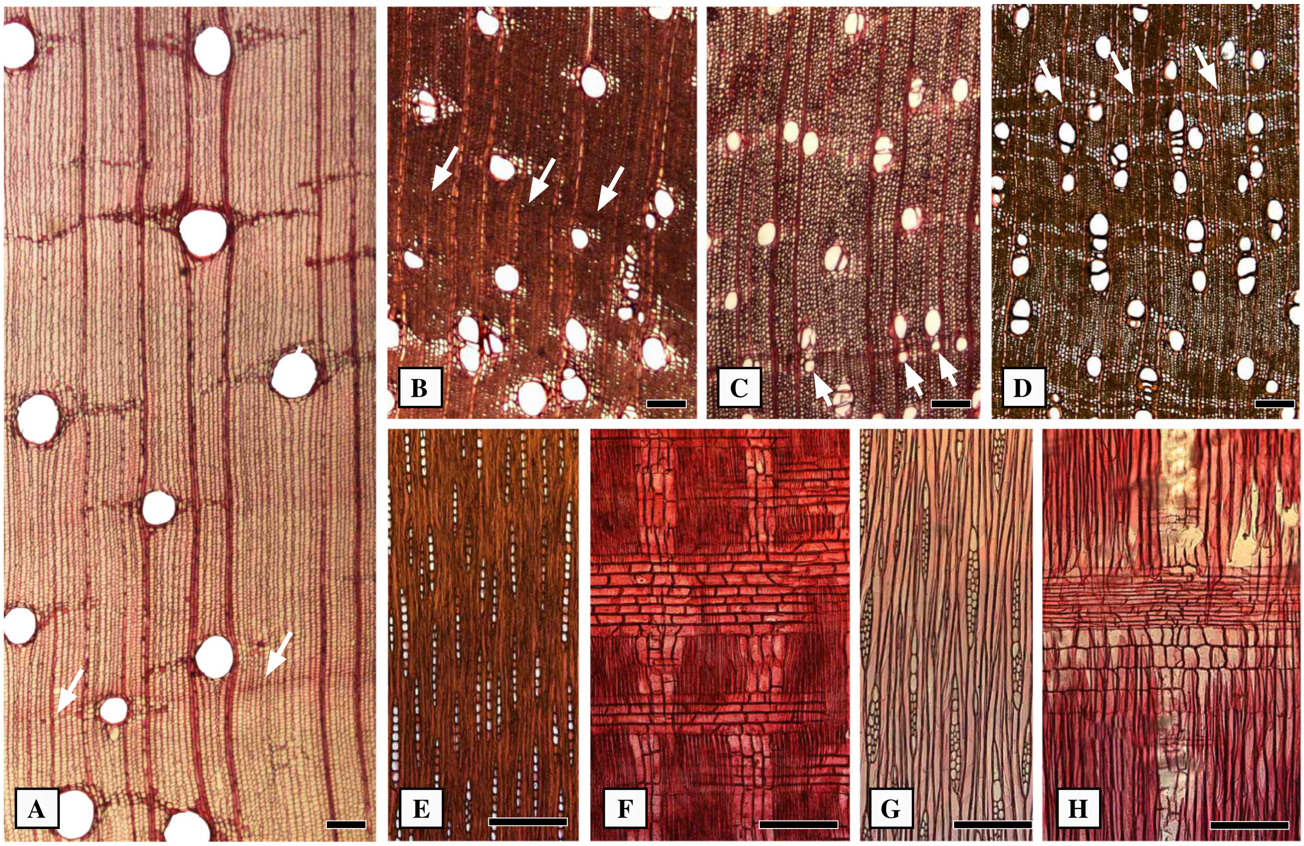

Fig. 3 Wood anatomy of Jacarandeae. **a** *Jacaranda copaia*, TS, winged-aliform parenchyma, with short confluences, and very wide vessels with about 300 µm. Growth rings delimited by radially flattened fibers (*arrows*). **b** *Digomphia densicoma*, TS, lozenge to winged-aliform parenchyma with short confluences, growth rings delimited by thicker-walled and radially flattened fibers (*arrows*). **c** *Jacaranda puberula* (section *Dilobos*), TS, winged-aliform parenchyma, with long confluences, growth rings delimited by thicker-walled fibers associated with narrow vessels (*arrows*). **d–f** *Jacaranda brasiliana* (section *Monolobos*). **d** TS, Winged-aliform parenchyma, forming long confluences, growth rings delimited by a line of marginal parenchyma (*arrows*). **e** LT, uniseriate rays. **f** LR, homocellular rays. **g**, **h** *Jacaranda puberula* (section Dilobos). **g** LT, multiseriate and heterocellular rays. **h** LR, heterocellular rays with four rows of upright to square cells. *Scale bars* 200 µm

Diagnostic features

The wood anatomy of members of Tecomeae is fairly homogeneous (except for *Deplanchea bancana*), with most differences being associated with the habit. The wood of self-supporting Tecomeae is characterized by the combination of narrow vessels (generally in high frequencies; except in *Deplanchea bancana*), scanty paratracheal axial parenchyma (except *Deplanchea bancana*, with winged-aliform parenchyma with long confluences) and septate fibers. These characters are also encountered in the lianas, except for the vessel width, which reaches wider diameters in the lianas. The lianas also have vessel dimorphism. The rays are non-storied and heterocellular.

Detailed description

Growth rings are distinct, delimited by more abundant and wider vessels in the limits of the earlywood (Fig. 4a), thick-walled and radially flattened fibers (Fig. 4b), and a line of marginal parenchyma (Fig. 4c). Very narrow vessels are sometimes associated with the marginal parenchyma (Fig. 4c). *Porosity* diffuse in the tropical species (Fig. 4b–d) and ring-porous to semi-ring porous (Fig. 4a) in the temperate and montane species (Table 1). *Vessels* are solitary to multiples of 2–3 (Fig. 4a, c, d), 2.54 ± 1.28 vessels/group. In *Tecomaria capensis* vessels are solitary to multiples of 2–4 or more, radially disposed (Fig. 4b). Vessels are narrow (55 ± 12 µm), with higher values in the lianas, and the highest values in the earlywood of *Campsis radicans* (average 300 µm). *Perforation plates* are simple, sometimes foraminate in *Deplanchea bancana*. *Intervascular pits* are small (5–7 µm). *Vessel-ray pits* are similar in size and shape to the intervessel pits. *Fibers* are septate (Fig. 4e), thin- to thick-walled, with simple pits. *Parenchyma* is normally scanty paratracheal to vasicentric, winged-aliform in *Deplanchea bancana*, forming long confluences (Fig. 4d); a line of marginal parenchyma often

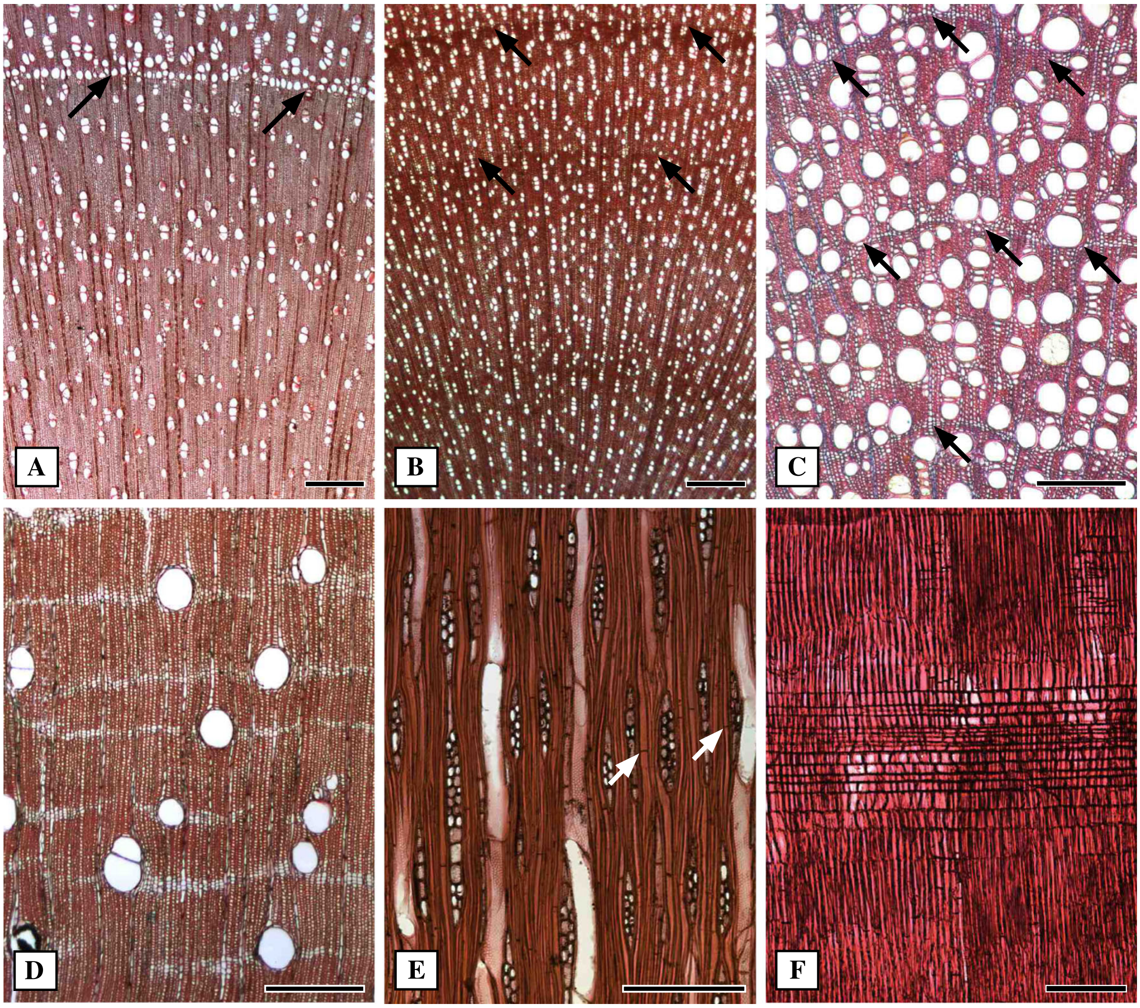

Fig. 4 Wood anatomy of Tecomeae s.s. **a** *Tecoma stans*, TS, semi-ring porous wood, narrow vessels solitary to multiple of 2–3, scanty paratracheal parenchyma. **b** *Tecomaria capensis*, TS, diffuse porous wood, narrow vessels, solitary to multiples of 2–4 or more common, radially disposed, growth rings delimited by thicker-walled and radially flattened fibers (*arrows*). **c** *Podranea ricasoliana*, TS, diffuse porous wood, growth rings delimited by a line of marginal parenchyma (*arrows*), vessel dimorphism present, scanty paratracheal parenchyma. **d** *Deplanchea bancana*, TS, diffuse porous wood, vessels solitary to multiples of 2–3, winged-aliform parenchyma with long confluences. **e** *Tecomaria capensis*, LT, biseriate heterogeneous rays, non-storied. **f** *Tecoma cochabambensis*, LR, heterocellular ray with body cells procumbent and three to four marginal upright to square cells. *Scale bars* **a**–**d** 500 µm, **e**, **f** 200 µm

delimits the growth rings (Fig. 4c). Parenchyma strands have 3–4 cells in the trees and shrubs, and 5–8 cells per strand in the lianas. *Rays* are non-storied (to irregularly storied in some samples of *Tecoma stans*), 2–3-seriate, heterocellular with 2–4 marginal upright to square cells (Fig. 4e); in the lianas heterocellular with procumbent, square and upright cells mixed (except in *Campsis radicans*, which has heterocellular rays with 2–3 marginal upright to square cells). In *Deplanchea bancana* rays homo and heterocellular with one row of square cells co-occur.

Delostoma

We sampled *Delostoma integrifolium*, one of the four species recognized in this genus (Lohmann and Ulloa 2006 onwards).

Diagnostic features

In this species vessels are narrow, the parenchyma is scanty paratracheal, rays are non-storied, heterocellular with one row of square marginal cells co-occurring with homocellular rays, and fibers are septate (Fig. 5a–d).

Detailed description

Growth rings are distinct, delimited by a line of marginal parenchyma (Fig. 5a, b). Very narrow vessels are sometimes associated with the marginal parenchyma (Fig. 5b). *Porosity* diffuse (Fig. 5a, b). *Vessels* are solitary to multiples of 3–5, (Fig. 5a, b), 2.93 ± 1.21 vessels/group, narrow (40 ± 20 µm), with 46 ± 20/mm^2 of frequency.

