

**A wood charcoal reference collection for the Anthracology of the northern Highlands of Ethiopia.**

**AUTHORS:** Abel RUIZ-GIRALT <sup>(1)</sup>, Charlène BOUCHAUD <sup>(2)</sup>, Aurélie SALAVERT <sup>(2)</sup>, Carla LANCELOTTI <sup>(1)</sup>, A. Catherine D'ANDREA <sup>(3)</sup>

(1) CaSEs – Complexity and Socioecological Dynamics Research Group. Departament de Humanitats, Universitat Pompeu Fabra & Departamento de Arqueología y Antropología, Institución Milá i Fontanals–Consejo Superior de Investigaciones Científicas, Barcelona, Spain.

(2) UMR 7209 (CNRS-MNHN) - Archéozoologie, Archéobotanique: Sociétés, pratiques et environnements, Muséum National d'Histoire Naturelle. 55, rue Buffon (CP 56), F-75005 Paris, France.

(3) Department of Archaeology, Simon Fraser University. Burnaby, British Columbia Canada, V5A 1S6, Canada.

**ORCID ID:**

Abel Ruiz-Giralt: 0000-0002-8472-043X

Charlène Bouchaud: 0000-0002-1318-027X

Aurélie Salavert: 0000-0002-7854-9170

Carla Lancelotti: 0000-0003-1099-7329

A. Catherine D'Andrea: 0000-0002-5847-4853

**CORRESPONDING AUTHOR:**

Abel Ruiz-Giralt: abel.ruiz@upf.edu



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The present reference collection is a work in progress. As so, new plant taxa will be added in the future. If possible, we will collect wood directly from current Tigray's vegetation in order to improve the utility of the collection in future anthracological analyses in the northern Highlands of Ethiopia. So far, both unburned wood and charcoal samples have been taken from the Muséum national d'Histoire naturelle (Paris) collections, namely the heritage collection of the xylothèque (contact: M. Tengberg) and working reference collection of the anthracothèque (UMR 7209, contact: A. Salavert) (Table 1). Plant species and genus were selected according to their importance in the different vegetation types present in the northern Highlands of Ethiopia following the information published by Friis et al. (2010) and their availability in the collections. The unburned wood samples were prepared for microscopic observation at the MNHN with the aid of Michel Lemoine (Centre National de la Recherche Scientifique, France), following an adaptation of the procedure described by Orvis et al. (2005): 4-10 centimeters long wood samples were wrapped with aluminum foil and heated to 400 °C for 90 minutes until full charcoalification using a muffle furnace Nabertherm L5/11. After cooling, all reference specimens were described and photographed. Table 1 summarizes the plant species and genus included in the reference collection.

Table 1.: Summary of plant species and genera included in the reference collection.

Family	Scientific name	Collection	Provenance	Source
Anacardiaceae	<i>Rhus</i> sp.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Apocynaceae	<i>Carissa schimperi</i> A.DC.	MNHN Xylotheque	Somalia	Revoil, G.
Boraginaceae	<i>Cordia lutea</i> Lam.	MNHN Anthracoteque	Peru	Mouterde, F.
Cannabaceae	<i>Celtis australis</i> L.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Capparaceae	<i>Maerua crassifolia</i> Forssk.	MNHN Anthracoteque	Pakistan	Tengberg, M.
Celastraceae	<i>Celastrus senegalensis</i> Lam.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Celastraceae	<i>Maytenus octogona</i> (L'Hér.) DC.	MNHN Anthracoteque	Peru	Mouterde, F.
Combretaceae	<i>Combretum trichanthum</i> Fresen.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Cupressaceae	<i>Juniperus macropoda</i> Boiss.	MNHN Anthracoteque	Pakistan	Thiébauld, S.
Ebenaceae	<i>Euclea racemosa</i> L.	MNHN Xylotheque	South Africa	Errington de la Croix, J.
Ebenaceae	<i>Diospyros lotus</i> L.	MNHN Anthracoteque	Unknown	Laboratoire de Montpellier
Euphorbiaceae	<i>Euphorbia</i> sp.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Euphorbiaceae	<i>Croton alnifolius</i> Lam.	MNHN Anthracoteque	Peru	Mouterde, F.
Fabaceae	<i>Acacia mellifera</i> (Vahl) Benth.	MNHN Anthracoteque	Djibouti	Thiébauld, S.
Malvaceae	<i>Gossypium</i> sp.	MNHN Xylotheque	U.S.A.	Schomburgk, R. H.
Malvaceae	<i>Grewia</i> sp.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Moraceae	<i>Ficus indica</i> L.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Oleaceae	<i>Olea europaea</i> L.	MNHN Anthracoteque	Italy	Laboratorio di Como
Oleaceae	<i>Olea cuspidata</i> W.	MNHN Anthracoteque	Pakistan	Thiébauld, S.
Pittosporaceae	<i>Pittosporum</i> <i>abyssinicum</i> Delile.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Podocarpaceae	<i>Podocarpus elongatus</i> (Aiton) L'hér. ex Pers.	MNHN Xylotheque	South Africa	Errington de la Croix, J.
Rhamnaceae	<i>Rhamnus pauciflora</i> Hochst. ex A.Rich.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Rosaceae	<i>Hagenia abyssinica</i> Willd.	MNHN Anthracoteque	Ethiopia	Salavert, A.
Rubiaceae	<i>Canthium</i> <i>schimperianum</i> A.Rich.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Sapindaceae	<i>Dodonaea viscosa</i> Jacq.	MNHN Xylotheque	Ethiopia	Schimper, G. H. W.
Stilbaceae	<i>Nuxia floribunda</i> Benth.	MNHN Xylotheque	South Africa	Errington de la Croix, J.

