Identification of the Timbers of Southeast Asia and the Western Pacific

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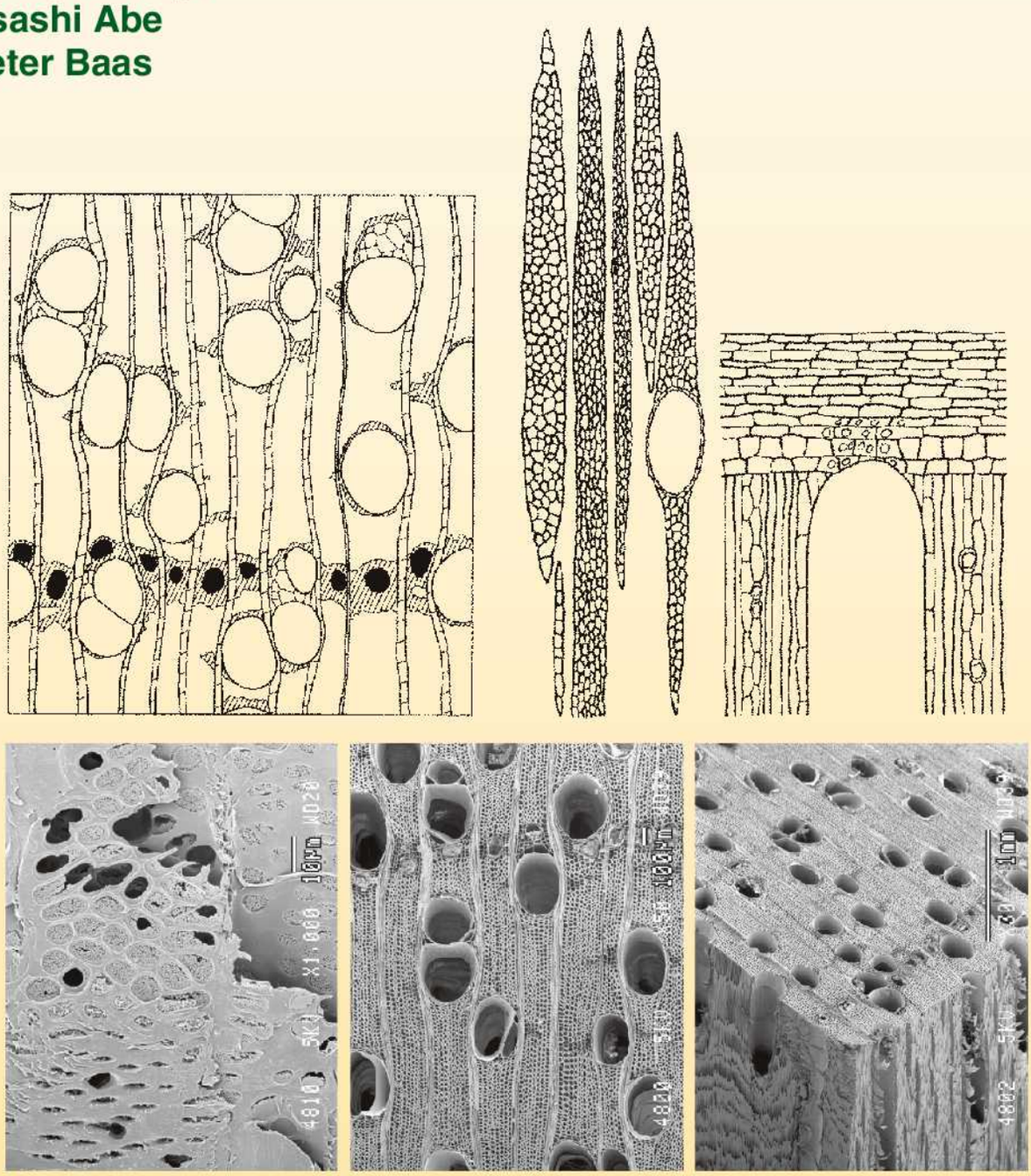

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Preface

The imports of roundwood timber into Japan increased rapidly in the 1960s, as a result of trade liberation and economic development. The main provenances of the imported timber were North America, Siberia and Southeast Asia. As the timbers from the former two regions were mostly conifers of the family Pinaceae and Cupressaceae (including Taxodiaceae) and the number of species were not many, there were no difficulties in wood identification. Timbers from Southeast Asia, however, were almost entirely composed of hardwoods and the species were very diverse. Timbers which had been imported into Japan so far from Southeast Asia were mainly Lauans (*Shorea* spp., *Parashorea malaanonan* and *Pentacme contorta*) and Apitong (*Dipterocarpus* spp.) from the Philippines, especially Mindanao. But, with depletion of the timber resources of the Philippines, the regions of the timber supply expanded to Sabah (Malaysia) and Kalimantan (Indonesia) in the late 1960s and to Sarawak (Malaysia) in the 1970s. As a result, logs of numerous tree species belonging to other families than Dipterocarpaceae were imported to Japan for the first time. Apart from some well-known species such as Meranti (*Shorea* spp.), Keruing (*Dipterocarpus* spp.) and Kapur (*Dryobalanosp* spp.) of the Dipterocarpaceae, unknown or little known tree species, most of which were woods of medium density, were imported to meet the demand of the Japanese timber industry. These woods were collectively referred to as MLH (Mixed Light Hardwoods). In addition, timber imports from Papua New Guinea (PNG) began and increased gradually in the 1980s following the restrictions on roundwood exports from Indonesia. The timbers from PNG, due to the unique flora of the region, were again from totally different species than the Southeast Asian ones, although the total volume of imported timbers from PNG was only limited.

It was a natural trend that Japanese industries required more information about the individual timbers to utilize them effectively and, for that purpose, timber identification was the most important first step. Responding to these needs, the original chapters of this book were written in Japanese by K. Ogata and published in the monthly journal “Wood Industry” from Vol. 30, No. 4 (1975) to Vol. 38. No. 10 (1983) for about eight-and-a-half years with the intention to serve as a manual for timber identification. Finally these chapters covered woods from about 180 timber groups belonging to about 60 families. Each article contained a brief explanation of the botanical and geographical background of the trees and the use of the timbers, description of wood anatomical characteristics and drawings. In 1985, these articles were compiled into the Japanese version of this book and published by the Wood Technological Association of Japan.

Recently the greater part of international trade of timber in Southeast Asia shifted from roundwood to processed lumber and other wood products. Consequently tropical timber imported as logs is now only a small fraction of the total of imported timber products. Nevertheless timber from these regions still remains very important in Japan and other timber importing countries and is botanically highly diverse. Recent demands for wood identification also shifted to finished wood products, problem-solving in wood processing, and so on.

Illegal logging and the trade of illegally harvested timber have not only led to a growing number of problems both in producing and consuming countries, but also seriously affect the global environment. Timber produced in sustainable forest management schemes is easily confused with illegally harvested timber, resulting in failures in sustainable forestry attempts and conservation. It is hoped that microscopic wood identification, as a practical control method presented in this book, can help the discrimination of illegally logged timber from timber products produced through sustainable forest management.

This English edition is issued as a service to wood scientists, students and people engaged in timber utilization outside Japan especially in the Asia-Pacific region. No attempt was made to comprehensively update and revise the original Japanese text including the drawings or to add all relevant recent literature references, except the addition of the description of the much cultivated *Acacia mangium* and the adjustment of some botanical families based on the recent changes in the classification of flowering plants. The families were rearranged in alphabetical sequence throughout the text. In this English edition, many photographs were newly added, including macrophotographs and scanning electron microphotographs (SEM photos) taken by T. Fujii and optical microphotographs by H. Abe. Standardized views are given in macrophotographs, optical microphotographs and SEM photographs taken at fixed magnifications and some anatomical characteristics are also shown in detail.

The anatomical descriptions follow a standard sequence of vessels, rays, axial parenchyma, wood fibres and mineral inclusions such as crystals and silica grains. Then, less common features, such as latex tubes and traces, axial/radial resin canals and so on, are described for those tree genera in which they occur.

For the description of anatomical characteristics, we mostly followed the IAWA Hardwood List (IAWA Committee, 1989), with some exceptions: (1) for vessel diameter, some of the largest (but not average) ones among solitary vessels were selected in transverse section and the tangential diameter including the wall was measured, because this seems more practical for identification purpose; (2) for intervessel pit diameter, the vertical instead of the horizontal diameter was measured because it is less variable in the size range; and (3) for ray height, only the highest ones were measured. Some features which are considered to be covered sufficiently by the drawings or not related directly to identification are omitted or limited to brief description; these include vessel outline, mean tangential diameter of vessels, vessel member length, cellular composition of rays, ray frequency and fibre wall thickness. Air dry specific gravity was measured on wood samples of the xylarium of the Forestry and Forest Products Research Institute (FFPRI), Tsukuba, Japan. It was calculated as the quotient of dry weight divided by the sum of the dry weight and the weight in water. The average value and the range of variation were recorded.

Photographs were mostly taken at standard magnifications, as follows: macro-photographs: × 10 (scale bar = 1 mm); optical microphotographs: × 20 (scale bar 100 µm) in transverse section, × 50 (scale bar = 200 µm) in tangential section and × 100 (scale bar = 100 µm) in radial section; SEM photographs: × 30 (scale bar = 100 µm) in transverse section and × 60 (scale bar = 100 µm) in tangential and radial sections. Deviating magnifications are indicated by a scale bar in each photograph. TWTw numbers are attached to the most of photographs. These are the unique accession numbers of the wood samples studied, linked to detailed information on collector, provenance, and if present, associated herbarium vouchers in the Wood Database of FFPRI (http://f030091.ffpri.affrc.go.jp/index-E.html). (TWTw is the international code for the xylarium of FFPRI).

Readers are advised to use this book in combination with information summarised in the three timber volumes of the PROSEA Handbook Series (PROSEA 5(1)-(3), 1993-98) which provides more detailed information on specific uses, properties and distribution areas of individual species. A rich source of additional anatomical information and illustrations of all genera can be found on the InsideWood website (http://insidewood.lib.ncsu.edu/search/). Readers who want to consult all the wood anatomical background literature for individual genera and families dealt with in this manual are referred to Gregory's very comprehensive bibliography (Gregory, 1994) and updates on the webbased bibliographies on micromorphology and economic botany provided by the Royal Botanic Gardens Kew in the UK (Kew Bibliographic Databases: http://www.kew.org/kbd/searchpage.do).

Special thanks are due to Mr. H. Miyauchi and Mr. M. Fukui of Kaiseisha Press for their much appreciated collaboration and effort, without which the publication of this book would have been impossible. Publication was supported in part by a Grant-in-Aid for publication of Scientific Research of JSPS (the Japan Society for the Promotion of Science).

The authors
Tsukuba & Leiden, January 2008.

Contents

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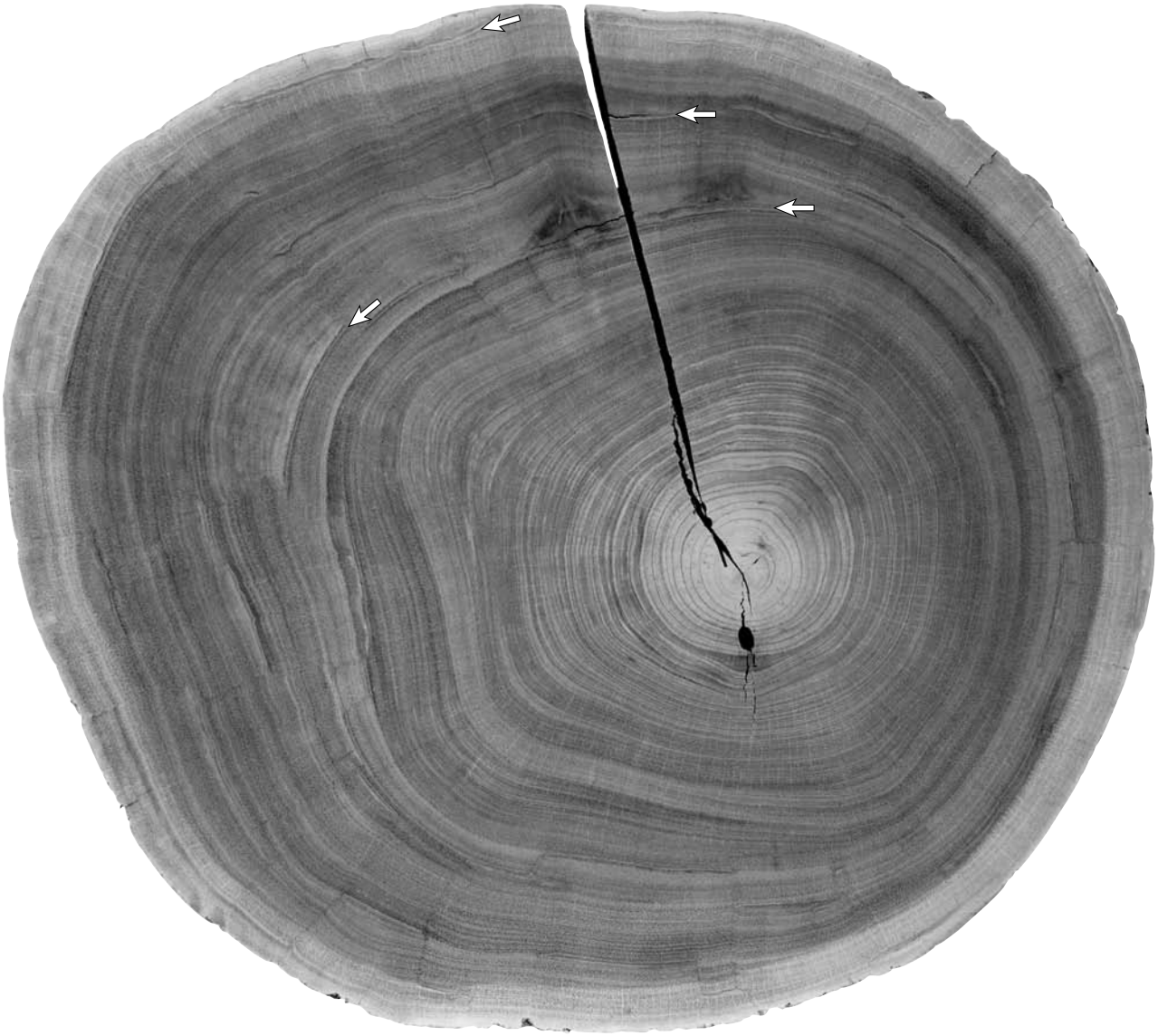
Abbreviations

L: Left, *C*: Centre, *R*: Right.

CS: Cross section, TS: Tangential section, RS: Radial section.

Identification of the Timbers of Southeast Asia and the Western Pacific



Koompassia excelsa (Becc.) Taubert (Leguminosae) (TWTw 5224) *Koompassia excelsa* is one of the largest trees in Southeast Asia, attaining sometimes more than 80 m tall and 2 m in diameter with a columnar bole and large, steep buttresses, and, for the magnificent appearance, is often called “Kayu Raja” which means king of trees in the Malay language. The wood is rather heavy with an average air dry specific gravity of ca 0.83 and that treated with preservatives is suitable for most heavy constructional purposes, but occasional presence of included phloem in irregularly spaced concentric bands in the stem (indicated by arrows) is a major defect of this wood from the viewpoint of utilization. (See text, p.26).

Alangiaceae

The family Alangiaceae consists of the sole genus *Alangium*. According to APG II (2003), Alangiaceae should be merged with Cornaceae.

Alangium: *Alangium* spp.

The genus *Alangium* consists of ca 20 species of trees and shrubs distributed from Africa, throughout Southeast Asia, to New Guinea and Fiji, with 2 shrubby species in Japan as the northern limit of the distribution. The wood anatomical characteristics of tropical and temperate species are somewhat different.

Macroscopic features. Sapwood and heartwood not differentiated by colour, pale yellowish grey to pale yellowish brown, without lustre. Texture medium-coarse. Grain almost straight. Air dry specific gravity (0.63-)0.75-0.97.

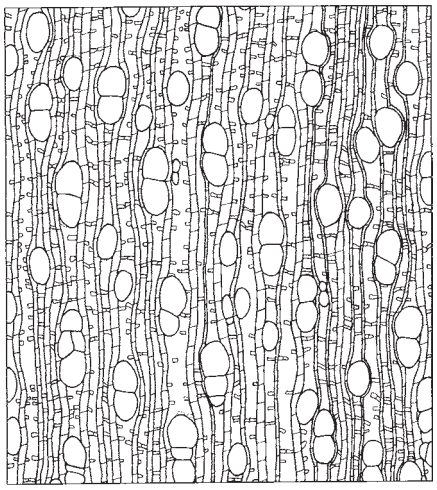
Microscopic features. Vessels solitary and in radial multiples of 2-3(-7), usually the latter predominant (Fig. 1); maximum tangential diameter (90-)120-140(-180) µm in solitary vessels and 140-170(-200) µm in vessel multiples; frequency 11-22/mm^2; perforations exclusively scalariform or reticulate with 10-15 (-20) bars (Fig. 2, D & E); intervessel pits alternate, 6-7 µm (*A. javanicum*) and 7-8 µm (*A. havilandii* and *A. meyeri*) in vertical diameter; vessel-ray pits simple, and round, oval or horizontally elongated (Fig. 2, D & E); tyloses sometimes present.

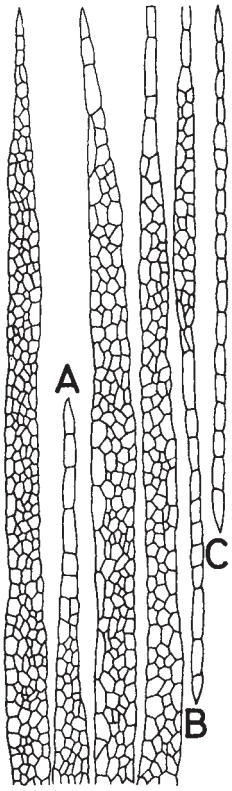
Rays 1-4- or 1-5-seriate, multiseriate rays up to 3200-8000 µm high with long multiseriate portions and often also with long uniseriate portions (Fig. 2, A & B).

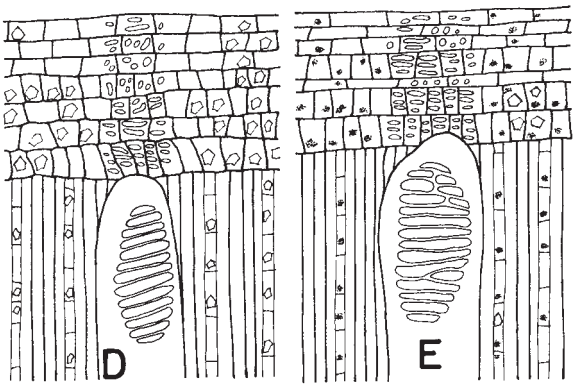
Axial parenchyma diffuse to diffuse-in-aggregates (Fig. 1), distinct in the microscope or also with a hand lens.

Fibres non-septate, 3.0 (1.8-3.5) mm long (*A. javanicum*) with a tangential diameter of 20-35 µm and walls 7-10 mm thick; pits found on radial walls, sparse and inconspicuous.

Crystals and/or silica grains often present in rays and axial parenchyma (Fig. 2, D & E).

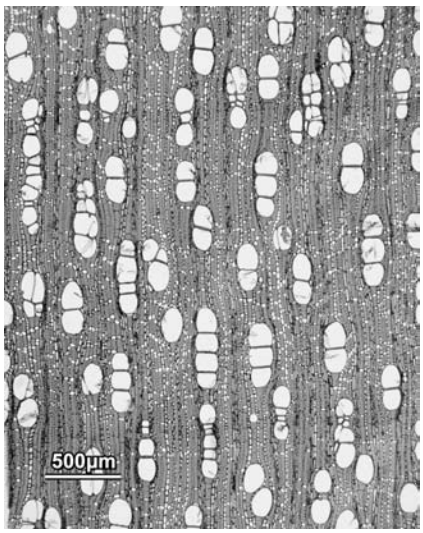


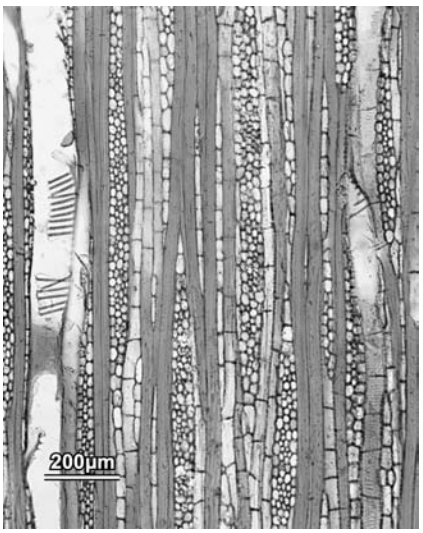


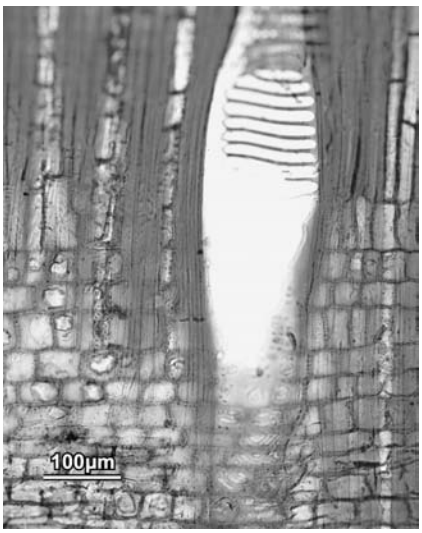


L **Fig. 1.** *Alangium javanicum*, × 25.

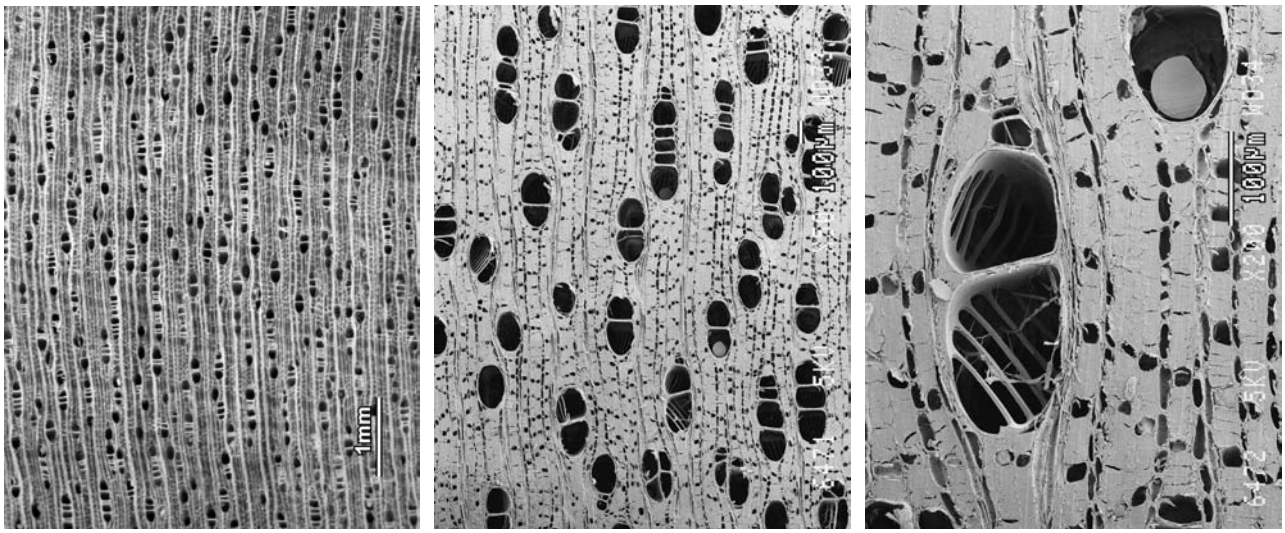
R **Fig. 2.** A-E: *Alangium javanicum*. - A-C: Ray types. -D & E: Radial section showing vessel-ray pits, scalariform perforation plate and crystals in ray and axial parenchyma cells (D) or crystals and silica grains in ray and axial parenchyma cells (E). A-E: × 80.



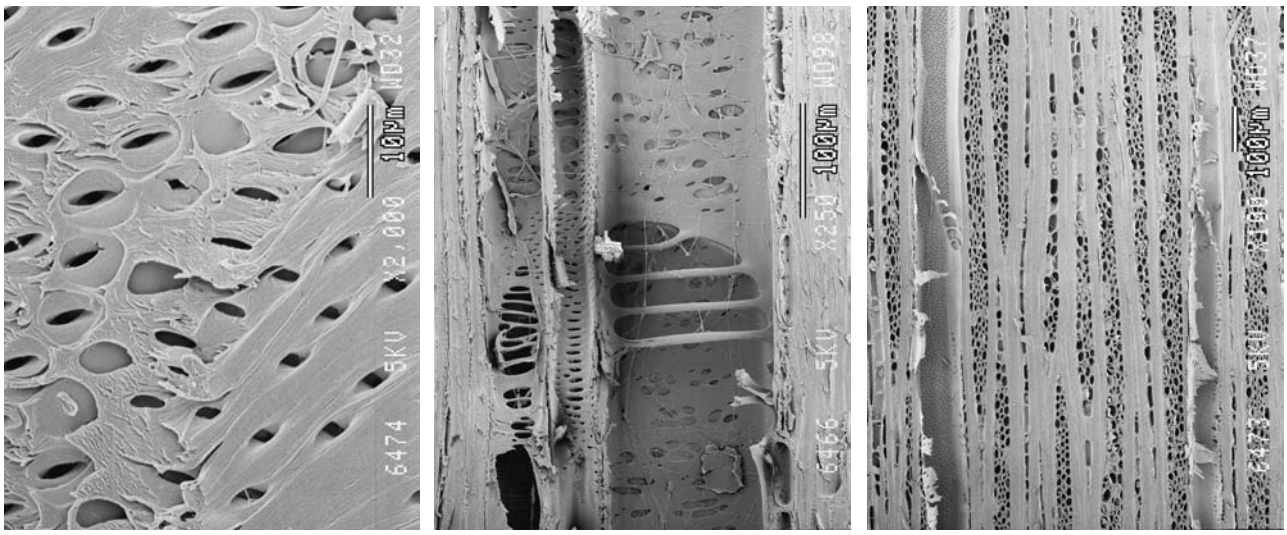




L R *Alangium javanicum* (BZFw 30875). C *A. javanicum* (BZFw 29090).



Alangium havilandii (TWTw 16721).
L (Macrophoto).
C Vessels solitary and in radial multiples of 2-3(-7) (CS: SEM).
R Perforations scalariform, fibres thick-walled and axial parenchyma diffuse in aggregate (CS: SEM).



Alangium havilandii (TWTw 16721).
L Intervessel pits alternate, non-vestured (TS: SEM).
C Perforations scalariform, intervessel pits simple, round to oval (RS: SEM).
R Rays 1-5-seriate (TS: SEM).

Alangium havilandii (TWTw 16721).
L Vessel-ray pits (RS: SEM).
C Crystals in ray and axial parenchyma cells (RS: SEM).
R Crystals in square to upright ray cells (RS: SEM).

Anacardiaceae

The family Anacardiaceae consists of ca 80 genera and 600 species of trees, shrubs, lianas or rarely perennial herbs distributed mainly in the tropical to subtropical regions of the world. According to Ding Hou (1978), there are 20 genera and ca 240 species in this family in the Malesian region (the Flora Malesiana region) (Table 1; total species number was partly amended based on Mabberley, 1997).