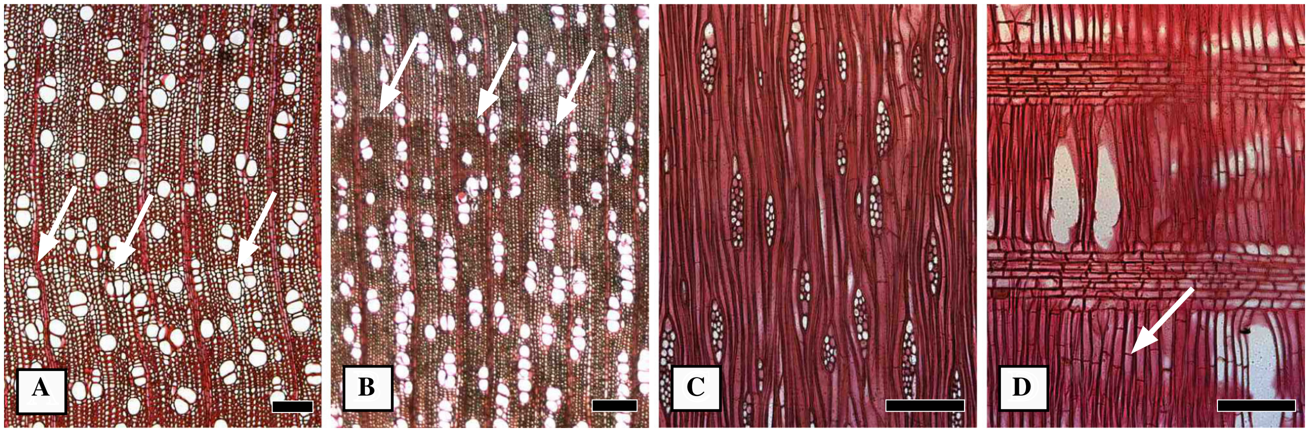

Fig. 5 Wood anatomy of *Delostoma integrifolium*. **a** TS, narrow vessels solitary to multiples of two to four, scanty paratracheal parenchyma to vasicentric, growth ring delimited by a line of marginal parenchyma. **b** TS, narrow vessels in radial arrangement, scanty paratracheal parenchyma, growth ring delimited by a line of parenchyma and radially flattened fibers (*arrows*). **c** LT, rays two to three-seriate, non-storied. **d** LR, homocellular rays, septate fibers (*arrows*). *Scale bars* **a, c, d** 200 μm, **b** 250 μm

Perforation plates are simple. *Intervascular pits* are minute (3–4 μm). *Vessel-ray pits* are similar in size and shape to the intervascular pits. *Fibers* are septate (Fig. 5d), thin- to thick-walled, with simple pits. *Parenchyma* is scanty paratracheal (Fig. 5a, b) to vasicentric, with a line of marginal parenchyma delimiting the growth rings (Fig. 5a, b). Parenchyma strands have 3–4 cells. *Rays* are non-storied, and predominantly 3-seriate (Fig. 5c, d), heterocellular with 1–2 rows of square marginal cells co-occurring with homocellular rays (Fig. 5c, d).

Crescentiina

Crescentiina are divided in two subclades, the *Tabebuia* alliance and the Paleotropical clade, each of which is described in detail below. Crescentiina are characterized by abundant, aliform confluent parenchyma, either with short or long confluences, short rays, generally homocellular or homocellular and heterocellular simultaneously, with the heterocellular rays having only one row of square marginal cells.

Tabebuia alliance (including Crescentieae)

We sampled 27 out of the 146 species currently included in the *Tabebuia* alliance, representing 13 out of the 14 genera currently included in this clade (Lohmann and Ulloa 2006 onwards); only *Romeroa*, a monotypic genus from Colombia, was not sampled. Sampling included *Amphitecna* (2 of 6 species), *Crescentia* (2 of 18 species), *Cybistax antisyphilitica* (monotypic), *Ekmanianthe* (both species), *Godmania* (1 of 2 species), *Handroanthus* (5 of 30 species), *Paratecoma peroba* (monotypic), *Parmentiera* (1 of 9 species), *Roseodendron* (1 of 2 species), *Sparattosperma* (1 of 2 species), *Spirotecoma* (1 of 4 species), *Tabebuia* (7 of 67 species), *Zeyheria* (both species). Of these, *Amphitecna*, *Crescentia*, and *Parmentiera* belong to tribe Crescentieae, a monophyletic group nested within the *Tabebuia* alliance.

Diagnostic features

The wood of representatives of the *Tabebuia* alliance is characterized by the small to medium vessels, associated with abundant vasicentric to aliform axial parenchyma with short to long confluences. All genera have storied or irregularly storied axial and radial elements. Fibers are non-septate. Lapachol (yellow compound) was encountered in the heartwood of a few genera, such as *Ekmanianthe*, *Godmania*, *Handroanthus* and *Zeyheria*.

Detailed description

Growth rings are distinct, delimited by a line (Fig. 6a, c, d) or band (Fig. 6b) of marginal parenchyma, sometimes associated with very narrow vessels (Fig. 6c), thick-walled and radially flattened fibers (very common in *Handroanthus* and *Tabebuia*), and in some species dilated rays (e.g., *Handroanthus impetiginosus*, *H. serratifolius*, *Paratecoma peroba*, *Sparattosperma leucanthum*). *Porosity* diffuse (Fig. 6a, b, d) to semi-ring porous (Fig. 6c). *Vessels* are solitary to multiples of 2–3, 1.62 ± 0.30 vessels/group, arranged tangentially in *Cybistax antisyphilitica*, narrow (60 ± 26 μm) in most genera, medium in *Handroanthus* and *Sparattosperma* (134 ± 45 μm), numerous (20 ± 12/

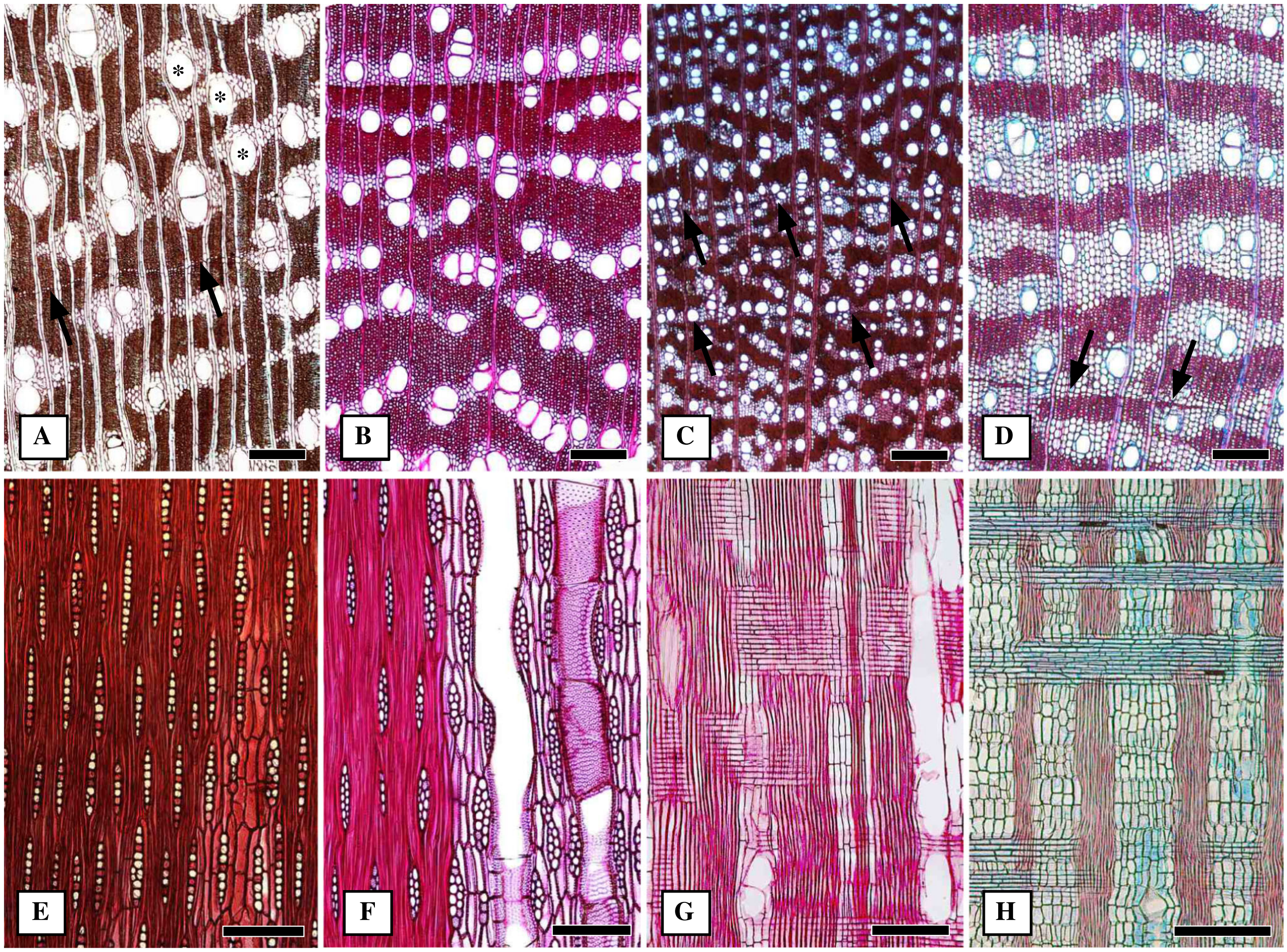

Fig. 6 Wood anatomy of the *Tabebuia* alliance (including Crescentieae). **a** *Handroanthus barbatus*, TS, diffuse porous wood, paratracheal aliform parenchyma, predominantly unilateral around certain vessels (*asterisks*), with short confluences, thick-walled fibers, growth rings delimited by a line of marginal parenchyma (*arrows*). **b** *Tabebuia roseoalba*, TS, diffuse-porous wood, aliform parenchyma, sometimes unilateral, with short confluences, growth rings delimited by a band of marginal parenchyma. **c** *Zeyheria montana*, TS, diffuse porous wood, aliform parenchyma with short to long confluences, thick walled fibers, growth rings delimited by a line of marginal parenchyma (*arrows*). **d** *Crescentia cujete*, TS, diffuse porous wood, abundant aliform parenchyma with long confluences forming bands, growth rings delimited by a line of marginal parenchyma. **e** *Crescentia alata*, LT, axial and radial elements storied, uniseriate rays, sometimes biseriate, two cells per parenchyma strand. **f** *Handroanthus chrysotrichus*, LT, all axial and radial elements storied, biseriate rays, parenchyma paratracheal with two cells per strand, large intervessel pits. **g** *Tabebuia fluviatilis*, LR, homocellular rays. **h** *Crescentia cujete*, LR, abundant axial parenchyma, homocellular rays. *Scale bars* **a, b, d, g, h** 100 μm, **c** 500 μm, **e, f** 200 μm

mm^2), 43 ± 4/mm^2 in *Cybistax antisyphilitica*. *Deposits* of lapachol are common in *Handroanthus* and *Zeyheria*. *Perforation plates* are simple, sometimes foraminate in *Tabebuia*, *Spirotecoma*, *Crescentia* and *Parmentiera*. *Intervessel pits* vary from small (∼5 μm in *Roseodendron donnel-smithii*) to large (∼18 μm in *Handroanthus chrysotrichus*). *Vessel-ray pits* are similar in size and shape to the intervessel pits. *Fibers* are non-septate, thin- to thick-walled and frequently very thick walled (e.g., *Handroanthus*, *Paratecoma peroba*, *Zehyeria*; Fig. 6a, c). *Parenchyma* ranges from vasicentric to aliform, forming short (Fig. 6a, b) to long confluences (Fig. 6c, d), usually forming bands (Fig. 6d). Unilateral aliform parenchyma (Fig. 6a, b) is common in some species (e.g., *Handroanthus albus*, *H. impetiginosus*, *Tabebuia roseoalba*). A gradual change from aliform, to aliform-confluent with short to long confluences and finally a marginal band within each growth ring is found in some members of this clade (*Crescentia alata*, *Handroanthus* and *Tabebuia*). All sampled species of *Amphitecna*, *Cybistax antisyphilitica, Crescentia alata* and some species of *Handroanthus* (e.g., *Handroanthus barbatus*, *H. chrysotrichus*, *H. impetiginosus*; Fig. 6e, f) have 2 cells per parenchyma strand, while others have 2–4 cells (e.g., *H. serratifolium*). *Rays* are usually storied (Fig. 6e, f) or irregularly storied, uniseriate (Fig. 6e) to 2–3-seriate (Fig. 6f), generally homocellular

(Fig. 6g, h), although homocellular and heterocellular rays with one marginal row of square cells are present in *Godmania aesculifolia*, *Sparattosperma leucanthum*, and in both species of *Zeyheria* sampled.

Paleotropical clade (including Coleeae)

We sampled 22 of the 139 species currently recognized in the Paleotropical clade, representing 15 out of the 19 genera currently included in this group (Lohmann and Ulloa 2006 onwards); only *Phylloctenium* (ditypic genus from Madagascar), *Dinklageodoxa* (monotypic genus from Liberia), and *Rhigozum* (seven species from Tropical Africa and Madagascar) were not sampled. More specifically, we sampled *Catophractes alexandri* (monotypic), *Colea* (2 of 21 spp), *Dolichandrone* (2 of 10 species), *Fernandoa* (2 of 14 species), *Heterophragma* (both species), *Kigelia africana* (monotypic), *Markhamia* (2 of 10 species), *Newbouldia laevis* (monotyic), *Ophiocolea floribunda* (1 of 5 species), *Pajanelia longifolia* (monotypic), *Phyllarthron bojeranum* (1 of 15 species), *Radermachera* (5 of 18 species), *Rhodocolea* (3 of 7 species), *Spathodea campanulata* (monotypic), *Stereospermum chelonoides* (1 of 20 species), and *Tecomella undulata* (monotypic). Of these, *Colea*, *Ophiocolea*, *Phyllarthron*, and *Rhodocolea* belong to tribe Coleeae, a monophyletic group nested within the Paleotropical clade.

Diagnostic features

The wood anatomy of most species from the Paleotropical clade is distinctive in having abundant paratracheal aliform confluent parenchyma, with short to long confluences, medium vessels, non-storied, 2–3-seriate, co-occurring homo and heterocellular rays, and thick walled, non-septate fibers. However, Coleeae differ from the rest of the clade by its apotracheal diffuse axial parenchyma that co-occurs with paratracheal vasicentric to aliform parenchyma, thin- to very thick-walled fibers, narrow vessels and homocellular uniseriate rays.