**ANACARDIACEAE**

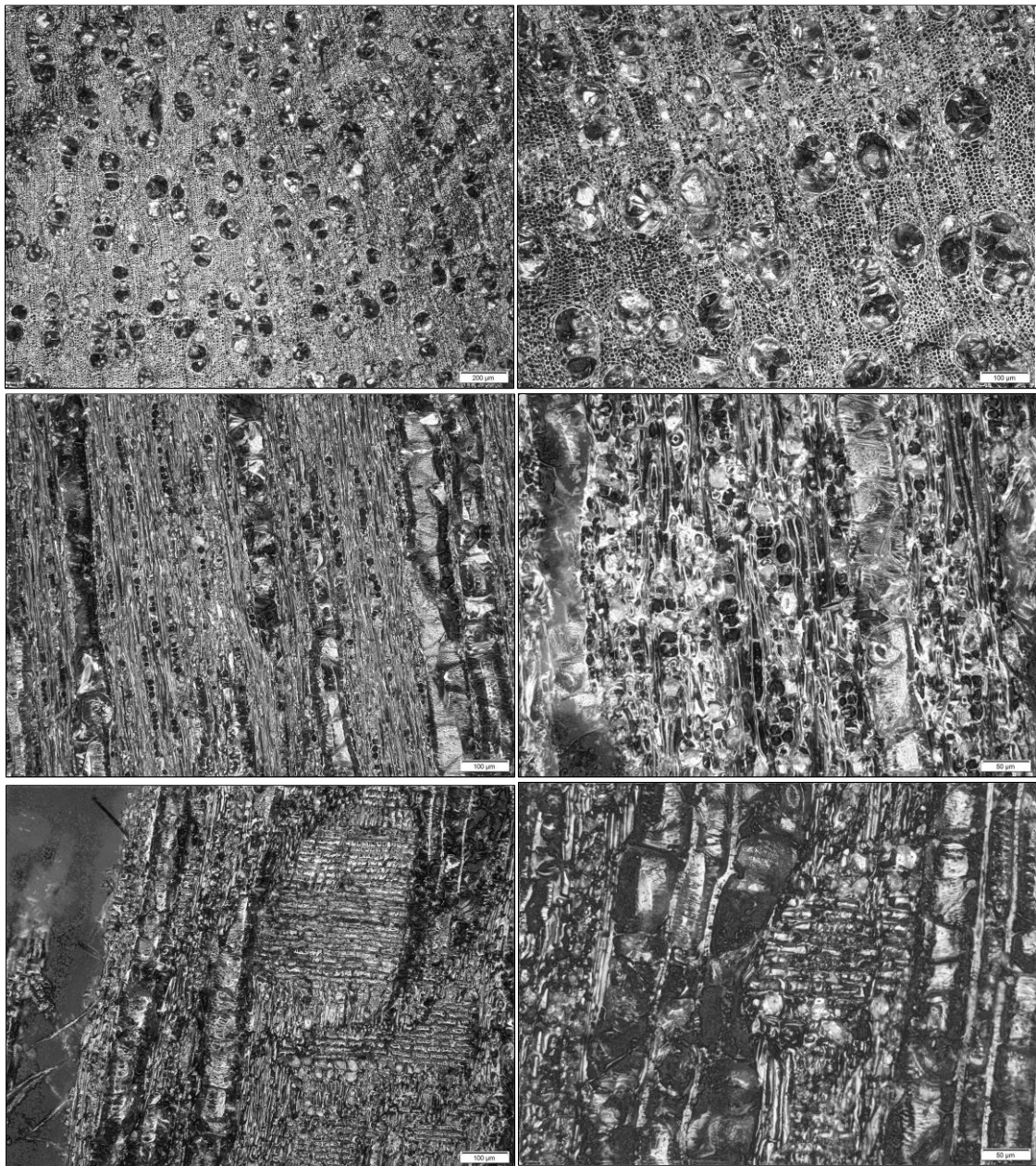
*Rhus sp.*

Growth rings distinct. Wood diffuse-porous. Vessels mid-sized, generally solitary or in radial groups of 2-4. Perforation plates simple. Intervessel pits alternate, elongated. Vessel-ray pits with reduced borders to apparently simple, pits rounded, sometimes pits horizontal (scalariform, gash-like) to vertical (palisade).

Axial parenchyma absent or extremely rare.

Rays 1-3seriates, mostly uniseriates. Heterocellular, composed of procumbent cells with 2 or more rows of square/upright cells.

Tyloses common. Prismatic crystals present, mainly in ray cells.



