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WOOD ANATOMY OF JACARANDA (BIGNONIACEAE): SYSTEMATIC RELATIONSHIPS IN SECTIONS MONOLOBOS AND DILOBOS AS SUGGESTED BY TWIG AND STEM WOOD RAYS

by

Gracielza Dos Santos & Regis B. Miller

Center for Wood Anatomy Research, USDA Forest Service, Forest Products Laboratory[1], One Gifford Pinchot Drive, Madison, Wisconsin 53705-2398, U. S. A.

SUMMARY

This report provides a generic description of the stem wood anatomy of 15 species of *Jacaranda* from sections *Monolobos* and *Dilobos.* In *Monolobos* (excluding *J. copaia),* the rays are homocellular and exclusively uniseriate, occasionally with a small biseriate portion. In *Dilobos,* the rays are heterocellular and 2-3(-4) cells wide. To verify the differences in ray structure, 27 species of twig specimens were examined and compared with stem specimens of the same section. The wood anatomy corroborates morphological evidence that suggests partitioning of *Jacaranda* into two distinct sections and supports the hypothesis that section *Dilobos* is primitive. The wood anatomy of *Jacaranda copaia* is distinct from that of other species in the genus. The vessels are larger in diameter and fewer per square millimetre, the vessel elements and fibres are longer, and the number of cells per parenchyma strand is higher. In addition, the rays are fewer per millimetre, taller, and homocellular to slightly heterocellular, with one irregular row of square cells, 2-3(-4) cells wide. *Jacaranda copaia* seems to be intermediate between sections *Monolobos* and *Dilobos.*

Key words: Bignoniaceae, *Jacaranda,* section *Monolobos,* section *Dilobos,* wood anatomy, rays.

INTRODUCTION

Jacaranda Jussieu is a neotropical genus in the family Bignoniaceae with 49 species. Distinctive characteristics of *Jacaranda* include a staminode that is longer than the stamens, 3-colpate pollen, and a chromosome number of 18. *Jacaranda* comprises shrubs, subshrubs, and medium to large trees with bipinnate leaves. The inflorescence is a few- to many-flowered terminal or axillary panicle or (rarely) a raceme; the corolla is blue or blue-purple to magenta, rarely white. Taxonomically the genus is divided

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into *two* sections, *Monolobos* and *Dilobos*, based on 1- and 2-thecate anthers, respectively. *Monolobos* has 18 species and is found primarily in the Antilles, Central America, and western South America. *Dilobos* has 31 species and is found primarily in sub-Amazonian Brazil and the adjacent Parank Valley (Gentry 1992).

Jacaranda has not been subjected to comprehensive systematic wood anatomical study. Most studies have focused on the commercially important *J. copaia* (Brazier & Franklin 1961; Fedalto et al. 1989; Kribs 1968; Mainieri et al. 1983; Mainieri & Chimelo 1989; Record & Mell 1924). Record and Hess (1940) briefly described the wood structure of *J. copaia* and *J. rhombifolia* (= *J. obtusifolia* subsp. *rhombifolia*). Panizza (1967) described the root, stem, flower, fruits, and seed anatomy of *J. caroba*, but only briefly described the secondary xylem. Morawetz (1982) described the wood of *J. oxyphylla*, *J. montana*, and *J. copaia*. More recently, Gasson and Dobbins (1991) tabulated the anatomical features of nine *Jacaranda* species in a comparative wood anatomy study of trees and lianas in Bignoniaceae. Mohiuddin (1995) studied the wood anatomy of *Jacaranda acutifolia*.[2]

Based on a recent study of the wood anatomy of the tribe Tecomeae, Dos Santos and Miller (1992) found a distinct difference in ray structure between the two sections of *Jucaranda*. At the time of the study, only *J. puberula* (four specimens) of the section *Dilobos* was available. To determine if there were any consistent wood anatomical differences between *Monolobos* and *Dilobos*, we expanded our study to include additional species.

MATERIAL AND METHODS

Forty-eight stem wood specimens representing 15 of the 49 species of *Jacaranda* were examined (Appendix 1). Acronyms for wood collections follow Stern (1988). Of the 48 specimens, 36 (10 species) were in *Monolobos* and 12 *(5* species) in *Dilobos*. Most stem wood specimens were greater than 40 mm in diameter; the four exceptions are listed in Appendix 1.

Although the 48 stem wood specimens of *Jacaranda* were from several major xylaria and were fairly representative of the species in section *Monolobos*, we did not have enough specimens of section *Dilobos* to support differences that occur primarily in ray structure. As a consequence, we decided to examine the ray structure of twig wood from herbarium sheets located at the Missouri Botanical Garden, selecting species in both *Monolobos and Dilobos* sections. Fifty-four specimens of twig wood were examined (Appendix 2), representing 5 species (13 specimens) of section *Monolobos* and 22 species (41 specimens) of section *Dilobos*. In total, we examined 102 specimens, representing 12 of 18 species in *Monolobos* and 24 of 31 species in *Dilobos*.

Standard techniques were used to prepare permanent microscope slides of stem wood specimens. For twigs, only radial and tangential sections were made. Stem speci-

2) According to Gentry (1992), *J. acutifolia* is endemic to Peru and closely related to *J. mimosifolia*, which is native to Bolivia and Argentina and also widely cultivated. Therefore, we assume that specimens originally labelled *J. acutifolia* and not native to Peru are, in fact, *J. mimosifolia.*

mens were macerated using Jeffrey's solution. Twenty-five randomly selected cells were measured for vessel element and fibre length, vessel diameter, and ray height using a sonic digitizer (Quirk 1981). The IAWA list of microscopic features (IAWA Committee 1989) was used for terminology and methodology. The anatomical descriptions generally follow Pernia and Miller (1991).