Detailed description

Growth rings are distinct, delimited by a line of marginal parenchyma associated with very narrow vessels (Fig. 7a, b), vessels of larger diameter (Fig. 7b), ticker-walled and radially flattened fibers (Fig. 7b), and sometimes dilated rays (e.g., *Fernandoa adenophylla*, *Markhamia lutea*, *Tecomella undulata*). *Porosity* is diffuse (Fig. 7a, e, f) or semi-ring porous (Fig. 7b), especially in species growing in more arid areas (e.g. *Catophractes alexandri*). *Vessels* are solitary or in multiples of 2–3 (Fig. 7a, b, e, f), 1.51 ± 0.44 vessels/group, medium (110 ± 20 μm), except in Coleeae, where they are narrow (60 ± 10 μm; Fig. 7f); frequencies are variable, ranging from 8 to 10/mm^2 in *Kigelia africana* and *Spathodea campanulata* to 24–40/mm^2 in *Tecomella undulata*, *Radermachera glandulosa*, and species of tribe Coleeae. *Intervessel pits* are small (4–5 μm) to minute in tribe Coleeae (<3 μm). *Vessel-ray pits* are similar in size and shape to intervessel pits. *Fibers* are thin- (Fig. 7b) to very thick-walled (Fig. 7a, e), with simple pits and occasionally septate. Within tribe Coleeae fibers are thin-walled in *Colea* and *Ophiocolea* and very thick-walled in *Rhodocolea* and *Phyllarthron*. Fibers are always septate in the sampled species of *Heterophragma*, *Radermachera*, and *Pajanelia longifolia*. *Parenchyma* is paratracheal vasicentric to aliform, with short (Fig. 7e) to long confluences (Fig. 7a, b). Apotracheal diffuse parenchyma is present in all genera from tribe Coleeae (Fig. 7e, f), less abundantly in *Phyllarthron bojeranum* and *Rhodocolea*, always co-occuring with paratracheal vasicentric to aliform parenchyma, with short to long confluences in *Rhodocolea multiflora* and *R. nycteriphilla*. Usually 3–4 cells per parenchyma strand (2 cells in *Spathodea campanulata*). *Rays* are non-storied, 3–4-seriate (Fig. 7c), homocellular (Fig. 7d) and heterocellular with one row of marginal square cells common (Fig. 7c). In representatives of tribe Coleeae rays are exclusively unicellular and homocellular (Fig. 7g, h), similarly to *Dolichandrone atrovirens*, *Kigelia africana*, *Stereospermum leucanthum*, and *Tecomella undulata* (which fall outside Coleeae).

Oroxyleae

We sampled *Millingtonia hortensis* (monotypic) and *Oroxylum indicum* (monotypic), two of the four genera and six species currently recognized in the tribe (Lohmann and Ulloa 2006 onwards). Only *Nyctocalos* (three species) and *Hieris curtisii* (monotypic), both lianas from Malesia, were not sampled.

Diagnostic features

The wood of Oroxyleae can be recognized by a unique combination of vessels with foraminate perforation plates, co-occurring with vessels of simple perforation plates, paratracheal vasicentric to aliform parenchyma, homocellular and non-storied rays, fibers generally non-septate.

Detailed description

Growth rings are distinct, delimited by a line of marginal parenchyma (Fig. 8a), thicker-walled and radially flattened

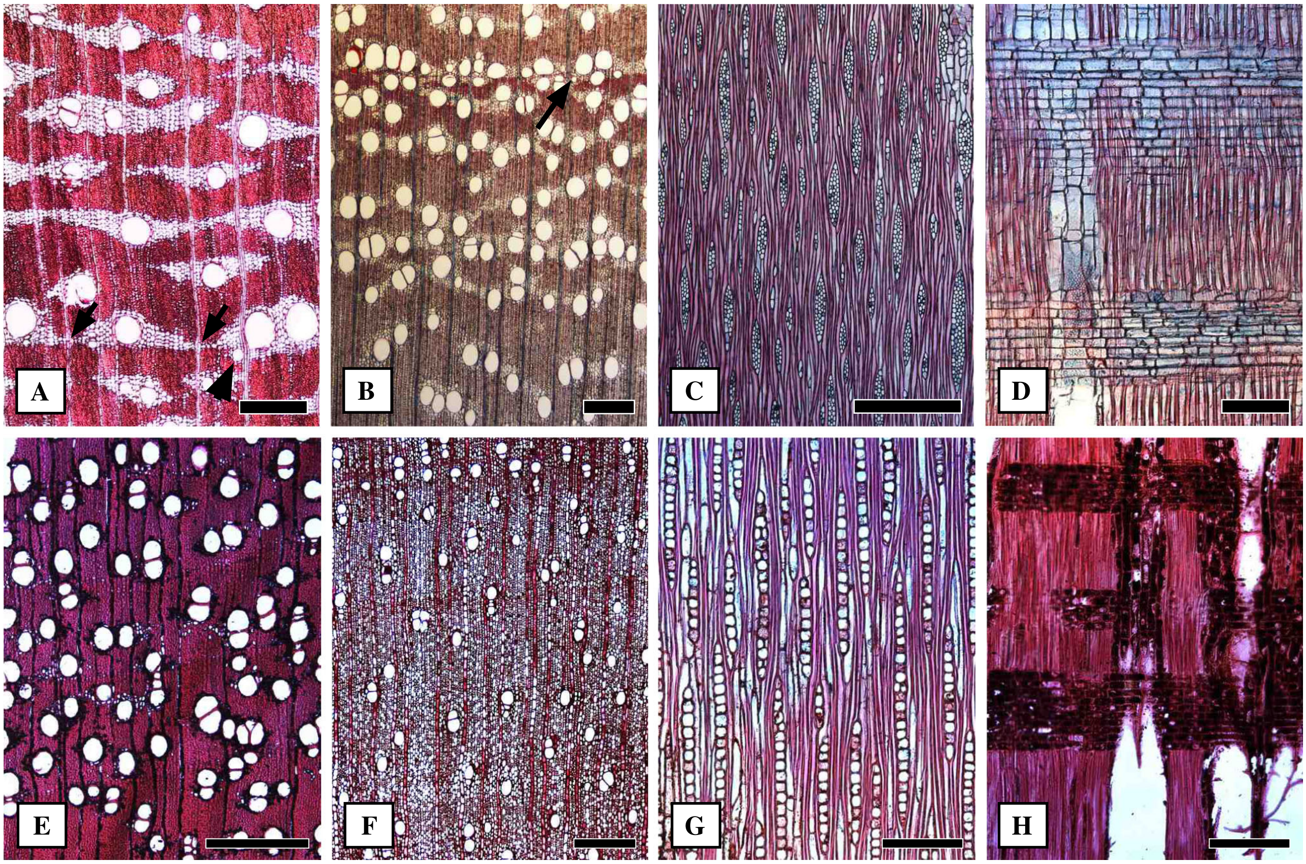

Fig. 7 Wood anatomy of the Paleotropical clade (including Coleeae). **a** *Stereospermum chelonoides*, TS, diffuse porous wood, vessels solitary to multiples of 2–3, growth rings delimited by a line of marginal parenchyma (*arrows*) associated with narrow vessels (*arrowhead*), paratracheal aliform parenchyma with short confluences. **b** *Markhamia lutea*, TS, semi-ring porous wood, vessels solitary to multiples 2–3, growth rings delimited by wide vessels and a line of marginal parenchyma associated with narrow vessels (*arrow*), aliform parenchyma with short to long confluences. **c** *Spathodea campanulata*, LT, rays 2–3-seriate, non-storied. **d** *Heterophragma roxburghii*, LR, homocellular rays. **e–h** Tribe Coleeae. **e** *Rhodocolea telfairae*, TS, diffuse porous, vessels solitary to multiples of 2–3, paratracheal aliform parenchyma with short confluences, and scanty diffuse apotracheal parenchyma, fibers very thick-walled. **f** *Ophiocolea floribunda*, TS, vessels solitary to multiples of 2–3, abundant apotracheal diffuse parenchyma combined with vasicentric paratracheal parenchyma, fibers thin-walled. **g** *Ophiocolea floribunda*, LT, uniseriate rays, non-storied. **h** *Rhodocolea telfairiae*, LR, homocellular rays. *Scale bars* **a, c**, **e**, **f** 500 µm, **b** 1 mm, **d**, **g**, **h** 200 µm

fibers, and dilated rays. *Porosity* diffuse (Fig. 8a, e). *Vessels* are solitary or in multiples of 2–3 (Fig. 8a, e), 1.59 ± 0.49 vessels/groups, narrow in *Millingtonia hortensis* (80 ± 26 µm; Fig. 8a) and medium in *Oroxylum indicum* (179 ± 16 µm; Fig. 8e); 25 ± 8/mm^2 of frequency in *Millingtonia hortensis* (Fig. 8a) and fewer, 4 ± 4/mm^2, in *Oroxylum indicum* (Fig. 8e). Vessels with foraminate perforation plates are common (Fig. 8d, h) co-occurring with vessels with simple perforation plates (more frequent). In *Millingtonia hortensis*, a combination of foraminate and reticulate perforation plates is frequently found at the same plate (Fig. 8d). *Intervessel pits* are small (4–5 µm). *Vessel-ray pits* are similar to the intervessel pits in size and shape. *Fibers* are thin- to thick-walled (Fig. 8a, e), with simple pits, non-septate to occasionally septate in some individuals of *Oroxylum indicum*. *Parenchyma* is vasicentric (Fig. 8a) to aliform (Fig. 8e), both with short confluences; 3–4 cells per parenchyma strand. *Rays* are homocellular (Fig. 8c, g), 3-seriate and non-storied (Fig. 8b, f).

Catalpeae

We sampled *Chilopsis linearis* (monotypic), and *Catalpa* (3 out of the 11), representing the two genera currently included in this clade (Lohmann and Ulloa 2006 onwards). In *Catalpa*, we sampled species from section *Macrocatalpa* (*Catalpa longissima*), and section *Catalpa* (*Catalpa bignonioides* and *Catalpa speciosa*).

Diagnostic features

Catalpeae are distinctive for the semi-ring porous to ring-porous wood found in *Chilopsis linearis* and *Catalpa*

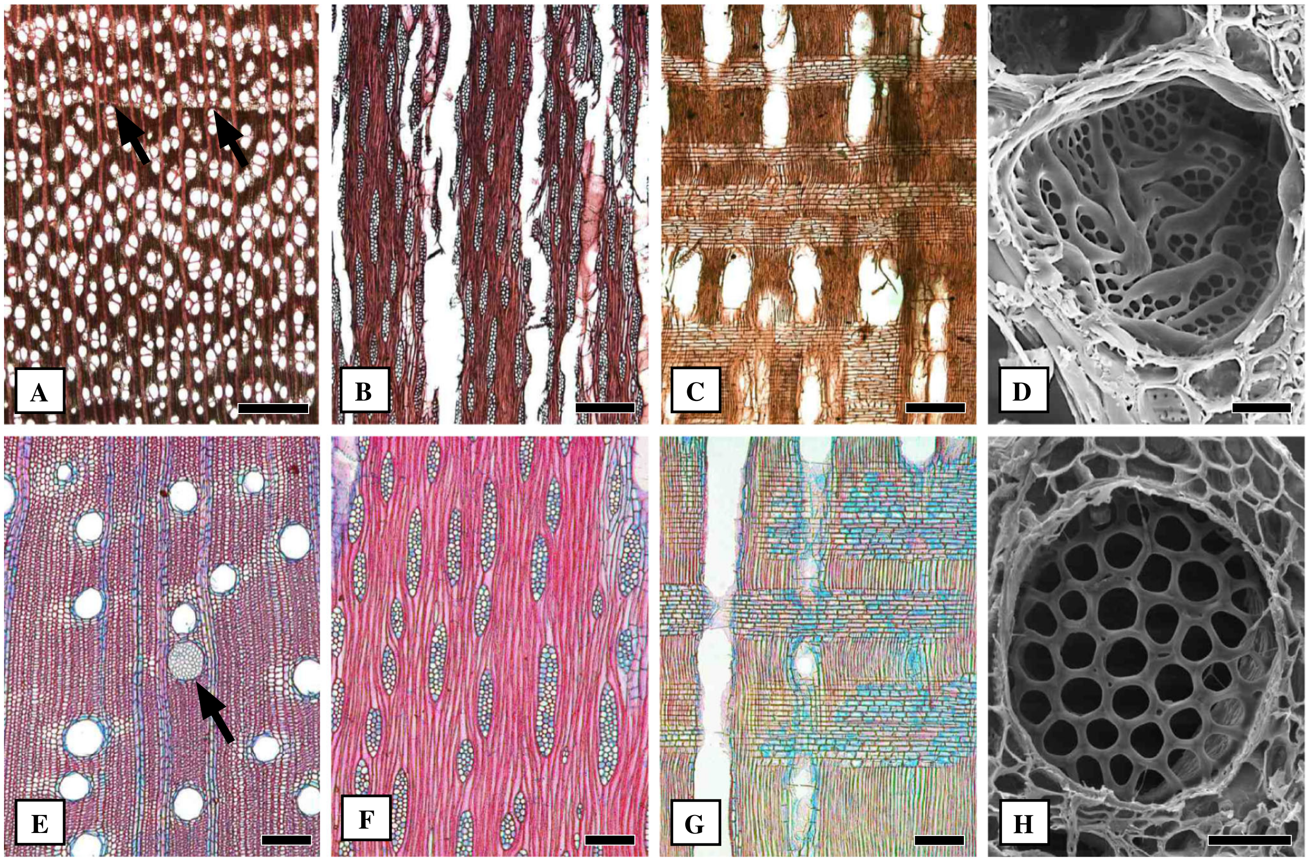

Fig. 8 Wood anatomy of Oroxyleae. **a–d** *Millingtonia hortensis*. **a** TS, vessels solitary to multiples of two to four, growth ring delimited by a line of marginal parenchyma (*arrows*) and thicker-walled and radially flattened fibers, vasicentric parenchyma, with short confluences. **b** LT, rays 3-seriate, non-storied. **c** LR, rays homocellular. **d** Scanning electron microscopy (SEM) of a vessel with a combination of foraminate and reticulate perforation plate together, typical of this species. **e**, **f** *Oroxylum indicum.* **e** TS, solitary vessels common, paratracheal aliform parenchyma with short confluences, foraminate perforation plate (*arrow*). **f** LT, rays 3-seriate, non-storied. **g** LR, rays homocellular. **h** SEM of a vessel with foraminate perforation plate. *Scale bars* **a** 500 μm, **b**, **c**, **e–g** 200 μm, **d** 20 μm, **h** 50 μm

(section *Catalpa*), as well as the presence of scanty paratracheal to vasicentric confluent parenchyma. In *Catalpa* (section *Macrocatalpa*) the parenchyma is aliform confluent. Tyloses are abundant in both sections, as are the septate fibers in the tropical and subtropical species (*Chilopsis linearis* and *C. longissima*) and the unique presence of simple to semi bordered vessel-ray pits.