**APOCYNACEAE**

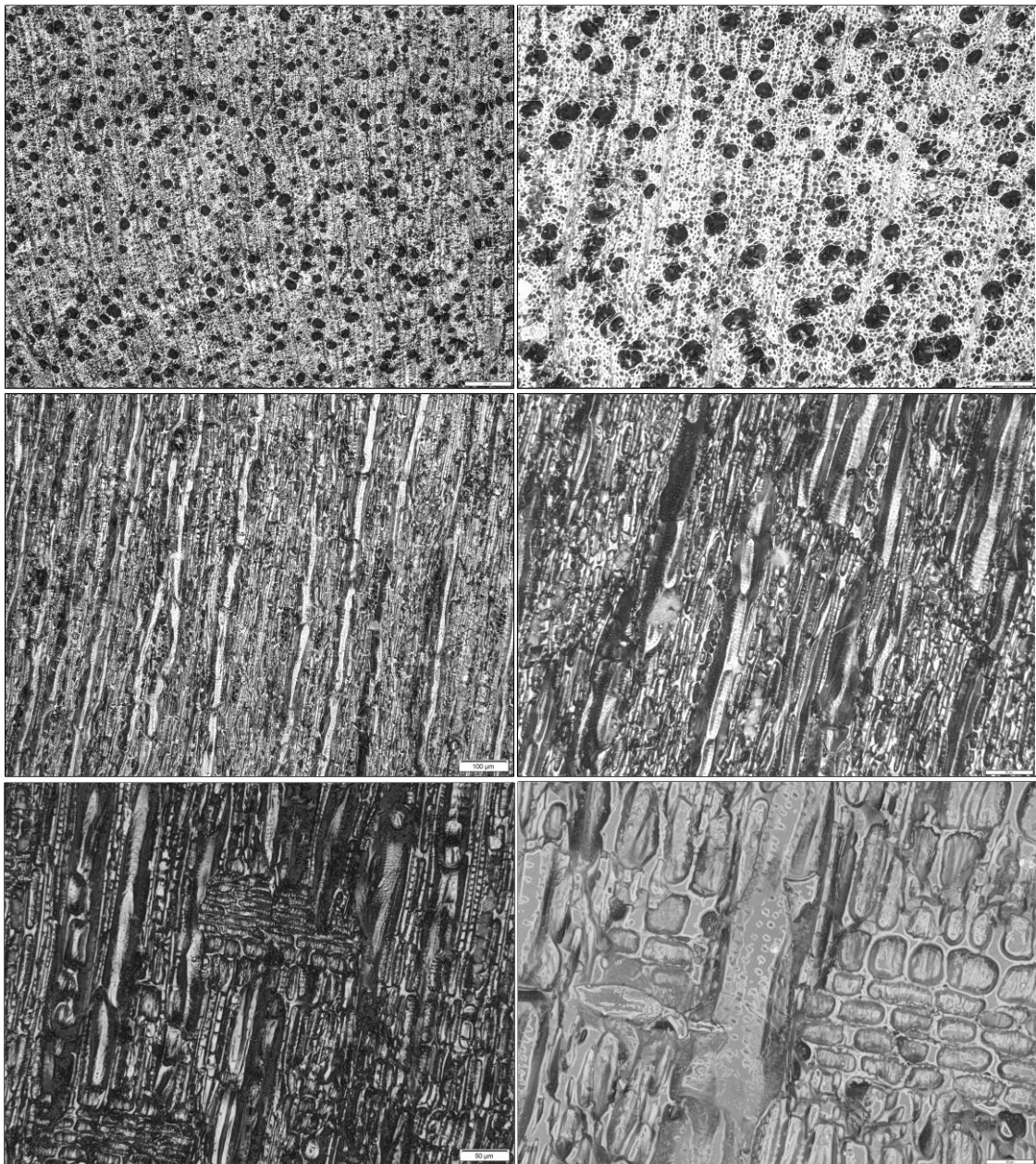
*Carissa schimperi.*

Growth rings indistinct or absent. Wood diffuse-porous. Small vessels, mostly isolated with angular outlines. Perforation plates simple. Intervessel pits alternate, vestured. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma diffuse, apotracheal, sometimes in aggregates. Over 4 cells per strand.

Rays 1-3seriates, with bigger elongated terminal cells. Heterocellular, composed of procumbent cells with 1-4 or more rows of square/upright cells.

Fibres pitting common. Prismatic crystals present, mainly in chambered axial parenchyma cells.