A wood anatomical study of Anacardiaceae in Southeast Asia to the western Pacific was conducted by Dadswell and Ingle (1948), and the characteristics were listed in a table. We modified this table based on our own observations, with heartwood colour and air dry specific gravity added (Table 2).

The anatomical characteristics of Anacardiaceae can be summarized as follows.

(a) Vessel perforations exclusively simple in most genera, but sometimes scalariform in *Campnosperma* and reticulate in *Euroschinus*.

(b) Intervessel pits rather large to large, 7-15 μm in vertical diameter. Vessel-ray pits simple or with reduced borders, rather large, round to oval, sometimes scalariform (e.g. *Campnosperma*).

(c) Rays generally not very large, 1-2- to 1-3-seriate, except those with radial resin canals, and up to 600-1000 μm high in most genera, but larger in *Spondias*. Usually with 1 to 2 or 3 rows of marginal upright cells.

(d) Axial parenchyma vasicentric or aliform, sometimes in irregular bands.

(e) Fibres with a tendency to be arranged in regular radial files in most genera. Septate fibres present in some genera; almost all fibres septate in *Dracontomelon* and *Koordersiodendron*, while fibres are only occasionally septate in *Rhus*. Pits found on radial walls, but generally minute and inconspicuous.

(f) Radial resin canals often present.

(g) Silica grains present in some genera.

Table 1 Species distribution of the genera of Anacardiaceae in Southeast Asia and the western Pacific

Genus	Malaya	Sumatra	Borneo	Java	Lesser Sunda Islands	Philippines	Sulawesi	Moluccas	New Guinea	Other	Total species
Androtium	1		1								1
Bouea	2	2	1	1						As	3
Buchanania	2	3	4	1	1	4	1	4	3	As, Pac, Austr	25
Campnosperma	3	2	3					1	2	As, Pac, S Am, Madag	10
Dracontomelon	1	2	2	1	1	1	1	1	2	As, Solomon, Fiji	8
Drimycarpus	1	1	1							As	2
Euroschinus									1	N Caled, Austr	6
Gluta	15	9	11	2			1	1	1	As, Madag	30
Koordersiodendron			1			1	1	1	1		1
Mangifera	11	11	10	4	4	3	3	3	3	As, Solomon	40-60
Melanochyla	9	2	14	1							25
Parishia	3	3	3			1				As	5
Pegia			1							As	3
Pentaspadon	3	2	1					1	1	As, Solomon	6
Pistacia	1					1				As, N & C Am, Canary	9
Pleiogynium			1		1	1	1	1	1	Solomon, Cook, Austr	2-3
Rhus	1	3	2	2	1	1	2	1	5	Trop to temp regions widely	200
Semecarpus	6	1	7	2	4	9	4	3	11	As, Pac, Austr	60
Spondias	2	3	3	2	2	2	2	2	3	As, trop Am	10
Swintonia	4	4	5			2				As	12

As: Asia, Austr: Australia, C Am: Central America, Canary: the Canary Islands, Cook: the Cook Islands, Fiji: the Fiji Islands, Madag: Madagascar, N Am: North America, N Caled: New Caledonia, Pac: Pacific regions, S Am: South America, Solomon: the Solomon Islands, temp: temperate, trop: tropical.

Table 2 Generic microscopic characteristics of Anacardiaceae in the Malesian region

Genus	Heartwood	Air dry specific gravity (× 100)	Vessels			Rays		Axial p	Sept fibres	Radial canals	Crystals		Silica grains	Others
			Max diam (μm)	V–V pit diam (μm)	Tyloses	Width (cells wide)	Max h (μm)				Rays	Axial p		
Bouea	pale pink br	51-89	200-230	8-9	–	1-2	800-1000	vasi, bd	–	–	+	–	–	
Buchanania	pale gr to pink br	(37-)48-56 (-73)	210-290	8-10	–	(1-)2-3(-4)	-870	vasi (alif)	–	+	–	–	–	sap smt toxic?
Campnosperma	pale pink br to pale gr br	32-56	100-150	8-10	–	1-2, 1-3	300-700	sparce	+	+	–	–	–	perf simple & scal
Dracontomelon	dark yel br to pink br with black str	33-79	(180-)250-320	(10-)11-12 (-13)	+	(1-)2-3(-6)	(500-)900-1100(-1600)	vasi - ali	++	–	++	±	–	
Euroschinus	pink br, oft yel green str	38	140-180	8-11	–	(1-)2-3	-700	vasi	+	+	+	±	–	perf simple & reticular
Gluta/Melanorrhoea	red br to dark red br	(45-)65-85 (-1.15)	200-280(-410)	10-12	+	(1-)2	350-700 (-1200)	vasi, bd	–	+	–	–	+	sap gen toxic
Koordersiodendron	red br	67-1.02	200-230	10-12	+	(1-)2-3	-800	vasi (ali)	++	+	+	±	–	
Mangifera	pale pink br to dark br, oft dark str	42-95	(200-)240-340	(8-)9-10(-11)	±	1, 1-2	400-800 (-1200)	alif, bd	–	–	+	–	–	
Melanochyla	dark br with black str	64-72	170-210	7-9	±	1-2(-3)	-700	vasi - ali (- confl)	–	+	+	–	–	sap oft toxic
Parishia	pale pink gr to br gr	(42-)56-80	150-180	7-8	–	1-2	-750	vasi (ali)	–	+	–	–	+	
Pentaspadon	pink yel br to pink br	66-79	140-200	8-9	+	2-4	-700	vasi	+	+	+	–	–	
Pistacia	yel br + dark br str	80-1.08	50-200	-9-	+	(1-)2-3(-4)	-700	vasi	–	+	+	–	–	ring- to semi-ring-p, sprl in nar v
Pleiogynium	red br to dark red br	88-98	140-190	9-10	+	(1-)2(-3)	-600	vasi - ali	+	+	+	±	–	
Rhus	pale pink br, oft green yel tinge	42-53	100-190	(6-)8-9	–	(1-)2-3(-4)	500-900	vasi	±	±	+	–	–	temp sp ring-p, sap oft toxic
Semecarpus	peal br, oft yel tinge	32-42	170-270	-10-	–	(1-)2-3(-4)	1100-1300	vasi - ali (- confl)	–	–	+	±	–	sap oft toxic
Spondias	pale gr yel to pale br yel	32-50	(180-)260-370	10-12	–	1-3, 4, 5, 6	1000-1800	vasi (ali)	+	+	±	±	–	
Swintonia	gr to gr br	57-88	240-310	13-15	–	1-2	-600	vasi, bd	–	+	±	±	+	sap oft toxic

ali: aliform, Axial p: Axial parenchyma, bd: banded, br: brown, confl: confluent, diam: diameter, gen: generally, gr: grey, h: height, Max: Maximum, nar v: narrow vessels, oft: often, perf: perforation, ring–p: ring–porous, scal: scalariform, Sept: Septate, smt: sometimes, sprl in nar v: spirals in narrow vessels, str: streaks, temp sp: temperate species, vasi: vasicentric, V–V pit: Intervessel pit, yel: yellow.

(1) Terentang: *Campnosperma* spp.

The genus *Campnosperma* consists of 10 to 15 species distributed in the tropical regions of Asia, Africa and Central and South America. The species are most abundant in Southeast Asia to the western Pacific, and generally called Terentang. *C. auriculatum* (Blume) Hook. f. is the most representative species of this region. *C. brevipetiolatum* Volkens in Sulawesi to New Guinea and *C. gummiferum* March. (Orey wood) in Central and South America are also known as commercial timber species.

Macroscopic features. Sapwood and heartwood not differentiated by colour, pale pinkish brown when fresh, turning pinkish grey to greyish brown. Texture even and rather fine. Grain straight or sometimes slightly interlocked. Wood rather soft and light with an air dry specific gravity of 0.43 (0.32-0.56). Sap usually not poisonous, but sometimes causing skin irritation in some people.

Microscopic features. Vessels mostly in radial multiples of 2(-3) (Fig. 3); maximum tangential diameter of solitary vessels 100-150 μm; frequency ca 20/mm^2; perforations simple and scalariform with 13-25 bars (Fig. 4, D & E), the ratio of the former and the latter variable according to the specimen; intervessel pits alternate, 8-10 μm in vertical diameter; vessel-ray pits horizontally elongated (Fig. 4, G); tyloses infrequent or absent.

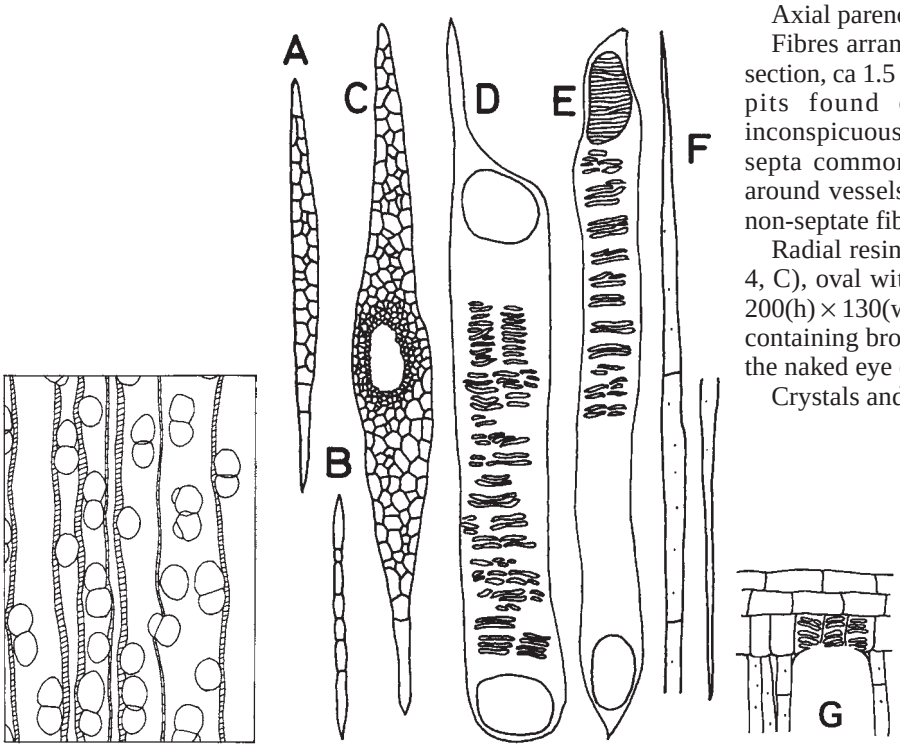
Rays 1-2- or 1-3-seriate, multiseriate rays 300-700 μm high (larger in width and height in the rays with radial resin canals), usually containing pinkish brown contents which are distinct to the naked eye in radial section.

Axial parenchyma apparently lacking (Fig. 3).

Fibres arranged in regular radial files in cross section, ca 1.5 mm long with walls ca 2 μm thick; pits found on radial walls minute and inconspicuous; septate fibres with 1-4 or more septa commonly present, especially abundant around vessels, often with larger diameter than non-septate fibres.

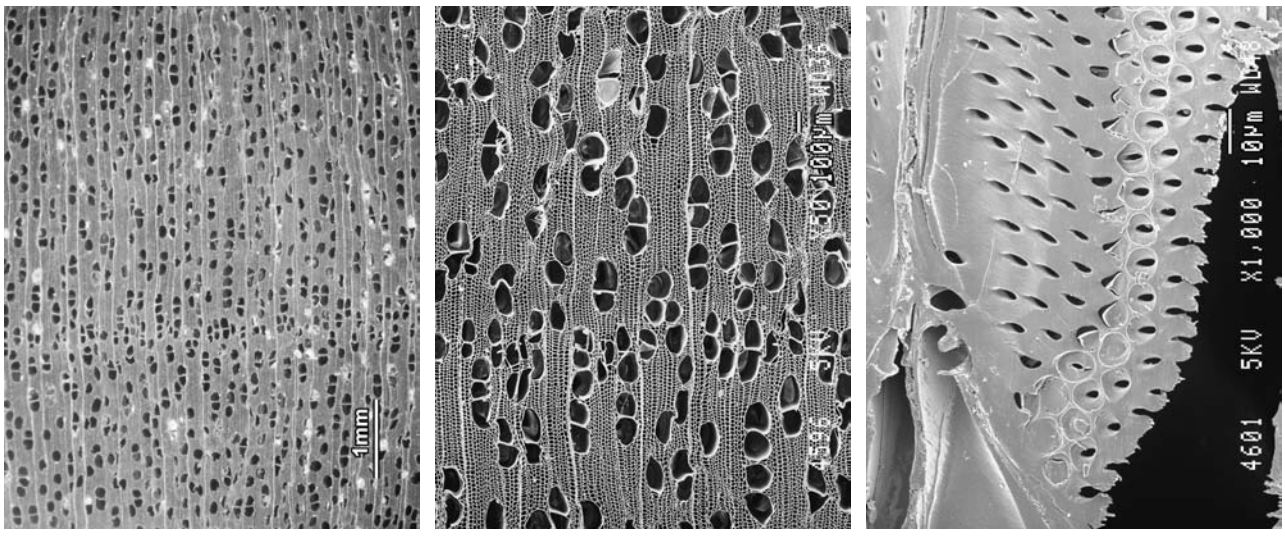
Radial resin canals present in some rays (Fig. 4, C), oval with a diameter of 70(h) × 50(w) to 200(h) × 130(w) μm in tangential section, usually containing brown-black resin, and discernible to the naked eye or with a hand lens.

Crystals and silica grains absent.



L **Fig. 3.** *Campnosperma auriculatum*, × 30.

R **Fig. 4.** A-D, F & G: *Campnosperma auriculatum*; E: *C. panamense*. - A-C: Ray types (radial resin canal present in C). - D: Vessel element with simple perforation plates. - E: Vessel element with simple and scalariform perforation plates. - F: Septate fibre. -G: Radial section showing vessel-ray pits. A-G: × 80.

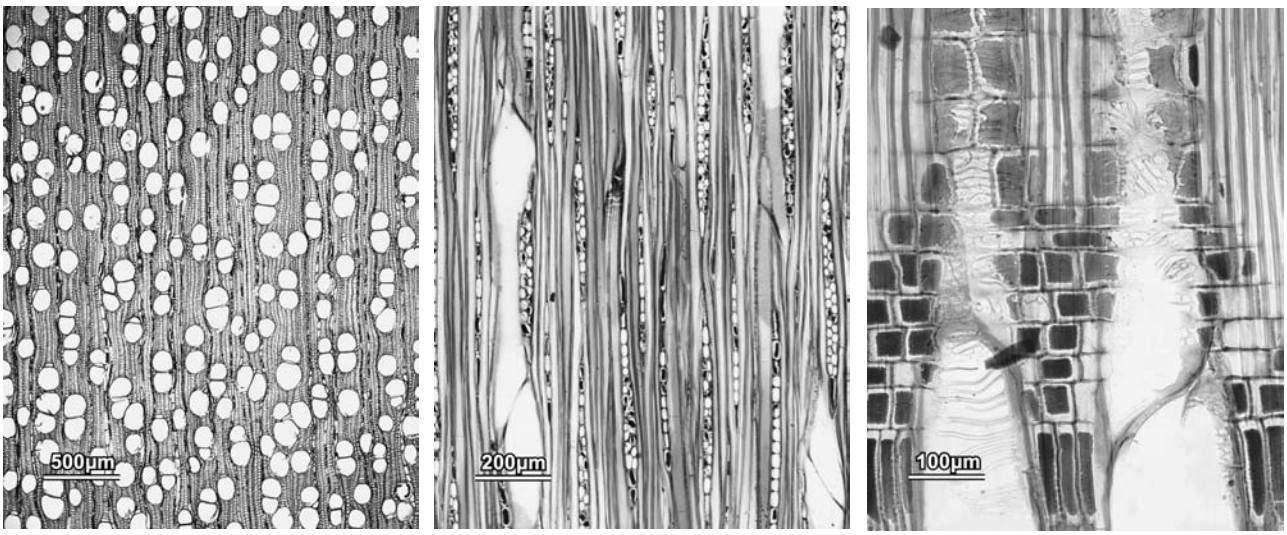


Campnosperma auriculatum (TWTw 3166).

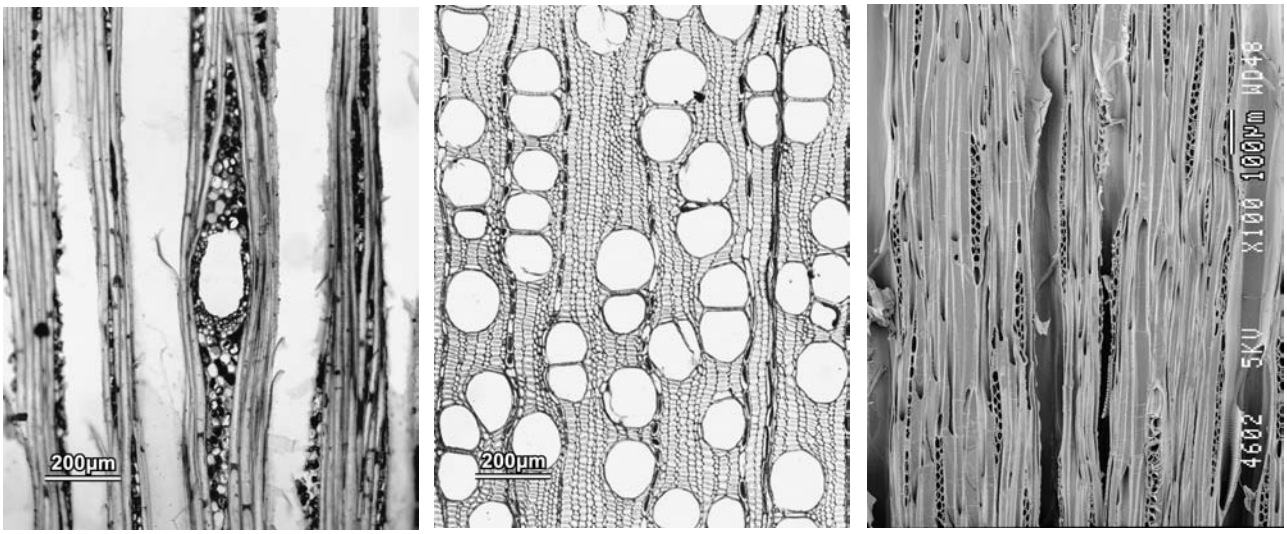
L (Macrophoto).

C Vessels mostly in radial multiples and axial parenchyma apparently lacking (CS: SEM).

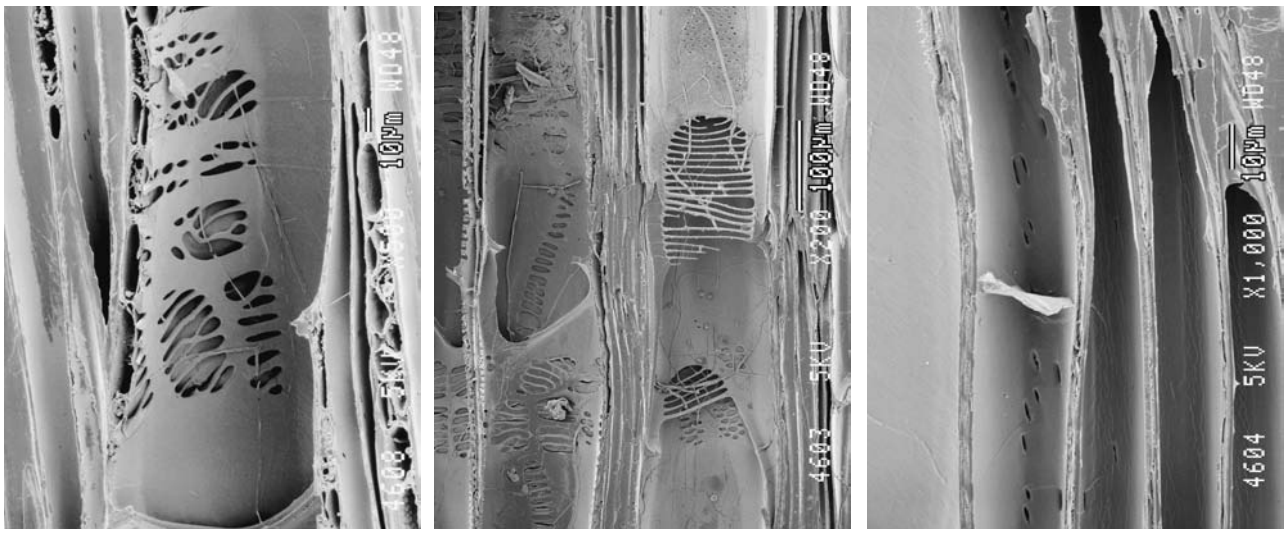
R Intervessel pits alternate, non-vestured (TS: SEM).



Campnosperma brevipetiolatum (TWTw 11267).



L R Campnosperma auriculatum (TWTw 3166). *C C. brevipetiolatum* (TWTw 11267).
R Rays 1-2-seriate (TS: SEM).



Campnosperma auriculatum (TWTw 3166).
L Perforations simple and vessel-ray pits elongated, gash-like to palisade (TS: SEM).
C Scalariform perforations, vessel-ray pits and vessel-axial parenchyma pits (RS: SEM).
R Septate fibres (RS: SEM).

(2) Dao: *Dracontomelon* spp.

The genus *Dracontomelon* consists of 5 to 8 species distributed in Southeast Asia to New Guinea. Among them, *D. puberulum* Miq. from Myanmar, throughout Southeast Asia, to New Guinea, *D. dao* (Blanco) Merr.& Rolfe from the Philippines to the Moluccas, *D. edule* (Blanco) Skeels in Borneo and the Philippines and *D. sylvestre* Blume in Borneo and the Philippines are known as commercial timber species.

Macroscopic features. Sapwood pale yellowish white when fresh, turning pale greyish brown, pale greyish pink or pale yellowish grey after drying. Heartwood dull yellowish brown, pale brown, pale pinkish brown or pinkish brown, usually with bluish black to greenish black streaks and with golden lustre. Texture rather coarse. Grain interlocked. Air dry specific gravity 0.33-0.79, commonly 0.50-0.65. Sap not poisonous.

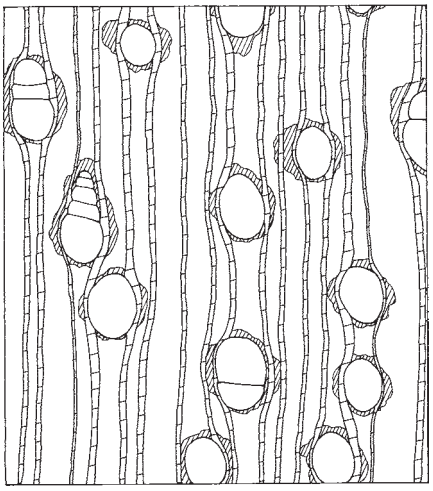
Microscopic features. Vessels solitary and in radial multiples of 2(-3), the former rather predominant; maximum tangential diameter of solitary vessels (180-)250-320 µm; frequency 4(2-5.5)/mm^2; perforations simple; intervessel pits alternate, (10-)11-12(-13) µm in vertical diameter; vessel-ray pits simple, and round to oval (Fig. 6, G); tyloses common.

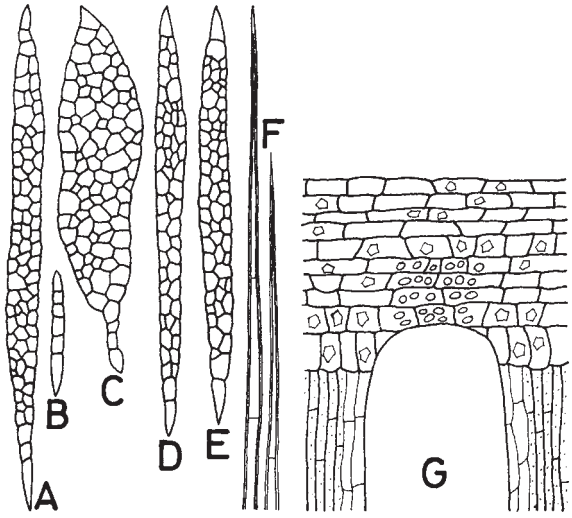
Rays mostly 2-3(-4)-seriate (uniseriates sparse), but 5-6-seriates common around knots (Fig. 6, C); maximum height of multiseriate rays (500-)900-1100(-1600) µm.

Axial parenchyma vasicentric to lozenge-aliform (Fig. 5), sometimes not very distinct in the microscope due to lack of contrast with fibres.

Fibres arranged in regular radial files in cross section; mostly or exclusively septate, 1.4 (1.0-1.9) mm long with a tangential diameter of 15-30 µm and a wall thickness of 1.5-3.0 µm; pits restricted to the radial walls minute and inconspicuous.

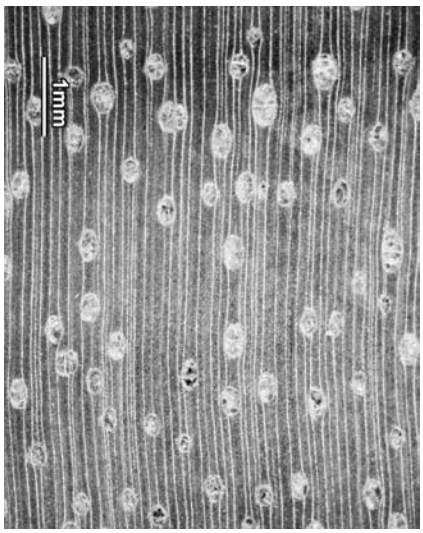
Crystals common in rays (Fig. 6, G). Silica grains absent.

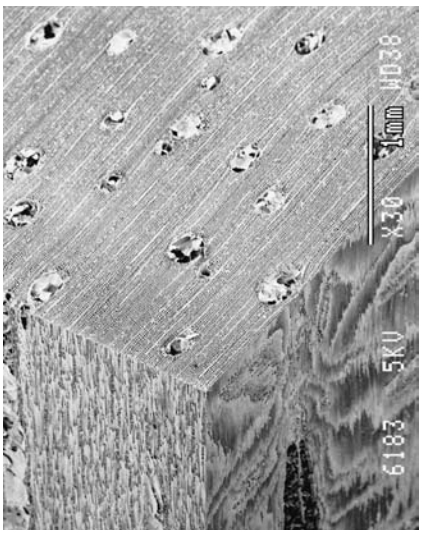




L **Fig. 5.** *Dracontomelon puberulum*, × 25.

R **Fig. 6.** A-C: *Dracontomelon dao*; D, F & G: *D. puberulum*; E: *D. edule*. - A-E: Ray types. - F: Septate fibre. -G: Radial section showing vessel-ray pits and crystals in ray cells. A-G: × 80.