Detailed description

Growth rings are distinct, delimited by a band of marginal parenchyma, vessels of two different diameters in *Chilopsis linearis* (Fig. 9c), *Catalpa speciosa* and *C. bignonioides* (section *Catalpa*; Fig. 9a), thicker-walled and radially flattened fibers. *Porosity* diffuse in *Catalpa longissima* (section *Macrocatalpa*; Fig. 9b), and semi-ring porous to ring-porous in *Catalpa speciosa, C. bignonioides* (section *Catalpa*; Fig. 9a), and *Chilopsis linearis* (Fig. 9c). *Vessels* are solitary or in multiples of 2–3, 1.43 ± 0.12 vessels/group in earlywood and tropical specimens, 19.27 ± 7.59 vessels/group in latewood, wide vessels with 200 ± 18 μm in the semi-ring to ring-porous woods (i.e., *Catalpa* section *Catalpa* + *Chilopsis*), and medium vessels with 131 ± 10 μm in *Catalpa longissima* (section *Macrocatalpa*); narrow vessels of latewood of 30 ± 6 μm; and frequency of 12 ± 5/mm^2 in *Catalpa speciosa* and 34 ± 10/mm^2 in *Chilopsis linearis*. Helical thickening is present in all vessels of *Catalpa speciosa* (section *Catalpa*) and *Chilopsis linearis*. *Perforation plates* are simple (Fig. 9f). *Intervessel pits* are small (5–7 μm). *Vessel-ray pitting* is simple to semi-bordered. *Fibers* are septate in the tropical and subtropical species (Fig. 9d, e) and non septate in the temperate species (Table 1), thin- to thick-walled, with simple pits. *Parenchyma* is scanty paratracheal to vasicentric in *Catalpa speciosa* and *Catalpa bignonioides* (section *Catalpa*) and *Chilopsis*, vasicentric forming bands when associated with the narrow vessels in the latewood of *Chilopsis linearis*. Bands of marginal parenchyma are

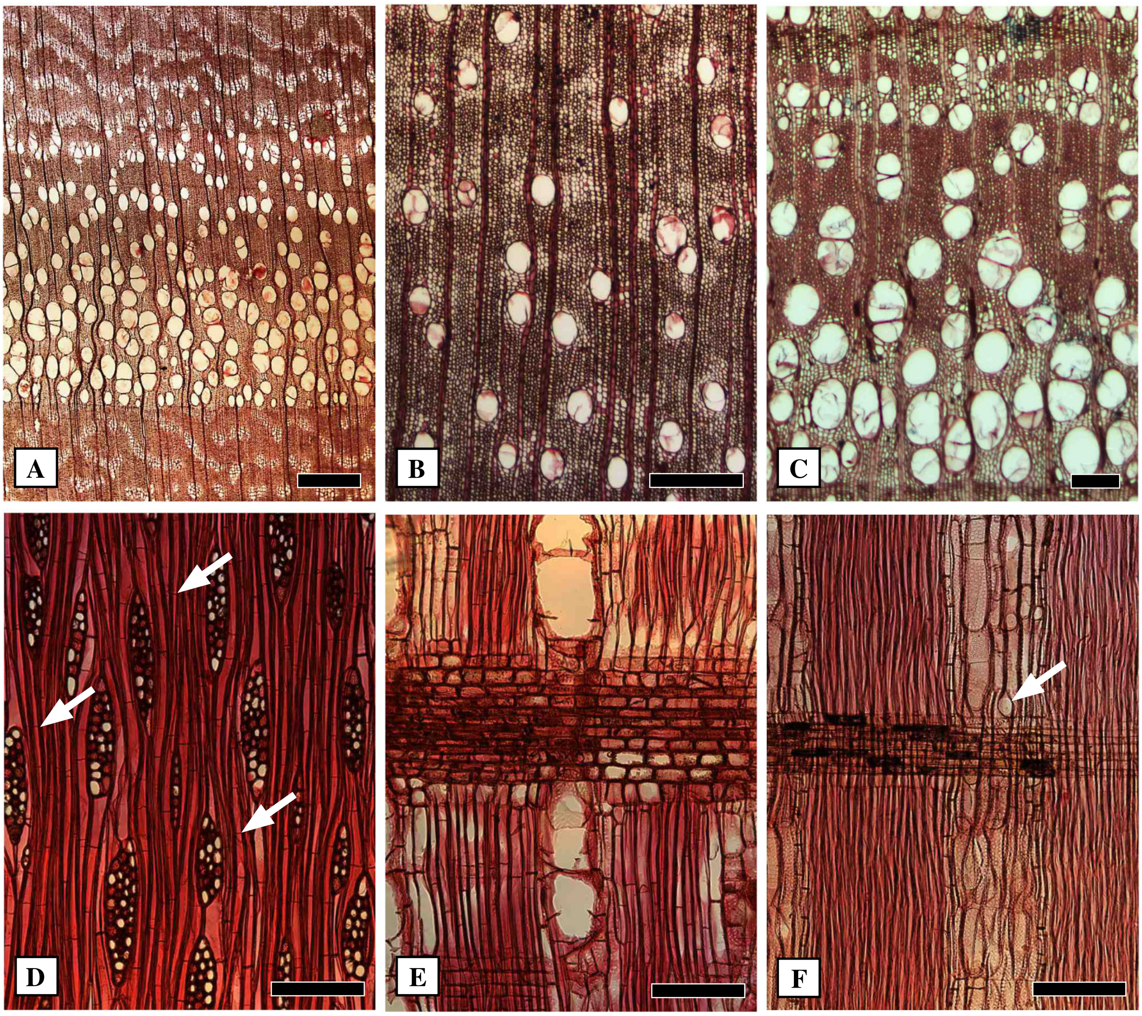

Fig. 9 Wood anatomy of Catalpeae. **a** *Catalpa speciosa* (section *Catalpa*), TS, semi-ring porous wood, earlywood vessels solitary to multiples of 2–3, associated with a band of marginal parenchyma, latewood vessels in clusters, scanty paratracheal parenchyma, tyloses common. **b** *Catalpa longissima* (section *Macrocatalpa*), TS, wood diffuse porous, vessels solitary to multiples of 2–3, parenchyma aliform, with short confluences, tyloses common. **c** *Chilopsis linearis*, TS, semi-ring porous wood, earlywood vessels solitary to multiples of 2–3, associated with a band of marginal parenchyma, latewood vessels generally in multiples, with paratracheal vasicentric parenchyma forming bands, tyloses common. **d** *Catalpa longissima*, LT, 2–3seriate rays, non-storied, septate fibers common (*arrows*). **e** *Chilopsis linearis*, LR, heterocellular rays with one row of square marginal cells. **f** *Catalpa speciosa*, LR, heteroellular ray, narrow vessels in clusters, showing simple perforation plates. *Scale bars* **a** 500 µm, **b–f** 200 µm

present. In *Catalpa longissima* (section *Macrocatalpa*), the parenchyma is aliform with short confluences (Fig. 9b). Parenchyma strands have 3–4 cells, as seen in tangential section. *Rays* are 3-seriate, non-storied (Fig. 9d), and heterocellular with one row of marginal square cells (Fig. 9e, f) co-occurring with homocellular rays.

Bignonieae

We sampled all 21 genera and 49 out of the 393 species currently included in Bignonieae (sensu Lohmann and Taylor 2014). Sampling included *Adenocalymma* (8 of 82), *Amphilophium* (5 of 47), *Anemopaegma* (1 of 45), *Bignonia* (4 of 28), *Callichlamys latifolia* (monotypic), *Cuspidaria* (2 of 19), *Dolichandra* (2 of 8), *Fridericia* (5 of 67), *Lundia* (3 of 13), *Manaosella cordifolia* (monotypic), *Mansoa* (3 of 12), *Martinella* (1 of 2), *Neojobertia* (both species), *Pachyptera* (1 of 4 species), *Perianthomega vellozoi* (monotypic), *Pleonotoma* (3 of 17 species), *Pyrostegia* (1 of 2 species), *Stizophyllum* (1 of 3 species), *Tanaecium* (3 of 17 species), *Tynanthus* (1 of 15 species), and *Xylophragma* (2 of 7 species).

Diagnostic features

Bignonieae are characterized by the presence of a cambial variant, denominated furrowed xylem, with four or multiples of four phloem wedges that interrupt the xylem

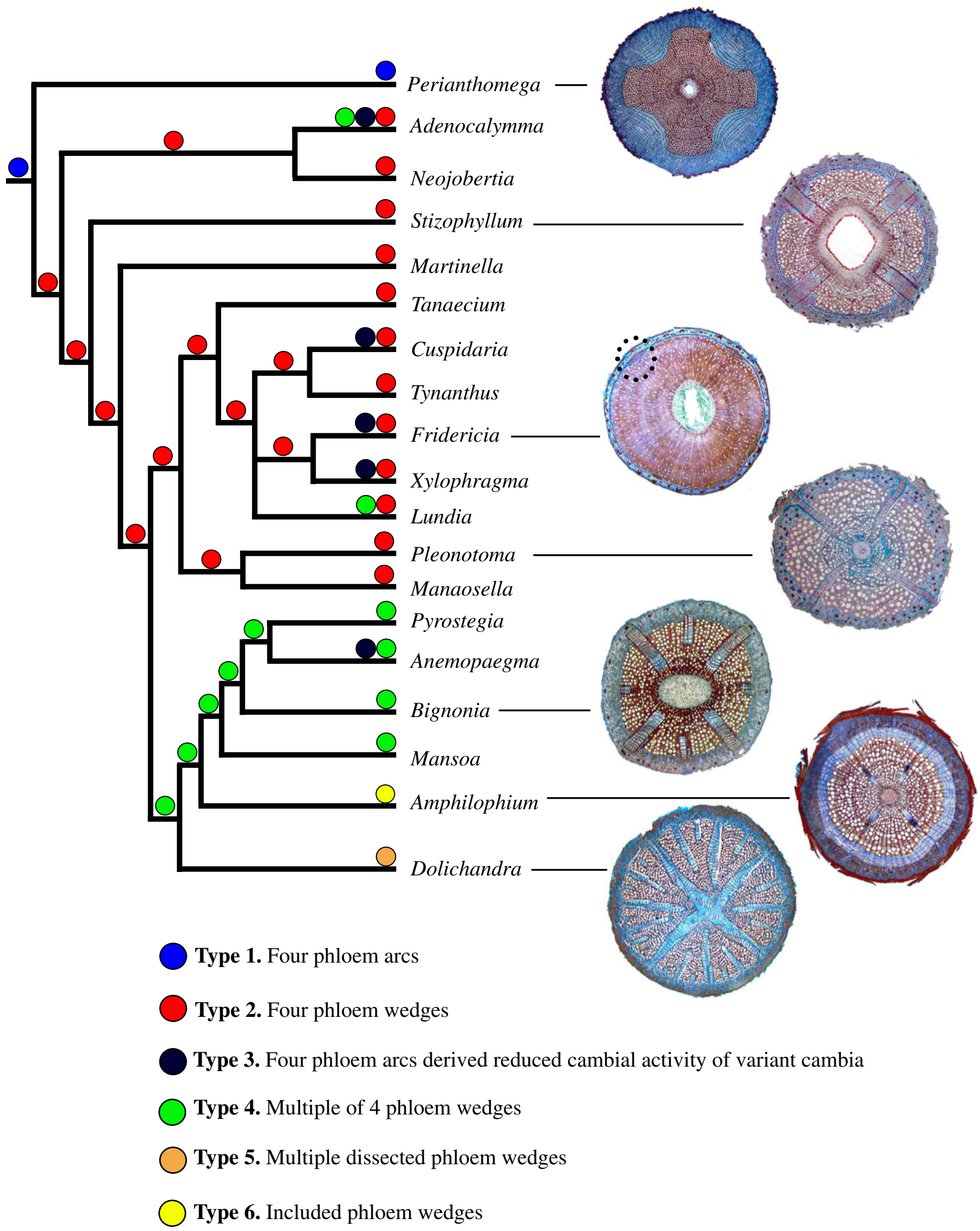

Fig. 10 Phylogenetic mapping of the six types of cambial variants found in Bignonieae; entire stem, as seen in transverse sections. *Type 1 Perianthomega vellozoi*, four broad phloem arcs. *Type 2 Stizophyllum riparium* and *Pleonotoma tetraquetra*, four phloem wedges. *Type 3 Fridericia platyphylla*, four narrow phloem arcs derived from a reduced activity of the variant cambia, typical of shrub species. *Type 4 Bignonia binata*, multiple of four phloem wedges. *Type 5 Dolichandra unguis-cati*, multiple dissected phloem wedges. *Type 6 Amphilophium crucigerum*, included phloem wedges

(Fig. 10). The wood anatomy of members of Bignonieae is characterized by scanty paratracheal to vasicentric axial parenchyma, generally tall (>1 mm) and heterocellular rays, and septate fibers (Fig. 11)