RESULTS

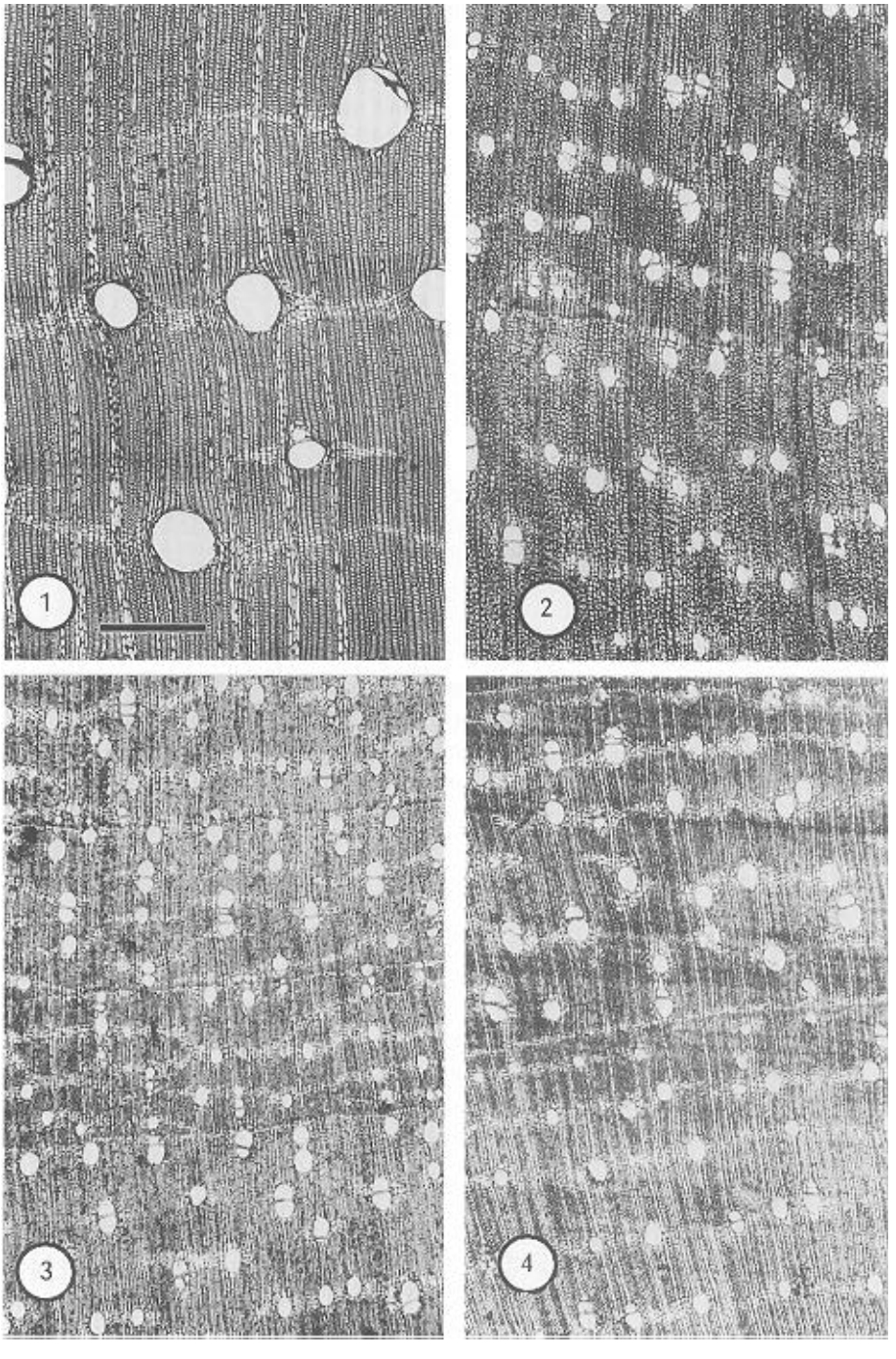
All features in the IAWA list (IAWA Committee 1989) were examined; those features not specifically mentioned were absent or did not apply. Only stem wood features are described in the following text and in Table 1. The values for vessels/mm^2, vessel diameter, vessel element length, fibre length, ray height, and rays/mm are ranges of means. Values for intervessel pit size and ray width are most frequent ranges.

Macroscopic features

Heartwood whitish to grey, not fluorescent. Sapwood colour not distinct from heartwood. Water and ethanol extracts not fluorescent; extracts colourless to a shade of brown. Burning splinter test full ash, white to grey. Basic specific gravity low (less than 0.40) to medium (0.40-0.74).

Microscopic features

Growth rings generally indistinct to somewhat distinct (delimited by marginal bands); diffuse-porous (Fig. 1-4). Vessels in short radial multiples and commonly in radial multiples of 4 or more; 55-136 µm in diameter (Fig. 2-4), in *J. copaia* 159-261 µm (Fig. 1); 236-508 µm in element length, in *J. copaia* 424-703 µm; 7-41 per mm^2, in *J. morii* 63-64 per mm^2 and *J. copaia* 3-7 per mm^2 (Fig. 1). Perforation plates simple. Intervessel pits alternate, circular, nonvestured; 8-10 µm in diameter, in *J. puberula* 10-12(-14) µm. Vessel-ray pitting with distinct borders, similar to intervessel pits in size and shape. Fibres nonseptate; thin- to thick-walled; pits simple to minutely bordered; 638-l193 µm in length, in *J. copaia* 816-1308 µm. Rays homocellular in section *Monolobos* (Fig. 5); in *J. copaia* homocellular to slightly heterocellular with one irregular row of square cells (Fig. 13); in section *Dilobos* heterocellular with one to several marginal rows of upright or square cells and heterocellular with procumbent, square, and upright cells mixed (Fig. 9). Rays 8-22 per mm, in *J. copaia* 5-7 per mm. Rays exclusively uniseriate or with only a small portion biseriate in section *Monolobos* (Fig. 6); 2-3, occasionally 4 cells wide in section *Dilobos* (Fig. 10) and *J. copaia* (Fig. 14). Ray height 177-442 µm, in *J. copaia* 315 -733 µm. Storied structure absent. Paratracheal parenchyma aliform to confluent, forming irregular bands; when aliform, mostly of the winged type. Banded parenchyma in seemingly marginal bands or in narrow lines; mostly one cell wide (Fig. 1-4). Axial parenchyma mostly 4 cells per parenchyma strand, 6-12 cells in *J. copaia.* Typical prismatic crystals absent; very small calcium oxalate crystals of different shapes in ray cells of several species of *Monolobos;* small crystals in axial parenchyma cells of *J. brasiliana;* crystals absent in species of *Dilobos.*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DISCUSSION

Anatomically, *Jacaranda* has a suite of features that delimit the genus. All species are diffuse porous with a similar vessel and axial parenchyma arrangement. The vessel elements have simple perforation plates and lack tyloses; the intervessel and vessel-ray pits are similar in size, shape, and arrangement. The fibres are nonseptate and thin- to thick-walled, with pits simple to minutely bordered. Axial parenchyma is typically aliform (winged type) to confluent, forming irregular bands, and apotracheal banded parenchyma is in seemingly marginal bands of one cell wide. Rays and other elements are not storied. Differences among species are mostly confined to rays.