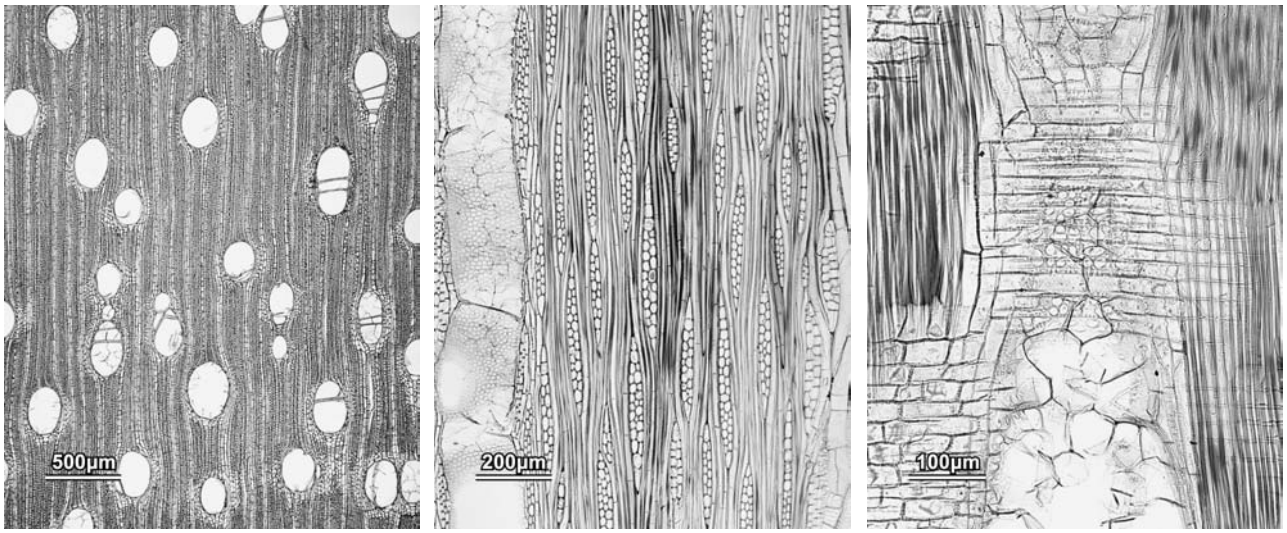


Dracontomelon puberulum (TWTw11859).

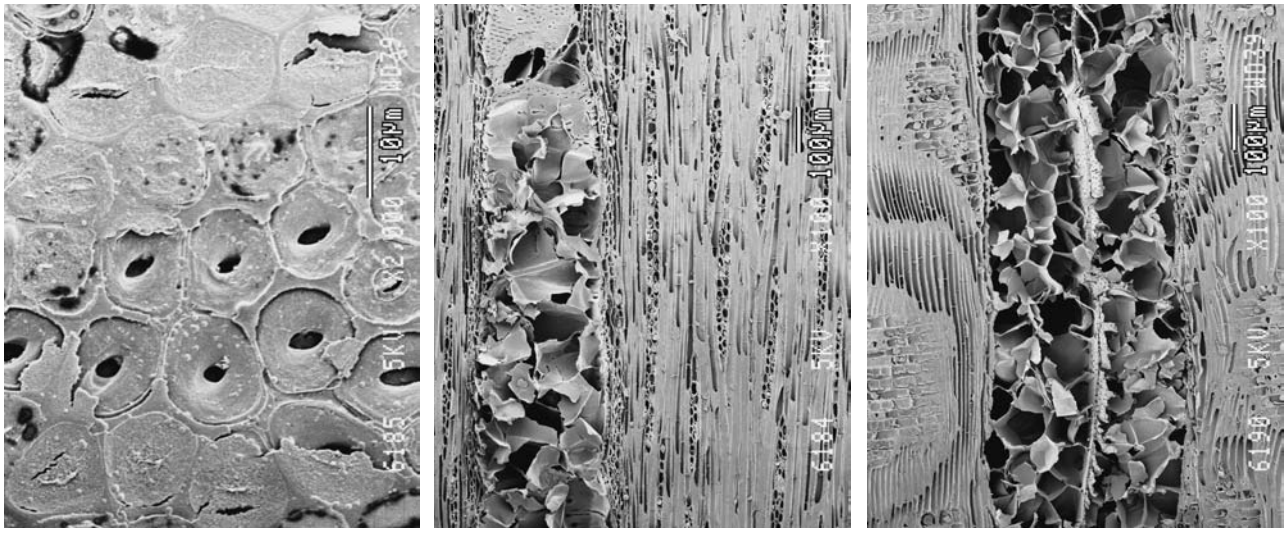
L (Macrophoto).

C Vessels mostly in radial multiples, axial parenchyma apparently lacking (CS: SEM).

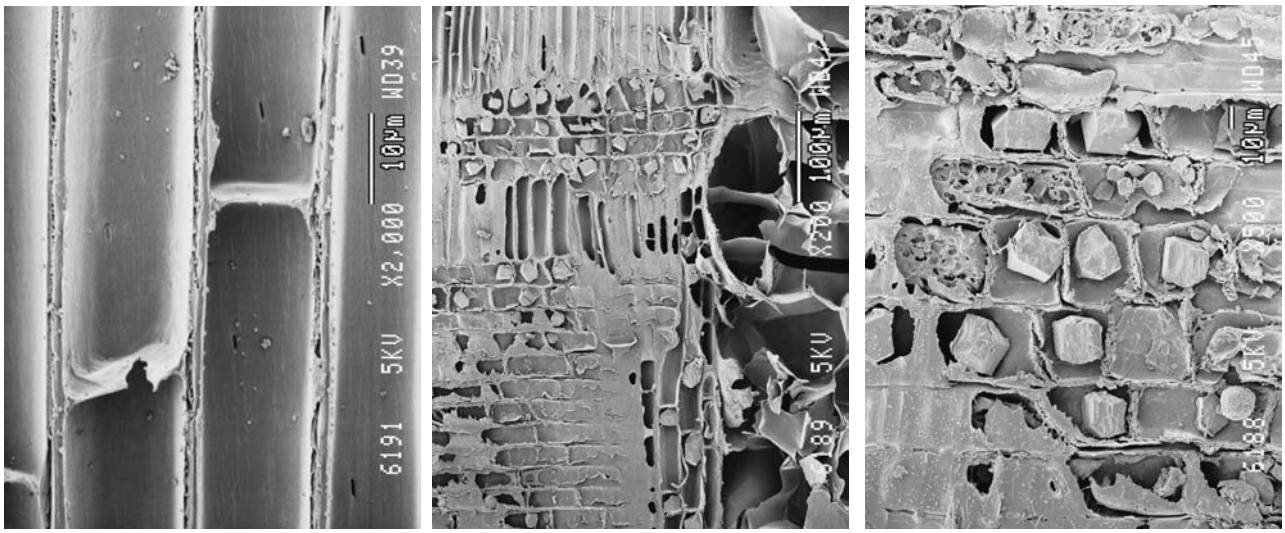
R Intervessel pits alternate, non-vestured (TS: SEM).



Dracontomelon puberulum (TWTw 11859).



Dracontomelon puberulum (TWTw11859).
L Intervessel pits alternate, non-vestured (TS: SEM).
C Rays mostly 2-3(-4)-seriate (TS: SEM).
R Tyloses (RS: SEM).



Dracontomelon puberulum (TWTw11859).
L Septate fibres (RS: SEM).
C R Crystals in ray and axial parenchyma cells (RS: SEM).

(3) Machang: *Mangifera* spp.

The genus *Mangifera* consists of ca 40 species widely distributed from India, throughout Southeast Asia, to New Guinea. Some of them, including *M. indica* L., native to Himalayan regions, are known for their fruits and are widely cultivated.

Macroscopic features. Wood pinkish brown, pale brownish grey, pale pinkish grey, pale yellowish grey or dark yellowish grey when sapwood and heartwood are not differentiated by colour, but sometimes dark brown heartwood with irregular black stripes distinct from sapwood. Without lustre. Texture medium-coarse. Grain interlocked and often wavy. Air dry specific gravity 0.42-0.95, commonly 0.50-0.70. Sap usually not poisonous, but causing allergic reactions in some people.

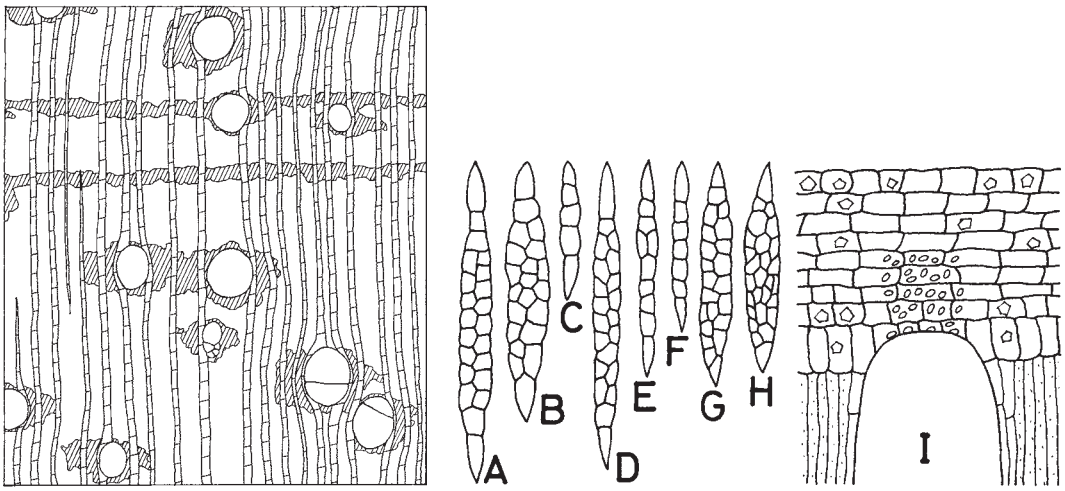
Microscopic features. Vessels solitary and in radial multiples of 2-3(-5-8), the former predominant (Fig. 7); maximum tangential diameter of solitary vessels (200-)240-340 µm; frequency 3(1.5-4.5)/mm^2; perforations simple; intervessel pits alternate, (8-)9-10(-11) µm in vertical diameter; vessel-ray pits simple, and round to oval with a vertical diameter of 10-15 µm (Fig. 8, I); tyloses often present.

Rays uniseriate (partially 2-seriate) or 1-2-seriate according to the species, up to 400-880(-1200) µm high.

Axial parenchyma aliform (to confluent) and in irregularly spaced bands (Fig. 7), which are distinct in the microscope, and seen as purplish stripes in tangential section to the naked eye.

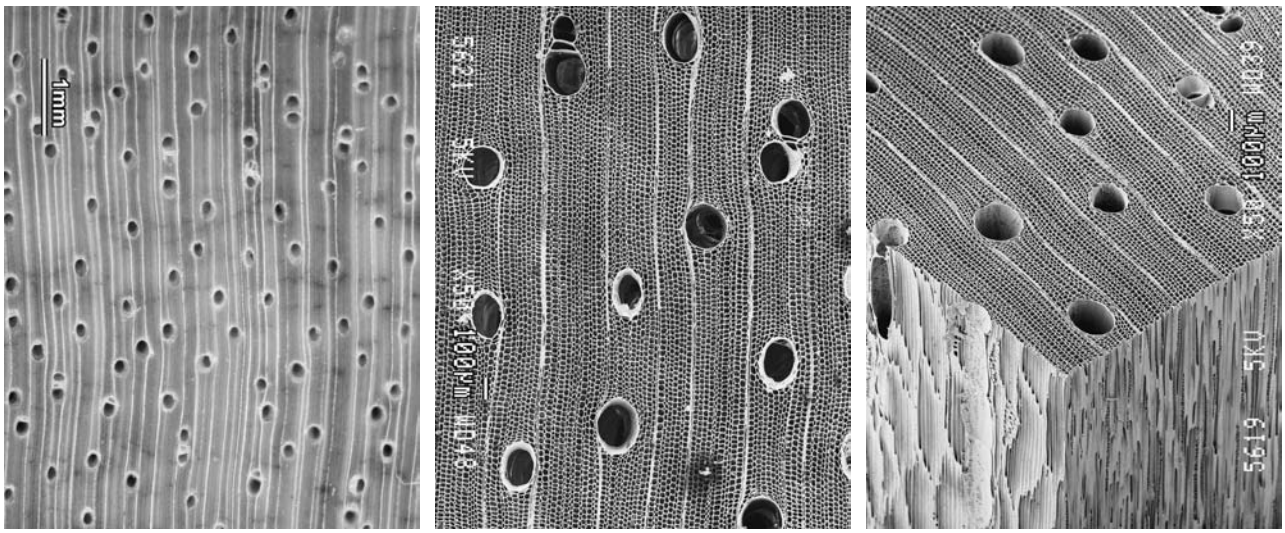
Fibres non-septate, arranged in regular radial files, 0.8 (0.6-1.1) mm long (*M. indica*), with a tangential diameter of 10-25 µm and a wall thickness of 1.5-4.0 µm; pits restricted to the radial walls minute and inconspicuous.

Crystals often present in rays (Fig. 8, I). Silica grains absent.



L **Fig. 7.** *Mangifera minor*, × 25.

C **Fig. 8.** A-C: *Mangifera minor*; D & I: *M. mucronulata*; E & F: *M. altissima*; G & H: *M. indica*. - A-H: Ray types. I: Radial section showing vessel-ray pits and crystals in ray cells. A-I: × 80.



Mangifera mucronulata (TWTw 11568).

L (Macrophoto).

C R Vessels mostly solitary and axial parenchyma aliform but indistinct. *C* (CS: SEM). *R* (3D: SEM).

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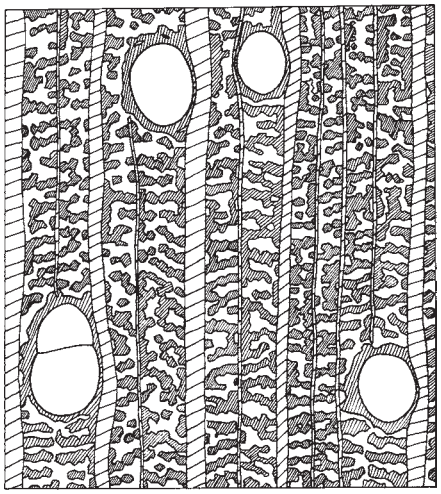
Bombacaceae

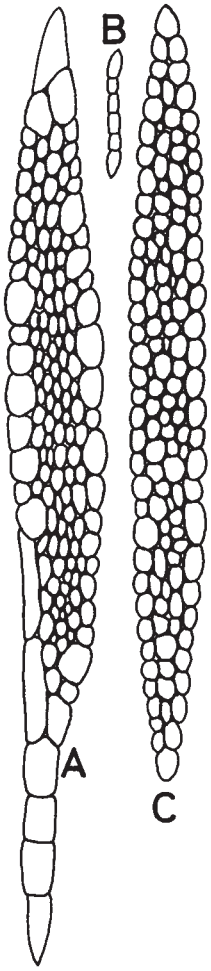
The family Bombacaceae consists of ca 30 genera and 250 species of trees distributed in the tropical regions of the world, especially in tropical America. In recent classifications, the Bombacaceae are treated as Malvaceae *sensu lato* (APG II, 2003).

(1) Kapok: *Ceiba pentandra* (L.) Gaertner

Kapok is said to be native to South America, but it has long been planted and is now found widespread throughout the tropics, so that its place of true origin is not clear. It is a fast growing tree up to 30 m tall, and the white to pale brown silky hairs in the seeds are used for stuffing pillows, beddings, cushions and life jackets. The wood is soft and light, and used for floaters, wooden models, toys, insulators, the core of plywood and boxes, but in these uses it is generally inferior to the wood of Balsa *Ochroma pyramidale* (Cav. ex Lam.) Urban which is softer and lighter.

Macroscopic features. Sapwood and heartwood not differentiated by colour, yellowish white to greyish yellow with a pale brown tinge. Vessels seen as pale brown streaks on longitudinal surfaces. Irregular terminal axial parenchyma lines found in cross section. Ripple marks present but not very distinct. Texture coarse. Grain usually interlocked. Air dry specific gravity 0.27 (0.19-0.35).





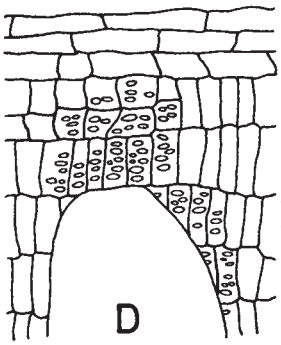
Microscopic features. Vessels mostly solitary, sometimes in radial multiples of 2-3(-6) (Fig. 29); maximum tangential diameter of solitary vessels 280-430 µm; frequency 1.5(0.5-3.5)/mm^2; perforations simple; intervessel pits alternate, 9-10 µm in vertical diameter; vessel-ray pits simple, small and oval (Fig. 30, D), but vessel-ray contacts infrequent due to intervening axial parenchyma; thin-walled tyloses sometimes present.

Rays of 2 distinct sizes, large rays 7-13-seriate, 800-2800(-3800) µm high, with sheath cells along the margins, small rays 1-2-seriate, low; ray cells round in tangential section, and with intercellular spaces between them (Fig. 30, A).

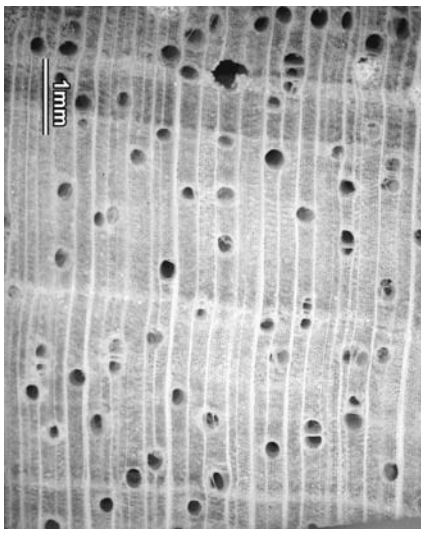
Axial parenchyma abundant, vasicentric and irregularly reticulate (Fig. 30); the strands usually of 4 cells and storied (seen as ripple marks to the naked eye).

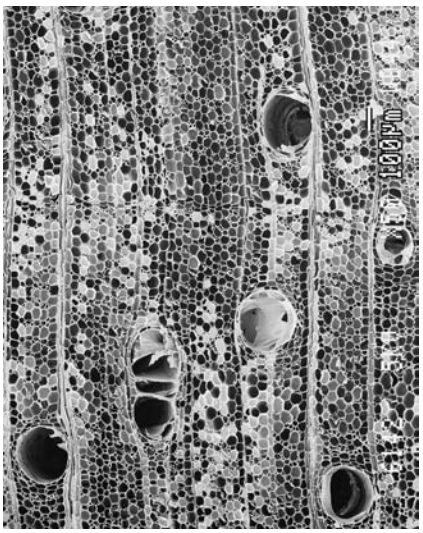
Fibres non-septate, interspersed among axial parenchyma; pits relatively sparse, found both in radial and tangential walls, nearly simple with distinct lens-shaped apertures; fibre length 1.6 (1.3-2.0) mm. Crystals and silica grains absent.

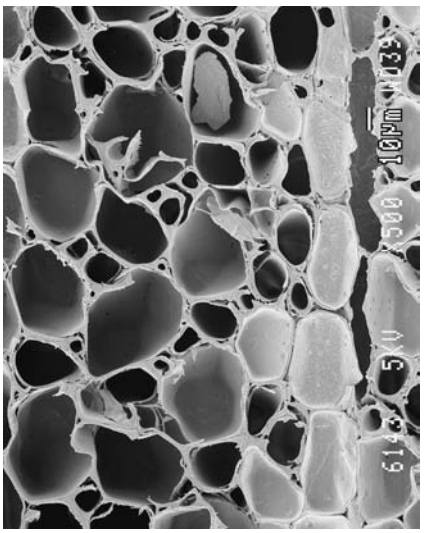
The wood of *Bombax malabaricum* DC. is similar to that of *Ceiba pentandra*, but differs in having rays in which sheath cells are not distinct (Fig. 30, C).



L **Fig. 29.** *Ceiba pentandra*, × 25.
R **Fig. 30.** A, B & D: *Ceiba pentandra*; C: *Bombax malabaricum*. - A-B: Ray types (sheath cells distinct in A). - D: Radial section showing vessel-ray pits. A-D: × 80.







Ceiba pentandra (TWTw 6504).
L (Macrophoto).
C Vessels mostly solitary, sometimes in radial multiples, and axial parenchyma vasicentric and irregularly reticulate (CS: SEM).
R Thin-walled fibres and wide axial parenchyma cells (CS: SEM).

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Casuarinaceae

The family Casuarinaceae has been considered to consist of the sole genus *Casuarina*, but in recent taxonomy it is divided into 4 genera, *Casuarina* (17 species mainly in Australia to the western Pacific), *Allocasuarina* (58 species in Australia), *Ceuthostoma* (2 species in Borneo and New Guinea) and *Gymnostoma* (18 species mainly in the western Pacific, some in Southeast Asia). In the present book, however, the traditional broad concept of *Casuarina sensu lato* (including *Allocasuarina*, *Ceuthostoma*, and *Gymnostoma*) is followed.

Casuarina: *Casuarina* (s.l.) spp.

The genus *Casuarina* (s.l.) consists of ca 80 species of trees distributed in Southeast Asia and the western Pacific including the northern part of Australia. *C. equisetifolia* L. is well known as a beach tree. Others are mostly inland species, and usually found on poor soils.

Macroscopic features. Sapwood pale yellowish brown with a pinkish grey tinge. Heartwood pinkish brown, brown, dark brown, reddish brown or red-purplish brown, without lustre. Texture fine to rather fine. Grain straight to shallowly interlocked, often wavy. Silvery grain present in species with broad rays. Air dry specific gravity 0.72-1.22 .

Microscopic features. Vessels exclusively solitary, arranged somewhat in diagonal pattern; tangential diameter of solitary vessels (70-)120-160(-210) µm; narrow vessels 20-30 µm in diameter present mixed with large vessels (Fig. 40 & 41); frequency 8-15/mm^2; perforations usually simple, but rare scalariform perforations with few bars are also present; thin layers of vasicentric tracheids present, the vessel-tracheid pits bordered, 3-4 µm in diameter; vessel-ray pits similar to vessel-tracheid pits (Fig. 42, J); tyloses absent; chalky contents sometimes found in vessels.

Rays essentially 1(-2)- to 1-3(-5)-seriate and very low, but broad rays which are 7-20-seriate (sometimes up to 80-seriate) and very high up to 3 cm often present especially in *C. cunninghamiana*, *C. glauca*, *C. junghuhniana*, *C. sumatrana* and *C. torulosa*; broad rays usually absent in *C. equisetifolia* and *C. stricta*, but present in 3 out of 11 specimens examined of *C. equisetifolia*; broad rays often compound and dissected by fibres and resembling aggregate rays (Fig. 41; Fig. 42, A, E & G).

Axial parenchyma in narrow bands, 0.1-0.2 to 0.2-0.4 mm apart (Fig. 40 & 41), visible with a hand lens.

Fibres non-septate, 1.0 (0.7-1.3) mm long (*C. equisetifolia*) with a tangential diameter of 10-20 µm and a wall thickness of 4-6 µm; bordered pits present on radial and tangential walls, rather abundant in the latter.

Crystals often present in broad rays and in short-chambered axial parenchyma cells (Fig. 42, G & I). Silica grains absent.

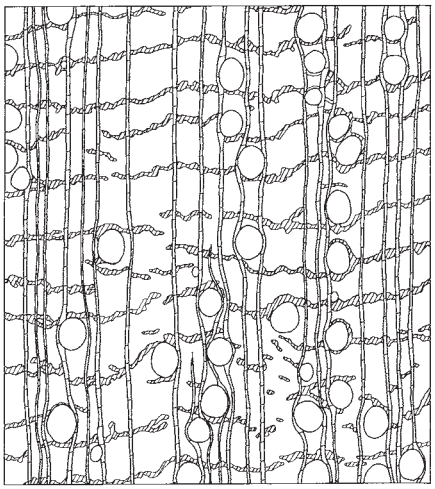
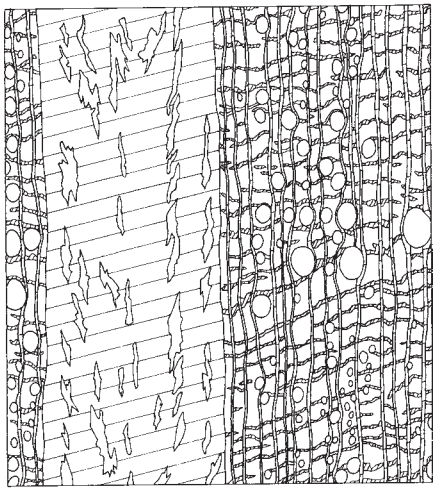
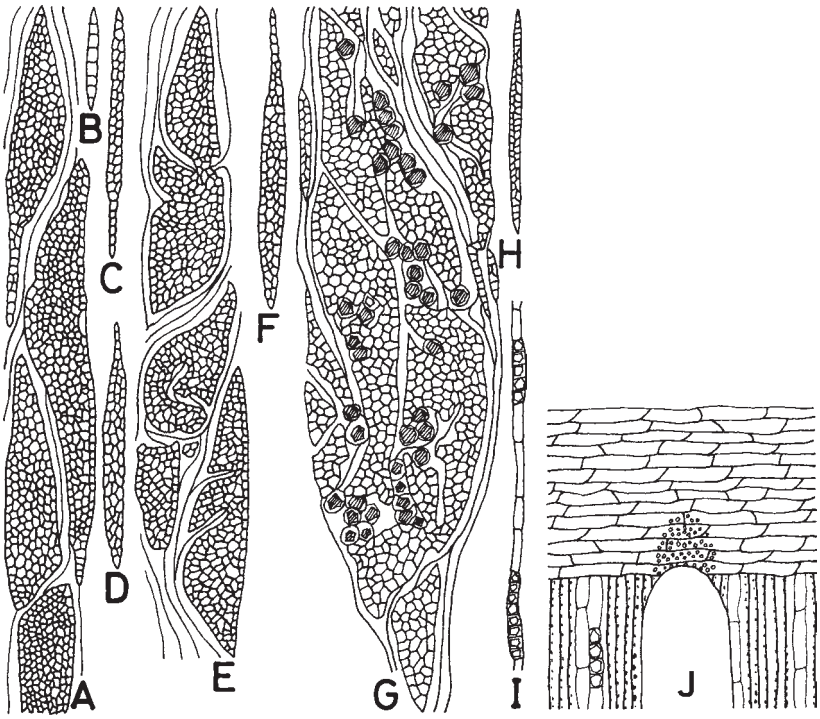


Fig. 40. *Casuarina equisetifolia,* × 25.





L **Fig. 41.** *Casuarina glauca*, × 25.

R **Fig. 42.** A & B: *Casuarina cunninghamiana*; C-E, I & J: *C. equisetifolia*; F & G: *C. glauca*; H: *C. stricta*. - A-H: Ray types (crystals present in G). - I: Crystals in chambered axial parenchyma cells. - J: Radial section showing vessel-ray pits. A-J: × 80.

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Datiscaceae

The family Datiscaceae consists of only 3 genera, *Octomeles*, *Tetrameles* and *Datisca*. The former two are monotypic, represented by *Octomeles sumatrana* Miq. and *Tetrameles nudiflora* R. Br., both of which are large trees distributed from Southeast Asia to the western Pacific, and *Datisca* consists of perennial herbs with 1 species in southern Asia and North-western America each.

Binuang: *Octomeles sumatrana* Miq.

The genus *Octomeles* consists of *O. sumatrana*, distributed in the Philippines, Sumatra, Borneo, Sulawesi, the Moluccas and New Guinea. It is widely called Binuang (or Benuang) in Southeast Asia and Erima or Ilimo in New Guinea. It is a fast growing species mainly found in secondary forests.

Macroscopic features. Wood unattractive pale yellowish white to pale yellow, without clear demarcation between sapwood and heartwood, sometimes with a pale reddish brown tinge in heartwood. Planed surfaces lustrous. Texture coarse. Grain generally heavily interlocked. Easily affected by blue-stain fungi. Wood light to rather light with an air dry specific gravity of 0.35 (0.26-0.45).