Cambial variants in Bignonieae have the conspicuous form of a cross in transverse section (Fig. 10). The stems of Bignonieae can be sorted in six types, according to the form and distribution of the phloem arcs/wedges. *Type 1* corresponds to four broad equidistant phloem arcs (Fig. 10) and is exclusive of *Perianthomega*, a monotypic genus that is sister to all other Bignonieae. In this type, the cambium lines the entire stem circumference, without disjunctions. *Type 2* corresponds to four equidistant phloem wedges, formed by the presence of a cambial disjunction and inclusion within the phloem wedges (Fig. 10). Type 2 is most common in Bignonieae, and is present in 12 of the 21 genera of the tribe (Fig. 10). *Type 3* corresponds to four narrow phloem arcs (Fig. 10) derived from delayed development of the phloem wedges and is typical of the shrubby species. This type was recorded in *Adenocalymma*

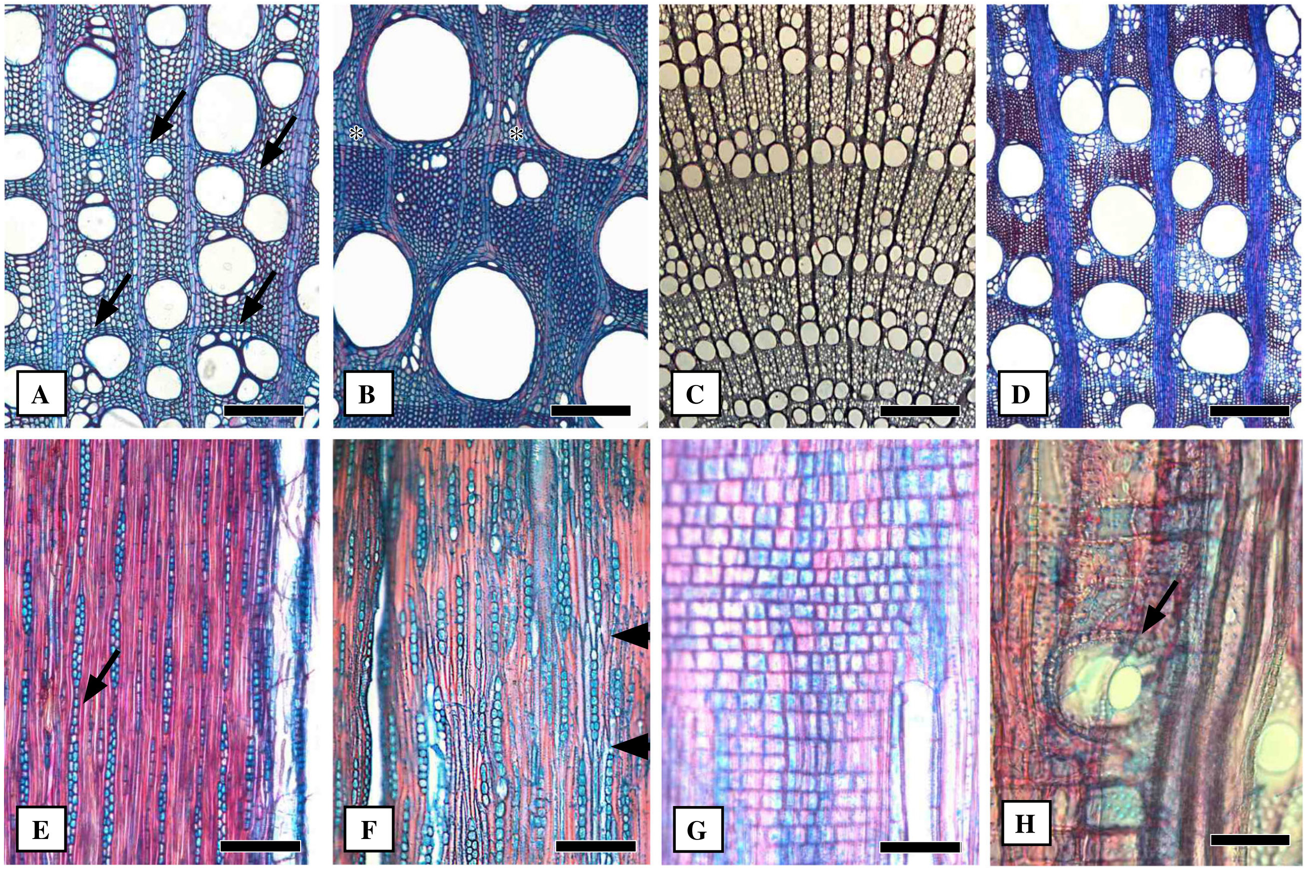

Fig. 11 Wood anatomy of Bignonieae. **a** *Mansoa difficilis*, TS, diffuse porous wood, growth rings delimited by thick-walled and radially flattened fibers (*arrows*), vessel dimorphism present. **b** *Tynanthus cognatus*, TS, semi-ring porous wood, delimited by radially flattened fibers and a marginal band of parenchyma, vessel dimorphism present. Wide vessels generally solitary. **c** *Bignonia capreolata*, TS, ring porous wood. **d** *Amphilophium crucigerum*, TS, diffuse porous wood, wide vessels generally solitary, combined with clusters of narrow vessels, wide rays. **e** *Stizophyllum riparium*, LT, biseriate rays, fusion of rays common (*arrow*). **f** *Dolichandra unguis-cati*, LT, uniseriate and short rays storied. Fibers also storied (*arrows*). **g** *Fridericia speciosa*, LR, heterocellular mixed rays. **h** *Neojobertia mirabilis*, LR, perforated ray cell (*arrow*) with simple perforation plate. *Scale bars* **a**, **b**, **e**, **f** 200 μm, **c** 800 μm, **d** 300 μm, **g** 150 μm, **h** 40 μm

nodosum, *A. peregrinum*, *Cuspidaria pulchra*, and *Fridericia platyphylla*, all shrubs growing in the *Cerrado* (Brazilian savannah). The wedges may be very reduced making it impossible to detect without magnification (circled in Fig. 10). *Type 4* corresponds to multiple of four phloem wedges. These species start their development with four phloem wedges, but form additional wedges between the previous ones, always in multiples of four. This type is encountered in the all species from the clade formed by *Amphilophium*, *Anemopaegma*, *Bignonia*, *Dolichandra*, *Mansoa*, and *Pyrostegia*, in most species of *Lundia* and a few *Adenocalymma* (Fig. 10). *Amphilophium* and *Dolichandra*, however, go further in their development generating the next two types to be described. *Type 5* corresponds to the 'multiple dissected type,' in which multiple of four phloem wedges are also formed, and in which the proliferation of unlignified axial and ray parenchyma dissects the secondary xylem in pieces. The presence of unlignified axial and ray parenchyma in the xylem, which produces this type, is exclusive to *Dolichandra* (Fig. 10). *Type 6* corresponds to the 'included phloem wedges type,' in which multiple of four phloem wedges are formed, but are gradually occluded by the regular cambium at the top of the phloem wedges, eventually including the secondary phloem within the secondary xylem. This type is exclusive to *Amphilophium* (Fig. 10).

Detailed description

Growth rings are distinct and are delimited by a line or band of marginal parenchyma (Fig. 11a, b), very narrow vessels, thicker-walled and radially flattened fibers (Fig. 11a, b) and dilated rays (Fig. 11b). Discontinuous and merging growth rings are common. *Porosity* usually semi-ring porous (Fig. 11b) to diffuse porous (Fig. 11a). The sole species growing in temperate latitudes, *Bignonia* *capreolata*, has ring-porous wood (Fig. 11c). *Vessels* exhibit dimorphism, with wide and narrow vessels combined (Fig. 11a-b, d); wide vessels with 240 ± 60 µm, predominantly solitary in some species (e.g., *Amphilophium crucigerum*, *Stizophyllum riparium*, *Lundia damazii*) to solitary and multiples of 2–3 (Fig. 11a–d), 2.57 ± 0.91 vessels/group. Narrow vessels (20 ± 6 µm) usually have a conspicuous arrangement, such as radial rows, around the wide vessels or in clusters (Fig. 11d). Frequency >50/mm^2. *Perforation plates* are simple. *Intervessel pits* are medium (8–10 µm in diameter). *Vessel-ray pits* are similar to intervessel pits in size and shape. *Fibers* are septate in most species, thin- to thick-walled (Fig. 11a, b, d), and with simple pits. *Parenchyma* is scanty paratracheal in most species (Fig. 11a), except for the clade formed by *Cuspidaria*, *Fridericia*, *Lundia*, *Tanaecium*, *Tynanthus*, and *Xylophragma* (Fig. 11b; the *Arrabidaea* and allies clade in Lohmann 2006) and *Callichlamys latifolia* (not assigned to any clade; Lohmann 2006) in which vasicentric to aliform parenchyma with short confluences and a marginal band of parenchyma are present (Fig. 11b). *Rays* are heterocellular mixed (Fig. 11g), higher than 1 mm in most species, with variable width, ranging from uniseriate and short (e.g., *Dolichandra unguis-cati*; Fig. 11f), 2-4 cells wide (e.g., *Stizophyllum riparium*; Fig. 11e) and others are wider (Fig. 11d), 5–10 cells wide (e.g., *Amphilophium crucigerum*). The wood under the phloem wedges (variant secondary xylem) has narrower vessels, and rays unicellular and short. An increase in ray width was observed in some species from the stem center towards the bark (e.g. *Amphilophium crucigerum*). Fusion of rays is common in all species (Fig. 11e). *Storied structure* is absent in most species, but present in the axial, ray parenchyma and fibers of *Dolichandra* (Fig. 11f), and in the fibers of *Perianthomega vellozoi* and all sampled species of *Amphilophium*, and *Mansoa*. Perforated ray cells vary from very abundant (e.g., *Dolichandra unguis-cati*; *Stizophyllum riparium*; Fig. 11h) to rare (e.g., *Perianthomega vellozoi*). *Silica* is present in the ray cells of *Pachyptera kerere*.

Discussion

Molecular phylogenetic studies of Bignoniaceae have indicated that several tribes and genera were not monophyletic as traditionally recognized (Spangler and Olmstead 1999; Zjhra et al. 2004; Lohmann 2006; Grose and Olmstead 2007a, b; Li 2008; Olmstead et al. 2009), leading to many changes in the circumscription of taxa within the family. While most of the genus-level clades recognized are well supported by molecular and morphological characters (Grose and Olmstead 2007b; Lohmann and Taylor 2014), several of the higher-level clades (i.e., comparable to tribal level), however, still lack morphological synapomorphies (Olmstead et al. 2009). In this study, we investigate the wood anatomy of representatives of all major lineages of the Bignoniaceae (except Tourretieae), highlighting the most conspicuous features of each clade (Table 2; Fig. 12), providing a thorough description of their wood anatomy, and suggesting potential synapomorphies (Table 3). The new systematic arrangement of the Bignoniaceae led to more homogeneous and predictable wood anatomical groups (Table 2; Fig. 12). Key features of each clade are summarized and discussed below.

Jacarandeae were originally described as a tribe by Bentham and Hooker (1876) and later treated as part of Tecomeae s.l. (Gentry 1980; Fischer et al. 2004), but has been resurrected as a tribe and is now known to be sister to all other Bignoniaceae (Olmstead et al. 2009). The two genera of Jacarandeae, *Digomphia* and *Jacaranda*, share wood anatomical traits that are common to other Bignoniaceae, such as the marginal parenchyma delimiting the growth rings, and paratracheal aliform parenchyma. However, *Digomphia* and *Jacaranda* share the presence of narrow vessels, winged-aliform parenchyma (more conspicuous in *Jacaranda*), and non-storied rays, which supports the circumscription of this tribe. Wood anatomical traits also support the traditional division of *Jacaranda* into sections *Monolobos* and *Dilobos* (Dos Santos and Miller 1997), which were delimited on the basis of number of anther thecae, one or two, respectively. *Jacaranda* section *Monolobos* is characterized by homocellular and uniseriate rays, while *Jacaranda* section *Dilobos* is characterized by heterocellular and multiseriate rays (Dos Santos and Miller 1997). The only exception to this rule is in *Jacaranda copaia*, which is currently assigned to section *Monolobos*, but has anatomical traits that are intermediate between both sections, having multiseriate rays of homocellular composition, and has a unique wood anatomy within the tribe, having the widest vessels in Bignoniaceae trees (~300 µm). Additional sampling of *Jacaranda* in molecular phylogenetic studies is still needed in order to test the monophyly of the *Jacaranda* sections as traditionally circumscribed. *Jacaranda* is an ideal genus for further comparative anatomical studies since it presents a great deal of diversity of habits, from underground xylopodial shrubs and subshrubs in the *Cerrado*, treelets, medium-sized to very tall fast-growing trees in forests (e.g. *Jacaranda copaia*), and twigs were shown to represent consistently the wood anatomy of the main trunk wood in the genus (Dos Santos and Miller 1997).