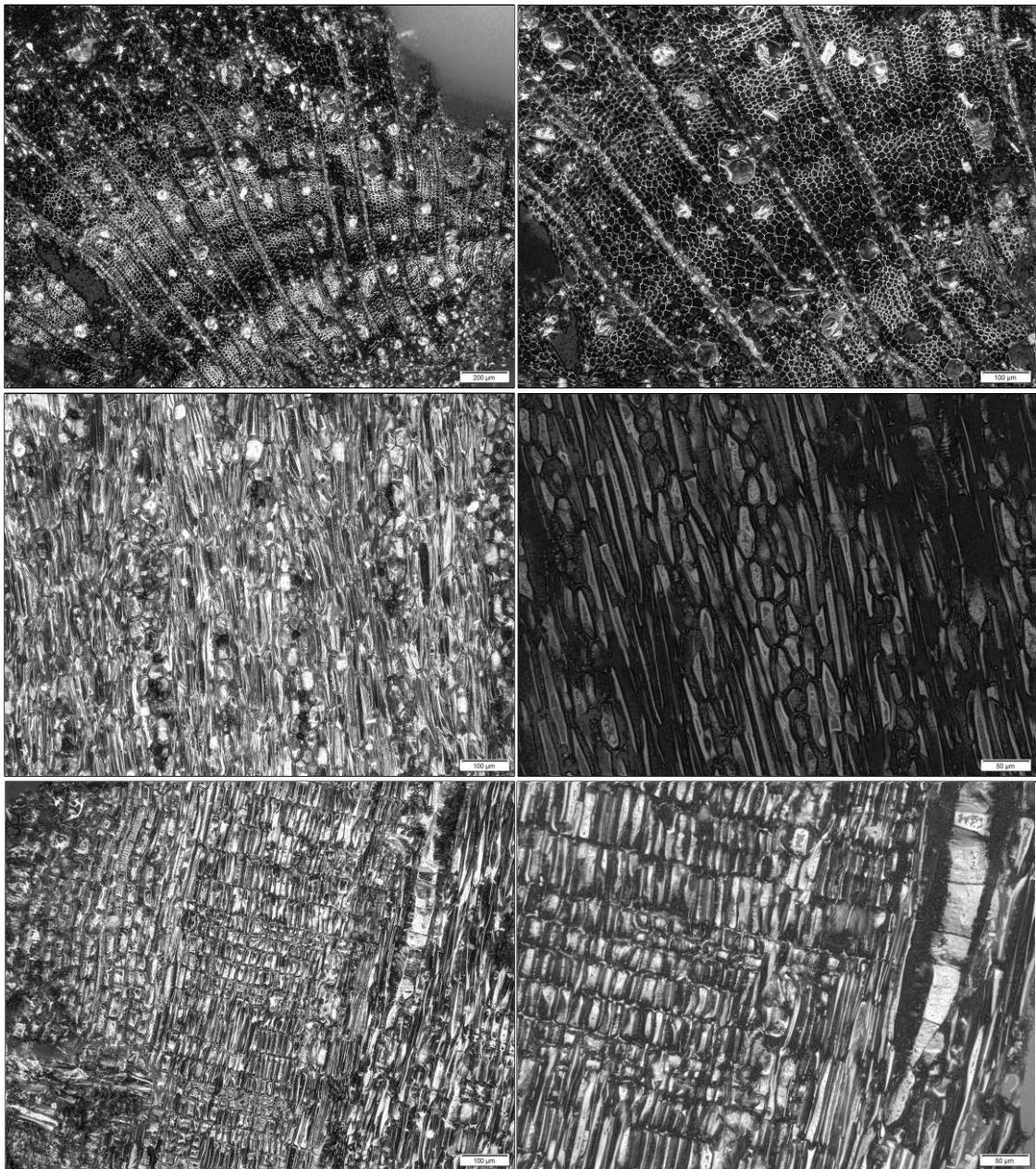
**BORAGINACEAE***Cordia lutea.*

Growth rings indistinct or absent. Wood semi-ring-porous to diffuse-porous. Small vessels, sometimes solitary, sometimes in small groups forming clusters. Perforation plates simple. Intervessel pits alternate, elongated. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma paratracheal, vasicentric, sometimes confluent forming parenchyma bands of more than 3 cells wide. 2-4 cells per strand.

Rays 2-4seriates, sometimes very long. Heterocellular, composed of procumbent and square/upright cells all mixed throughout the ray.

Tyloses common. Prismatic crystals present, usually in square/upright ray cells.