Microscopic features. Vessels mostly solitary, sometimes in radial multiples of 2(-3) (Fig. 59); tangential diameter of solitary vessels 140-240(-270) µm; frequency 5 (2-8)/mm^2; perforations simple; intervessel pits alternate, 5-7(-8) µm in vertical diameter, the apertures often coalescent; vessel-ray pits simple, and oval, arranged in palisade (cf. Fig. 60, F), but usually axial parenchyma present between vessels and rays, where pits between vessels and axial parenchyma are simple or bordered, and often unilaterally compound (Fig. 60, D); tyloses infrequent.

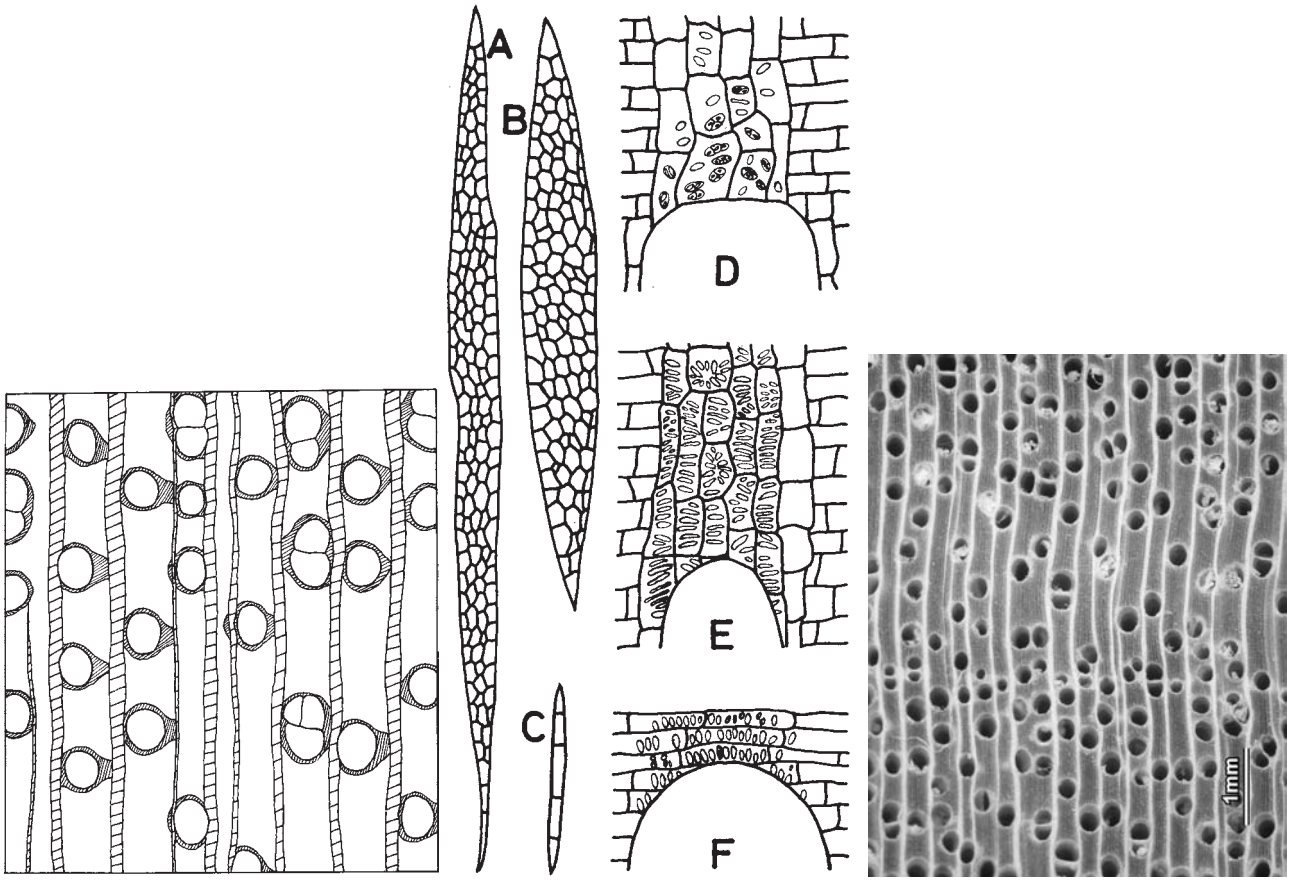
Rays 1-4- to 1-5(-7)-seriate, sometimes with coloured contents; height of multiseriate rays 400-2500 µm (maximum 800-2500 µm).

Axial parenchyma vasicentric, sometimes weakly aliform (Fig. 59), more distinct with a hand lens as pale tissue around the vessels than in the microscope.

Fibres non-septate, 1.7 (1.2-2.3) mm long, 40 µm in tangential diameter, with walls 1.5-2 µm thick.

Crystalline substances resembling crystal sand sometimes found in rays and axial parenchyma cells. Silica grains absent.

The wood of *Tetrameles nudiflora* is very similar to that of Binuang in its macroscopic and microscopic features. The difference from Binuang is that the wood has indistinct ripple marks due to the storied arrangement of its fusiform elements, especially the fibres, and pits between vessels and axial parenchyma are simple only (Fig. 60, E).



L **Fig. 59.** *Octomeles sumatrana*, × 25.

C **Fig. 60.** A-D: *Octomeles sumatrana*; E & F: *Tetrameles nudiflora*. - A-C: Ray types. - D & E: Vessel-axial parenchyma pits. - F: Radial section showing vessel-ray pits. A-C: × 80; D-F: × 120.

R *Octomeles sumatrana* (TWTw 11540) (Macrophoto).

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Ebenaceae

The family Ebenaceae consists of 2 genera, *Diospyros* and *Euclea.*

Kayu Malam: *Diospyros* spp.

The genus *Diospyros* consists of ca 480 woody species distributed in tropical to temperate regions. The centre of the distribution of this genus is in the tropics and species are especially abundant in Southeast Asia and Africa. However, some species occur in temperate regions. For example, Kaki (*D. kaki* Thunb.), which is perhaps of Chinese origin, has been widely cultivated in Japan for its fruit and the heartwood rarely with black streaks is used for handicrafts, and the wood of Persimon (*D. virginiana* L.) which is native to the southeastern part of North America is favoured for the production of golf club heads. The genus *Maba* is sometimes separated from the genus *Diospyros*. The genus *Euclea*, on the other hand, comprises ca 12 species distributed in tropical Africa to Asia and the Comoro Islands.

Some species of *Diospyros* have a black heartwood, which is called ebony. The following kinds of ebony have been distinguished.

Streaky ebony: Wood black with greyish or reddish brown streaks.

Green ebony: Wood black with a blue-green tinge, without lustre.

Marblewood: Wood with black and yellowish stripes like a marble or zebra.

In PROSEA 5 (2) (Lemmens et al., 1995), about 45 ebony species from Southeast Asia and the Malesian region are described, including *D. blancoi* A. DC. (Syn.: *D. discolor* Willd.), *D. philippensis* (Desr.) Guerke, *D. buxifolia* (Blume) Hiern, *D. celebica* Bakh., *D. durionoides* Bakh., *D. ebenum* Koenig, *D. ferrea* (Willd.) Bakh. and *D. rumphii* Bakh. The species in Borneo are usually small to medium-sized trees and only a few have a black heartwood used as ebony.

Kayu Malam is the name to the species of *Diospyros* used widely in Malesia, because the bark of the trees of this genus is generally characteristically blackish, and "kayu" means wood or tree and "malam" means night or darkness in the Malay language. They are also called Kayu Hitam or Kayu Arang ("hitam" means black, and "arang" means charcoal).

Macroscopic features. Sapwood pale greyish yellow, pale brown, pale reddish brown or pinkish brown, sometimes with a greyish black tinge in dry woods, and often with brownish or blackish vessel lines on longitudinal surfaces; black heartwood developed only in certain species as mentioned above, and in most species black heartwood is very small in volume and limited to the central stem part or lacking without clear demarcation from sapwood. Texture moderately fine to medium-coarse, but very fine in ebony due to blackish cell contents in all tissues. Grain straight to shallowly interlocked. Air

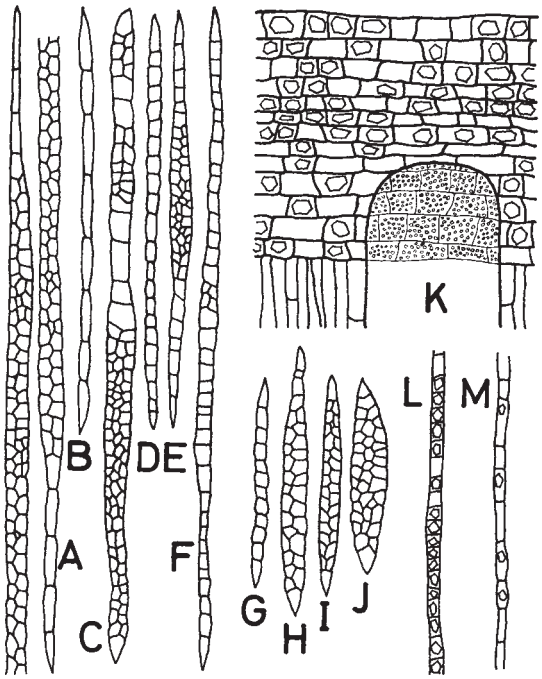
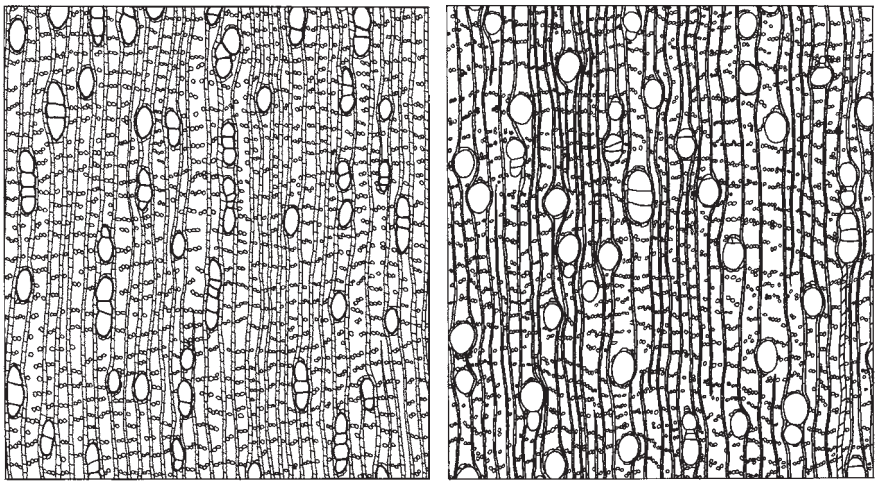


Fig. 102. A & B: *Diospyros borneensis*; C: *D. papuana*; D: *D. ebenum*; E: *D. hallieri*; F & K: *D. ferrea*; G & M: *D. mollis*; H: *D. virginiana*; I & J: *D. kaki*; L: *D. frutescens*. - A-J: Ray types. - K: Radial section showing vessel-ray pits and crystals in ray cells. - L & M: Crystals in chambered axial parenchyma cells. A-M: × 80.



L **Fig. 100.** *Diospyros mollis*, × 25.
C **Fig. 101.** *Diospyros philippensis*, × 25.

このプレビューでは表示されない頁があります。

Fagaceae

The family Fagaceae consists of 7 genera and ca 900 species of trees and shrubs distributed mainly in the tropical to temperate regions of the northern hemisphere.

(1) Berangan: *Castanopsis* spp.

The genus *Castanopsis* consists of ca 120 woody species distributed from India, throughout tropical to subtropical (partly temperate) Asia, to the western Pacific. One species, *C. chrysophylla* A. DC., is present in the western part of North America. For this American species, a separate genus *Chrysolepis* is often applied. Berangan is the name used to the trees of the genus *Castanopsis* in Malaysia.

Macroscopic features. Sapwood pale yellowish grey with a brown tinge, usually not sharply differentiated from the somewhat darker heartwood, but sometimes golden brown heartwood distinct. Usually with golden lustre. Texture rather coarse to coarse. Grain straight to shallowly interlocked. Stained black in contact with iron in a wet condition. Air dry specific gravity 0.53-0.96.

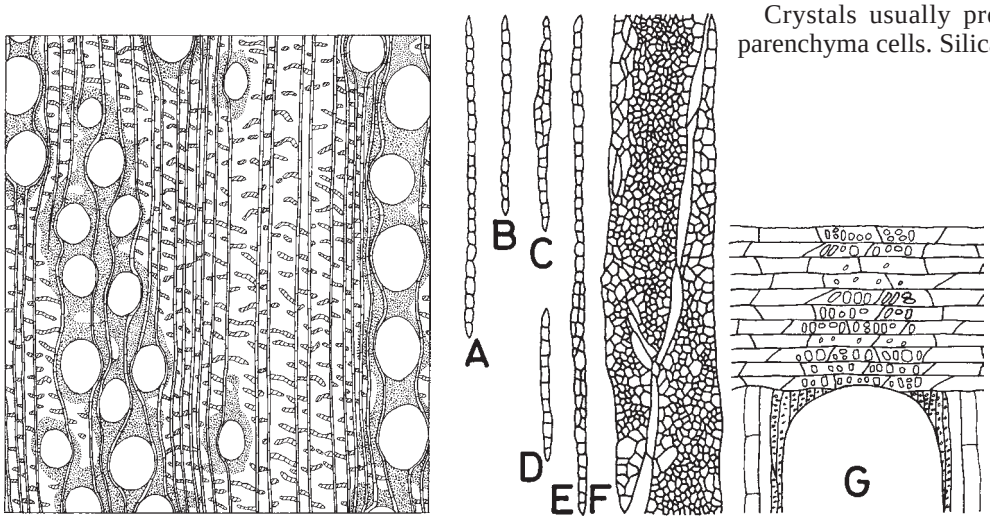
Microscopic features. Vessels exclusively solitary, arranged typically in an oblique to radial pattern (Fig. 121); maximum tangential diameter 280-330 µm; perforations simple; vessel-ray pits simple, and round to oval, usually in palisade, sometimes elongated horizontally also (Fig. 122, G); tyloses present; vasicentric tracheids present in several layers, which are seen as a paler sheath around the vessels with a hand lens (Fig. 121).

Rays usually uniseriate (partially biseriate), sometimes 1-2-seriate, up to 600-1000 µm high; broad rays occasionally present in some species in Japan and Taiwan (Fig. 122, F), but not reported in species from tropical Asia.

Axial parenchyma diffuse-in-aggregates to in interrupted short tangential lines (Fig. 121), which are not very distinct in the microscope due to lack of contrast with fibres.

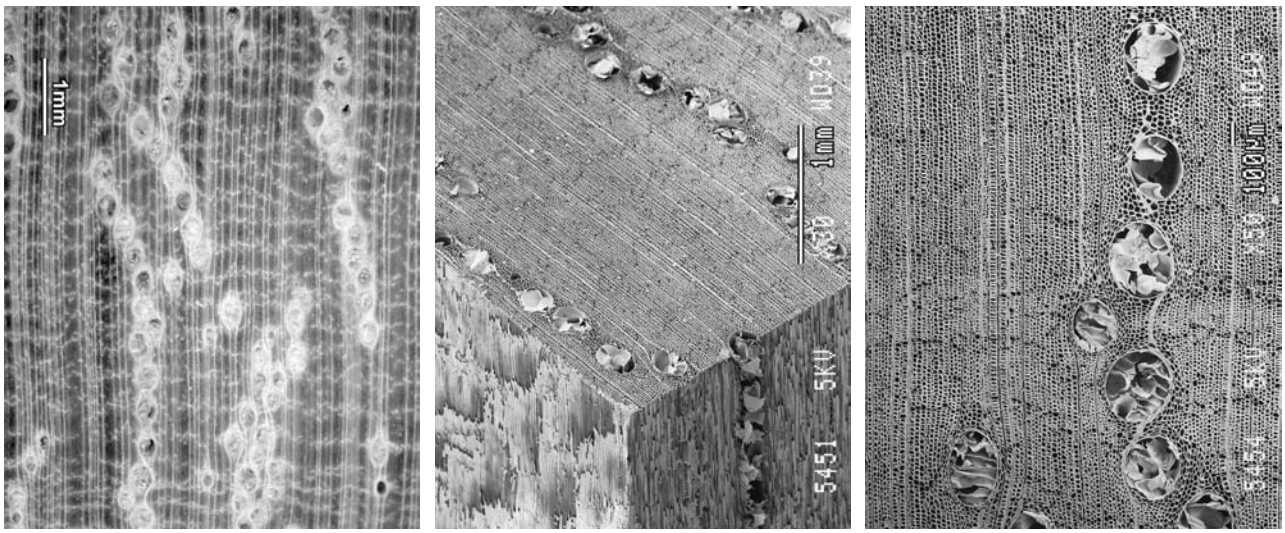
Fibres non-septate, 1.4 (1.0-1.8) mm long (*C. javanica*), with a tangential diameter of 25-37 µm and a wall thickness 2-3 µm; pits on radial walls minute, infrequent and inconspicuous.

Crystals usually present in chambered axial parenchyma cells. Silica grains absent.



L **Fig. 121.** *Castanopsis javanica* (vasicentric tracheids around vessels), × 25.

R **Fig. 122.** A, B & G: *Castanopsis javanica*; C-E: *Castanopsis* sp.; F: *C. longicaudata*. - A-F: Ray types. - G: Radial section showing vessel-ray pits and vasicentric tracheids. A-G: × 80.



Castanopsis javanica (TWTw 4418).

L (Macrophoto).

C R Vessels exclusively solitary, arranged typically in an oblique to radial pattern, and axial parenchyma diffuse-in-aggregates to in interrupted short tangential lines. C (3D: SEM). R (CS: SEM).

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Gonystylaceae

The family Gonystylaceae, which consists of single genus *Gonystylus*, is close to Thymelaeaceae, and often treated as a subfamily of the latter (APG II, 2003).

Ramin: *Gonystylus* spp.

The genus *Gonystylus* consists of ca 20 woody species distributed in the Malay Peninsula, Sumatra, Borneo, the Philippines, Sulawesi, New Guinea, Solomons and Fiji. Borneo is the centre of distribution with about 15 species, but to the east of Sulawesi there is only one species, *G. macrophyllus* (Miq.) Airy Shaw. The most important timber species is *G. bancanus* (Miq.) Kurz growing in the peat swamp forests in Malaya, Sumatra and Borneo, and is called Ramin in the Malay language. *G. macrophyllus*, *G. forbesii* Gilg (Sumatra and Borneo), *G. velutinus* Airy Shaw (Sumatra and Borneo), *G. maingayi* Hook. f. (Malaya and Sumatra) and *G. confusus* Airy Shaw (Malaya and Sumatra) are also important species. The timbers of all these species are treated commercially as Ramin. The fibrous bark of Ramin gives irritant effects to the skin when the timbers are processed. The wood anatomical characteristics are similar throughout the genus.

Macroscopic features. Wood pale yellowish white with slight lustre, without demarcation between sapwood and heartwood. Pale brownish yellow streaks of vessels distinct on longitudinal surfaces. Texture fine to rather fine. Grain straight to shallowly interlocked. Wood moderately heavy with an air dry specific gravity of 0.64 (0.54-0.75).

Microscopic features. Vessels solitary and in radial multiples of 2-3(-6), usually the latter predominant (Fig. 131); maximum tangential diameter 120-190 µm in solitary vessels and 170-230 µm in vessel multiples; frequency 7(4-12)/mm^2; perforations simple; intervessel pits alternate, 4 µm in vertical diameter, apertures often coalescent, vestured; vessel-ray pits similar to intervessel pits (Fig. 132, G); tyloses absent.

Rays usually exclusively uniseriate except for occasional biseriate parts, but sometimes biseriates common according to the specimen; maximum height 700-2000 µm; without coloured contents.

Axial parenchyma winged-aliform to confluent with narrow wings (Fig. 131).

Fibres non-septate, 1.6 (1.2-1.9) mm long (*G. bancanus*) with abruptly tapering ends (Fig. 132, D), ca 25 µm in tangential diameter with walls 4-5 µm thick; with a tendency to storied arrangement; many minutely bordered pits present on radial walls.

Crystals usually present in rays, small and sometimes styloid, 1 to several per cell, but absent in some specimens (Fig. 132, F); crystals occasionally also in axial parenchyma (Fig. 132, E). Silica grains absent.

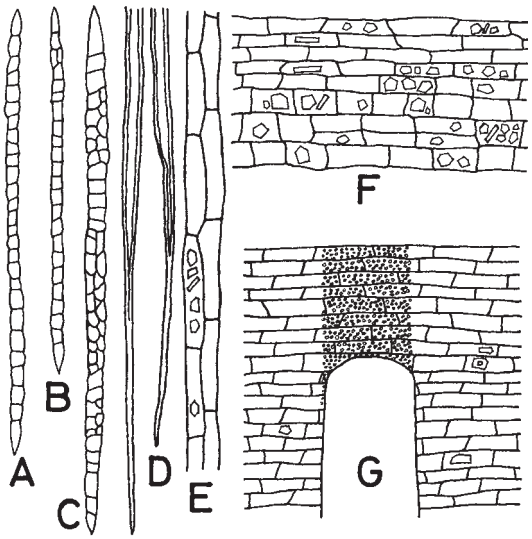
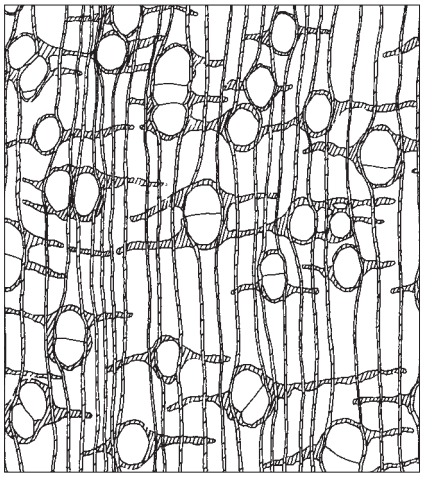
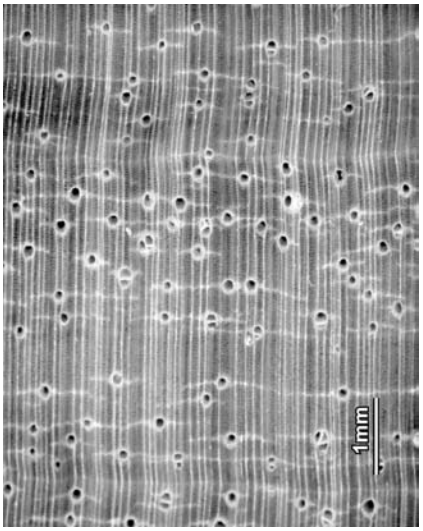
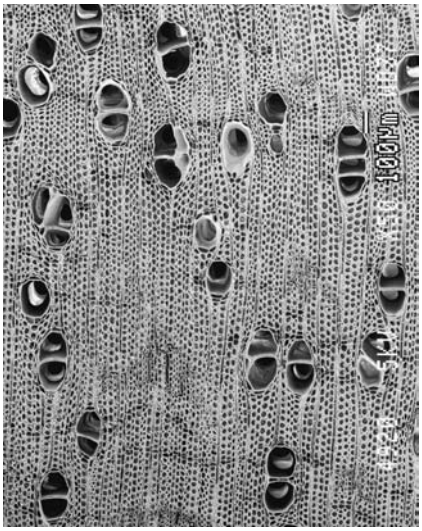


Fig. 132. A-G: *Gonystylus bancanus*. - A-C: Ray types. - D: Libriform wood fibre. - E & F: Crystals in axial parenchyma cells (E) and ray cells (F). - G: Radial section showing vessel-ray pits. A-G: × 80.







L **Fig. 131.** *Gonystylus bancanus*, × 25.
C *Gonystylus punctatus* (TWTw 2461). R *G. bancanus* (TWTw 4435).
C (Macrophoto).
R Axial parenchyma winged-aliform to confluent with narrow wings (CS: SEM).

このプレビューでは表示されない頁があります。

Hamamelidaceae (Altingiaceae)

The family Hamamelidaceae consists of ca 30 genera and 100 species of trees and shrubs distributed widely in the world, especially in the subtropical regions of East Asia. *Altingia*, traditionally classified in Hamamelidaceae, is recognized as a separate family, in recent DNA-based classifications (APG II, 2003)

Rasamala: *Altingia excelsa* Noronha

Altingia excelsa occurs in Bhutan, Assam, Myanmar, Malaya, Sumatra and Java, and attains a height of 40-50 (-60) m and a diameter of 80-110(-120) cm. Rasamala (Rasamalah) is a name used in Java, where it grows in the mountain forests, 500-1700 m above sea level, mixed with species of *Lithocarpus*, *Quercus* and *Castanopsis*, or often in pure stands, and is often called "the king of mountain forests" because of its magnificent stems.

The wood is regarded as one of the best in Java, though it is said that it dries slowly and is prone to warping, twisting and checking. Trial plantations of this species were first made in Java already in the middle of the 19 th century, and the species has potential to become an important plantation tree in mountain forests in the tropics. There are 6 other species in the genus *Altingia* occurring from the eastern Himalaya to South China.

Macroscopic features. Sapwood pale brown to brown, merging gradually into dark brown to dark reddish brown heartwood, without much lustre. Texture rather fine to fine. Grain interlocked. Air dry specific gravity 0.74-0.85.

Microscopic features. Vessels almost exclusively solitary, some in radial multiples of 2(-4) (Fig. 145); frequency 44-60/mm^2; maximum tangential diameter of solitary vessels 100-120 µm; perforations scalariform with 15-20 bars (Fig. 146, G); vessel-ray pits scalariform to gash-like, usually found only in the cross fields between vessels and marginal upright ray cells (Fig. 146, H); tyloses common.

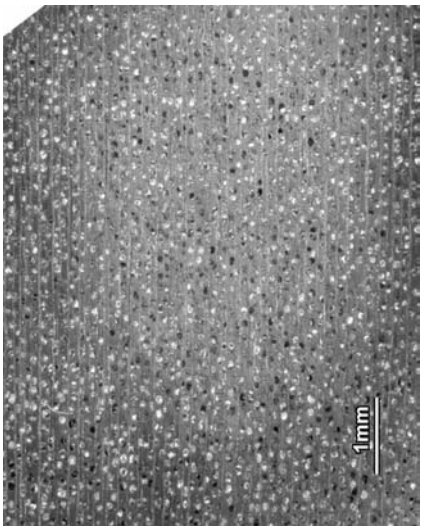
Rays 1-3- to 1-4-seriate, 3(4)-seriates predominant; maximum height 1300-2200 µm; usually with coloured contents.

Axial parenchyma diffuse (Fig. 145), not abundant, but distinct in the microscope due to the sharp contrast with thick-walled fibres.

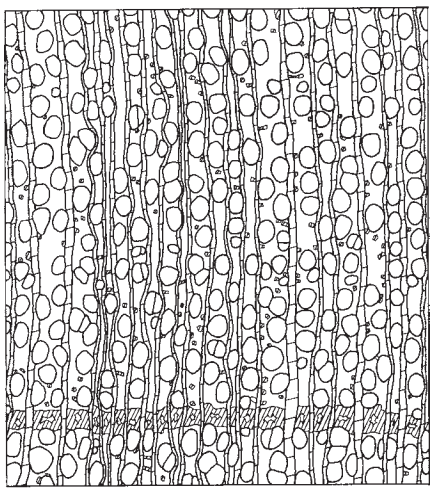
Fibres non-septate, 2.3 (1.5-3.3) mm long, with a tangential diameter of 25-45 µm and a wall thickness of ca 7-15 µm; large bordered pits fairly abundant both on radial and tangential walls.