Both in earlier work (Dos Santos & Miller 1992) and the study reported here, we observed a distinct difference in ray structure between sections *Monolobos* and *Dilobos*, and differences between *J. copaia* and other species of *Jacaranda* (see Table 1). Since *J. copaia* is distinct, it is discussed separately from the other species in sections *Monolobos* and *Dilobos*.

Jacaranda copaia

Jacaranda copaia is distinct from the other species in the genus (Table 1). The vessels are larger in diameter and fewer per square millimetre (Fig. l), the vessel elements and fibres are longer, and the number of cells per parachyma strand is higher. In addition, the rays are fewer per millimetre, taller, homocellular to slightly heterocellular with one irregular row of square cells, and 2-3(-4) cells wide (Fig. 13 & 14). Our description of *J. copaia* coincides with descriptions by Record and Mel1 (1924), Record and Hess (1940), Brazier and Franklin (1961), Kribs (1968), Morawetz (1982), Mainieri et al. (1983), Fedalto et al. (1989), Mainieri and Chimelo (1989), and Gasson and Dobbins (1991). Record and Hess (1940) stated that their description is for both *J. copaia* and *J. rhombifolia* (= *J. obtusifolia* subsp. *rhombifolia*), and they did not mention any differences between the two species. On handwritten notes from the SJRw wood collection files that we attribute to Robert Hess, one specimen (SJRw 27207) is labeled *J. filicifolia* (= *J. rhombifolia* = *J. obtusifolia* subsp. *rhombifolia*) and accompanies notes that describe *J. copaia*. Although Record and Hess (1940) did not identify the specimens used for their description, it is very likely that their description of *J. rhombifolia* was based on SJRw 27207. We examined the unvouchered wood specimen SJRw 27207, which was determined by S. J. Record and collected by L. Junker in Surinam in 1929, and we conclude that SJRw 27207 is *J. copaia*.

Fig. 1-4. Transverse sections of stem wood showing vessel distribution and size, and winged aliform to confluent parenchyma. - 1: *Jacaranda copaia,* MADw 37924 (*Monolobos*) . - 2: *J. puberula,* SJRw 23445 (*Dilobos*); note faint delimitation of growth ring. - 3: *J. caucana,* SJRw 33762 (*Monolobos*); note marginal bands of parenchyma. - 4: *J. obtusifolia,* SJRw 53817 (*Monolobus*); note marginal bands of parenchyma. - Scale bar = 500 µm for Fig. 1-4.

Table 1. Anatomical features of *Jacaranda* stem wood.

Jacaranda species	Specimens (number)	Vessel				Fibre length[a] (μm)	Ray				Crystals[d]
		Frequency[a] (per mm^2)	Diameter[a] (μm)	Element length[a] (μm)	Pit size[b] (μm)		Frequency[a] (per mm)	Height[a] (μm)	Width (# cells)	Type[c]	
Section *Monolobos*											
J. arborea	1	21	106	462	8	1160	11	368	1	Homo	+
J. brasiliana	3	12–23	78–83	294–314	8	841–955	16–22	177–234	1	Homo	+/–
J. caerulea	3	13–31	88–108	313–508	8	740–956	14–17	191–306	1	Homo	+/–
J. caucana	6	7–23	77–118	278–434	8–10	830–1121	12–16	234–350	1	Homo	+/–
J. copaia	7	3–7	159–261	424–703	8–10	816–1308	5–7	315–733	2–3	Homo	–
J. cuspidifolia	3	11–26	78–95	320–363	8–10	856–910	12–17	217–269	1	Homo	–
J. hesperia	3	8–14	128–136	378–489	8–10	802–886	9–11	320–380	1	Homo	+/–
J. mimosifolia	5	22–39	64–82	283–351	8–10	638–786	13–17	206–244	1	Homo	–
J. obtusifolia	4	10–11	64–100	236–434	8–10	724–1082	12–18	219–314	1	Homo	–
J. poitaei	1	15	84	426	8	1034	12	305	1	Homo	+
Section *Dilobos*											
J. caroba	1	11	88	384	10	960	10	319	2–3	Hetero	–
J. glabra	3	16–41	63–87	371–437	8–10	934–1044	9–11	375–442	2–3	Hetero	–
J. micrantha	1	21	95	310	10	864	10	223	2–3	Hetero	–
J. morii	2	63–64	55–59	347–376	8–10	715–799	8–9	326–390	1–2	Hetero	–
J. puberula	5	19–31	70–101	350–507	10–12(–14)	783–1193	9–11	238–400	2–3	Hetero	–

a) Range of mean values. Single numbers represent values from one specimen only.
b) Most frequent range.
c) Homo = homocellular; Hetero = heterocellular.
d) + = present; – = absent; +/– = present in some specimens, absent in others.

Stem wood differences between sections Monolobos and Dilobos

In section *Monolobos*, the rays are homocellular and predominantly uniseriate with a occasional biseriate portion (Fig. 5 & 6). In section *Dilobos*, the rays are distinctly heterocellular and 2-3(-4) cells wide (Fig. 9 & 10). Morawetz (1982) did not specifically comment on the wood anatomical differences in sections of *Jacaranda*, but he did remark that *J. oxyphylla, J. montana,* and *J. copaia* can be separated on the basis of their wood anatomical features. He mentioned that rays are heterocellular and 1-3(-4) cells wide in *J. oxyphylla* (section *Dilobos)*, heterocellular and 1-2 cells wide in *J. montana* (*Dilobos*), and homocellular and 2-3 cells wide in *J. copaia*. In general, Morawetz's descriptions agree with our descriptions for section *Dilobos* and *J. copaia*.