**CANNABACEAE**

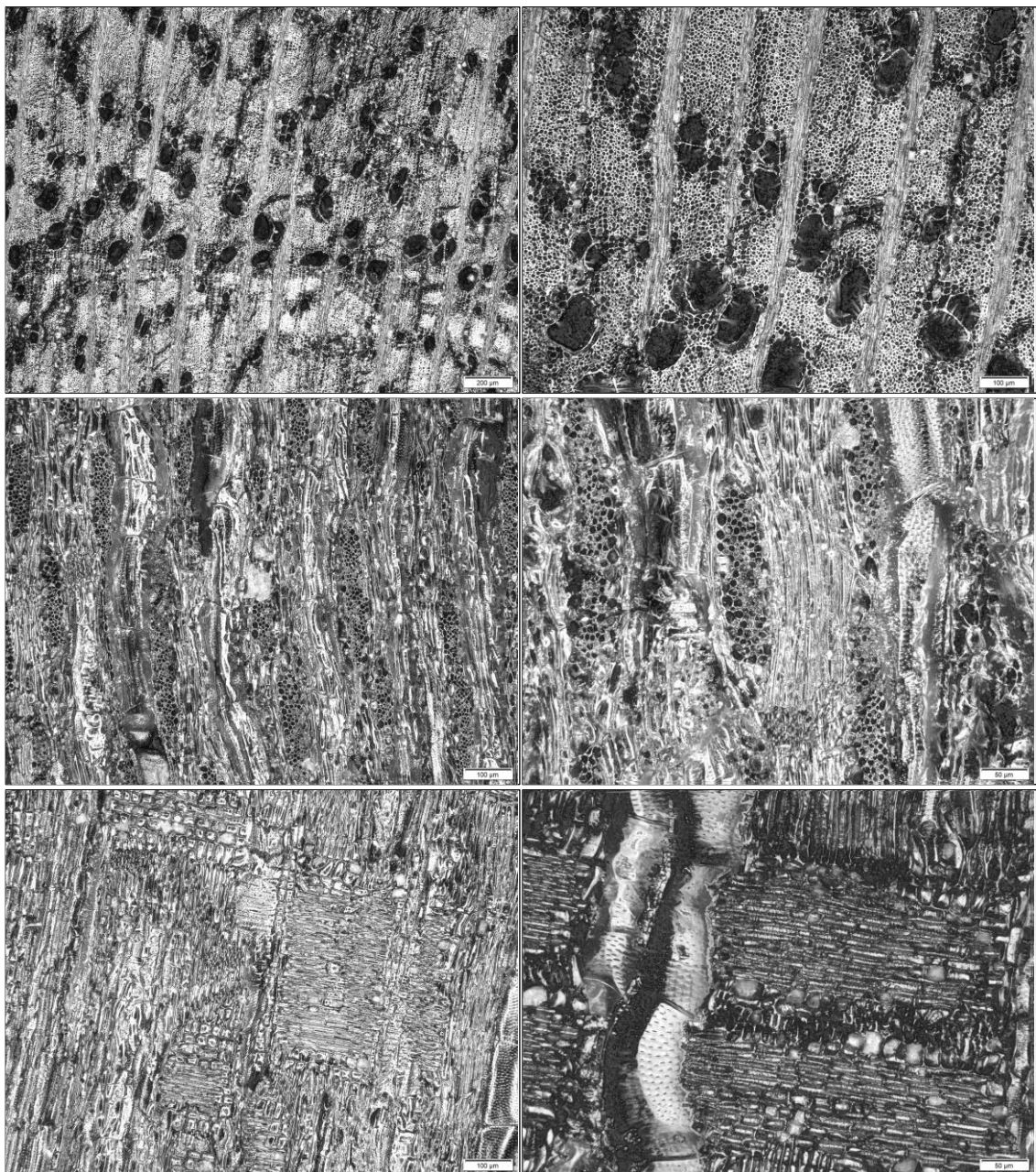
*Celtis australis.*

Growth rings distinct. Wood ring-porous. Big vessels, usually forming clusters and featuring a dendritic distribution. Solitary vessel outline angular. Simple perforation plates. Intervessel pits alternate. Helical thickening present. Vessel-ray pits generally with distinct borders, similar to intervessel pits in size and shape; sometimes with much reduced borders to apparently simple, pits rounded.

Axial parenchyma paratracheal vasicentric, confluent. 2-4 cells per strand.

Rays mostly 4-8seriates, rarely 1-3seriates, sometimes with bigger terminal cells. Heterocellular, sometimes body ray cells procumbent with 1-2 rows of square/upright cells, sometimes all mixed. Sheat cells present.

Libriform fibres present. Prismatic crystals present in square/upright ray cells.