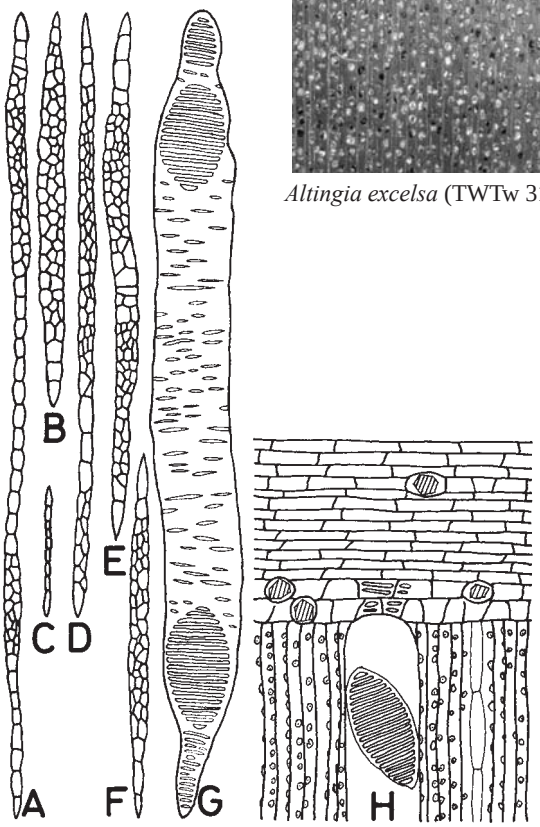
Crystals common in rays (Fig. 146, H). Silica grains absent.

Traumatic resin canals often present, 20-40 µm in diameter, regular in the shape, in continuous tangential series (Fig. 145) and distinct even to the naked eye as white lines.



Altingia excelsa (TWTw 3123) (Macrophoto).





L **Fig. 145.** *Altingia excelsa* (traumatic resin canals in a concentric band), × 25.

R **Fig. 146.** A-H: *Altingia excelsa*. - A-F: Ray types. - G: Vessel element with scalariform perforation plates. - H: Radial section showing vessel-ray pits and crystals in ray cells. A-H: × 80.

このプレビューでは表示されない頁があります。

Icacinaceae (Stemonuraceae)

The family Icacinaceae consists of ca 50 genera and 400 species of trees, shrubs and lianas distributed mainly in the tropical regions of the world. According to DNA-evidence, the traditional Icacinaceae have been split into different families, and *Cantleya* is now classified in Stemonuraceae (APG II, 2003).

Cantleya: *Cantleya corniculata* (Becc.) Howard

The genus *Cantleya* is a monotypic genus distributed in Malaya, Sumatra and Borneo. It attains a height of 40 m, and a diameter of 60(-l50) cm, but is not very common.

Macroscopic features. Sapwood pale yellowish brown. Heartwood yellowish brown to brown, clearly differentiated from sapwood. With slight lustre. Texture rather fine to fine. Grain almost straight to shallowly interlocked. Wood with a fragrance when fresh. Air dry specific gravity 1.00-1.14.

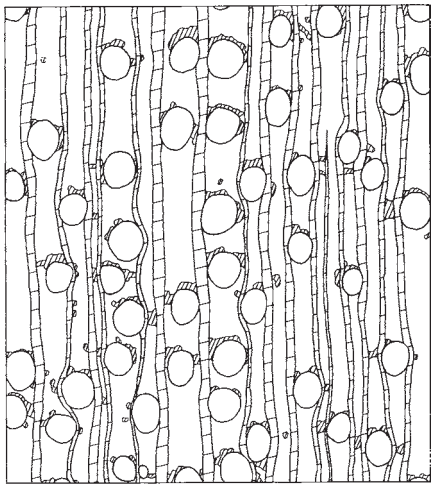
Microscopic features. Vessels almost exclusively solitary, but rarely in radial multiples (Fig. 149); tangential diameter 150-200 µm; frequency 6.5-12/mm^2; perforations mostly simple, but occasionally scalariform in relatively narrow vessels; vessel-ray pits not very common, simple or bordered, round to oval, irregular in size (Fig. 150, G); sclerotic tyloses often present.

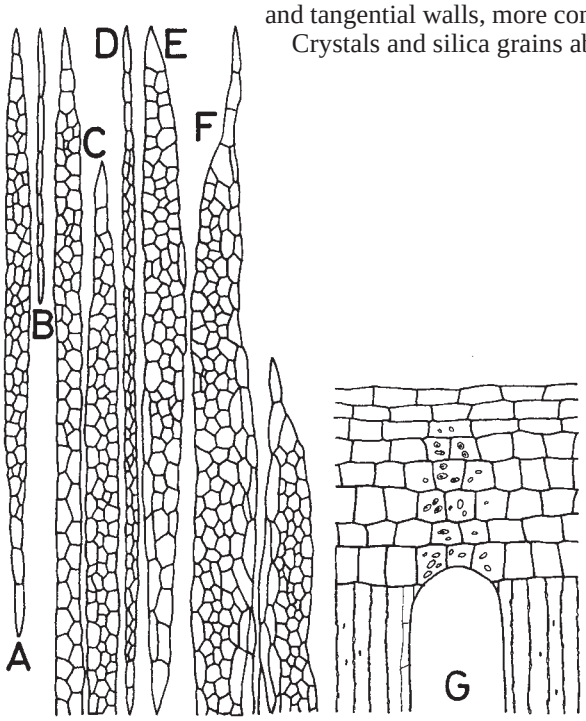
Rays 1-2(-3)- to 1-4(-5)-seriate; maximum height 1300-2800 µm; without coloured contents.

Axial parenchyma scanty paratracheal to vasicentric sometimes with short wings, with a tendency to unilateral arrangement, and scanty diffuse (Fig. 149).

Fibres non-septate, 2.0 (1.6-2.6) mm long, with a tangential diameter of 20-50 µm and a wall thickness of ca 10-20 µm; rather large, bordered pits present on radial and tangential walls, more conspicuous on the latter.

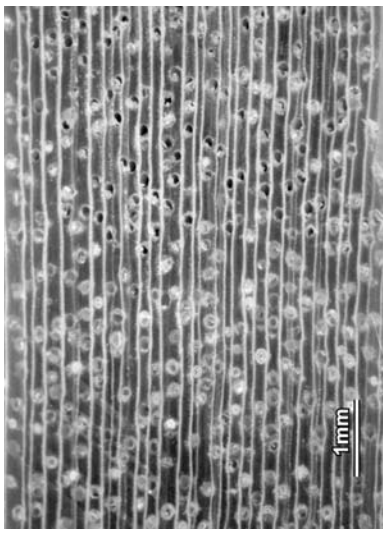
Crystals and silica grains absent.

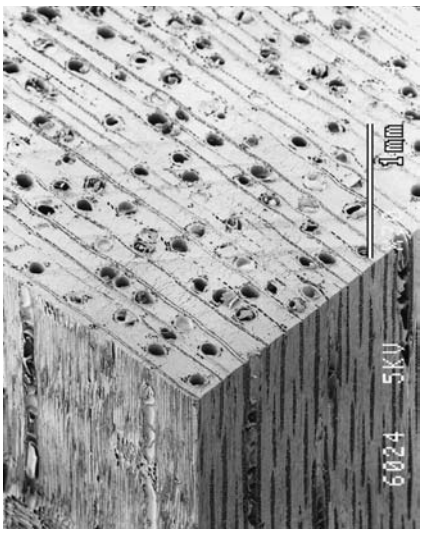


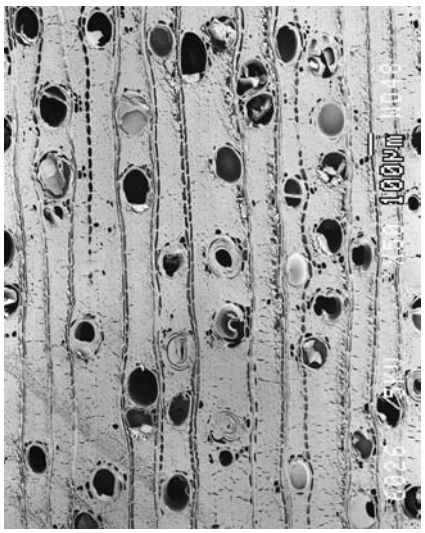


L **Fig. 149.** *Cantleya corniculata*, × 25.

R **Fig. 150.** A-G: *Cantleya corniculata*. - A-F: Ray types. - G: Radial section showing vessel-ray pits. A-G: × 80.







Cantleya corniculata (TWTw 3140).

L (Macrophoto).

C R Vessels almost exclusively solitary, and axial parenchyma scanty paratracheal to vasicentric. *C* (3D: SEM). *R* (CS: SEM).

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Lauraceae

The family Lauraceae consists of ca 35-45 genera and 2500 or more species, all of which, except the genus *Cassytha,* are woody, distributed mostly in the tropical to subtropical regions of the world, especially Southeast Asia and South America. Some species produce spices, camphor, medicines and edible fruits. Belian mentioned below or Greenheart *Nectandra rodiaei* Hook. in South America are known for their heavy and durable wood, but most Lauraceae species have medium-weight woods that are generally called Medang in the Malay language regions. Main genera in Southeast Asia are *Actinodaphne*, *Alseodaphne*, *Beilschmiedia*, *Cinnamomum*, *Cryptocarya*, *Dehaasia*, *Endiandra*, *Litsea*, *Nothaphoebe* and *Phoebe*. It is difficult to distinguish each genus clearly on the basis of wood anatomical characters.

(1) Belian: *Eusideroxylon zwageri* Teijsm. & Binnend.

Eusideroxylon is a monotypic genus. Belian is a medium-sized to large tree attaining a height of 40 m and a diameter of 120 cm. It is distributed in Borneo, Sumatra and the Sulu Archipelago. In Borneo it is generally fairly common in Kalimantan, Sarawak and Sabah, but it has not been recorded in Brunei. It is known as one of the best and durable woods in these regions. It withstands fungal and insect attack, marine borers and termites for many years, and is used mostly for heavy structural work, bridges and harbours, sleepers, house foundations, roof shingles and poles for pepper cultivation.

The name Belian is used in Sabah and Sarawak. It is called Ulin, Onglen or Kayu Besi in Kalimantan and Tambulian in the Sulu Archipelago. The English name is Borneo lronwood.

Potoxylon melagangai (Sym.) Kosterm., which was first described and is often treated even now as *Eusideroxylon melagangai* Sym., is distributed in the same regions and is also common in Brunei. The wood of this species is lighter than Belian with an air dry specific gravity of 0.52-0.85, and has more reddish colour and inferior quality to that of Belian in strength and durability.

Macroscopic features. Sapwood pale yellow, and heartwood brownish yellow when fresh, on exposure turning brown and chocolate brown to blackish brown respectively, clearly demarcated from sapwood. Texture medium-coarse. Grain straight or shallowly interlocked. Air dry specific gravity 1.04 (0.83-1.09) .

Microscopic features. Vessels solitary and in radial multiples of 2-3(-5) (Fig. 153); tangential diameter of solitary vessels 100-240 µm (maximum 200-240 µm); frequency 2.5-5.5/mm^2; perforations simple; intervessel pits alternate, ca 9-12 µm in vertical diameter; vessel-ray pits round to oval, rather sparse (Fig. 154, G); tyloses present almost in all vessels, sometimes sclerotic.

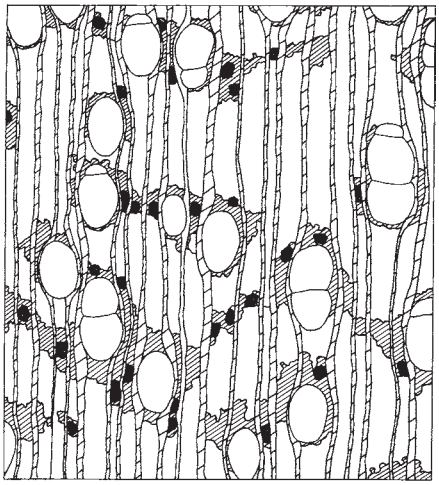
Rays 1-3 to 1-4(-5)-seriate, mostly 2-3- or 4-seriate, uniseriates low and sparse; maximum height 2300-2800 µm; with rather thick cell walls (2-5-3.5 µm thick).

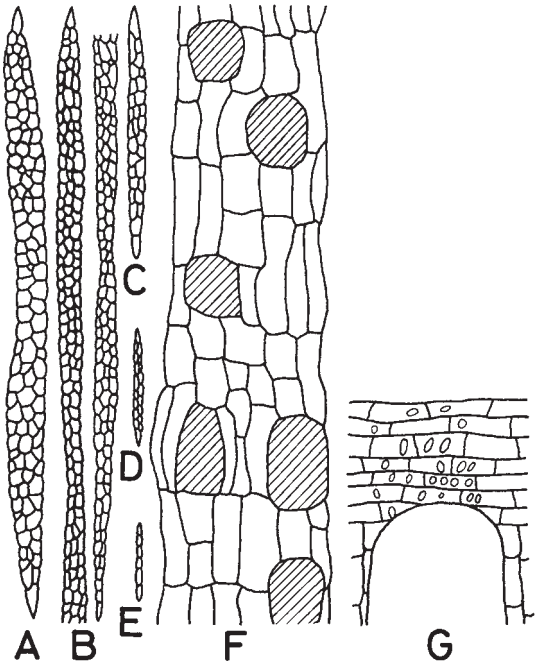
Axial parenchyma aliform to confluent (Fig. 153), pale brown to the naked eye and with a hand lens around the vessels; sometimes in concentric bands.

Fibres non-septate, 1.9 (1.2-2.6) mm long, with a tangential diameter of 15-40 µm and a wall thickness of ca 5-12 µm; minute simple pits present on radial and tangential walls, but rather sparse and inconspicuous.

Oil cells present associated with axial parenchyma, with a tangential diameter of 40-75 µm, a radial diameter of 50-100 µm and a longitudinal diameter of 90-220 µm, somewhat angular (Fig. 154, F).

Crystals and silica grains absent.





L **Fig. 153.** *Eusideroxylon zwageri* (black spots: oil cells), × 25.

R **Fig. 154.** A-G: *Eusideroxylon zwageri*. - A-E: Ray types. - F: Oil cells in axial parenchyma. - G: Radial section showing vessel-ray pits. A-G: × 80.

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Magnoliaceae

The family Magnoliaceae consists of 13 genera and ca 240 species of trees and shrubs distributed in the temperate to tropical regions especially of Asia and America.

Table 9 Some generic microscopic characteristics of Magnoliaceae

Genus	Vessels			Oil cells	No. of species	Distribution
	Perforations	Bars [1]	Intervessel pits			
Alcimandra	scalariform	8-15	scalariform	–	1	SE Asia
Aromadendron	scalariform	6-10	scalariform	+	3	SE Asia
Elmerrillia	scalariform (+ simple)	1-10	scalariform	+	4	Borneo～New Guinea
Kmeria [2]	scalariform	8-12	scalariform	–	2	SE Asia
Liriodendron	scalariform	2-16	opposite	–	2	Asia, N America
Magnolia	simple (+ scalariform)	(1-10)	scalariform	– (+)	80	Asia, America
Manglietia	scalariform	1-12	scalariform	–	25	SE Asia
Michelia	scalariform	1-7	scalariform	+	30	Asia
Talauma	scalariform	4-25	scalariform	+	50	Asia, C & S America

[1] Number of bars in scalariform perforation. [2] Data about *Kmeria* from Canright (1955).

(1) Elmerrillia: *Elmerrillia* spp.

The genus *Elmerrillia* consists of ca 7 species distributed in Borneo, the Philippines, Sulawesi, the Moluccas and New Guinea. Most species are small to medium-sized trees, but *E. papuana* Dandy from the Moluccas to New Guinea is up to 35 m high and 90 cm in diameter and produces a good wood similar to that of the species of the genus *Michelia* in its macroscopic and microscopic characteristics. It is called Wau Beech in Papua New Guinea.

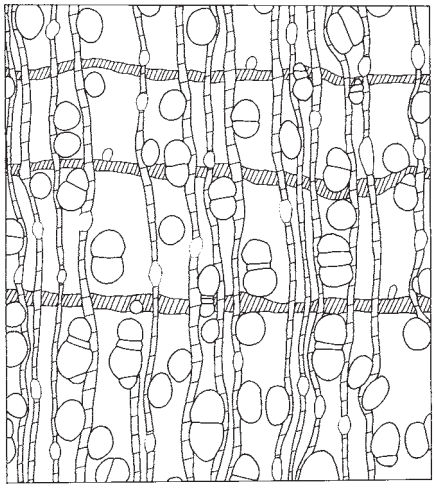
Macroscopic features. Sapwood pale yellowish white, heartwood pale yellowish brown to pale brown, sometimes with a green tinge, with golden lustre. Texture medium-coarse. Grain interlocked. Air dry specific gravity 0.46-0.59.

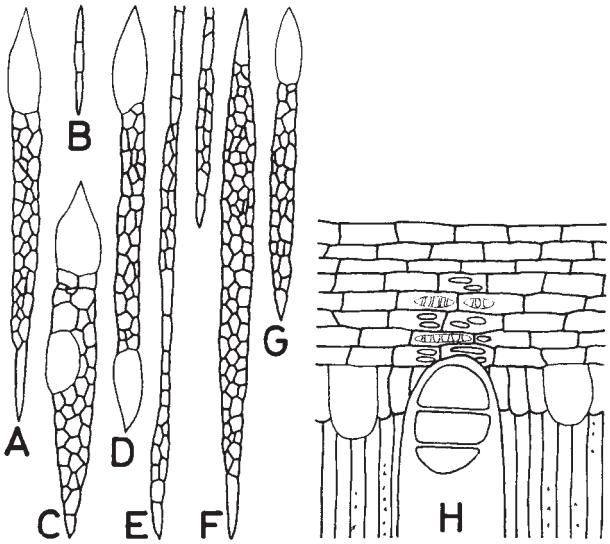
Microscopic features. Vessels solitary and in radial multiples of 2-3 to 2-4(-6), the percentage of the former and the latter almost even or the latter predominant (Fig. 210); frequency 7-16/mm^2; maximum tangential diameter of solitary vessels 180-220 μm; perforations exclusively scalariform with 1-6(-10) bars (Fig. 211, H), or scalariform and occasionally simple, according to the species or the specimen; intervessel pits scalariform, ca 10 μm in vertical diameter; vessel-ray pits simple, and horizontally elongated, often unilaterally compound (Fig. 211, H); tyloses absent.

Rays 1-3- to 1-4(-5)-seriate, 1-2-seriates sparse, with a maximum height of 450-1100 μm.

Axial parenchyma in marginal bands, 2-4 cells wide, at irregular intervals of 2-5 mm (Fig. 210), visible to the naked eye or with a hand lens as pale bands.

Fibres non-septate, 1.5 (0.9-2.1) mm (*E. mollis*) and 1.8 (1.0-1.4) mm long (*E. papuana*), with a tangential diameter of 20-45 μm and a wall thickness of 2-3 μm; minutely bordered pits present on radial walls, but not abundant and not conspicuous. Large oil cells often (but not always) present, usually in ray margins, sometimes in the body of the rays (Fig. 211, A-D & G), discernible with a hand lens as minute dots. Crystals and silica grains absent.





L **Fig. 210.** *Elmerrillia mollis*, × 25.

R **Fig. 211.** A-C: *Elmerrillia papuana*; D: *E. mollis*; E: *Manglietia glauca*; F: *Talauma hodgsonii*; G: *T. gioi*. - A-G: Ray types (oil cell present in A, C, D & G). - H: Radial section showing vessel-ray pits, a scalariform perforation plate and oil cells in ray). A-H: × 80.

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Nothofagaceae

The family Nothofagaceae was formerly included in the family Fagaceae, but recently both are treated as separate families. Nothofagaceae are monogeneric consisting only of the genus *Nothofagus*.

New Guinea Beech: *Nothofagus* spp.

The genus *Nothofagus* consists of ca 37 species, that is, 11 in Chile and Argentine, 5 in New Zealand, 3 in Australia, 5 in New Caledonia and 13 in New Guinea. There are some good timber species including Red Beech *N. fusca* Oerst., Silver Beech *N. menziesii* (Hook. f.) Oerst. and Black Beech *N. solandri* (Hook. f.) Oerst. in New Zealand, Myrtle Beech *N. cunninghamii* (Hook.) Oerst. in southeastern Australia and Tasmania, Coigue *N. dombeyi* (Mirb.) Oerst. and Rauli *N. procera* (Poepp. & Endl.) Oerst. in Chile, and Roble *N. obliqua* (Mirb.) Oerst. in Chile and Argentine.

Most species from New Guinea are distributed only in the mainland, but 1 species occurs also in New Britain. They grow usually in the mountains from 1200 to 3000 m above sea level, so that the timbers are not much exploited. The wood anatomical characters of New Guinean species described below are different in some points from those of the species from other regions.

Macroscopic features. Sapwood pale brown to pale greyish brown. Heartwood light brown to reddish brown, without much lustre. Texture medium-coarse. Grain almost straight or shallowly interlocked. Growth rings indistinct. Air dry specific gravity 0.80-0.87.

Microscopic features. Vessels solitary and in radial multiples of 2-3 to 2-5(-9) (Fig. 247); evenly distributed, 9-16/mm^2; maximum tangential diameter of solitary vessels 200 µm; perforations simple; intervessel pits round in outline, rather loosely arranged, alternate, sometimes partially opposite, (7-)9-10 µm in vertical diameter; vessel-ray pits simple, small, and round and elongated horizontally (Fig. 248, H); helical thickenings sometimes present in tails of vessels of some species; tyloses usually abundant.

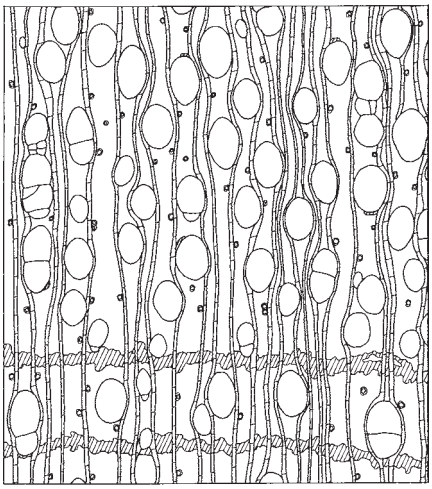
Rays 1-2(-3)-seriate; maximum height 1000-1200 µm high; generally with coloured contents.

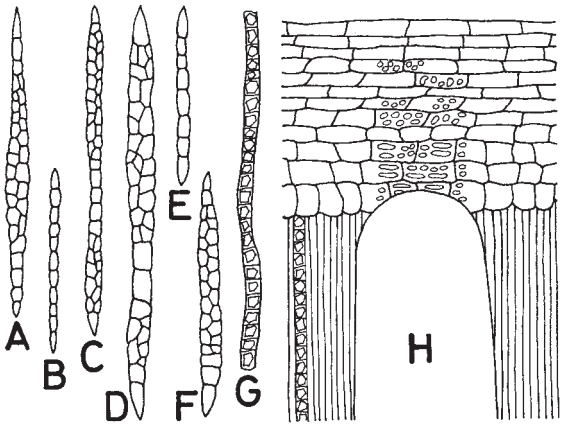
Axial parenchyma scanty paratracheal and in irregularly spaced bands, 1-5 mm apart (Fig. 247).

Fibres mostly neatly arranged in radial files; 1.4 (1.0-1.8) mm long (*N. grandis*), with a tangential diameter of 12-25 µm, with walls 3-5 µm thick; pits present on radial walls, but rather sparse and inconspicuous; septate fibres sometimes present but generally sparse.

Crystals present in chambered axial parenchyma cells (Fig, 245, G & H). Silica grains absent.

In comparison with the New Guinean species, the characteristics of the species of other regions are as follows. Growth rings (annual rings) distinct; texture fine to rather fine; vessels narrower with a maximum diameter of 40-120 µm in solitary vessels and numerous (50-120/mm^2); perforations usually simple, but often scalariform in narrow vessels near the boundary of growth rings; intervessel pits opposite to scalariform, 6-7 µm in vertical diameter; vessel-ray pits present only in cross fields between vessels and marginal upright ray cells, small, and oval and scalariform; helical thickenings present throughout vessels in some species, e.g. *N. moorei*; rays uniseriate only or 1-2(-3)-seriate; axial parenchyma marginal and not very distinct; septate fibres abundant in some species, especially in latewood; fibre-tracheids present in layers along the boundary of growth rings; silica grains present in rays of New Zealand species: *N. solandri*, *N. truncata* and *N. fusca*, especially in latewood. It is rather unusual that silica grains are present in the species of such a high latitude region as New Zealand.





L **Fig. 247.** *Nothofagus grandis* (black dots: crystalliferous chambered axial parenchyma cells), × 25.

R **Fig. 248.** A-C, G & H: *Nothofagus grandis*; D-F: *N. perryi*. - A-F: Ray types. - G: Crystals in chambered axial parenchyma cells. - H: Radial section showing vessel-ray pits and crystals in chambered axial parenchyma cells. A-H: × 80.

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Olacaceae

The family Olacaceae consists of ca 25 genera and 200 species of trees, shrubs and lianas distributed mainly in the tropical regions of the world.

Kulim: *Scorodocarpus borneensis* (Baillon) Becc.

The genus *Scorodocarpus* is monotypic and distributed in the lowlands of Malaya, Sumatra and Borneo. The tree can be up to 35 m tall and 70 cm in diameter, and is characteristic in having a strong garlic smell of the sap. The wood structure is very similar to that of *Ochanostachys amentacea* Mast. of the same family and it is difficult to distinguish them.

Macroscopic features. Heartwood dull dark brown with a purple tinge, without lustre. Sapwood paler, and gradually merging into heartwood without clear demarcation. Texture rather fine to fine. Grain generally interlocked, sometimes almost straight. Air dry specific gravity 0.64-1.08, commonly 0.85-0.95.

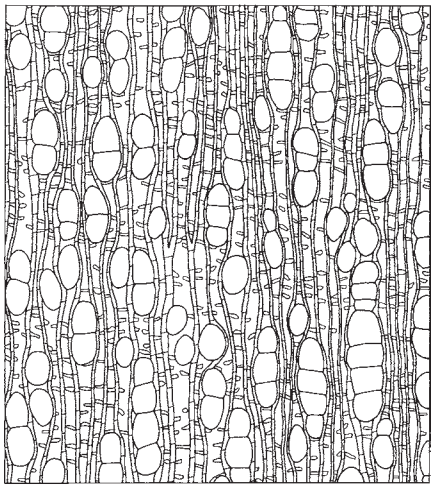
Microscopic features. Vessels solitary and in radial multiples of 2 to 2-4(-7), usually the latter predominant (Fig. 249); frequency 10-23/mm^2; maximum tangential diameter of solitary vessels 130-160 µm; perforations scalariform with 2-6 bars (Fig. 250, C & D); intervessel pits alternate to opposite, often elongated horizontally, 10-12 µm in vertical diameter; vessel-ray pits not very common, simple, and round to oval (Fig. 250, D); thin-walled tyloses usually common.