Tecomeae sensu Olmstead et al. (2009) are much more narrowly circumscribed than the tribe Tecomeae previously recognized (Gentry 1992; Fischer et al. 2004). Even though morphological features are still lacking to diagnose this widely distributed tribe (occurring in America, Africa,

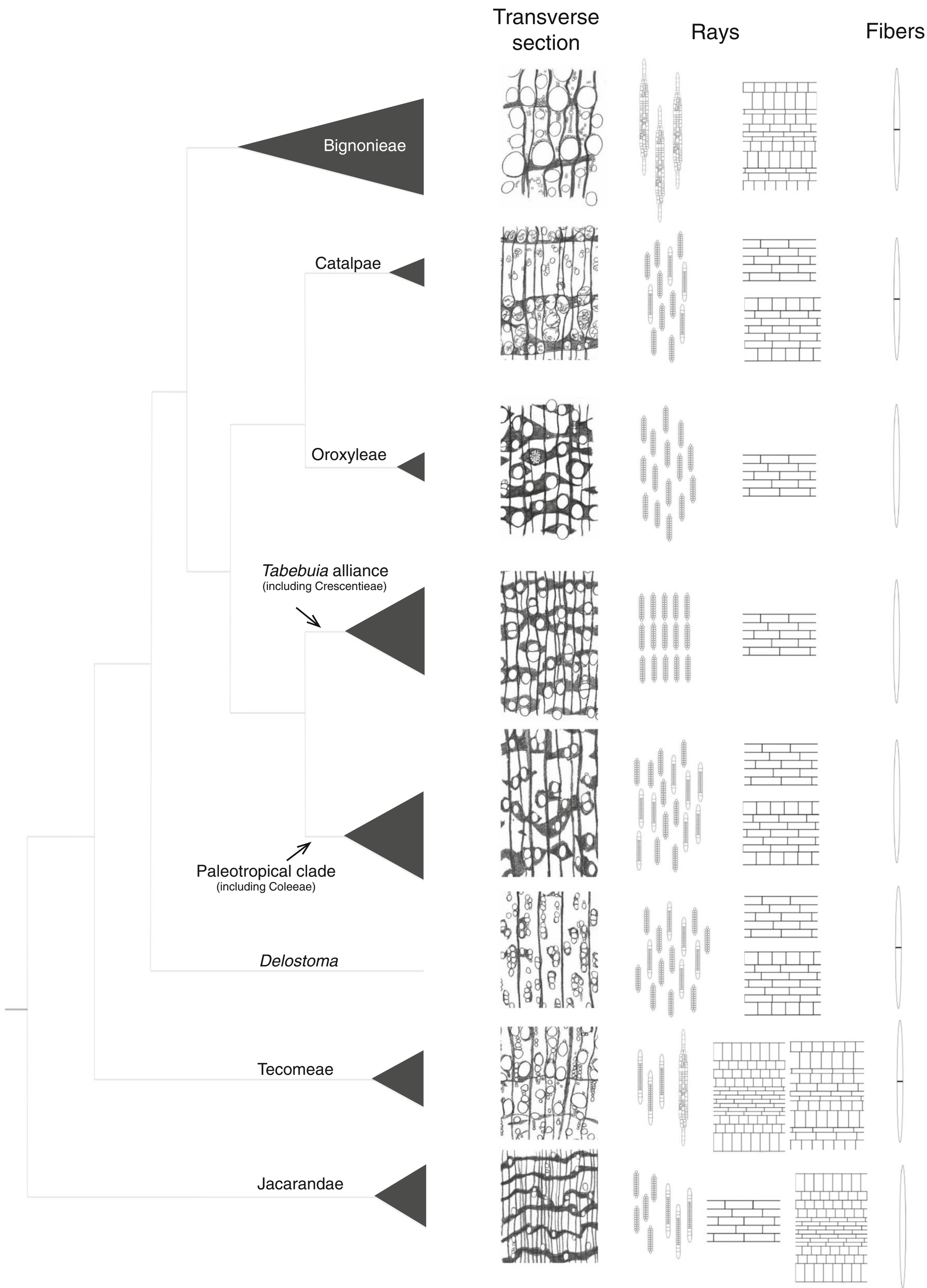

Fig. 12 Drawing summarizing of the most conspicuous wood anatomical features of major Bignoniaceae clades

Table 3 Potential wood anatomical synapomorphies

Taxa	Anatomical synapomorphy
Jacarandeae	Axial parenchyma winged-aliform
Catalpeae	Vessel-ray pits simple to semi-bordered
Oroxyleae	Foraminate perforation plates common
Bignonieae	Cambial variant: xylem furrowed by four to multiple of four phloem arcs/wedges
Tabebuia alliance	Storied structure
Coleeae	Diffuse axial parenchyma
Amphilophium	Included phloem wedges
Dolichandra	Multiple dissected phloem wedges derived of unlignified parenchyma proliferation
Perianthomega	Four broad phloem arcs

Asia and Oceania; see Olmstead et al. 2009), Tecomeae s.s. are quite homogeneous in wood anatomy (except from *Deplanchea*, whose wood anatomy looks very much like Jacarandeae), combining features that set aside members of Tecomeae from most other Bignoniaceae. In particular, heterocellular rays with body procumbent and several marginal upright to square cells to heterocellular mixed in some lianas (e.g., *Pandorea jasminoides*), septate fibers, scanty paratracheal parenchyma, and rather narrow vessels (except in the lianas) characterize all members of this clade.

Delostoma is a clade of four species of Neotropical treelets and shrubs. Traditionally, *Delostoma* was included within Tecomeae s.l. (Gentry 1980; Fischer et al. 2004), however, *Delostoma*, which bears simple leaves and double calyx, has been difficult to relate to either Paleotropical or Neotropical Bignoniaceae both morphologically (Gentry 1980) and wood anatomically (Dos Santos and Miller 1992). In the most recent phylogeny of Olmstead et al. (2009), *Delostoma* emerged in its own clade, not closely related to any other representatives of Bignoniaceae. Wood anatomically this genus is most similar to Tecomeae s.s., exhibiting heterocellular rays, septate fibers and small vessels usually in radial disposition. It differs from other Tecomeae mainly by the longer tracheary elements (Dos Santos and Miller 1992).

The *Tabebuia* alliance (Olmstead et al. 2009) are composed primarily of Neotropical trees and shrubs with palmately compound leaves; only a few members have simple leaves (e.g., *Crescentia*, *Tabebuia nodosa*). Members of several genera within this clade have invaluable timbers for interior and civil construction (e.g., *Handroanthus*, *Roseodendron*, *Cybistax*, *Paratecoma*). *Tabebuia* s.l., the largest genus within this clade, was shown to be polyphyletic (Grose and Olmstead 2007a) and subdivided in three smaller genera (Grose and Olmstead 2007b): *Tabebuia* (67 species), *Handroanthus* (30 species), and *Roseodendron* (two species).

Wood anatomical traits strongly support the new generic circumscription. More specifically, the *Tabebuia* Group I proposed by Dos Santos and Miller (1992), which coincides with the Lapacho group of Record and Hess (1943), is characterized by very dense wood and high specific gravity (higher than 0.74), olive brown to blackish heartwood, abundant lapachol in the heartwood vessels, coinciding perfectly with *Handroanthus*. Additional anatomical features of this clade are the large intervessel pits (usually >10 µm), very thick-walled fibers, storied structure and 2–3-seriate rays. The Bignoniaceae species with greatest economical value due to the high quality timber (Record and Hess 1943; Gentry 1992) are now included in this genus. In addition, *Tabebuia* Groups II and III proposed by Dos Santos and Miller (1992) correspond to the newly circumscribed *Tabebuia* s.s. (Grose and Olmstead 2007b). This clade is characterized by the medium basic specific gravity (0.40–0.74), light colored heartwood, not very distinct heartwood and sapwood, and lack of lapachol (Dos Santos and Miller 1992), as well as by small intervessel pits (5–8 µm), 1–2 seriate rays, that are irregularly storied to storied, and thin to thick-walled fibers. Finally, *Tabebuia chrysea* and *Tabebuia donnell-smithii*, two of four species that did not belong to Groups I, II, or III proposed by Dos Santos and Miller (1992), are now treated under *Roseodendron*. The other two species, *Tabebuia nodosa* and *Tabebuia fluviatilis* are also considered quite anomalous anatomically (Dos Santos and Miller 1992) and further phylogenetic data is still needed to confirm their placement among the three segregated genera.

Lapachol (naphthoquinone) was first described in *Tabebuia avellanedae* (= *Handroanthus impetiginosus*) in the XIX century and has antimicrobial properties and numerous applications in pharmacology (Hussain et al. 2007). Inclusion of lapachol in the vessels was evident in dense woods of the *Tabebuia* alliance by Dos Santos and Miller (1992) and us, such as in the genera *Ekmanianthe*, *Godmania*, *Handroanthus* and *Zeyheria*. Studies involving chemical extractions found lapachol in a number of other Bignoniaceae (Hussain et al. 2007), such as *Fernandoa*, *Heterophragma*, *Kigelia, Newboldia*, *Phyllarthron*, *Radermachera*, *Stereospermum*, *Tecomella* (Paleotropical clade), *Cybistax*, *Paratecoma peroba* (*Tabebuia* alliance), *Catalpa* (Catalpeae), *Dolichandra unguis-cati* and *Dolichandra quadrivalvis* (Bignonieae). Broad chemical extractions of members of the entire family are needed to investigate further the exact distribution of this feature within the Bignoniaceae and its possible taxonomic value.

Tribe Crescentieae, a monophyletic group nested within the *Tabebuia* alliance (Grose and Olmstead 2007a; Olmstead et al. 2009), is also distinct anatomically, especially due to the abundant aliform confluent parenchyma that forms large bands accounting for almost half of the cells in the wood.

The other seven genera scattered within the *Tabebuia* alliance clade (Olmstead et al. 2009) are much smaller [i.e., *Cybistax* (monotypic), *Ekmanianthe* (ditypic), *Godmania* (ditypic), *Paratecoma* (monotypic), *Sparattosperma* (monotypic), *Spirotecoma* (four species), and *Zeyheria* (ditypic)] and share with the rest of the *Tabebuia* alliance narrow to medium vessels, aliform paratracheal parenchyma, forming short to long confluences, storied or irregularly storied structure (likely an anatomical synapomorphy of the *Tabebuia* alliance; Pace and Angyalossy 2013), exclusively or mostly with homocellular rays and thin to thick-walled non-septate fibers. *Ekmanianthe* was described as having diffuse-in-aggregate axial parenchyma by Gasson and Dobbins (1991); however, neither our specimens nor the ones studied by Dos Santos and Miller (1992) had this feature.

The Paleotropical clade is composed of trees and a few shrubs of pinnately compound leaves (Olmstead et al. 2009), except for members of Coleeae, a tribe endemic to Madagascar, which includes shrubs with simple leaves (Zjhra et al. 2004; Olmstead et al. 2009). Members of this clade are anatomically similar to the *Tabebuia* alliance, except for the absence of storied structure and medium sized vessels.

Members of Coleeae, a monophyletic group nested within the Paleotropical clade are characterized by cauliflory, indehiscent fruits, and pinnately compound leaves (genus *Phylloctenium* with simple leaves and spines; Zjhra et al. 2004). Wood anatomy of Coleeae is unique, with apotracheal diffuse parenchyma and uniseriate rays. Within the tribe, two groups can be recognized by wood anatomy; the first formed by *Colea* and *Ophiocolea*, with thin-walled fibers and abundant apotracheal parenchyma, and the other by *Rhodocolea* and *Phyllarthron*, with very thick-walled fibers and scanty apotracheal parenchyma. The wood anatomical similarities of *Colea* and *Ophiocolea* support the sister group relationship suggested for both genera in the most recent phylogenies of the family (Zjhra et al. 2004; Olmstead et al. 2009).

Oroxyleae were treated initially within Bignonieae due to similarities in fruit dehiscence. Oroxyleae were subsequently set apart as a tribe due to the Asian distribution of its members (vs. Neotropical in Bignonieae), absence of tendrillate vines, and a stem without cambial variants (Gentry 1980). Oroxyleae have been shown to be a monophyletic group distinct from Bignonieae (Spangler and Olmstead 1999; Olmstead et al. 2009), supporting Gentry's proposal. Representatives of Oroxyleae have wood anatomical traits that set them apart, such as the presence of foraminate perforation plates, homocellular non-storied rays, and lack of cambial variants.

Catalpeae include two genera, *Catalpa* and *Chilopsis*, with *Catalpa* being divided into two sections, *Catalpa* section *Catalpa* and *Catalpa* section *Macrocatalpa*. Species of *Catalpa* are disjunctly distributed, with some species occurring in North America (along with *Chilopsis*) and others in east Asia (Li 2008). Catalpeae are rather homogeneous anatomically, except for the absence of semi-ring to ring porous wood and its paratracheal aliform parenchyma with short confluences in the tropical species (e.g., *Catalpa longissima* in section *Macrocatalpa*). All species have vessels of medium diameter (130–200 µm), common presence of tyloses, 3-seriate rays, heterocellular, septate fibers in tropical and subtropical species, and the presence of simple to semi-bordered vessel-ray pittings, a novel character typical of this clade (and potential synapomorphy) that has been previously overlooked.

Bignonieae are the most species-rich clade of Bignoniaceae, accounting for almost half of the species in the family (Lohmann 2006; Olmstead et al. 2009). Bignonieae are clearly monophyletic (Spangler and Olmstead 1999; Lohmann 2006; Olmstead et al. 2009) and unite all Neotropical lianas of the family and a few shrubs (Lohmann 2006). This clade shares a series of unique morpho-anatomical features, such as terminal leaflets modified into tendrils and the presence of a cambial variant (Schenck 1893; Dobbins 1971; Gentry 1980; Dos Santos 1995; Lohmann 2006; Pace et al. 2009; Lohmann and Taylor 2014). The wood of representatives of Bignonieae is similar to that of other lianas (Carlquist 1985, 2001) exhibiting vessel dimorphism, heterocellular rays, and cambial variants (Angyalossy et al., in press). The wood of Bignonieae differs from lianas of other families by the presence of a generally scanty paratracheal parenchyma, septate fibers, and no vasicentric-tracheids. Parenchyma is only more abundant in the *Arrabidea* and allies clade (sensu Lohmann 2006), comprising *Cuspidaria*, *Fridericia*, *Lundia*, *Tanaecium*, *Tynanthus* and *Xylophragma*. The only genus not assign to any clade in Lohmann (2006), *Callichlamys latifolia* (monotypic), shares this unusual abundance of parenchyma with members of the *Arrabidea* and allies clade and might be better placed within this clade, although additional phylogenetic studies are still needed in order to confirm its placement. Storied structure is present in some species, sometimes only in fibers, and sometimes in the axial and ray parenchyma. Silica was found exclusively in one species of Bignonieae, *Pachyptera kerere*, and is absent elsewhere in the family. Sampling of the other four species of the genus is needed to determine whether this is a feature exclusive of this species or a potential synapomorphy of the entire genus within the Bignoniaceae.