**CAPPARACEAE**

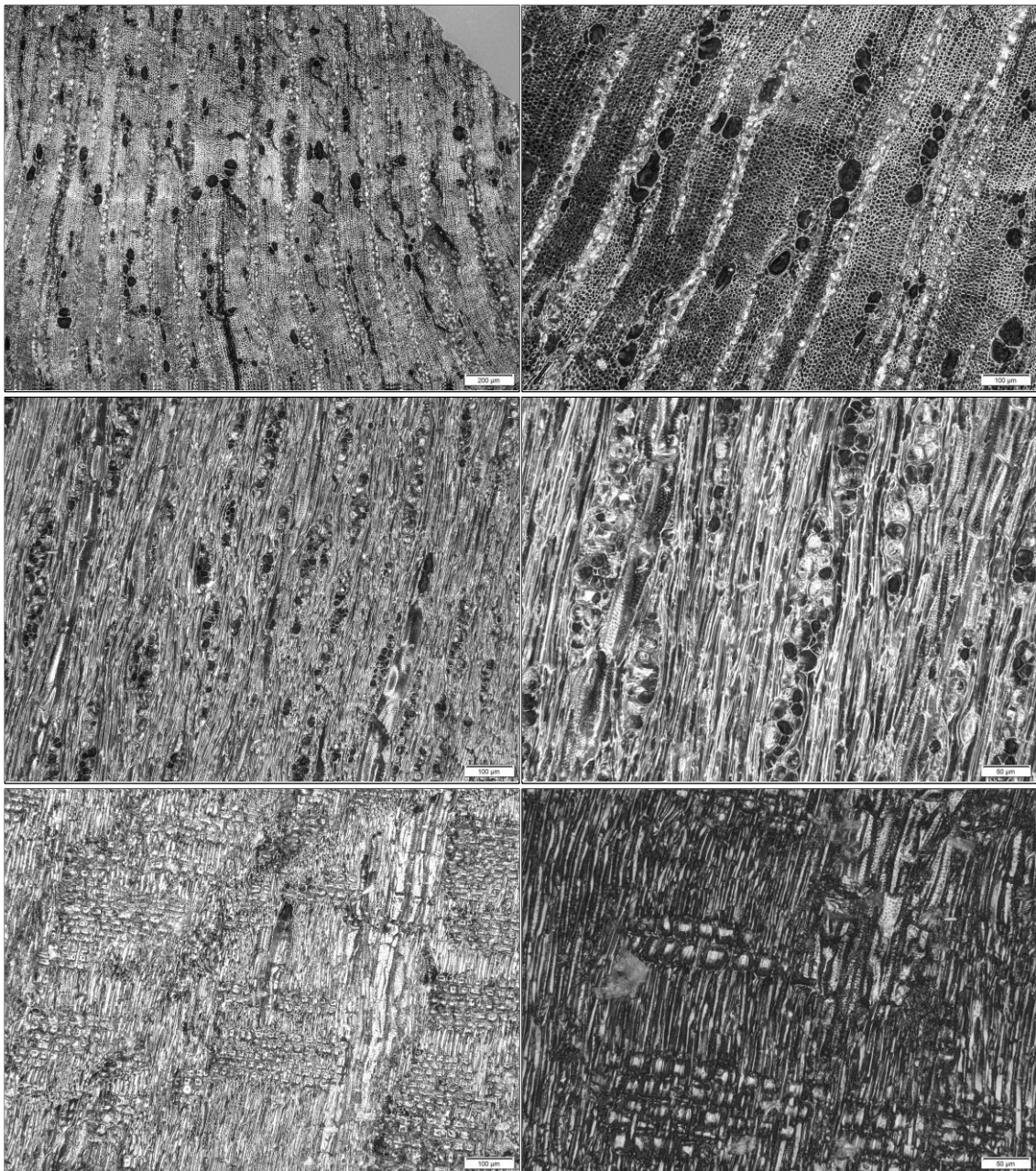
*Maerua crassifolia.*

Growth rings indistinct or absent. Wood diffuse-porous. Vessels mid-sized, in radial groups of 2-4. Perforation plates simple. Intervessel pits alternate, vestured, with polygonal shape. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma paratracheal, scanty paratracheal to vasicentric. 2 cells per strand.

Rays 1-3seriates, usually long. Homocellular, all cells procumbent to heterocellular, all cell types mixed

Prismatic crystals present.





**CELASTRACEAE**

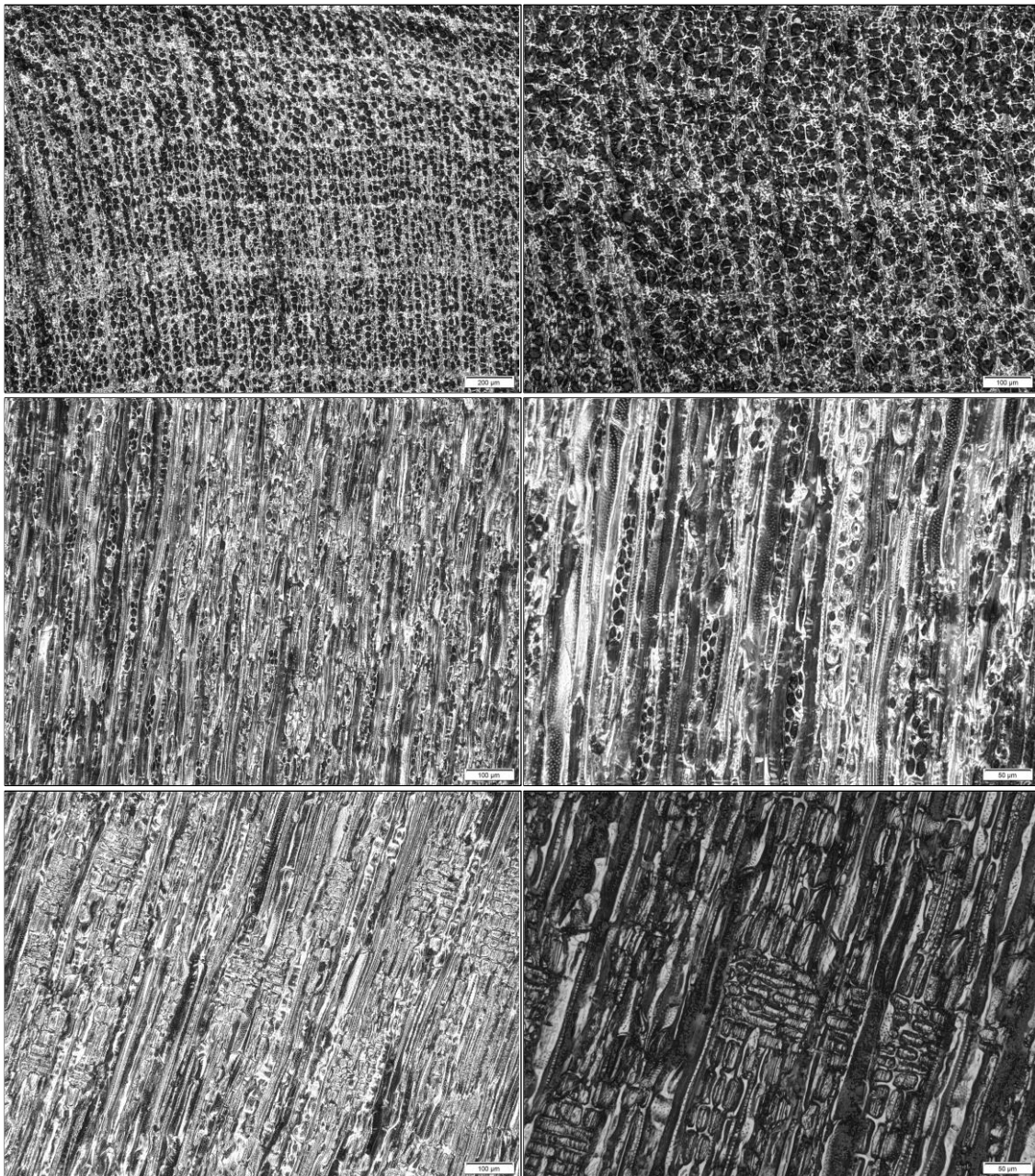
*Celastrus senegalensis*.