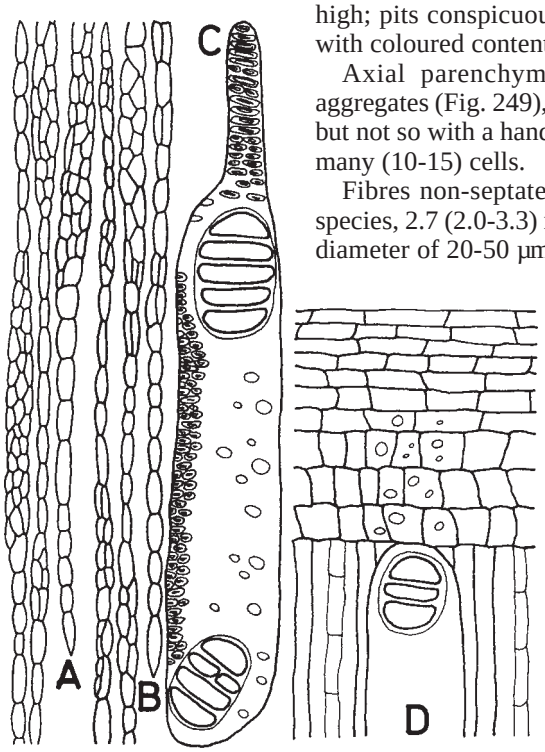
Rays 1-2- to 1-3-seriate, uniseriates sparse; multiseriates composed of multiseriate portions of procumbent cells and uniseriate portions of upright cells, up to 4500-9000 µm high; pits conspicuous on radial walls; usually with coloured contents.

Axial parenchyma diffuse to diffuse-in-aggregates (Fig. 249), distinct in the microscope but not so with a hand lens; strands generally of many (10-15) cells.

Fibres non-septate, very long for hardwood species, 2.7 (2.0-3.3) mm long, with a tangential diameter of 20-50 µm and walls 8-15 µm thick; minute pits present on radial walls, but sparse and inconspicuous.

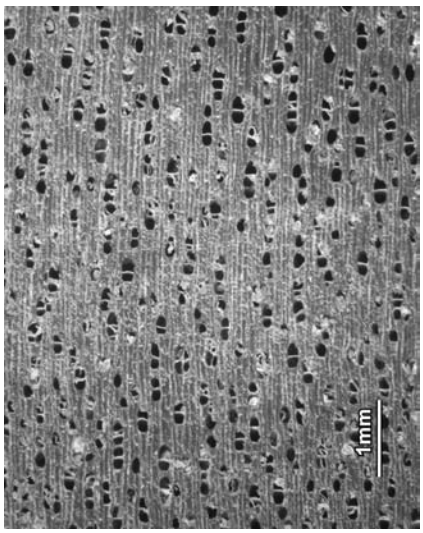
Crystals and silica grains absent.

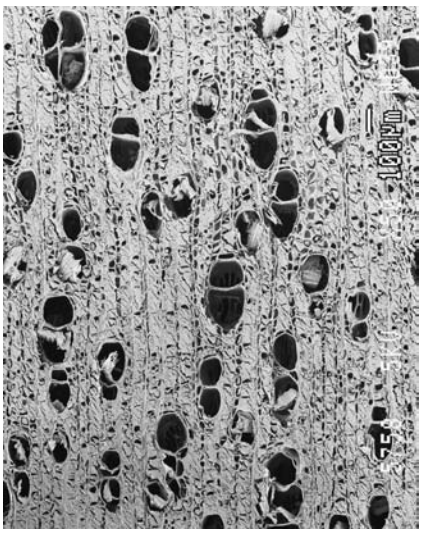


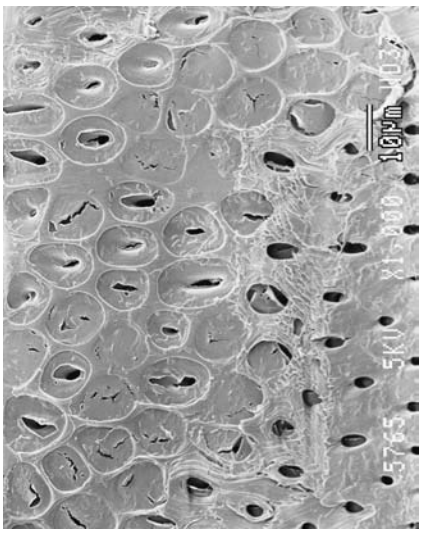


L **Fig. 249.** *Scorodocarpus borneensis*, × 25.

R **Fig. 250.** A-D: *Scorodocarpus borneensis*. - A & B: Ray types. - C: Vessel element with scalariform perforation plates. - D: Radial section showing vessel-ray pits and scalariform perforation plate. A-D: × 80.







Scorodocarpus borneensis (TWTw 7759).

L (Macrophoto).

C Axial parenchyma diffuse to diffuse-in-aggregates (CS: SEM).

R Intervessel pits alternate (TS: SEM).

このプレビューでは表示されない頁があります。

Polygalaceae

The family Polygalaceae consists of ca 17 genera and 1000 species of trees, shrubs, lianas and herbs distributed widely in the world.

Xanthophyllum: *Xanthophyllum* spp.

The genus *Xanthophyllum* consists of ca 60 woody species distributed in Southeast Asia to the western Pacific including New Guinea.

Macroscopic features. Sapwood and heartwood not differentiated by colour, pale yellowish white, pale greyish yellow, pale brownish yellow or brownish yellow. Without distinct lustre. Texture coarse to rather coarse. Grain interlocked. Air dry specific gravity 0.65-1.05, commonly 0.75-0.95.

Microscopic features. Vessels exclusively solitary; very irregular in distribution, crowded in some parts and sparse in others in cross section, sometimes in a zigzag pattern (Fig. 251); frequency 0.5-3/mm^2; maximum tangential diameter 280-390 µm; narrow vessels 40 µm in diameter present among large vessels (Fig. 251); perforations simple; vessel-ray pits bordered, small, 3-4 µm in vertical diameter (Fig. 252, M); tyloses absent; often with white to pale yellow chalky deposits.

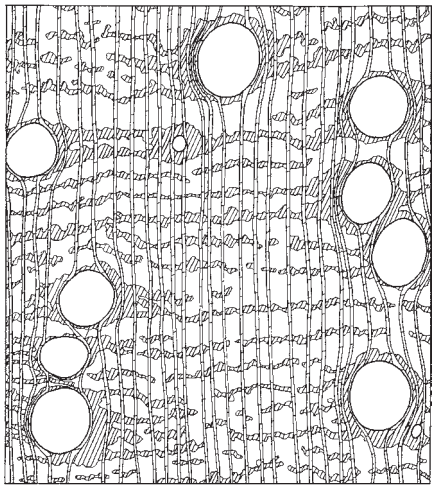
Rays uniseriate or 1-2-seriate, up to 1300-2300 µm high; without coloured contents.

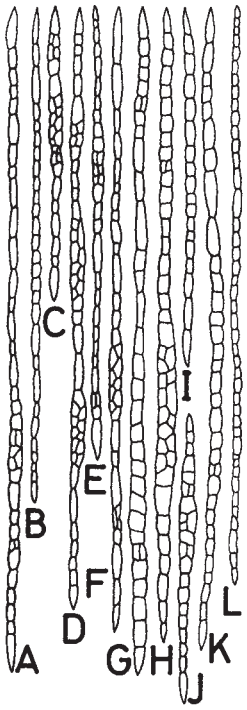
Axial parenchyma paratracheal in broad sheaths around the vessels and in closely spaced bands 0.05-0.2 mm apart (Fig. 251), distinct in the microscope or also with a hand lens.

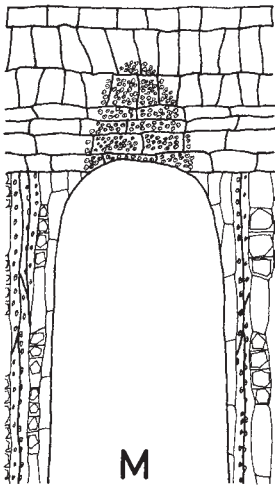
Fibres non-septate, 1.8 (1.1-2.3) mm (*X. affine*) and 1.7 (1.2-2.3) mm long (*X. papuanum*), with a tangential diameter of 17-35 µm, walls 3-8 µm thick; large bordered pits present on radial and tangential walls, more conspicuous on the latter.

Crystals often present in chambered axial parenchyma cells (Fig. 252, M). Silica grains present in rays and axial parenchyma in some species but sparse and not very conspicuous.

The wood anatomy of this genus is somewhat similar to that of the genus *Parinari* of the family Chrysobalanaceae especially in the distribution pattern of vessels and ray types (narrow rays), but in *Parinari*, heartwood is more brownish, vasicentric axial parenchyma not well developed, vessel-ray pits are simple and oval, and silica grains distinct in the rays.

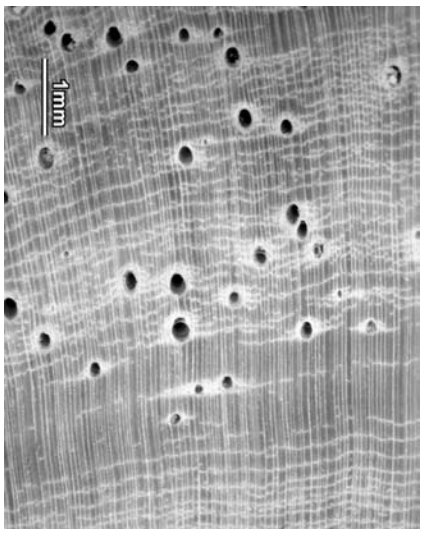


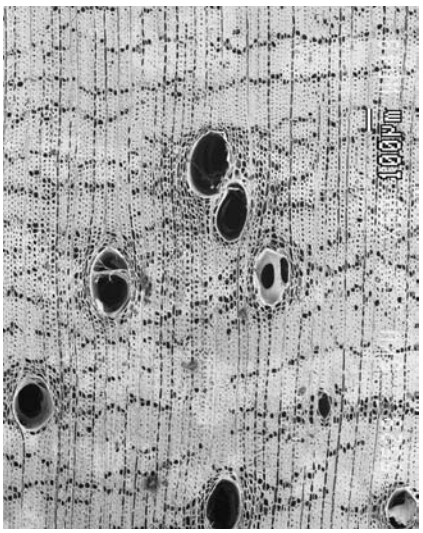


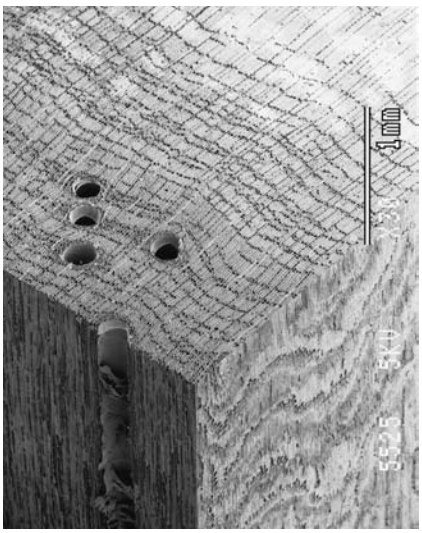


L **Fig. 251.** *Xanthophyllum affine*, × 25.

R **Fig. 252.** A-C: *Xanthophyllum affine*; D & E: *X. amoenum*; F: *X. ellipticum*; G & H: *X. excelsum*; I-K & M: *X. papuanum*; L: *X. scortechinii*. - A-L: Ray types. - M: Radial section showing vessel-ray pits and crystals in chambered axial parenchyma cells. A-M: × 80.







Xanthophyllum ferrugineum (TWTw 16874).

L (Macrophoto).

C R Vessels exclusively solitary and irregular in the distribution, and axial parenchyma paratracheal in broad sheaths and in closely spaced bands. C (CS: SEM). R (3D: SEM).

このプレビューでは表示されない頁があります。

Rhamnaceae

The family Rhamnaceae consists of ca 58 genera and 900 species of trees, shrubs and lianas distributed widely in the world.

Ziziphus: *Ziziphus* spp.

The genus *Ziziphus* comprises ca 100 species distributed mainly in the tropical to subtropical regions of the world. Some species, including *Z. jujuba* Mill., are often planted for their edible fruits. The trees of this genus are generally not important from the viewpoint of wood utilization because most are rather small trees, but some species, e.g. *Z. talanai* (Blanco) Merr. in the Philippines and *Z. grewioides* (Warb.) Perry in New Guinea, reach timber size and the timber, especially that of the latter species, is sometimes imported into Japan. The following description is based on *Z. grewioides*.

Macroscopic features. Sapwood dull brown. Heartwood dark brown to blackish brown with some shades, and with slight lustre. Chalky deposits present in some vessels. Texture rather fine. Grain shallowly interlocked. Air dry specific gravity ca 0.89.

Microscopic features. Vessels solitary and in radial multiples of 2-3 (Fig. 253); frequency ca 9/mm^2; maximum tangential diameter of solitary vessels 160 µm; perforations simple; intervessel pits alternate, 4-5 µm in vertical diameter; vessel-ray pits similar to intervessel pits (Fig. 254, I); tyloses absent.

Rays 1-5-seriate, usually 1-4-seriate, up to 900 µm high.

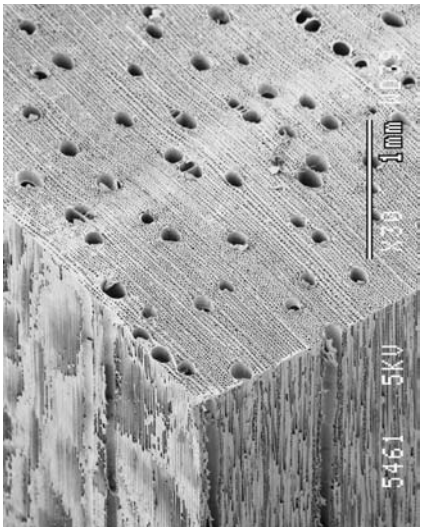
Axial parenchyma aliform (Fig. 253), appearing as slightly paler tissues as seen with a hand lens.

Fibres non-septate, 1.2 (0.8-1.4) mm long, with a tangential diameter of 15-25 µm and walls ca 4 µm thick; minute pits present on radial walls, but sparse and inconspicuous.

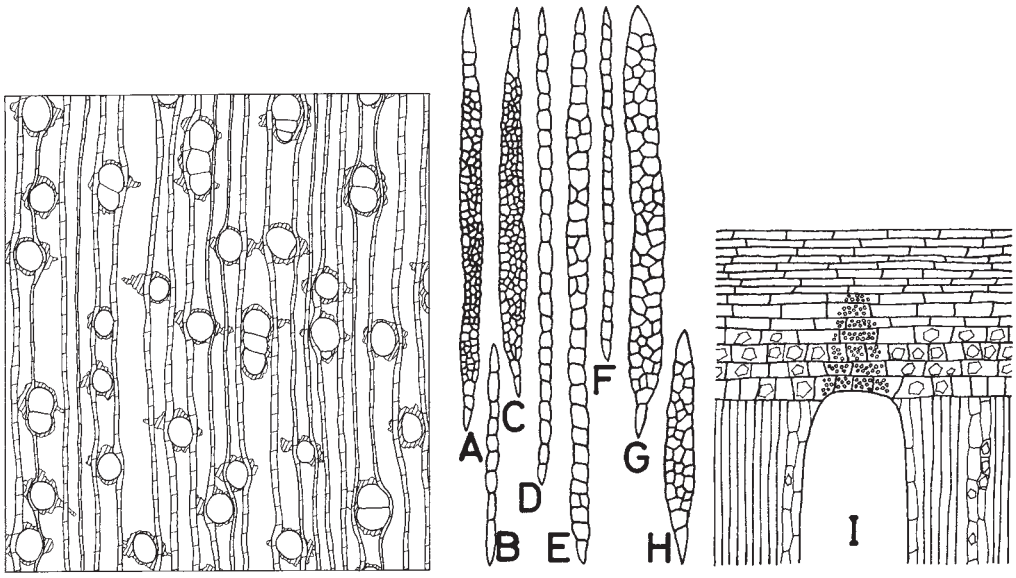
Crystals fairly abundant in upright ray cells and also sometimes present in axial parenchyma cells (Fig. 254, I). Silica grains absent.

The wood of another New Guinean species, *Z. angustifolius* (Miq.) Hatusima ex v. Steenis, is very similar to that of *Z. grewioides*, but its intervessel pits are smaller, 3-4 µm in vertical diameter. In 3 specimens examined of *Z. talanai* from the Philippines, the vessels are larger with a maximum diameter of solitary vessels of 200-210 µm and rays exclusively uniseriate. Rays are uniseriate or 1-2-seriate also in *Z. jujuba* and *Z. spina-christi*. Axial parenchyma is aliform in many species, including *Z. angustifolius*, *Z. grewioides*, *Z. jujuba*, *Z. spina-christi* and *Z. talanai*, but confluent to banded in *Z. cinnamomum*, and vasicentric and diffuse in *Z. thyrsiflorus*. As mentioned above, the wood anatomy of *Ziziphus* is fairly variable from species to species and lacks uniformity.

The wood of *Z. grewioides* has some similarity to that of species of *Celtis* (Cannabaceae/Ulmaceae) from New Guinea in the distribution pattern of axial parenchyma, the type of rays and the presence of crystals in uniseriate parts of rays, but the wood of *Celtis* is generally pale-coloured and has broader rays, 1-5 to 1-7(-(8) cells wide.



Ziziphus grewioides (TWTw 16889) (3D: SEM).



L **Fig. 253.** *Ziziphus grewioides*, × 25.

R **Fig. 254.** A & B: *Ziziphus angustifolius*; C & I: *Z. grewioides*; D: *Z. spina-christi*; E: *Z. jujuba*; F: *Z. talanai*; G & H: *Z. thyriflorus*. - A-H; Ray types. - I: Radial section showing vessel-ray pits and crystals in ray and axial parenchyma cells. A-I: × 80.

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Santalaceae

The family Santalaceae consists of ca 35 genera and 500 species of trees, shrubs and herbs, which are generally semi-parasitic on the roots of other plants. The family is widely distributed in tropical to subtropical regions.

Sandalwood: *Santalum album* L.

The genus *Santalum* consists of 25 woody species distributed in eastern Java, the Lesser Sunda Islands, Sulawesi, the Pacific (east to Hawaii) and Australia. Species belonging to this genus are all shrubs or small trees, parasitic on the roots of other plants, from which they obtain water and minerals. The species of this genus have some fragrance in the heartwood and rootwood, and some species, especially *Santalum album*, have been cultivated for their fragrant wood. *S. album* is a shrub to small tree, 3 to 10 m tall, found wild in the southern part of India and the eastern part of Java and Timor. It is said that the species was native to Timor originally and introduced later to other regions. Nowadays, the Mysore and Madras regions of India are famous for the cultivation of the tree, which can be up to 25 to 30 cm in diameter. Its wood is used for small wooden articles such as statues, wood crafts, wooden boxes, combs, etc.

Macroscopic features. Sapwood pale yellowish white, without fragrance. Heartwood pale yellowish brown when fresh, turning gradually dull yellowish brown to brown, with strong fragrance which is persistent even in old wood. Without lustre. With oily touch on the surfaces of wood. Texture fine. Grain straight or shallowly interlocked. Air dry specific gravity of heartwood 0.89-1.00.

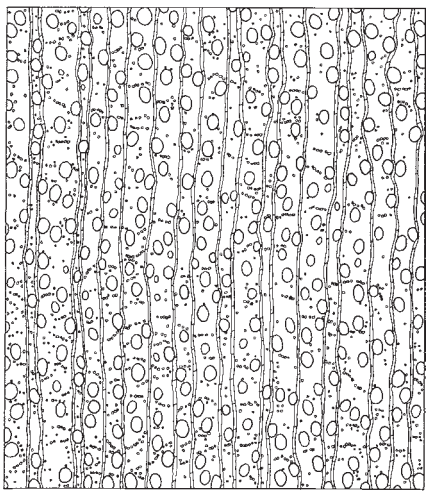
Microscopic features. Vessels almost exclusively solitary, rarely in radial pairs (Fig. 279); frequency 45-88/mm^2; maximum tangential diameter of solitary vessels 70-80(-90) µm; perforations simple; vasicentric tracheids present around vessels and pits found between them 3-4 µm in vertical diameter; vessel-ray pits similar to intervessel pits, but not very common (Fig. 280, N); tyloses sometimes present.

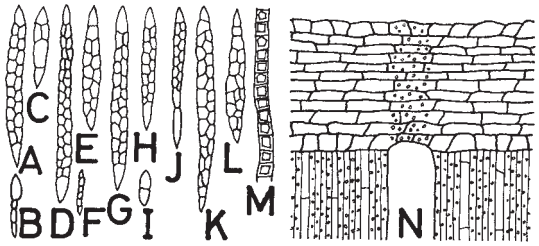
Rays 1-2-seriates, biseriates predominant; maximum height 300-320(-390) µm; marginal cells often swollen like oil cells.

Axial parenchyma diffuse to diffuse-in-aggregates (Fig. 279), distinct in the microscope but not clear with a hand lens.

Fibres non-septate, 1.2 (0.8-1.5) mm long, with a diameter of 13-20 µm and a wall thickness of 3-6 µm; bordered pits fairly abundant on radial and tangential walls.

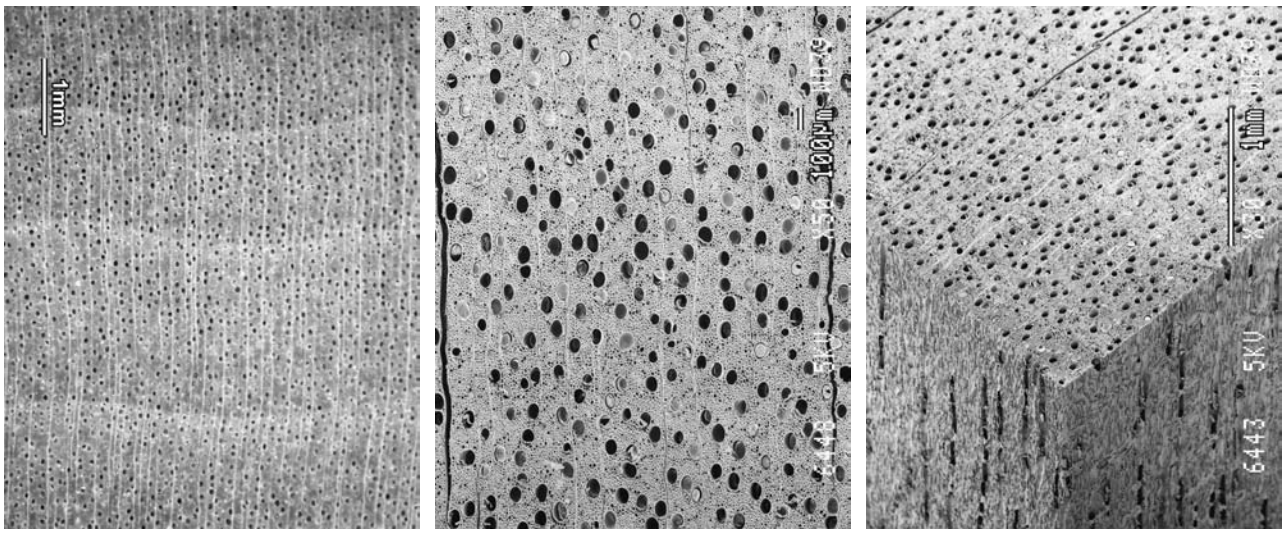
Crystals present in 3-20-chambered axial parenchyma cells (Fig. 280, M). Silica grains absent.





L **Fig. 279.** *Santalum album,* × 25.

R **Fig. 280.** A-D, M & N: *Santalum album*; E-G: *S. ellipticum*; H-J: *S. freycinetianum*; K & L: *S. pyrularium*. - A-L: Ray types. - M: Crystals in chambered axial parenchyma cells. - N: Radial section showing vessel-ray pits. A-N: × 80.



Santalum album (TWTw 8358).

L (Macrophoto).

C R Vessels almost exclusively solitary, rarely in radial pairs, and axial parenchyma diffuse to diffuse-in-aggregates. *C* (CS: SEM). *R* (3D: SEM).

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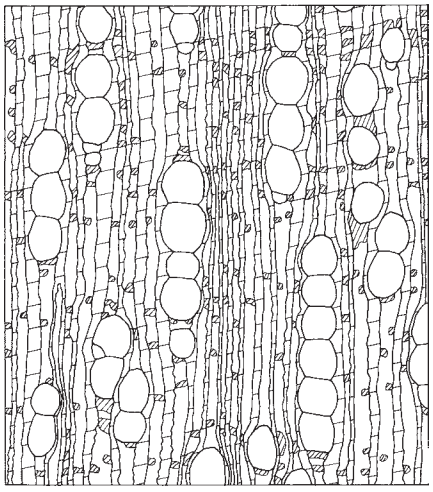
Tetrameristaceae

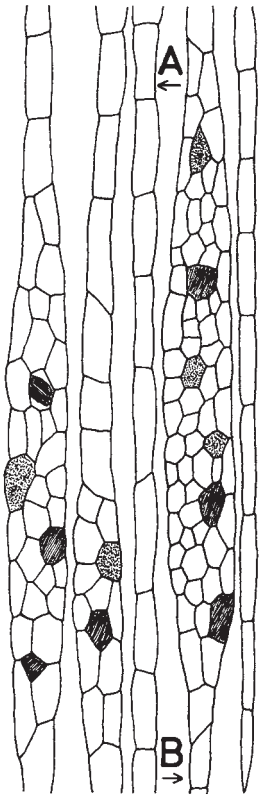
The family Tetrameristaceae, which is sometimes considered to be related to the family Theaceae, Marcgraviaceae or Ochnaceae, is represented by *Tetramerista glabra* Miq. and a few allied species in Southeast Asia. A small tree, *Pentamerista neotropica* Maguire, discovered in 1972 in the Guayana Highlands of northern South America also belongs to this family.

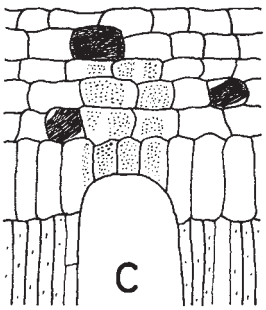
Punah: *Tetramerista glabra* Miq.

Tetramerista glabra is a large tree distributed in swamp forests in Malaya, Sumatra and Borneo. The dusts produced in processing timbers often cause irritant effects to nose and eyes. Punah is the name of this species in Malaya.

Macroscopic features. Sapwood pale greyish brown, and heartwood yellowish brown, brown or orange brown, without lustre, often with pale yellow to white chalky deposits in vessels. Texture rather coarse. Grain almost straight to shallowly interlocked, sometimes wavy. Air dry specific gravity 0.72 (0.62-0.80). The wood lathers when rubbed with water due to some kind of saponin in its chemical contents.







Microscopic features. Vessels solitary and in radial multiples of 2-4 to 2-8, usually the latter predominant (Fig. 320); pores somewhat angular; frequency 4-11/mm^2; maximum tangential diameter of solitary vessels 220-280 µm; perforations simple; intervessel pits alternate, 3-4 µm in vertical diameter; vessel-ray pits similar to intervessel pits (Fig. 321, C); tyloses absent.

Rays 1-3- to 1-5-seriate, uniseriates sparse and the broadest, that is 3-, 4- or 5-seriates common; mostly very high, up to 5000-14000 µm, alternating with long uniseriate portions and shorter multiseriate portions; composed of large upright or square cells (Fig. 321, A & B).