The shape and distribution of the cambial variants represent synapomorphies of major clades in the tribe (Lohmann 2006) and are of great importance for the wood development of its species in this clade (Lima et al. 2010). Most Bignonieae (12 out of 21 genera) have four phloem wedges. Other clades, however, have a different anatomical architecture. *Perianthomega*, for instance, is the only genus with four broad phloem arcs. Three other clades are different by developing multiples of four phloem wedges, namely: *Lundia*, some *Adenocalymma* and a speciose clade that reunites *Amphilophium*, *Anemopaegma*, *Bignonia*, *Dolichandra*, *Mansoa*, and *Pyrostegia.* All these genera develop multiple of four phloem wedges that progress in a predictive manner from four, eight, 16, 32, 64 and so on. *Amphilophium* and *Dolichandra* go through additional developmental changes that are further described below.

Amphilophium is characterized by phloem wedges that get included within the secondary xylem (Dos Santos 1995; Pace et al. 2009), an anatomical feature that is derived from the outgrowth of the cambium at the sides of the phloem wedges including these wedges within the xylem (Pace et al. 2009), similarly to what happens in *Strychnos millepunctata* (Loganiaceae; Veenendaal and Den Outer 1993; Angyalossy et al., in press). *Amphilophium* is a newly circumscribed genus (Lohmann and Taylor 2014) that unites all species from six previously recognized genera (Fischer et al. 2004): *Amphilophium*, *Distictella*, *Distictis*, *Glaziovia*, *Haplolophium*, and *Pithecoctenium*; most of these were included in the subtribe Pithecocteniinae of Melchior (1927). Mapping the included phloem wedges onto the phylogeny of Bignonieae reconstructs this type of cambial variant as ancestral in this tribe (Pace et al. 2009), suggesting it as a potential synapomorphy of the clade and providing further support for the circumscription of this genus.

Dolichandra is one of the genera with multiple of four phloem wedges which develop a novel type of cambial variant called “multiple-dissected” phloem wedges (Dos Santos 1995; Pace et al. 2009). In this genus, non-lignified axial and ray parenchyma is present and proliferates during development dissecting the secondary xylem (Pace et al. 2009). *Dolichandra* (sensu Lohmann and Taylor 2014) reunites four genera previously treated as separate: *Dolichandra*, *Macfadyena*, *Melloa* and *Parabignonia* (Fischer et al. 2004). Members of these genera share this unique type of cambial variant (Dos Santos 1995; Lohmann 2006; Pace et al. 2009), supporting the new circumscription of these genera adopted by Lohmann and Taylor (2014). The evolution of cambial variants in Bignonieae seems to have involved terminal additions towards complexity enhancement and heterochrony (Pace et al. 2009).

The present study illustrates the diversity of wood anatomy encountered in Bignoniaceae and identifies key diagnostic character that provide further support to the new circumscription of newly established genera (Grose and Olmstead 2007b; Lohmann and Taylor 2014), tribes and higher-level clades in the family (Olmstead et al. 2009; Table 3). The wood anatomical synapomorphies identified in this study are: (a) Jacarandeae have a unique winged-aliform parenchyma, (b) Catalpeae are the only tribe where all members have simple to semi-bordered vessel-ray pits, (c) Oroxyleae have foraminate perforations plates common, (d) the *Tabebuia* alliance has storied structure, (e) Coleeae have apotracheal diffuse parenchyma, (f) Bignonieae have a cambial variant called furrowed xylem whose types also support genera within the tribe, such as (g) *Amphilophium*, which has included phloem wedges, (h) *Dolichandra*, with multiple-dissected phloem wedges, (i) *Perianthomega* with four broad phloem arcs. These results represent a first step towards a better characterization of Bignoniaceae clades with anatomical characters. These findings highlight the importance of wood anatomical studies as important sources of morphological characters to diagnose major plant clades as a whole.

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Appendix

Taxa sampled, followed by collector vouchers, wood collections and/or herbaria accession (following index Xylariorum and index Herbariorum) and collection location. The MAD herbarium was incorporated into the WIS herbarium in 2002 but is kept there as a separate collection.

Adenocalymma bracteatum DC., *Castanho 153*, *Lohmann 861* (SPFw, SPF), Rio Negro, Amazonas, Brazil.

Adenocalymma comosum* (Cham.) DC.**, *Pace 53* (SPFw, SPF), Living collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Adenocalymma divaricatum* Miers**, *Udulutsch 2808* (SPFw, HRCB), Lençóis, Bahia, Brazil. ***Adenocalymma flaviflorum (Miq.) L.G. Lohmann, *Sousa-Baena 2* (SPFw, SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Adenocalymma neoflavidum*** L.G. Lohmann, *Zuntini 23* (SPFw, SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Adenocalymma nodosum*** (Silva Manso) L.G. Lohmann, *Pace 20* (SPFw, SPF), Uberlândia, Minas Gerais, Brazil. ***Adenocalymma peregrinum*** (Miers) L.G. Lohmann, *Pace 26* (SPFw, SPF), Living collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Adenocalymma salmoneum*** J.C. Gomes, Lohmann 658 (SPFw, SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Amphilophium crucigerum* (L.) L.G. Lohmann**, *Pace 1*, *Pace 2*, *Pace 3*, *Pace 34* (SPFw, SPF), São Paulo, São Paulo, Brazil. ***Amphilophium elongatum*** (Vahl) L.G. Lohmann, *Pace 45* (SPFw, SPF), Living collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Amphilophium magnoliifolium*** (Kunth) L.G. Lohmann, *Lohmann 851* (SPFw, SPF), Rio Negro, Amazonas, Brazil; *Dos Santos 272* (MADw, MAD, MO, MG), Porto de Moz, Pará, Brazil. ***Amphilophium paniculatum*** (L.) Kunth, *Pace 46* (SPFw, SPF), Living collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Amphilophium pulverulentum* (Sandwith) L.G.Lohmann**, *Dos Santos 279* (MADw, MAD, MO, MG), Senador Jose Porfirio (Sozel), Pará, Brazil. ***Amphitecna latifolia* (Mill.) A.H.Gentry**, *Fairchild Tropical Garden x-3-369*, Florida, USA. ***Amphitecna regalis* (Linden) A.H.Gentry**, *Nee & Taylor 29900*, Las Choapas, 5 km Nw of El Doce, Uxpanapa Region, Veracruz, Mexico. ***Anemopaegma chamberlaynii* (Sims) Bureau & K. Schum.**, *Zuntini 15* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Bignonia campanulata* Cham.**, *Pace 39* (SPFw, SPF), Livings collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Bignonia capreolata* L.**, *Nogle* s.n. (MADw), Norfolk County, Dismal swamp, Virginia, USA; *Wilson 19* (MADw, F), Cow Creek, Texas, USA. ***Bignonia magnifica*** W. Bull, *Pace 51* (SPFw, SPF), Livings collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Bignonia prieurei* DC.**, *Zuntini 13* (SPFw, SPF), Linhares, Espírito Santo, Brazil; *Dos Santos 87* (MADw, MAD, MO, MG), Marabá, Pará, Brazil. ***Callichlamys latifolia*** (Rich.) K. Schum, *Zuntini 175* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil.; *Pace 42* (SPFw), Livings collection Plantarum Institute, Nova Odessa, São Paulo, Brazil; *Pace 63* (SPFw, SPF), Ducke Forest Reserve, Manaus, Amazonas, Brazil; ***Campsis radicans* (L.) Seem.**, *Hicock 841* (SJRw, Y), Connecticut, USA; *Pond 448* (MADw, MAD), Camden County, Dismal Swamp, North Carolina, USA. ***Catalpa bignonioides* Walter**, *Erdman &* DeVall s.n. (MADw, MAD, NY), Gainesville, Florida, USA. ***Catalpa longissima* (Jacq.) Dum.Cours.**, *Pimentel & Garcia 965* (SJRw, NCI), San Cristóbal, El Tablaso, Nigua riverside, Cordillera central, Dominican Republic; *Collector unknown* s.n. (USw2942, US), Hispaniola Island. ***Catalpa speciosa* (Warder ex Barney) Warder ex Engelm.**, *Collector unkown* s.n. (SJRw, RBHw3217), location unknown; *Collector unkown* s.n. (SJRw, Uw17977), location unknown. ***Catophractes alexandri* D.Don**, *Dechamps 1219* (MADw, Tw, MAD), Mocamedes, Angola. ***Chilopsis linearis* (Cav.) Sweet**, *Pidgeon* s.n. (SJRw, WIS), Otero County, New Mexico, USA; *Johnson* s.n. (MADw, BWCw), Campaign Wash, Arizona, USA; *Collector unkown* s.n. (Kw), location *unknown*. ***Colea gentryi* M. L. Zhjra**, *Zhjra 714* (MADw, WIS), Masoala Peninsula, Madagascar, Africa. ***Colea resupinata* M. L. Zhjra**, *Zhjra 785* (MADw, GAS holotype, TAN isotype, WIS), Vokoanina watershed, Masoala Peninsula, Antsiranana, Madagascar. ***Crescentia alata* Kunth**, *Wiemann & Lemckert 23* (MADw, CR, LSU), Cañas, Guanacate, Costa Rica; *Collector unkown* s.n. (SJRw), Cuastecomate, Mexico; *Ortega 12* (USw), Sinaloa, Mexico. ***Crescentia cujete* L.**, *Pace 80*, São Paulo, São Paulo, Brazil; *Dugand 149* (MADw, SJRw, MAD), Totuma, Colombia. ***Cuspidaria pulchra* (Cham.) L.G.Lohmann**, *Pace 24* (SPFw, SPF), Uberlândia, Minas Gerais, Brazil. ***Cybistax antisyphilitica* (Mart.) Mart.**, *Reitz & Klein 7354* (MADw, HBRw, HBR), Salto do Pilão, Lontras, Santa Catarina, Brazil; *Collector unknown* s.n. (BWCw, SJRw42602), São Paulo, Brazil. ***Delostoma integrifolium* D.Don**, *Acosta-Solis 6694* (MADw, SJRw, MAD, F), Limón, Bolivar, Ecuador; *Acosta-Solis 11648-A* (MADw, F), Ecuador. ***Deplanchea bancana* (Scheff.) Steenis**, *Lai* et al. *68559* (Kw, K), Sarawak, Malaysia; *Forest Department of Java 2751* (SJRw, L), Menjabing, Dutch East Indies. ***Digomphia densicoma* (Mart. ex DC.) Pilg.**, *Nee 31168* (MADw,VEN, NY), Cerro de la neblina, Amazonas, Venezuela; *Maguire 28311* (BWCw, USw), Mérida, Venezuela. ***Dolichandra unguiculata* (Vell.) L.G. Lohmann**, *Zuntini 176* (SPFw, SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Dolichandra unguis-cati* (L.) L.G. Lohmann**, *Ceccantini 2687* (SPFw, SPF), Matozinhos, Minas Gerais, Brazil; *Groppo 322* (SPF), São Paulo, São Paulo, Brazil. ***Dolichandra quadrivalvis* (Jacq.) L.G.Lohmann**, *Gentry 58691* (MADw, MO), São Paulo, São Paulo, Brazil. ***Dolichandrone atrovirens* (Roth) K.Schum.**, *Brown* s.n. (DDw, DD), Dehradun, India; *Collector unkown* s.n. (SJRw), Myanmar.; *Kanehira* 132 (SJRw), Palau, Micronesia. ***Ekmanianthe actinophylla* (Griseb.) Urb.**, *Fors 11* (MADw, SJRw, MAD), Havana, Cuba; *Leon 14358* (SJRw, NY), Cuba. ***Fernandoa adenophylla* (Wall. ex G.Don) Steenis**, *collector unknown* s.n. (Kw 108, 427, 433, 435), location unknown. ***Fernandoa***