Gasson and Dobbins (1991) also did not mention sections in *Jacaranda*, but they presented data for nine species: two species in *Dilobos* and seven in *Monolobos*. The descriptions of all seven species in *Monolobos* and *J. micrantha* in *Dilobos* agree with our findings. However, our results do not agree with Gasson and Dobbins' data for *J. glabra*, which were based on one specimen originally labelled as *J. longiflora* (Uw 19329). The three specimens of *J. glabra* that we examined were collected with herbarium material, and A. Gentry (the late taxonomist of Bignoniaceae) examined the herbarium material for BWCw 28670 and USw 15495 and confirmed the material to be *J. glabra*. We also examined Uw 19329 (collected by Krukoff 1390) and an additional specimen also labelled *J. longiflora*, USw 9063 (collected by Krukoff 1503), and both samples appeared to be *J. copaia*. To further verify our identification, we consulted Gentry's database collection and found that he had examined the herbarium material for Krukoff 1503 and determined it to be *J. copaia* subsp. *spectuabilis.* In conclusion, since both Krukoff's collections were apparently misidentified initially, we assume that Uw19329, included in Gasson and Dobbins' (1991) study as *J. glabra*, is indeed *J. copaia*.

Record and Hess (1940) described J. *copaia* and *J. rhombifolia* (= *J. obtusifolia* subsp. *rhombifolia*), but they listed *J. caeralea* (section *Monolobos), J. caroba* (section *Dilobos),* and *J. copaia* in their dichotomous key. In their key, the rays of *J. caerulea*

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Fig. 5-8. Stem and twig wood of section *Monolobos.* - 5: *J. mimosifolia*, USw 8299, radial section of stem showing homocellular rays. - 6: *J. mimosifolia*, USw 8299, tangential section of stem showing uniseriate rays. - 7: *J. praetermissa*, Anderson et al. 36677, radial section of twig showing homocellular rays. - 8: *J. praetermissa*, Anderson et al. 36677, tangential section of twig showing uniseriate rays. - Scale bar = 150 µm for Fig. 5-8.

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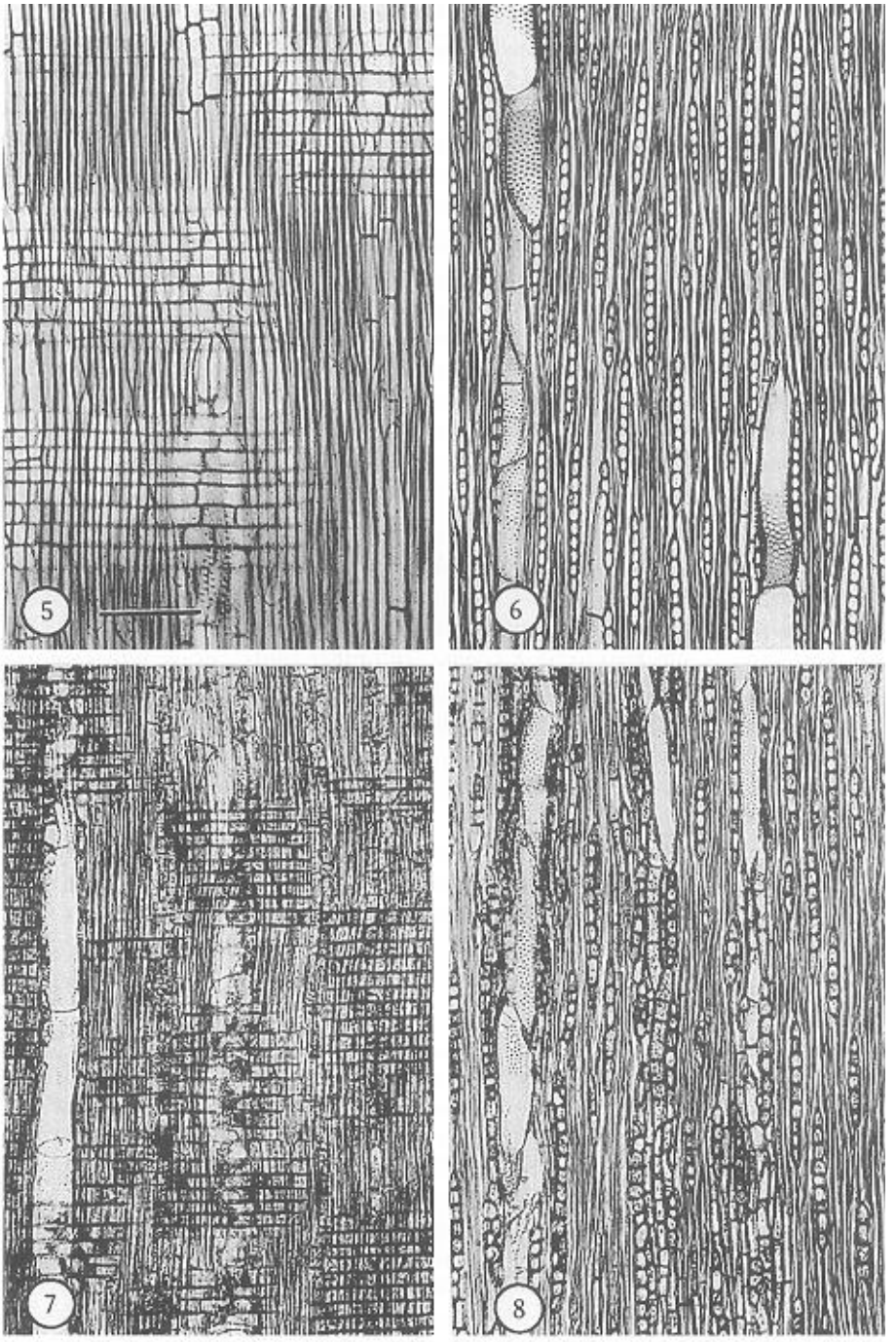
Fig. 9-12. Stem and twig wood of section *Dilobos.* - 9: *J. glabra*, Uw 26265, radial section of stem showing heterocellular rays with several rows of upright cells. - 10: *J. glabra*, Uw 26265, tangential section of stem showing multiseriate rays (2-3 cells wide) with long uniseriate extensions and interconnected rays. Uniseriate portions often as wide as multiseriate ones. - 11: *J. glabra*, Foster 9382, radial section of twig showing heterocellular rays with several rows of upright cells. - 12: *J. glabra*, Foster 9382, tangential section of twig showing multiseriate rays with uniseriate extensions and interconnected rays. - Scale bar = 150 µm for Fig. 9-12.