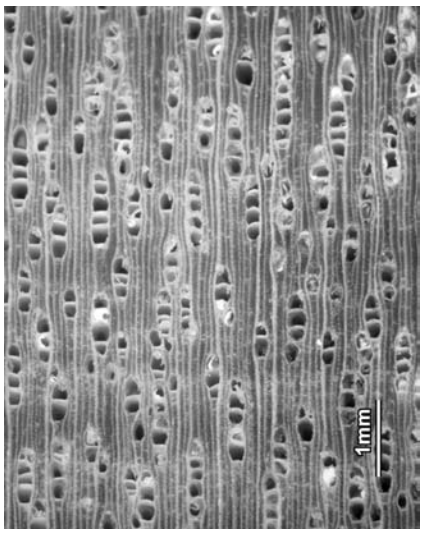
Axial parenchyma scanty paratracheal and diffuse (and diffuse-in-aggregates) (Fig. 320), the latter with a tendency to be in tangential short lines especially near the border of growth rings, usually distinct with a hand lens and in the microscope.

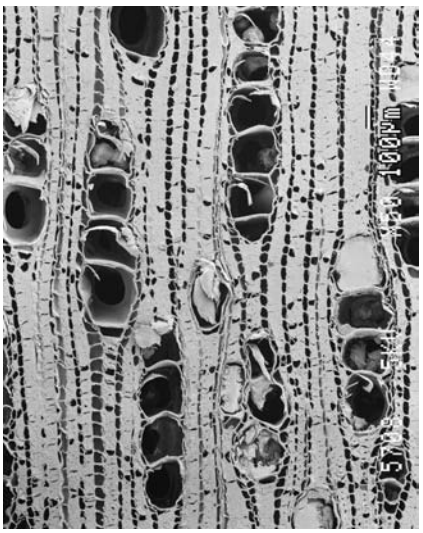
Fibres non-septate, 2.7 (2.0-3.3) mm long, with a tangential diameter of 35-80 µm, with very thick walls and almost occluded lumina; minute pits present on radial walls but inconspicuous.

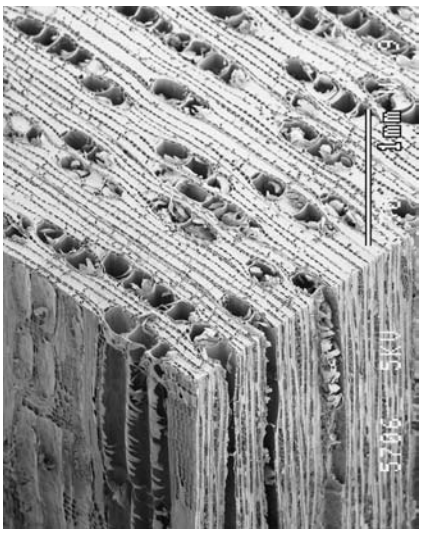
Raphides present in multiseriate portions of rays (Fig. 321, A-C). Silica grains absent.

L **Fig. 320.** *Tetramerista glabra*, × 25.

R **Fig. 321.** A-C: *Tetramerista glabra*. - A & B: Ray types. - C: Radial section showing vessel-ray pits. (Raphides present in A-C.) A-C: × 80.







L C R *Tetramerista glabra* (TWTw 17728).

L (Macrophoto).

C R Vessels mostly in radial multiples. *C* (CS: SEM). *R* (3D: SEM).

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Ulmaceae

The family Ulmaceae consists of ca 15 genera and 170 species of trees and shrubs distributed in the tropical to temperate regions of the world, especially in the northern hemisphere. According to the recent molecular phylogeny-based classification (APG, 1998; APG II, 2003 & Stevens, 2007), some genera, including the genus *Celtis*, which have been so far included in the family Ulmaceae are transferred to Cannabaceae or Celtidaceae. However, the genus *Celtis* is treated here in the family Ulmaceae for practical reasons.

Celtis: *Celtis* spp.

The genus *Celtis* consists of 50-60 woody species distributed mainly in the tropical to subtropical regions of the world, with some species also in temperate regions. There are about 9 species occurring from Southeast Asia to New Guinea, among which 6 in the New Guinea region including New Britain and the Solomon Islands reach timber size (*C. hildebrandii* Soepadmo, *C. latifolia* (Blume) Planch., *C. paniculata* (Endl.) Planch., *C. philippinensis* Blanco, *C. rigescens* (Miq.) Planch. and *C. rubrovenia* Elmer) .The wood of tropical species is usually diffuse-porous, but that of temperate species, for example *C. sinensis* Pers. var. *japonica* (Planch.) Nakai and *C. jessoensis* Koidz. in Japan is usually ring-porous.

Macroscopic features. Sapwood and heartwood not differentiated by colour, pale yellowish white, pale greyish yellow, pale greyish brown or pale yellowish brown, with slight lustre. Texture rather fine to medium-coarse. Grain interlocked and sometimes wavy. Air dry specific gravity 0.50-0.92. Easily affected by blue-stain fungi.

Microscopic features. Vessels solitary and in radial multiples of 2-4(-7), generally the former rather predominant (Fig. 330); frequency 5-15/mm^2, usually 5-7/mm^2; maximum tangential diameter of solitary vessels 160-260 mm; perforations simple; intervessel pits alternate, (4.5-)5-6(-6.5) mm in vertical diameter; vessel-ray pits small, oval, sometimes elongated, usually not common (Fig. 331, I); tyloses absent.

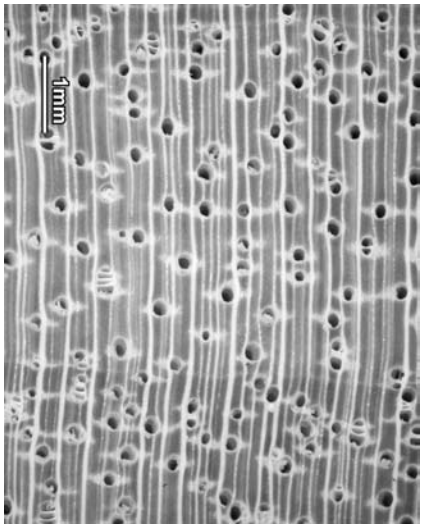
Rays with a tendency to 2 sizes, uniseriates and 4-5- to 4-7-seriates; the latter with a maximum height of up to 600-1800 mm.

Axial parenchyma aliform to confluent and sometimes in irregular bands (Fig. 330), visible as slightly paler tissues than surrounding fibres with a hand lens but sometimes not very distinct in the microscope.

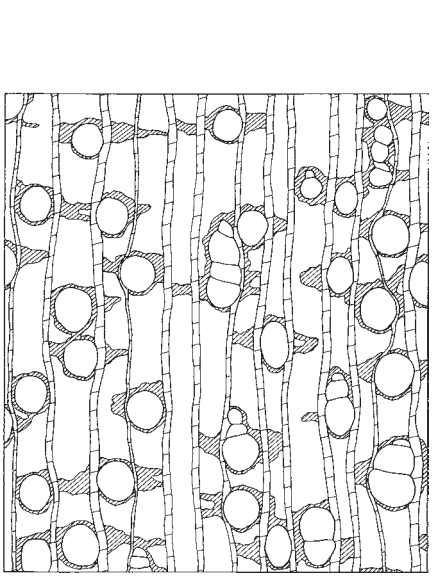
Fibres non-septate, 1.3 (0.9-1.8) mm (*C. hildebrandii*) and 1.2 (0.9-1.6) mm long (*C. latifolia*), with a tangential diameter of 15-25 mm; minute pits present on radial walls, but sparse and inconspicuous; often storied with axial parenchyma.

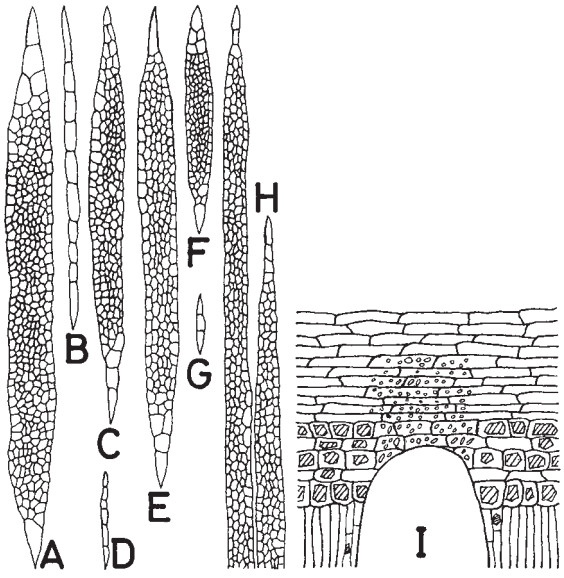
Crystals present in upright ray cells and also often in axial parenchyma cells (Fig. 331, I). Silica grains absent.

The wood of *Celtis* has some similarity to that of *Ziziphus grewioides* (Rhamnaceae).



Celtis kajewskii (TWTw 11541) (Macrophoto).





L **Fig. 330.** *Celtis hildebrandii*, × 25.

R **Fig. 331.** A & B: *Celtis luzonica*; C & D: *C. rigescens*; E: *C. latifolia*; F & G: *C. philippinensis*; H & I: *C. hildebrandii*. - A-H: Ray types. - I: Radial section showing vessel-ray pits and crystals in ray and axial parenchyma cells. A-I: × 80.

このプレビューでは表示されない頁があります。

Verbenaceae

The family Verbenaceae ("the old Verbenaceae") consists of 40-100 genera and 1000-3000 species of trees, shrubs, lianas and herbs distributed mainly in the tropical to temperate regions of the world. The number of genera and species is differs much according to the author. Acording to the recent molecular phylogeny-based classification (APG, 1998; APG II, 2003 & Stevens, 2007), many genera (including *Gmelina*, *Peronema*, *Tectona*, *Teijsmanniodendron* and *Vitex*) of Verbenaceae were moved to the family Labiatae. However, these genera are treated here in Verbenaceae for practical reasons.

(1) Gmelina: *Gmelina arborea* Roxb.

The genus *Gmelina* consists of 20-30 woody species distributed in Africa, Southeast Asia and the western Pacific. *G. arborea*, native to India and Myanmar to Indochina, is a fast growing species and often used in plantation forestry in the tropics.

Macroscopic features. Heartwood pale brownish yellow, pale yellowish brown or yellowish white with a dull lustre. Sapwood paler than heartwood. Texture medium-coarse. Grain shallowly interlocked or almost straight. Air dry specific gravity (0.42-)0.50-0.54(-0.69).

Microscopic features. Vessels solitary and in radial multiples of 2-3(-5), generally the former predominant (Fig. 332); frequency 3-7(-12)/mm^2, with a slight tendency to a diagonal pattern; maximum tangential diameter of solitary vessels (180-)210-260 µm; perforations simple; intervessel pits alternate, (8-)9(-11) µm in vertical diameter; vessel-ray pits similar to intervessel pits in shape, but mostly simple (Fig. 333, L); thin-walled tyloses common.

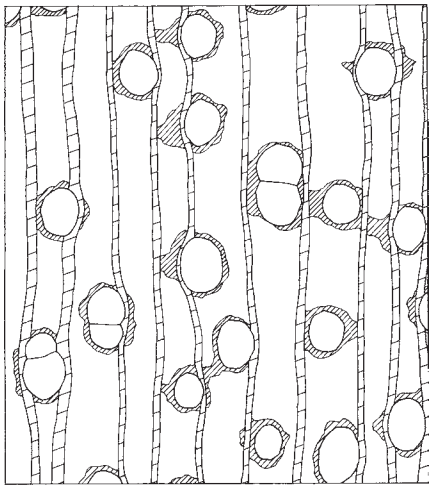
Rays usually 1-3- to 1-4-seriate, sometimes up to 5-6-seriate; maximum height usually 420-550 µm, sometimes up to 1000 µm; without coloured contents.

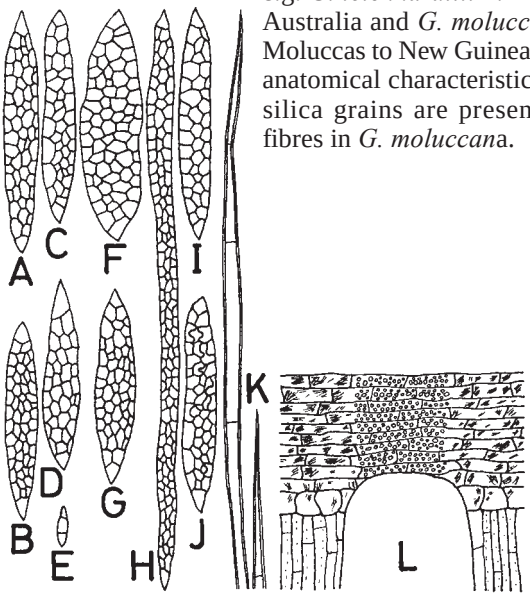
Axial parenchyma vasicentric to winged-aliform, sometimes partly confluent (Fig. 332), not very distinct in the microscope due to lack of contrast with fibres.

Fibres exclusively septate with 1 to several septa per fibre (Fig. 333, K); 1.1 (0.7-1.5) mm long, with a tangential diameter of 18-30 µm and walls 2-3.5 µm thick.

Acicular crystals present in rays, usually very common (Fig. 333, L), but sometimes infrequent according to the specimen. Silica grains absent.

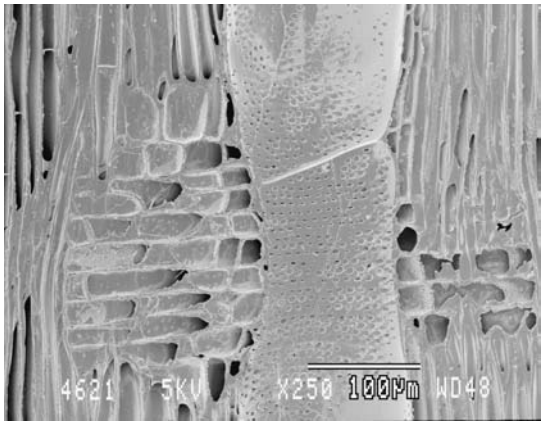
The wood of some other species of the genus *Gmelina*, e.g. *G. leichhardttii* F. Muell. in North Queensland, Australia and *G. moluccana* (Blume) Backer in the Moluccas to New Guinea, is very similar in the wood anatomical characteristics to that of *G. gmelina*, but silica grains are present in axial parechyma and fibres in *G. moluccan*a.

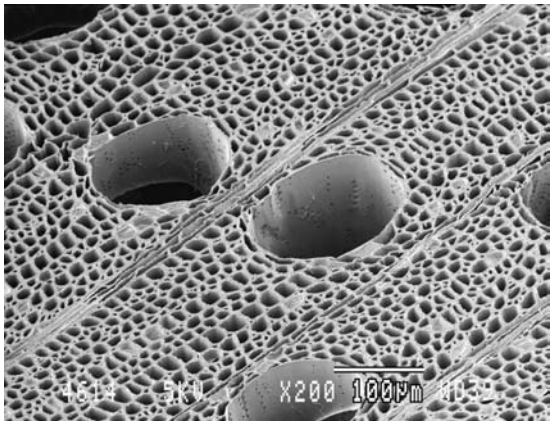




L **Fig. 332.** *Gmelina arborea*, × 25.

R **Fig. 333.** A-H, K & L: *Gmelina arborea*; I: *G. leichardtii*; J: *G. moluccana*. - A-J: Ray types. - K: Septate fibre. - L: Radial section showing vessel-ray pits and acicular crystals in ray cells. A-L: × 80.





Gmelina arborea (TWTw 11383).

L Vessel-ray pits similar to intervessel pits (RS: SEM).

R Axial parenchyma vasicentric to winged-aliform, but indistinct (CS: SEM).

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Conifers

In Southeast Asia and the Pacific, conifers are not abundant and only represented by few species belonging to the family Araucariaceae, Pinaceae and Podocarpaceae.

For the identification of coniferous woods, the type of cross-field pits is important. The pits are usually classified into 5 types: cupressoid, taxodioid, piceoid, pinoid and window-like (Fig. 344).

Araucariaceae

The family Araucariaceae consists of the genera *Agathis*, *Araucaria*, and *Wollemia*. The genus *Agathis* is divided into 10 to more than 20 species according to different authors. Important timber species in Southeast Asia and the western Pacific are *A. dammara* (Lambert) Rich. from Malaya to New Guinea, *A. borneensis* Warb. in Borneo, *A. celebica* (Koord.) Warb. in Sulawesi, *A. philippinensis* Warb. in the Philippines and Sulawesi, and *A. rhomboidalis* Warb. in Malaya and Sumatra.

The genus *Araucaria* consists of ca 18 species distributed in the western Pacific and South America. Among them, the species whose timbers are imported into Japan are Hoop Pine *A. cunninghamii* Aiton ex A. Cunn. from New Guinea and eastern Australia and Klinki Pine *A. hunsteinii* K. Schum. from Papua New Guinea. The wood is similar in both genera (*Agathis* and *Araucaria*).

The genus *Wollemia* is monotypic and represented by *W. nobilis* W.G. Jones et al., which was discovered in New South Wales, Australia, in 1995.

The following descriptions are based on *Agathis* and *Araucaria*.

Macroscopic features. Wood pale yellowish white, pale yellow, pale yellowish brown or pale brown, without much difference between sapwood and heartwood, generally paler in *Araucaria* than in *Agathis*, sometimes with brown streaks in *Agathis* which is seemingly compression wood. With characteristic satin-like lustre. Air dry specific gravity 0.50 (0.35-0.75).

Microscopic features. Resin canals, ray tracheids and axial parenchyma absent. Hexagonal bordered pits in 2-3(-4) rows present on radial walls of tracheids (Fig. 345) (Among all coniferous families, this feature is only found in Araucariaceae). Cross-field pits cupressoid to taxodioid and 3 to several per cross-field. Anatomically, both genera (*Agathis* and *Araucaria*) are not separable, but in *Agathis* coloured contents are often present in fibres adjacent to rays.

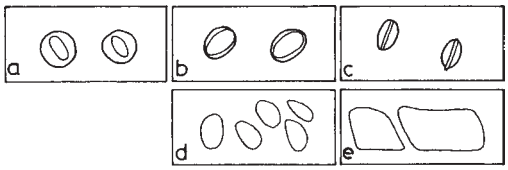


Fig. 344. Types of cross-field pits of conifers. - a: Cupressoid. - b: Taxodioid. - c: Piceoid. - d: Pinoid. - e: Window-like.

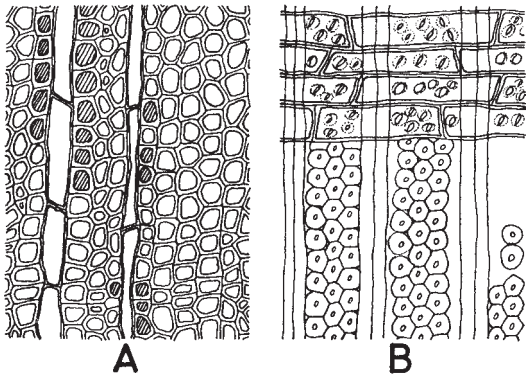
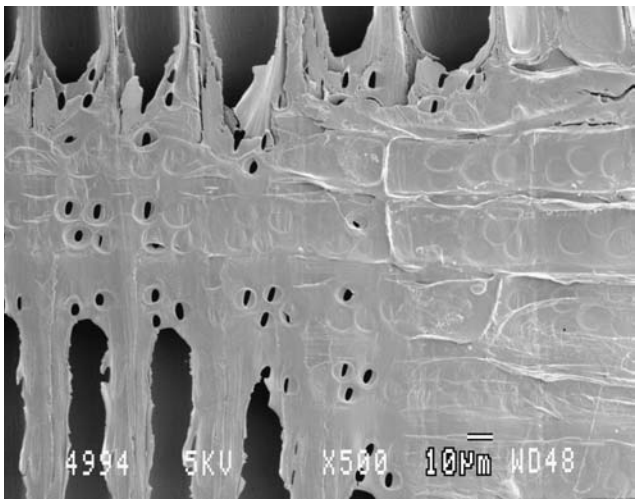
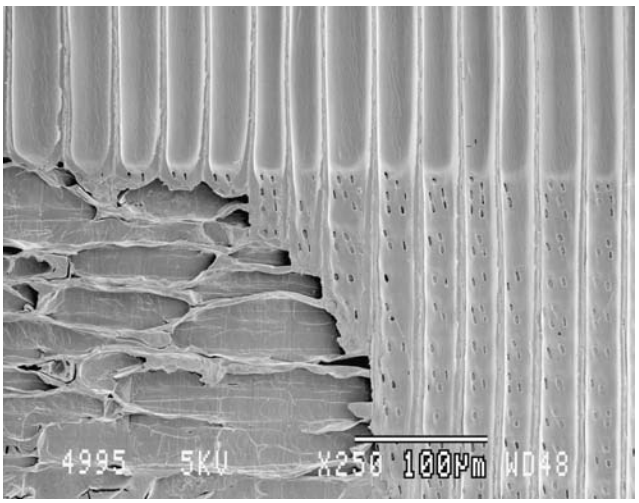


Fig. 345. A & B: *Agathis dammara*. - A: Tracheids with coloured contents (shaded portion). - B: Cross-filed pits and tracheids with alternate arrangement of bordered pits. A: × 80; B: × 160.





Agathis borneensis (TWTw 3103).
Cross field pits cupressoid to taxodioid (RS: SEM).

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Pinaceae

The family Pinaceae consists of 12 genera and ca 220 species mostly distributed in the temperate to subalpine regions of the northern hemisphere. Only the following species of the genus *Pinus* are found in the tropical regions of Southeast Asia.

Khasia Pine (*Pinus kesiya* Royle ex Gordon): 3-needled pine distributed from Myanmar to Indochina and the northern part of Luzon of the Philippines, and found in rather high mountains between 600 and 2000(-3000) m above sea level. It is called Benguet Pine in the Philippines and has earlier been given the scientific name *P. insularis* Endl., but it is widely accepted now that *P. kesiya* and *P. insularis* are conspecific.

Merkus Pine (*Pinus merkusii* Jungh. & de Vriese): 2-needled pine distributed from Myanmar to Indochina, the northern half of Sumatra and the northern part of Luzon, and found at lower altitude than *P. kesiya*, between 150 and 1000(-2000) m.

Caribbean Pine (*Pinus caribaea* Morelet): 3-needled pine native to the Caribbean, introduced to Southeast Asia as a fast-grown plantation pine.

These 3 *Pinus* species are members of the hard pine group and their woods are similar.

Macroscopic features. Heartwood yellowish to reddish brown with an air dry specific gravity of 0.50-0.85. Generally in wild trees, growth rings are present with distinct earlywood and latewood like annual rings in temperate pines, but in the trees planted in lowlands, heartwood colour is paler, the density lower, and growth rings are indistinct.

Microscopic features. Axial and radial intercellular (resin) canals present and visible with a hand lens which easily distinguishes this genus from Araucariaceae and Podocarpaceae. Axial parenchyma absent. The distinction of 3 species are as follows.

P. caribaea: cross-field pits pinoid, 2 to several per cross field; inner walls of ray tracheids conspicuously dentate.

P. kesiya: cross-field pits window-like, 1 to 2 per cross field; inner walls of ray tracheids rather conspicuously dentate (Fig. 346, E).

P. merkusii: cross-field pits window-like to pinoid, 1 to several per cross field; inner walls of ray tracheids inconspicuously dentate (Fig. 346, B).

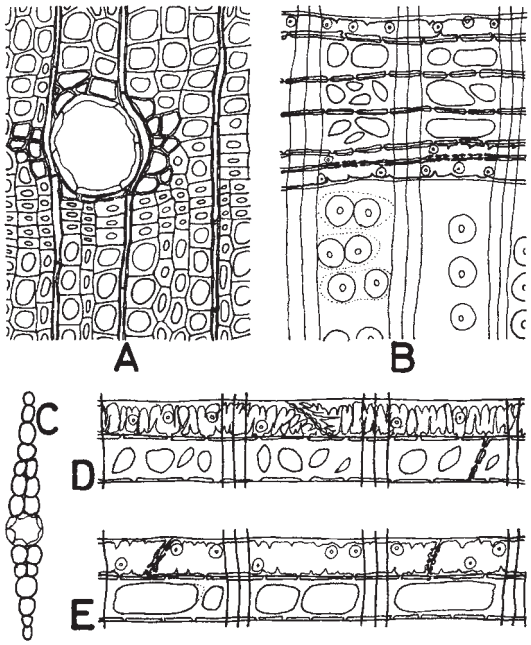
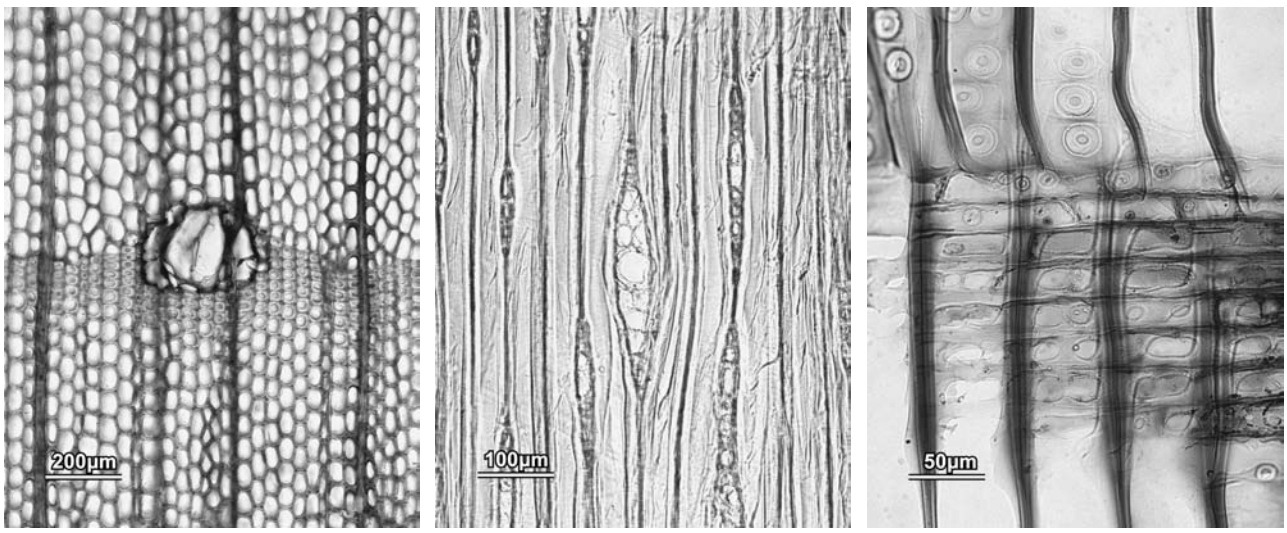


Fig. 346. A-C: *Pinus merkusii*; D: *P. caribaea*; E: *P. kesiya*. - A: Axial intercellular (resin) canal. - B: Cross-field pits and inner walls of ray tracheids. - C: Radial intercellular (resin) canal. - D & E: Cross-fiels pits and inner walls of ray tracheids. A: × 80; B: × 160; C: × 80; D &E: × 240.



L *Pinus merkusii* (TWTw 11045). C *P. merkusii* (TWTw 10240). R *P. kesiya* (TWTw 5802).

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Podocarpaceae

The family Podocarpaceae is classified into 7 to 17 genera and 130 to 170 species according to different authors. They are mainly distributed in the southern hemisphere. The following timber species are widely distributed from Southeast Asia to New Guinea: *Dacrydium elatum* (Roxb.) Wall. ex Hook., *D. beccarii* Parl., *Podocarpus imbricatus* Blume, *P. wallichianus* C. Presl. (Syn. *P. blumei* Endl.), *P. neriifolius* D. Don, and *P. amarus* Blume. *Dacrydium pierrei* Hickel from Thailand to Indochina, *Podocarpus philippinensis* Foxw. from the Philippines, *P. motleyi* Dümmer from Malaya and Borneo, and *Phyllocladus hypophyllus* Hook. f. from Borneo to New Guinea also reach timber size. Timbers of Podocarpaceae are usually called Podocarpus, Igem or Kayu China on the Japanese market.