magnifica **Seem**, *Schlieben 459* (SJRw, MAD), Tanganyika, Tanzania. ***Fridericia chica*** (Bonpl.) L.G. Lohmann, *Pace 50* (SPFw), Living collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Fridericia conjugata*** (Vell.) L.G. Lohmann, *Pace 44* (SPFw), Living collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Fridericia platyphylla*** **(Cham.) L.G. Lohmann**, *Pace 22*, *Pace 23* (SPFw, SPF), Uberlândia, Minas Gerais, Brazil. ***Fridericia samydoides*** **(Cham.) L.G. Lohmann**, *Pace 49* (SPFw, SPF), Livings collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Fridericia speciosa*** **Mart.**, *Pace 40* (SPFw, SPF), Livings collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Godmania aesculifolia*** **(Kunth) Standl.**, *Breedlove 9563* (MADw, DS), Chiapas, Mexico; *Williams 10233* (MADw, F), Aragua, Venezuela; *Smith 3368* (SJRw, MAD), British Guiana. ***Handroanthus barbatus*** **(E.Mey.) Mattos**, Loureiro s.n (BCTw11727, INPA); *Maguire 41572* (SJRw, NY), Rio Pacimoni-Yatua, Venezuela. ***Handroanthus chrysotrichus*** **(Mart. ex DC.) Mattos**, *Pinho 6* (BCTw, SP), São Simão, São Paulo, Brazil; *Pace 188*, *190* (SPFw, SPF), São Paulo, São Paulo, Brazil. ***Handroantus impetiginosus*** **(Mart. ex DC.) Mattos**, *Ducke 363* (SJRw, MAD), Brazil; *Pinho 2* (BCTw, SP), São Simão, São Paulo, Brazil. ***Handroanthus serratifolius*** **(Vahl) S.O.Grose**, *Lima* s.n. (BCTw), Pará, Brazil; *Silva 3281* (BCTw, INPA), Jari, Pará, Brazil. ***Heterophragma quadriloculare*** **(Roxb.) K.Schum.**, *Brown* s.n. (SJRw, DDw1106), India; *Dehra Dun* s.n. (SJRw, DDw 241), India; *Pearson* s.n. (MADw), India. ***Heterophragma sulfureum*** **Kurz**, *Conservator of Forests 1238* (SJRw), Burma. ***Jacaranda brasiliana*** **Lam.**, *Collector unknown* s.n. (FPBw1755), Brazil; *Collector unknown* s.n. (SJRw, MAD), Brazil. ***Jacaranda copaia*** **(Aubl.) D.Don**, *Cabrera 41*, *42* (MADw, MAD), Puerto Carare, Santander, Colombia. ***Jacaranda obtusifolia*** **Bonpl.**, *Conservator of Forests 2049* (SJRw), British Guiana; *Smith 3125* (SJRw, MAD), British Guiana. ***Jacaranda puberula*** **Cham.**, *Hoehne 28168* (SJRw, MAD), Brazil; *Reitz 14198* (BWCw, MAD), Santa Catarina, Brazil. ***Jacaranda ulei*** **Bureau & K.Schum.**, *Dos Santos 167*, *168* (MADw, MAD, MO, MG), Parauapebas, Pará, Brazil. ***Kigelia africana*** **(Lam.) Benth.**, *Schlieben 368* (SJRw, MAD), Tanganyika, Democratic Republic of Congo. ***Lundia damazii*** **C. DC.**, *Pace 55*, *Pace 56* (SPFw, SPF), São Paulo, São Paulo, Brazil. ***Lundia glazioviana*** **Kraenzl.**, *Zuntini 126* (SPFw, SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Lundia longa*** **(Vell.) DC.**, *Zuntini 1* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil; *Pace 227* (SPFw, SPF), Biological Reserve of Poço das Antas, Rio de Janeiro, Brazil. ***Manaosella cordifolia*** **(DC.) A.H. Gentry**, *Pace 41* (SPFw, SPF), Brazil, Livings collection Plantarum Institute, Nova Odessa, São Paulo, Brazil; *Dos Santos 88* (MADw, MAD, MO, MG), Maraba, Rio Doce S.A. Forest reserve, 48 km from Marabá, Pará, Brazil; *Dos Santos 308* (MADw, MAD, MO, MG), Senador José Porfirio, Xingu riverside. ***Mansoa difficilis*** (Cham.) Bureau & K. Schum., *Pace 35* (SPFw), São Paulo, São Paulo, Brazil; *Zuntini 4* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Mansoa onohualcoides*** A.H. Gentry, *Zuntini 276* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Mansoa standleyi*** (Steyerm.) A.H. Gentry, *Pace 43* (SPFw), Living collection Plantarum Institute, Nova Odessa, São Paulo, Brazil. ***Markhamia lutea*** **(Benth.) K.Schum.**, *collector unknown* s.n. (Kw525), Equatorial Guinea. ***Markhamia stipulata*** **(Wall.) Seem.**, *collector unknown* s.n. (Kw440), Thailand. ***Martinella obovata*** **(Kunth) Bureau & K. Schum.**, *Zuntini 7* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil; *Dos Santos 237* (MADw, MAD, MO, MG), Porto de Moz, Xingu riverside, Pará, Brazil; *Dos Santos 317* (MADw, MAD, MO, MG), Gurupa, Moju riverside, tributary of the Amazon river, Pará, Brazil. ***Millingtonia hortensis*** **L.f.**, *van Beusekom 3426* (TWTw, L), Saeat Kanchanaburi, Thailand; *Brown 3160* (SJRw, DDw), India; *collector unknown* s.n. (Kw), Thailand. ***Neojobertia mirabilis*** **(Sandwith) L.G. Lohmann**, *Dos Santos 48* (MADw, MAD, MO, MG), Buriticupu Forest Reserve, Maranhão, Brazil. ***Noeojobetia*** **sp. nov.**, *Zuntini 18*, Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Newbouldia laevis*** **(P.Beauv.) Seem.**, *Vigne 1722* (SJRw, MAD), Gold Coast, Nsuta, Ghana. ***Ophiocolea floribunda*** **(Bojer ex Lindl.) H.Perrier** *Zhjra s.n.* (MADw, MAD), Masoala Peninsula, Madagascar. ***Oroxylum indicum*** **(L.) Kurtz**, *China Academy of Foresty* s.n. (TWTw7424, CAFw13841), China; *Jacobs 8493* (TWTw, L), Lampung, Sumatra; *Kanehira* s.n. (TWTw, FUw B.401), Java, Indonesia; *Brown 1179* (SJRw, DDw), India. ***Pachyptera kerere*** **(Aubl.) Sandwith**, *Castanho 143*, *Lohmann 834* (SPF), Negro riverside, Amazonas, Brazil; *Santos 226* (MADw, MAD, MO, MG), Melgaco, Marajó Island; Mapari riverside, Pará, Brazil; *Dos Santos 274* (MADw, MAD, MO, MG), Porto de Moz; Xingu riverside near the Açai river, Pará, Brazil; *Dos Santos 291* (MADw, MAD, MO, MG), Senador José Porfirio, Xingu river near foz do Igarapé Guará; *Dos Santos 292* (MADw, MAD, MO, MG), Marabá, Rio Doce S.A. Forest reserve, Sororó riverside. ***Pajanelia longifolia*** **(Willd.) K.Schum.**, *Conservator of Forests 8188* (SJRw), Rangoon, Burma; *collector unknown* s.n. (Kw528), Malaya, Malaysia. ***Pandorea jasminoides*** **(Lindl.) K.Schum.**, *Pace 18*, *19* (SPFw, SPF), Cultivated in Campinas, São Paulo, Brazil. ***Paratecoma peroba*** **(Record) Kuhlm.**, *Castro 284*, *578* (BCTw), Rio Doce, Espírito Santo, Brazil. ***Parmentiera cereifera*** **Seem.**, *Curtis* s.n. Fairchild Bot. Gard. X4- 183 (MADw), Florida, USA. ***Parmentiera macrophylla*** **Standl.**, *Cooper 402* (MADw, SJRw, MAD), Panama; *Stork 1894* (SJRw, MAD), Costa Rica. ***Perianthomega vellozoi*** **Bureau**, *Pace 10*, *Pace 15* (SPFw, SPF), Mata do Paraíso, Viçosa, Minas Gerais, Brazil; *Pace 28*, *Pace 29* (SPFw, SPF), Santa Cruz de la Sierra, Santa Cruz, Bolivia. ***Phyllarthron bojeranum*** **DC.**, *G 31* (SJRw, CTFw), Region Cotier Est, Madagascar. ***Pleonotoma melioides*** **(S. Moore) A.H. Gentry**, *Dos Santos 174* (MADw, MAD, MO, MG), Parauapebas, Serra dos Carajas Biological Reserve; *Dos Santos 298* (MADw, MAD, MO, MG), Senador José Pontifírio, Pará, Brazil. *Pleonotoma stichadenia* **K. Schum.**, *Zuntini 7* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil; *Dos Santos 187* (MADw, MAD, MO, MG), Parauapebas, Pará, Brazil. ***Pleonotoma tetraquetra*** **(Cham.) Bureau**, *Ozório-Filho* 11, São Paulo, São Paulo, Brazil. ***Podranea ricasoliana*** **(Tanfani) Sprague**, *Pace 11* (SPF), São Paulo, São Paulo, Brazil. ***Pyrostegia venusta*** **(Ker Gawl.) Miers**, *Pace 17* (SPFw, SPF), Campinas, São Paulo, Brazil; *Pace 36* (SPFw, SPF), São Paulo, São Paulo, Brazil. ***Radermachera ignea*** **(Kurz) Steenis**, *Conservation of Forests 2444* (SJRw), Burma. ***Radermachera gigantea*** **(Blume) Miq.**, *Van de Koppel 4780* (SJRw, L), Java, Indonesia. ***Radermachera glandulosa*** **(Blume) Miq.**, *Janssonius 1214 g* (SJRw), Java, Indonesia; *collector unknown* s.n. (Kw), Burma. ***Radermachera pinnata*** **(Blanco) Seem.**, *Philippine Bureau of Forestry 342* (SJRw), Phillipines. ***Radermachera sinica*** **(Hance) Hemsl.**, *NTU 408*, Taiwan. ***Rhodocolea multiflora*** **Zhjra**, *Zhjra 836*, Vokonina, Masoala Peninsula, Madagascar. ***Rhodocolea nycteriphilla*** **Zhjra**, *Zhjra 810*, Vokonina, Masoala Pensinsula, Madagascar. ***Rhodocolea telfairae*** **(Bojer ex Hook.) H.Perrier**, *collector unknown* s.n. (SJRw10766), Madagascar. ***Roseodendron donnell-smithii*** **(Rose) Miranda**, *Williams 8734* (MADw, F), Fortuno, Coatzacoalcos River, Veracruz, Mexico; *Williams 9382* (MADw, F), Ubero, Oaxaca, Mexico; *William 9458* (MADw, F), Mexico; *collector unknown* s.n. (Kw920), Venezuela. ***Sparattosperma leucanthum*** **(Vell.) K.Schum.**, *collector unknown* s.n. (BCTw 2486), Brasília, Distrito Federal, Brazil. ***Spathodea campanulata*** **P.Beauv.**, *Chevalier 140* (SJRw, K), Gabon; *collector unknown* s.n. (Kw529), Uganda. ***Spirotecoma spiralis*** **(C.Wright ex Griseb.) Pichon**, *Bucher 90* (SJRw, MAD), Cuba. ***Stereospermum chelonoides*** **(L.f.) DC.**, *Istituto Botanico dell'Università di Firenze 706* (BCTw), India. ***Stizophyllum riparium*** **(Kunth) Sandwith**, *Pace 16*, *Pace 33* (SPFw, SPF), São Paulo, São Paulo, Brazil; *Zuntini 9* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Tabebuia aurea*** **(Silva Manso) Benth. & Hook.f. ex S.Moore**, *Gerolamo 3* (SPFw), São Paulo, São Paulo, Brazil. ***Tabebuia cassinoides*** **(Lam.) DC.**, *Williams 13809* (MADw, F), Puerto Ayacucho, Amazonas, Venezuela. ***Tabebuia fluviatilis*** **(Aubl.) DC.**, *Lobato 447* (MADw, MGw, MG), Barcarena, Pará, Brazil; *Conservation of Forests 4071* (SJRw), British Guiana; *collector unknown* (SJRw12019), location unknown). ***Tabebuia heterophylla*** **(DC.) Britton**, *Dungand 33754* (BCTw), Colombia. ***Tabebuia obtusifolia*** **(Cham.) Bureau**, *Kuhlmann* (BCTw, RB), Espírito Santo, Brazil. ***Tabebuia rigida*** **Urb.**, *Instituto de Tecnologia do Rio Grande do Sul* s.n. (BCTw), Rio Grande do Sul, Brazil. ***Tabebuia roseoalba*** **(Ridl.) Sandwith**, *CVRD Morais Jesus* s.n. (BCTw), Linhares, Espírito Santo, Brazil. ***Tanaecium bilabiatum*** **(Sprague) L.G. Lohmann**, *Lohmann 850* (SPF), Rio Negro Amazonas, Brazil. ***Tanaecium duckei*** **(A.Samp.) A.H.Gentry**, *Dos Santos 179*, *186*, Serra do Carajás Biological Reserve, Companhia Vale do Rio Doce, Parauapebas, Pará, Brazil. ***Tanaecium pyramidatum*** **(Rich.) L.G. Lohmann**, *Pace 14*, *Pace 35* (SPFw, SPF), São Paulo, São Paulo, Brazil; *Dos Santos 101* (MADw, MAD, MO, MG), Marabá, Rio Doce S.A. forest reserve, Sororó riverside, Pará, Brazil. ***Tecoma cochabambensis*** **(Herzog) Sandwith**, *Salomon 6684* (MADw, MO) Murillo, La Paz, Bolivia. ***Tecoma fulva*** **(Cav.) G.Don**, *collector unknown* s.n. (SJRw32082), location unknown. ***Tecoma stans*** **(L.) Juss. ex Kunth**, *Jack 5693* (SJRw, MAD), Santa Clara, Belmonte, Cuba; *Dugant 216* (SJRw, MAD), Colombia; *Williams 12254* (MADw, F), Federal District, Venezuela. *Pace 422*, *423* (SPFw, SPF, MO), Magdalena Ocotlán, Oaxaca, Mexico. ***Tecomaria capensis*** **(Thunb.) Spach**, *Rimbach 832* (SJRw, MAD), Ecuador. ***Tecomella undulata*** **(Sm.) Seem.**, *colletor unknown* s.n. (Kw550), location unknown. ***Tynanthus cognatus*** **(Cham.) Miers**, *Pace 9a*, *Pace 9b* (SPFw, SPF), São Paulo, São Paulo, Brazil. ***Xylophragma myrianthum*** **(Cham. ex Steud.) Sprague**, *Zuntini 263* (SPF), Vale do Rio Doce Forest Reserve, Espírito Santo, Brazil. ***Xylophragma pratense*** **(Bureau & K.Schum.) Sprague**, *Dos Santos 140* (MADw, MAD, MO, MG), Marabá, Rio Doce S.A. forest reserve, Pará, Brazil. ***Zeyheria montana*** **Mart.**, *Pacheco 2762* (SJRw), Minas Gerais, Brazil; *Heringen 4130* (BCTw, MADw), Rio de Janeiro, Brazil. ***Zeyheria tuberculosa*** **(Vell.) Bureau ex Verl.**, *Schmidt 143* (SJRw, M), Bolivia.

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