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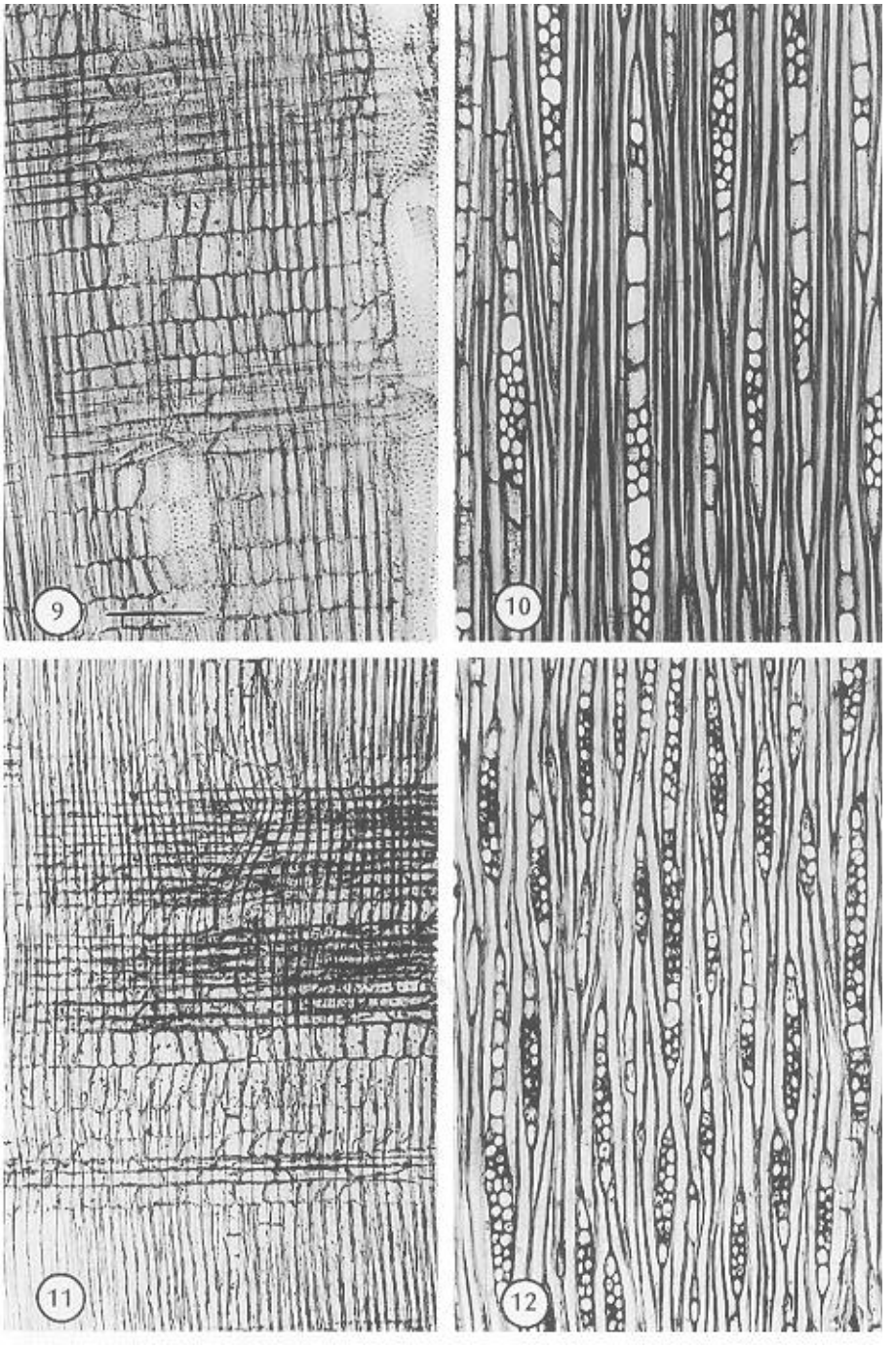