Growth rings indistinct or absent. Wood diffuse-porous, with a high vessel density. Small vessels, in radial groups of 4 or more, usually forming clusters. Solitary vessel outline angular. Perforation plates simple. Intervessel pits alternate, minute, vestured. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma paratracheal scanty. 3-4 cells per strand.

Rays 1-3seriate, very long with multiseriate portions as wide as the uniseriates. Heterocellular, body ray cells procumbent with 2-4 or more rows of square/upright cells. Sheat cells present.

Fibre pitting common. Septate fibres present. Crystals absent.



**CELASTRACEAE**

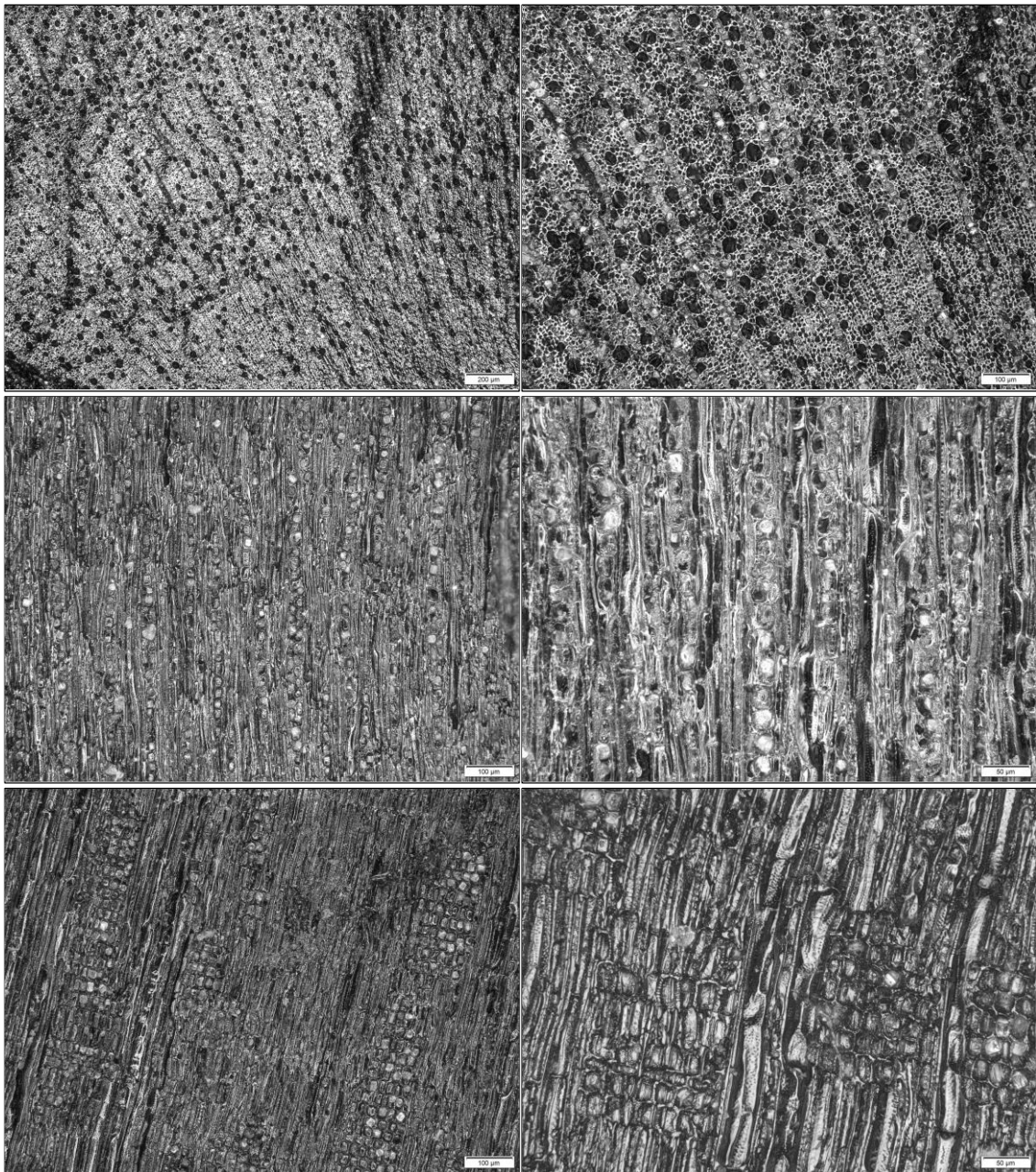
*Maytenus octogona*.