Macroscopic features. Heartwood of *Podocarpus* and *Dacrydium* is pale yellow, yellow, yellowish brown or brown, sometimes with dull purplish brown streaks. Air dry specific gravity 0.35-0.90, mostly 0.45-0.60. Growth rings not very apparent, without clear distinction between earlywood and latewood or only with narrow latewood.

Microscopic features. Resin canals and ray tracheids absent. Generally axial parenchyma cells abundant and is distinct in the microscope due to their dark contents (Fig. 347, A), but usually not with a hand lens. However, axial parenchyma is rare or almost absent in some species, e.g. *Podocarpus amarus* and all species of *Phyllocladus*. Sometimes with white contents in tracheids, visible with a hand lens as white dots scattered among the tracheids in cross section, easily misunderstood as axial parenchyma but not found in microscopic sections treated with boiling water or solvents. Cross-field pits variable, cupressoid, taxodioid or sometimes nearly window-like (*Phyllocladus*) (Fig. 347, C-F), the type of which characterizes each species, but species identification based only on this characteristic is difficult.

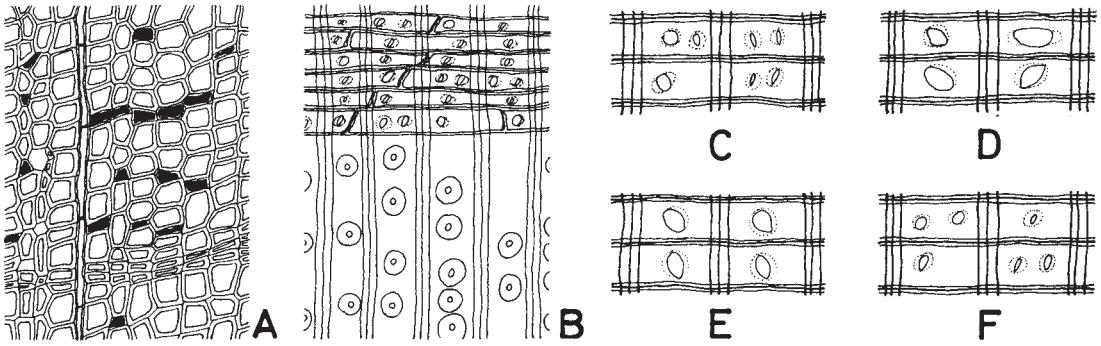
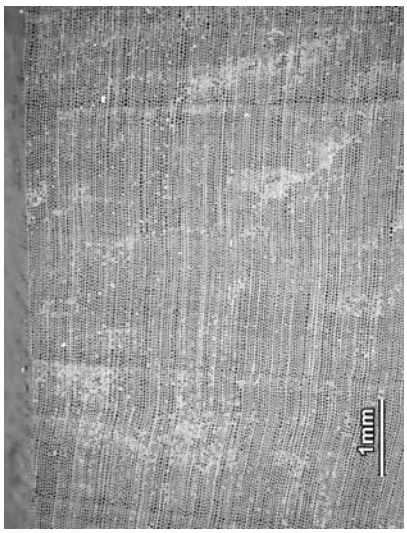


Fig. 347. A & B: *Podocarpus neriifolius*; C: *Dacrydium elatum*; D: *Phyllocladus hypophyllus*; E: *Podocarpus amarus*; F: *Podocarpus. imbricatus*. - A: Axial parenchyma cells. - B: Cross-field pits. - C-F: Cross-filed pits. A: × 80; B: × 160; C-F: × 240.



Dacrydium sp. (TWTw 5550) (Macrophoto).

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Ray Classification

The ray classification by Kribs (1935, amended in 1959), which is used in Table 10 (Meliaceae) and Table 13, is as follows:

1. Heterogeneous type I
   a. Uniseriate rays composed of vertically elongate cells which are unlike the cells of the multiseriate part of the multiseriate rays.
   b. Multiseriate rays with uniseriate tails or wings as long or longer than the multiseriate portion of the ray, and composed of vertically elongate cells similar to those of the uniseriate rays; cells of the multiseriate portion are round to oval (tangential section) and radially elongated (radial section).
2. Heterogeneous type II
   a. Uniseriate rays composed of vertically elongate cells which are unlike those of the multiseriate portion of the multiseriate rays.
   b. Multiseriate rays with one large vertically elongate marginal cell, or with uniseriate tails or wings shorter than the multiseriate portion of the ray, and composed of vertically elongate cells similar to those of the uniseriate rays; the cells of the multiseriate portion are round to oval (tangential section), and radially elongated (radial section).
3. Heterogeneous type III
   a. Uniseriate rays usually of two types: some of the uniseriates are composed of vertically elongate cells, and some are composed of cells which are nearly identical to those of the multiseriate portion of the multiseriate rays (tangential section).
   b. Multiseriate rays with square marginals (not vertically elongate), usually a single row; if tails are present, marginals are square, not vertically elongate; cells of the multiseriate portion are round to oval (tangential section), and radially elongate (radial section).
4. Homogeneous
   a. Uniseriate rays composed of cells which are identical to those of the multiseriate rays (tangential section).
   b. Multiseriate rays without square or vertically elongate marginal cells; the cells are all round or oval (tangential section), and radially elongate (radial section); with or without tails.
5. Uniseriate rays only, heterogeneous
   Composed of radially and vertically elongate cells.
6. Uniseriate rays only, homogeneous
   Composed of radially elongate cells only.

Simplified figures of the each type are shown in Fig. 348.

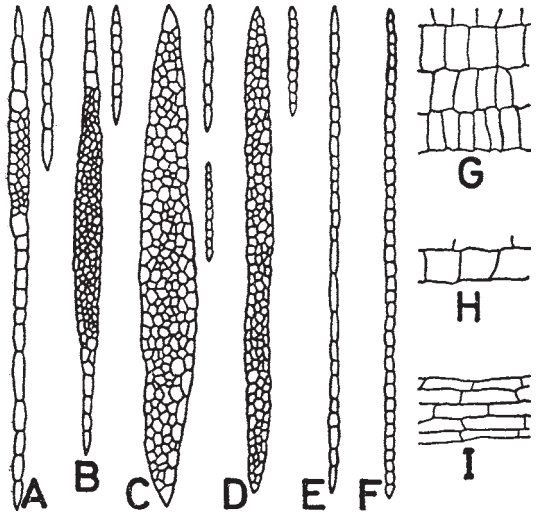

Fig. 348. Simplified figures of Kribs' ray types. A: Heterogeneous type I; B: Heterogeneous type II; C: Heterogeneous type III; D: Homogeneous; E: Uniseriate rays only, heterogeneous; F: Uniseriate rays only, homogeneous. (G: Upright ray cells; H: Square ray cells; I: Procumbent ray cells.)

Table 12 Divisions about the frequency and diameter of vessels, the maximum height of rays and air dry specific gravity used in Table 13

Division	Vessels		Rays	Air dry specific gravity
	Frequency (No/mm^2)	Diameter (μm)	Maximum height (mm)	
I	-2	-90	-0.5	-0.35
II	2-5	90-150	0.5-1.0	0.35-0.55
III	5-15	150-230	1.0-2.5	0.55-0.75
IV	15-40	230-300	2.5-4.0	0.75-0.95
V	40-	300-	4.0-	0.95-

Summary Table

Anatomical characteristics of families and genera of hardwoods (dicotyledons) are summarized in Table 13. Some arbitrary size classes for vessels, rays and air dry specific gravity used in this table are shown in Table 12.

Table 13 Microscopic characteristics of families and genera of dicotyledons (1)

Family	Genus	Page	Vessels						Rays		
			Exclusively solitary	Frequency	Maximum diameter	Multiple perforations	V-V Pit diameter (μm) (*: vestured)	V-R pits[1]	Maximum width (cells wide)	Maximum height	Types (Heterogeneous)
Alangiaceae	*Alangium*	2	–	Ⅲ–Ⅳ	Ⅱ (Ⅲ)	+	6–8	oval- linear	4–5	Ⅳ–Ⅴ	(Ⅰ) Ⅱ
Anacardiaceae	*Campnosperma*	6	–	Ⅳ	Ⅱ	±	8–10	linear	2–3	Ⅰ–Ⅱ	Ⅱ–Ⅲ
	Dracontomelon	8	–	Ⅱ	(Ⅲ) Ⅳ (Ⅴ)	–	11–12	oval	3 (4)	Ⅰ–Ⅱ	Ⅱ–Ⅲ
	Gluta/Melanorrhoea	12	–	Ⅱ	Ⅲ–Ⅳ (Ⅴ)	–	10–12	oval	1 (2)	Ⅰ–Ⅱ (Ⅲ)	Ⅱ–Ⅲ
	Mangifera	10	–	(Ⅰ) Ⅱ	(Ⅲ) Ⅳ–Ⅴ	–	9–10	oval	2	Ⅱ (Ⅲ)	Ⅱ (Ⅲ)
	Spondias	14	–	Ⅱ	Ⅲ–Ⅴ	–	10–12	oval	3–6	Ⅲ	Ⅲ
	Anacardiaceae	6	–	Ⅱ (–Ⅳ)	Ⅱ–Ⅴ	∓	(6) 7–15	oval, (linear)	2–4 (–6)	Ⅰ–Ⅲ	Ⅱ–Ⅲ
Anisophylleaceae	*Combretocarpus*	16	–	Ⅰ–Ⅱ	Ⅳ–Ⅴ	–	5–6	oval- linear	10–13	Ⅴ	Ⅱ–Ⅲ
Annonaceae	Annonaceae	18	–	Ⅱ–Ⅲ (Ⅳ)	Ⅱ–Ⅳ	–	3–9	←	(3–) 5–15	Ⅲ–Ⅴ	Ⅱ–Ⅲ
Apocynaceae	*Alstonia*	22	–	Ⅲ	Ⅱ–Ⅲ	–	5–6*	←	(2) 3 (4)	Ⅱ	Ⅱ–Ⅲ
	Dyera	24	–	Ⅱ–Ⅲ	Ⅱ–Ⅲ	–	5–6*	←	(2) 3 (4)	Ⅲ	Ⅱ–Ⅲ
	Cerbera	26	–	Ⅱ	Ⅱ	–	4–5*	←	2	Ⅱ–Ⅲ	Ⅰ (Ⅱ)
	Wrightia	28	–	Ⅰ	Ⅰ	–	3 (4)*	←	2–3	Ⅱ–Ⅲ	Ⅰ (Ⅱ)
Avicenniaceae	*Avicennia*	30	–	Ⅳ (Ⅴ)	Ⅰ–Ⅱ	–	(2) 3–4	←	3–5 (–10)	Ⅲ	Ⅱ
Bombacaceae	*Ceiba*	32	–	Ⅳ–Ⅴ	Ⅳ–Ⅴ	–	9–10		7–13	Ⅲ–Ⅳ	Ⅱ–Ⅲ
	Durio	34	–	Ⅲ–Ⅴ	Ⅲ–Ⅴ	–	6–7	←	3–8	Ⅲ–Ⅳ	Ⅱ–Ⅲ
Boraginaceae	*Cordia*	38	–	Ⅲ	Ⅲ–Ⅴ	–	6–7	←	5	Ⅱ–Ⅲ	Ⅲ
Burseraceae	*Canarium*	40	–	Ⅱ–Ⅲ	Ⅲ–Ⅴ	–	7–10	oval	3 (4)	Ⅰ–Ⅱ	Ⅲ
	Burseraceae	43	–	Ⅲ–Ⅴ	Ⅲ–Ⅴ	–	(6) 7–9 (10)	oval	1–3 (4)	(Ⅰ) Ⅱ	(Ⅱ) Ⅲ
Casuarinaceae	*Casuarina*	48	+	Ⅱ–Ⅲ	Ⅱ–Ⅲ	(+)	3–4	←	3–20 (–80)	Ⅱ–Ⅴ	homo
Celastraceae	*Lophopetalum*	52	–	Ⅱ	Ⅱ	–	3–4	←	1	Ⅱ	homo
Chrysobalanaceae	*Parinari*	54	+	Ⅰ–Ⅱ	(Ⅳ) Ⅴ	–	–	palisade	1–2	Ⅲ–Ⅳ	hetero
Combretaceae	*Lumnitzera*	56	–	Ⅳ–Ⅴ	Ⅰ–Ⅱ	–	5–6*	←	1	(Ⅰ) Ⅱ	hetero
	Terminalia	58	–	Ⅱ–Ⅲ (Ⅳ)	Ⅲ	–	(6) 7–8 (–10)*	←	1–4 (–6)	Ⅰ–Ⅲ	(Ⅱ) Ⅲ
Crypteroniaceae	*Dactylocladus*	62	–	Ⅲ	Ⅲ–Ⅳ	–	6–8*	oval- linear	1	Ⅲ	hetero
Ctenolophonaceae	*Ctenolophon*	64	+	Ⅳ	Ⅲ–Ⅴ	+	–	minute	4–5	Ⅳ	(Ⅰ) Ⅱ
Cunoniaceae	*Schizomeria*	66	–	Ⅳ	Ⅱ	∓	(6) 7–8	oval- linear	2	Ⅱ–Ⅲ	Ⅱ
Datiscaceae	*Octomeles*	68	–	Ⅱ (Ⅲ)	Ⅲ	–	5–7 (8)	palisade	4–5 (–7)	(Ⅱ) Ⅲ	(Ⅱ) Ⅲ
Dilleniaceae	*Dillenia*	70	+	Ⅲ	Ⅲ	+	–	oval	5–12	Ⅴ	Ⅱ (Ⅲ)
Dipterocarpaceae (Dipterocarpoideae)	*Anisoptera*	74	+	Ⅲ	Ⅲ–Ⅳ	–	5 (–6)*	oval	5–9	Ⅲ–Ⅳ	Ⅱ (Ⅲ)
	Cotylelobium	76	+	Ⅲ (Ⅳ)	Ⅱ–Ⅲ	–	5*	oval	4–6	Ⅲ	Ⅱ (Ⅲ)
	Dipterocarpus	82	+	Ⅱ–Ⅲ	(Ⅲ) Ⅳ–Ⅴ	–	6–7*	oval	(3–) 5–7 (–10)	Ⅲ–Ⅳ (Ⅴ)	Ⅱ–Ⅲ
	Dryobalanops	84	+	(Ⅱ) Ⅲ	(Ⅲ) Ⅳ (Ⅴ)	–	5–7*	oval	4–6 (–7)	Ⅲ (Ⅳ)	Ⅱ–Ⅲ
	Upuna	80	+	Ⅱ	Ⅱ–Ⅲ	–	5*	oval	5 (–6)	Ⅲ	Ⅰ–Ⅱ
	Vatica	78	±	(Ⅲ) Ⅳ (Ⅴ)	(Ⅰ) Ⅱ (Ⅲ)	∓	5–7*	oval	(4–) 5–8 (–12)	Ⅲ (Ⅳ)	Ⅱ–Ⅲ
	Hopea	86	–	Ⅱ–Ⅳ	Ⅱ–Ⅳ	–	(2–) 5–7*	oval	(2–) 3–5 (–7)	(Ⅰ) Ⅱ–Ⅲ	Ⅱ–Ⅲ
	Neobalanocarpus	88	–	Ⅲ (Ⅳ)	Ⅲ	–	5 (–6)*	oval	3–4	Ⅰ	Ⅲ
	Parashorea malaanonan	90	–	Ⅱ–Ⅲ	Ⅳ–Ⅴ	–	5–8*	oval	4–8 (–10)	Ⅱ–Ⅲ	(Ⅱ) Ⅲ
	Pentacme	92	–	Ⅱ–Ⅲ	(Ⅲ) Ⅳ–Ⅴ	–	4–8*	oval	4–6 (–8)	(Ⅱ) Ⅲ (Ⅳ)	Ⅱ–Ⅲ
	Shorea (*Anthoshorea*)	94	–	(Ⅱ) Ⅲ	Ⅲ–Ⅳ	–	5–7*	oval	4–6 (–7)	Ⅱ–Ⅲ (Ⅳ)	Ⅱ–Ⅲ
	Shorea (*Doona*)	102	–	Ⅲ–Ⅳ	Ⅲ–Ⅳ	–	5–6*	oval	3–5	Ⅱ	(Ⅱ) Ⅲ
	Shorea (*Richetioides*)	96	–	Ⅲ	Ⅲ–Ⅳ	–	5–7*	oval	(4–) 5–6 (–8)	Ⅲ–Ⅳ	Ⅱ–Ⅲ

このプレビューでは表示されない頁があります。

Techniques for Hand-sectioning

The microscopic study of wood is usually carried out on thin sections cut with a microtome using standard microtechnical procedures. However, this requires not only a good microtome, but is also laborious and time-consuming. Therefore, if it is just for identification, a rapid and convenient technique of free hand-sectioning with a disposable blade "NT-Cutter blade L-type" (Fujii, 2003) is recommended. The procedure is as follows:

1. Hold the block in your hand and make clean surfaces with a blade to ascertain the transverse (cross), radial and tangential directions in the sample.
2. Trim the sample block with a blade to expose the proper cross, tangential and radial surfaces. An area of 0.5 to 1 cm^2 is enough for each surface. Dip the block in water for a while so that it is wet and softened.
3. With a fresh blade or at least with an undamaged area of the blade, cut free hand sections from each surface. The sections may be irregular in shape and uneven in thickness, but this is not a big problem..
4. Place these sections on a slide glass, add some drops of glycerin, and put a cover glass on them.
5. Heat the slide on a hot-plate (of a type that is available for household use) at 100-150 ˚C for several minutes to completely remove any air bubbles from the sections.
6. Take the slide glass off the hot-plate, cool down, and then clean and dry the bottom surface of the slide glass with paper tissue if necessary.
7. The sections are now ready for microscopic investigation. The time needed for steps 1 to 6 is only a few minutes.

If the sections need to be preserved as permanent microscopic slides, the following procedure should be followed:

a. Immerse the temporary microscopic slide into water in a petri dish, remove the cover glass, and rinse out all glycerin.
b. When many samples are processed at once, pick up each set of sections in a small basket made of fine mesh, preferably of stainless steel. Prepare a series of solutions in separate containers (petri dishes) in line and process successively.
c. If necessary, sections are stained with a dye. Put the sections (or the basket with sections) in 0.5 % crystal violet in 30 % ethanol for several minutes and rinse well with water. Then immerse in 1.0 % safranin solution in 30 % ethanol for 10 to 30 minutes and again rinse well with water.
d. Transfer the sections into ca 100 % ethanol and dehydrate thoroughly in fresh ca 100 % ethanol. Direct immersion in absolute alcohol (ca 100 % ethanol) from water does not cause any distortion to the wood sections, although a series of graded ethanol, for example 30 %, 50 %, 75 %, 80 %, 95 %, and 100 %, is recommended for sample dehydration of softer tissues as explained in botanical textbooks.
e. Put the sections in xylene. To avoid cloudiness caused by residual glycerin or water within sections, the sections may be transferred through a mixture of xylene and creosote (1:1) from ethanol to xylene.
f. Mount the sections in Canada balsam on a glass slide.
g. Dry and harden the sections in an oven at around 60 ˚C for several days.

When the presence of silica bodies needs to be ascertained, the same procedure should be followed. Because silica bodies have a refractive index very close to that of water and glycerin, they are not conspicuous in glycerin-mounted microscopic slides, but become distinct and "shiny" in Canada balsam owing to the distinctly different refractive indices.

The procedure from (a) to (g) mentioned above is as follows:

① Rinse with water (twice)
↓
② Crystal violet (ca 5 minutes)
↓
③ Rinse with water
↓
④ Safranin (10-30 minutes)
↓
⑤ Rinse with water
↓
⑥ Pure ethanol (twice)
↓
⑦ Xylene + Creosote
↓
⑧ Xylene
↓
⑨ Mount in Canada balsam on a glass slide
↓
Oven (ca 60 ˚C, several days)

Literature Cited

Airy Shaw, H.K. 1965. Diagnoses of new families, new names, etc., for the seventh edition of Willis's "Dictionary". Kew Bull. 18: 249-273.

APG. 1998. An ordinal classification for the families of flowering plants. Ann. Missouri Bot. Gard. 85: 531-553.

APG II. 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Bot. J. Linn. Soc. 141: 399-436.

Ashton, P.S. 1982. Dipterocarpaceae. Fl. Mal. ser. I, Vol. 9: 237-552.

Baas, P. & Zweypfenning, R.C.V.J. 1979. Wood anatomy of the Lythraceae. Acta Bot. Neerl. 28: 117-155.

Burgess, P.F. 1966. Timbers of Sabah. Sabah For. Rec. No 6: 501 pp.

Canright, J.E. 1955. The comparative morphology and relationships of the Magnoliaceae. IV. Wood and nodal anatomy. J. Arn. Arb. 36: 119-140.

Carlquist, S. 1988. Comparative wood anatomy. Systematic, ecological and evolutionary aspects of dicotyledon wood. Springer-Verlag. 436 pp.

Chattaway, M.M. 1959. The anatomy of bark. VII. Species of Eugenia (sens. lat.). Trop. Woods 111: 1-14.

Dadswell, H.E. & Ingle, H.D. 1948. The anatomy of timbers of the South-west Pacific area I. Anacardiaceae. Austr. J. Sci. Res., ser. B, 1: 391-415.

De Wilde, W.J.J.O. 2000. Myristicaceae. Fl. Mal., ser. I, Vol. 14: 1-632.

DeZeeuw, C.H. 1977. Pakaramoideae, Dipterocarpaceae of the western hemisphere. Part 3. Stem anatomy. Taxon 26: 368-380.

Desch, H.E. 1941. Dipterocarp timbers of the Malay Peninsula. Malayan For. Rec. No. 14: 171 pp.

Desch, H.E. 1954. Manual of Malayan Timbers. Vol. 1. Malayan For. Rec. No. 15: 328 pp.

Ding Hou. 1978. Florae Malesianae precursors LVI. Anacardiaceae. Blumea 24: 1-41.

Evans, J.P., Gasson, P.E. & Lewis G.P. 2006. Wood anatomy of the Mimosoideae (Leguminosae). IAWA J. Suppl. 5. 118 pp.

Fujii, T. 2003. Application of the "NT-Cutter" knife blade to microtome sectioning of wood. IAWA J. 24: 241-245.

Gottwald, H. & Parameswaran, N. 1966. Das sekundäre Xylem der Familie Dipterocarpaceae, anatomische Untersuchungen zur Taxonomie und Phylogenie. Bot. Jb. 85: 410-508.

Gregory, M. 1994. Bibliography of systematic wood anatomy of Dicotyledons. IAWA J. Suppl. 1. 265 pp.

Hess, R.W. 1946. Keys to American woods. XIX. Special fibers in parenchyma-like arrangement. Trop. Woods 85: 15-16.

Hou, D. 1978. Anacardiaceae. Fl. Mal., ser. I, Vol. 8: 395-548.

IAWA Committee. 1989. IAWA list of microscopic features for hardwood identification (Editors: Wheeler, E.A., Baas, P. & Gasson, P.E.). IAWA Bull. n.s. 10: 219-332.

Ingle, H.D. & Dadswell, H.E. 1953. The anatomy of the timbers of the south-west Pacific area. III. Myrtaceae. Austr. J. Bot. 1: 353-401.

Klaassen, R. 1999. Wood anatomy of the Sapindaceae. IAWA J. Suppl. 2. 214 pp.

Kostermans, A.J.G.H. 1952. Notes on two leguminous genera from eastern Indonesia. Reinwardtia 1: 451-457.

Kostermans, A.J.G.H. 1959. A monograph of the genus Heritiera Aiton. Reinwardia 4: 465-583.

Kribs, D.A. 1930. Comparative anatomy of the woods of the Meliaceae. Am. J. Bot. 17: 724-738.

Kribs, D.A. 1935. Salient lines of structural specialization in the wood rays of dicotyledons. Bot. Gaz. 96: 547-557.

Kribs, D.A. 1959. Commercial foreign woods on the American market. Pennsylvania State Univ. 203 pp.

Lam, H.J. & other researchers. 1952-1957. Blumea 6-10.

Lam, H.J. & other researchers. 1957-1959. Nova Guinea, n.s. 8 & 10.

Leenhouts, P.W. 1956. Burseraceae. Fl. Mal., ser. I, Vol. 5: 209-296.

Mabberley, D.J. et al. 1995. Meliaceae. Fl. Mal., ser. I, Vol. 12: 1-407.

Mabberley, D.J. 1997. The plant book. A portable dictionary of the vascular plants. 2nd. ed. Cambridge Univ. Press.

Marco, H.F. 1935. Systematic anatomy of the woods of Rhizophoraceae. Trop. Woods 44: 1-20.

Metcalfe, C.R. & Chalk, L. 1950. Anatomy of the dicotyledons. 2 vols. Clarendon Press, Oxford. 1500 pp.

Miller, R.B. 1975. Systematic anatomy of the xylem and comments on the relationships of Flacourtiaceae. J. Arn. Arb. 56: 20-102.

Morton, C.M. 1995. A new genus and species of Dipterocarpaceae from the Neotropics 2. Stem anatomy. Brittonia 47: 237-247.

Pennington, T.D. & Styles, B.T. 1975. A generic monograph of the Meliaceae. Blumea 22: 419-540.

Pike, K. 1956. Pollen morphology of Myrtaceae from the southwest Pacific area. Austr. J. Bot. 4: 13-53.

PROSEA (Plant resources of South-East Asia) No (1). Timber trees: Major commercial timbers (Editors: Soerianegara, I. & Lemmens, R.H.M.J.). Pudoc Scientific Publishers, Wageningen. 610 pp.; No 5(2). 1995. Timber trees: Minor commercial timbers (Editors: Lemmens, R.H.M.J., Soerianegara, I. & Wong, W.C.). Backhuys Publishers, Leiden. 655 pp.; No. 5(3). 1998. Timber trees: Lesser-known timbers (Editors: Sosef, M.S.M., Hong, L.T. & Prawirohatmodjo, S.). Backhuys Publishers, Leiden. 859 pp.

Ramesh, K.R. & Purkayashtha, S.K. 1972. Indian Woods, Vol. 3. Dehra Dun, India.

Schmidt, R. 1972. A resolution of the Eugenia-Syzygium controversy (Myrtaceae). Amer. J. Bot. 59: 423-436.

Sidiyasa, K. & Baas, P. 1998. Ecological and systematic wood anatomy of Alstonia (Apocynaceae). IAWA J. 19: 207-229.

Stevens, P. F. (2001 onwards). Angiosperm Phylogeny Website. Version 8, June 2007.

Symington, C.F. 1943. Foresters' manual of dipterocarps. Malayan For. Rec. No. 16. 244 pp.

Ter Welle, B.J.H. et al. 1986. The systematic wood anatomy of the Moraceae (Urticales) V. Genera of the tribe Moreae without urticaceous stamens. IAWA Bull. n.s. 7: 175-193.

Van Vliet, G.J.C.M. 1976. Wood anatomy of the Rhizophoraceae. Leiden Botanical Series No. 3: 20-75.
Warburg, O. 1897. Monographie der Myristicaceen. Nova Acta Academia Caesareae Leopoldiana-Caroliniana 68: 1-680.
Whitmore, T.C. 1972. Staphyleaceae. Tree flora of Malaya. A manual of foresters. Vol. 1. Malayan For. Rec. No. 26.

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Aaa: common name, Aaa: family name, *Aaa*: genus or species name

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