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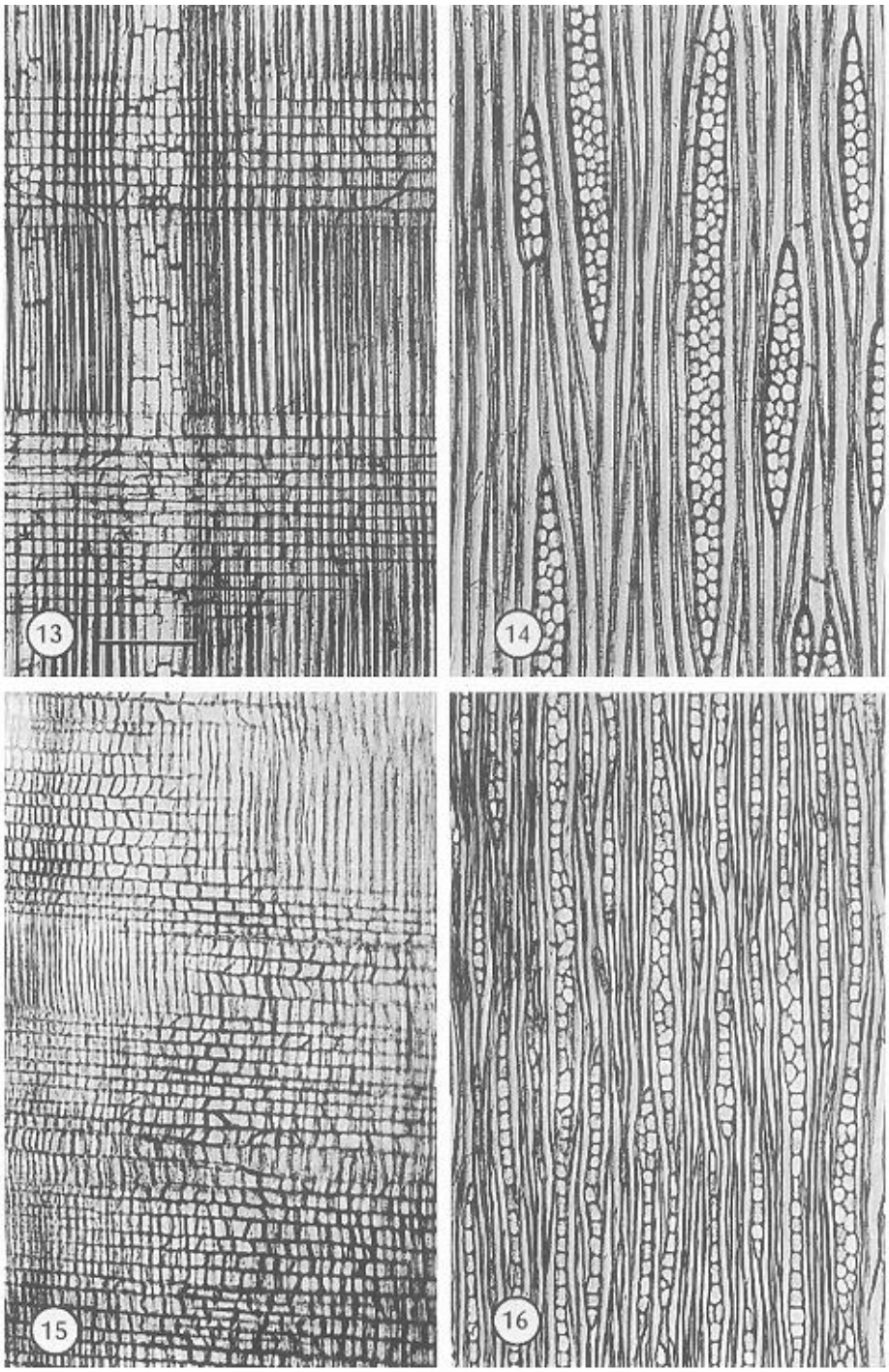
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are mostly uniseriate and homocellular, and those of *J. caroba* are 3-4 cells wide and heterocellular. Based on Hess's notes from the SJRw wood collection files, there are three wood types within *Jacaranda:* Type 1, based on several specimens of *J. copaia* and the misidentified SJRw 27207; Type 2, based on *J. acutifolia, J. arborea, J. caerulea, J. mimosifolia, J. sagraeana* (= *J. caerulea),* and two specimens of *J. rhombifolia* (= *J. obtusifolia* subsp. *rhombifolia*); and Type 3, based on *J. caroba* and *J. semiserrata* (= *J. puberula*). Hess noted that species in Types 1 and 2 are in *Monolobos* and species in Type 3 are in *Dilobos* and that the rays are the most distinguishing feature among the different wood types. Rays in Type 1 are "mostly 2-3(-4) cells wide and homogeneous, occasionally with irregular marginal cells," in Type 2 "uniseriate and homogeneous," and in Type 3 "1-3 cells wide and distinctly heterogeneous." Although Hess's notes were not published, they support our findings.

In his description of the cultivated *J. acutifolia* (see footnote 1) from Bangladesh, Mohiuddin (1995) reported the rays as 1-3(-4) cells wide and 'heterogeneous' (mostly Kribs types II and III). Based on Mohiuddin's photographs and description, we suggest that his single sample is not *J. acutifolia* (*J. mimosifolia*), but rather a species of *Jacaranda* in section *Dilobos.*

Twig wood differences between sections Monolobos and Dilobos

It is well documented in the literature that ray structure changes with cambial age (e.g., Kribs 1935; Barghoorn 1940, 1941a, 1941b; Chattaway 1951; Carlquist 1962, 1988). As already mentioned, we compared the ray structure of twig specimens from herbarium sheets with ray structure from stem wood specimens. The largest diameter for twig specimens was 12 mm. We found no significant difference in ray structure from pith to bark. For the stem specimens, we studied the outermost part of the stem whenever possible. We found little or no variation in ray structure between twig and stem wood specimens.

As in stem wood, rays in twigs of section *Monolobos* are almost exclusively uniseriate, occasionally with only a small biseriate portion (Fig. 8), and are primarily composed of typical procumbent cells (Fig. 7). Also as in stem wood, rays in twigs of section *Dilobos* are predominantly 2-3 cells wide, occasionally uniseriate (Fig. 12), distinctly heterocellular (Fig. 11), and often interconnected (Carlquist 1988). In both twig and stem wood of *Dilobos,* the uniseriate portion of rays is often as wide as the multiseriate portion (Fig. 10 & 12).

Fig. 13-16. Stem and twig wood of *Jacaranda copaia,* SJRw 35952. - 13: Radial section of stem showing homocellular to slightly heterocellular rays. - 14: Tangential section of stem showing multiseriate rays (2-3 cells wide). - 15: Radial section of twig showing heterocellular rays with one to several rows of more or less upright or square cells and very weakly procumbent central cells. - 16: Tangential section of twig showing uniseriate and biseriate rays with long uniseriate extensions and interconnected rays. - Scale bar = 150 µm for Fig. 13-16.

Jacaranda copaia shows some additional anatomical differences between twig and stem wood. The rays in twig specimens are more distinctly heterocellular, with one to a few rows of upright and/or square cells (Fig. 15). The cells are also frequently mixed throughout the rays. Rays are 1-2(-3) cells wide (Fig. 16).

Nineteen twig specimens representing six species were selected to compare twig and stem wood of the same species. One twig specimen of *J. copaia* (SJRw 35952) represented the same collection as the stem specimen. Comparing twig and stem woods of SJRw 35952, we found few anatomical differences in ray structure. Likewise, no significant differences were found between twig and stem ray structure from different collections of the same species. Because there are no significant differences in ray structure between twig and stem from the same collection or from the same species but different collections, we conclude that the ray structure from the twig specimens without a stem collection represents the ray structure of the mature sample.

CONCLUSIONS

Our data support the morphological classification of *Jacaranda* into sections *Monolobos* and *Dilobos.* Anatomically, *J. copaia* is distinct from the other species of *Jacaranda.* Gentry (personal communication) suggested that *J. copaia* is morphologically an isolated species within the genus. The wood structure of *Monolobos* and *Dilobos* seems to reflect phylogenetic trends within the genus, supporting Gentry's position that *Dilobos* is presumably more primitive than *Monolobos.* Trends in ray evolution suggest an advanced position for *Monolobos,* which has almost exclusively uniseriate and homocellular rays, and a primitive position for *Dilobos,* which has wider and heterocellular rays. *Jacaranda copaia* seems to occupy an intermediate position between the two sections.

Our study of twig and stem wood specimens showed that ray structure in *Jacaranda* does not undergo much ontogenetic change from primary to secondary xylem. The paedomorphosis theory states that "in particular woods, features of the primary xylem are ontogenetically protracted into the secondary xylem" (Carlquist 1988: 292). Thus, with regard to rays, *Jacaranda* seems to be a paedomorphic wood.

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APPENDIX 1 - Stem wood material

Section *Monolobos*

Jacaranda arborea Urb.: D. Mattheus & W. Crosby 61, Cuba, MAD, SJRw 9215. — *J. brasiliana* (Lamarck) Pers.: Maguire et al. 56104, Brazil, NY, Uw 16357; Rizzini & A.M. Filho s.n., Brazil, Minas Gerais, FPBw 1755; Brazil, Pará, BCTw 8122. — *J. caerulea* (L.) Jussieu: J.G. Jack 7315, Cuba, A, SJRw 16766; J. Schiffino 248, Dominican Republic, US, USw 20374; W.E. Broadway 42, Trinidad, US, Aw 20929. — *J. caucana* Pittier: FMS 1342, PRFw 8816; H.M. Curran 162, Colombia, MAD, SJRw 1606; A. Dugand 1018, Colombia, MAD, SJRw 33762; W.L. Stern et al. 743, Panama, MO, SJRw 54717; M. Scott s.n., USA, Florida, PRFw 20504; M.B. Little & C.G. Veillon s.n., Venezuela, MER, MERw 953. — *J. copaia* (Aublet) D. Don: A.C. Smith 3474, Guyana, MAD, SJRw 35952; Cabrera 40, Colombia, MAD, MADw 37923; Cabrera 41, Colombia, MAD, MADw 37924; Cabrera 42, Colombia, MAD, MADw 37925; J. Cuatrecasas 15264, Colombia, MAD, SJRw 42849; Bernardi 233, Venezuela, MER, USw 26793; Little 15612, Venezuela, MER, MERw 65. — *J. cuspidifolia* Mart. ex DC.: E. Schmidt 87, Bolivia, MAD, USw 21518; Maguire et al. 56388, Brazil, NY, Uw 16395; H. Nogle 4800, USA, California, USw 23387. — *J. hesperia* Dugand: J. Cuatrecasas 17661, Colombia, Valle, F, SJRw 43254; H.P. Fuchs & Zanella 21945, Colombia, U, Uw 15750; Cuatrecasas 15282, Colombia, U, Uw 25347. — *J. mimosifolia* D. Don: M. Scott, USA, Florida, PRFw 12755; Cult. Greenhouse s.n., Netherlands, U, Uw 6471, 18 mm diam.; Argentina, PRFw 11368; C.R. Mowry 1881,USA, California, USw 20716; M. Scott 6, USA, Florida, USw 8299. — *J. obtusifolia* H & B: A.C. Smith 3125, Guyana, MAD, SJRw 35817; A.C. Smith 2119, Guyana, MAD, SJRw 35464; BGFD 2049, Guyana, NY, SJRw 46393; Wurdack & Addley 42694, Venezuela, NY, SJRw 54136. — *J. poitaei* Urb., W. Cati 4361, Tortuga Is., BWCw 9834.

Section *Dilobos*

Jacaranda caroba (Vell.) DC: Argentina, SJRw 3984. — *J. glabra* (DC.) Bur. & K. Schum.: Prance 14226, Brazil, Amazonas, NY, BWCw 28670, 33 mm diam.; F. Woytkowski 5413, Peru, MO, USw 15495, 27 mm diam.; Maas 4604, Peru, U, Uw 26265. — *J. micrantha* Cham.: Reitz & Klein 5690, Brazil, Santa Catarina, MAD, BWCw 16824. — *J. morii* A. Gentry: G. Dos Santos 166, Brazil, Pará, MO, MADw 47248, 15 mm diam.; G. Dos Santos 167, Brazil, Pará, MO, MADw 47249, 10 mm diam. — *J. puberula* Cham.: H.M. Curran 720, Argentina, MAD, SJRw 1724; O. Handro 28168, Brazil, MAD, SJRw 23445; Reitz & Klein 3682, Brazil, Santa Catarina, MAD, SJRw 51988 ; O. Vecchi 89, Brazil, São Paulo, SPSF, SJRw 3140; Reitz 14198, Brazil, Santa Catarina, MAD, BWCw 15651.

APPENDIX 2 - Twig wood examined for ray structure

Section *Monolobos*

Jacaranda brasiliana (Lamarck) Pers., L.B. Smith 2621, Brazil, Ceará, MO, 7 mm diam.; E.P. Heninger & C.T. Rizzini 17460, Brazil, Minas Gerais, MO, 6 mm diam.; G.E. Schatz et al. 768, Brazil, São Paulo, MO, 6 mm diam. — *J. copaia* (Aublet) D. Don: Navy 508, Surinam, MAD, 6 mm diam.; Navy 510, Surimam, MAD, 5 mm diam.; E. Jenssen 14, Peru, MAD, 6 mm diam.; F.C. Englesing 54A, Nicaragua, MAD, 6 mm diam.; A.C. Smith 3474, Guyana, MAD, SJRw 35952, 11 mm diam. — *J. mimosifolia* D. Don: C.H. & P.M. Dodson 11550, Ecuador, MO, 9 mm diam.; USDA s.n., Peru, MO, 6 mm diam. — *J. orinocensis* Sandw.: A. Gentry & B. Stein 46271, Venezuela, Amazonas, MO, 5 mm diam. — *J. praetermissa* Sandw.: W.R. Anderson et al. 36677, Brazil, Bahia, MO, 7 mm diam.; W.R. Anderson et al. 36433, Brazil, Bahia, MO, 6 mm diam.

Section *Dilobos*

Jacaranda bracteata Bur. & K. Schum.: G. Hatschbach & O. Guimarães 47013, Brazil, Bahia, MO, 7 mm diam.; D. Araújo 4285, Brazil, Rio de Janeiro, MO, 6 mm diam.; A. Gentry 49467, Brazil, Rio de Janeiro, MO, 5 mm diam. — *J. campinae* A. Gentry & Morawetz: Cleofe et al. 2683, Brazil, Amazonas, MO, 5 mm diam.; Cid Ferreira 5900, Brazil, Amazonas, MO, 5 mm diam.; Cid Ferreira 5816, Brazil, Amazonas, MO, 5 mm diam. — *J. carajasensis* A. Gentry: M.G. Silva & R. Bahia 3040, Brazil, Pará, MO, 5 mm diam. — *J. caroba* (Vell.) DC.: H.C. Cutter 8011, Brazil, Goiás, MO, 6 mm diam.; Cordeiro & R. Mello-Silva 10027, Brazil, Minas Gerais, MO, 8 mm diam.; D.C. Zappi 9342, Brazil, Minas Gerais, MO, 5 mm diam. — *J. crassifolia* Morawetz: I. Silberbaner-Gottsberger 11-8175, Brazil, Rio de Janeiro, MO, 7 mm diam.; I. Silberbaner-Gottsberger 11-12878, Brazil, Rio de Janeiro, MO, 8 mm diam. — *J. duckei* Vattimo: B.G.S. Ribeiro & G.S. Pinheiro 1196, Brazil, Maranhão, MO, 12 mm diam.; Lindeman et al. 700, Surinam, MO, 8 mm diam. — *J. glabra* (DC.) Bur. & K. Schum.: L. Besse et al. 1931, Ecuador, MO, 9 mm diam.; W. Palacios 3027, Ecuador, MO, 10 mm diam.; A. Gentry et al. 52287, Peru, MO, 12 mm diam.; S.F. Smith et al. 729, Peru, MO, 10 mm diam.; Robin B. Foster 9382, Peru, MO, 10 mm diam. — *J. intricata* A. Gentry & Morawetz: W. & Morawetz 22-151280, Brazil, Goiás, MO, 6 mm diam. *J. irwinii* A. Gentry: R.M. Harley 22664, Brazil, Bahia, MO, 6 mm diam. — *J. jasminoides* (Thunb.) Sandw.: R.M. Harley et al. 16404, Brazil, Bahia, MO, 5 mm diam.; G.F. Pabst 4349, Brazil, Rio de Janeiro, MO, 5 mm diam.; A. Gentry & E. Zardini 49497, Brazil, Rio de Janeiro, MO, 5 mm diam. — *J. macrantha* Cham.: D. Sucre 4487, Brazil, Rio de Janeiro, MO, 9 mm diam. — *J. macrocarpa* Bur. & K. Schum.: R. Vasquez & N. Jaramillo 7983, Peru, Loreto, MO, 12 mm diam.; A. Gentry & J. Aronson 25015, Peru, Loreto, MO, 8 mm diam. — *J. micrantha* Cham.: Landrum 4094, Brazil, Paraná, MO, 8 mm diam. — *J. montana* Morawetz: J.P.L. Sobrinho 1601, Brazil, Rio de Janeiro, MO, 8 mm diam.; A. Gentry et al. 58800, Brazil, São Paulo, MO, 8 mm diam.; A. Gentry et al. 59034, Brazil, São Paulo, MO, 7 mm diam. — *J. mutabilis* Hassl.: A. Macedo 2470, Brazil, Minas Gerais, MO, 11 mm diam.; D. Hunt & G.F. Ramos 5911, Brazil, Mato Grosso, MO, 7 mm diam. — *J. obovata* Cham.: S.A. Mori et al. 9601, Brazil, Bahia, MO, 5 mm diam.; R.M. Harley 17089, Brazil, Bahia, MO, 6 mm diam.; A. Peixoto 3065, Brazil, Espirito Santo, MO, 7 mm diam. — *J. oxyphylla* Cham.: R.M. Silva et al. 8057, Brazil, São Paulo, MO, 6 mm diam.; G. Gotsberger s.n., Brazil, São Paulo, MO, 7 mm diam. — *J. paucifoliata* Mart. ex DC., E.P. Heninger & C.T. Rizz 17591, Brazil, Goiás, MO, 4 mm diam. — *J. racemosa* Cham.: M. Stella Silvestre 148, Brazil, Minas Gerais, MO, 10 mm diam. — *J. rufa* Manso: I.L. Amaral et al. 1040, Brazil, Pará, MO, 7 mm diam. — *J. simplicifolia* K. Schum.: C. Proença 95, Brazil, Brasilia, MO, 7 mm diam. — *J. subalpina* Morawetz: Silberbaner-Gotsberger et al. 114-14878, Brazil, Rio de Janeiro, MO, 7 mm diam. — *J. ulei* Bur. & K. Schum.: H.S. Irvin et al. 10684, Brazil, Brasilia, MO, 5 mm diam.; W.R. Anderson 6253, Brazil, Goiás, MO, 6 mm diam.