Growth rings indistinct or absent. Wood diffuse-porous. Small vessels, usually solitary, sometimes in radial groups of 2-4 or more cells. Perforation plates simple. Intervessel pits alternate, minute, with polygonal shape. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal, diffuse. 4 or more cells per strand.

Rays mostly uniseriates, rarely 2-3seriates. Heterocellular, all cells square/upright to all cell types mixed.

Fibre pitting common. Septate and non-septate fibres present, forming parenchyma-like fibre bands. Prismatic crystals present in ray cells.



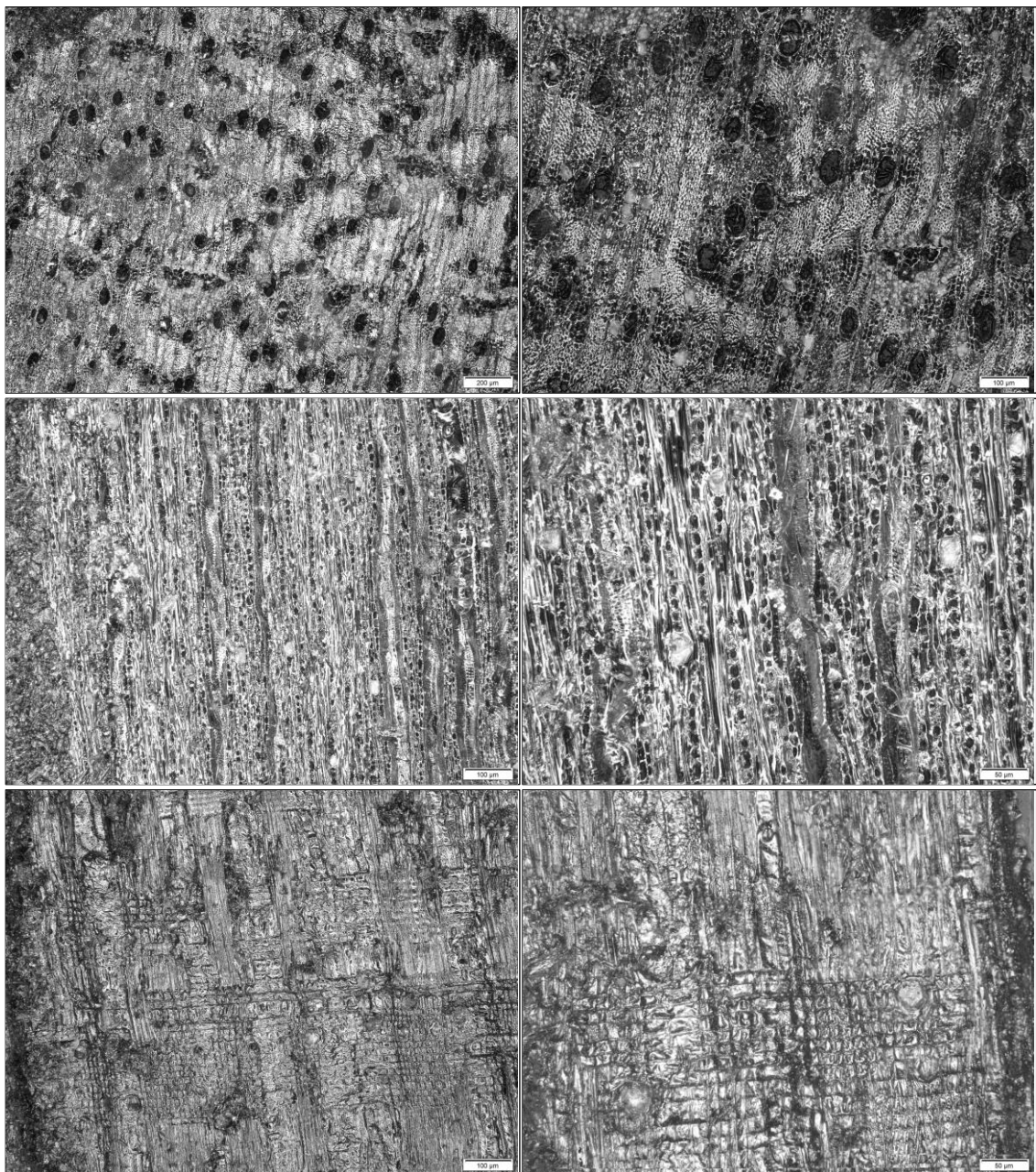
**COMBRETACEAE***Combretum trichanthum.*

Growth rings indistinct or absent. Wood diffuse-porous. Vessels mid-sized, mostly isolated, featuring a diagonal/dendritic distribution. Perforation plates simple. Intervessel pits alternate, elongated, vestured. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse, paratracheal vasicentric, sometimes aliform, and confluent, forming bands of more than three cells wide. 2-6 or more cells per strand.

Rays mostly uniseriata, rarely 2-3seriata. Generally homocellular, with all cells procumbent, but sometimes heterocellular, all cell types mixed.

Libriform fibres present. Septate and non-septate fibres present. Prismatic crystals present in axial parenchyma cells. Druses present in axial parenchyma cells.



**CUPRESSACAE**

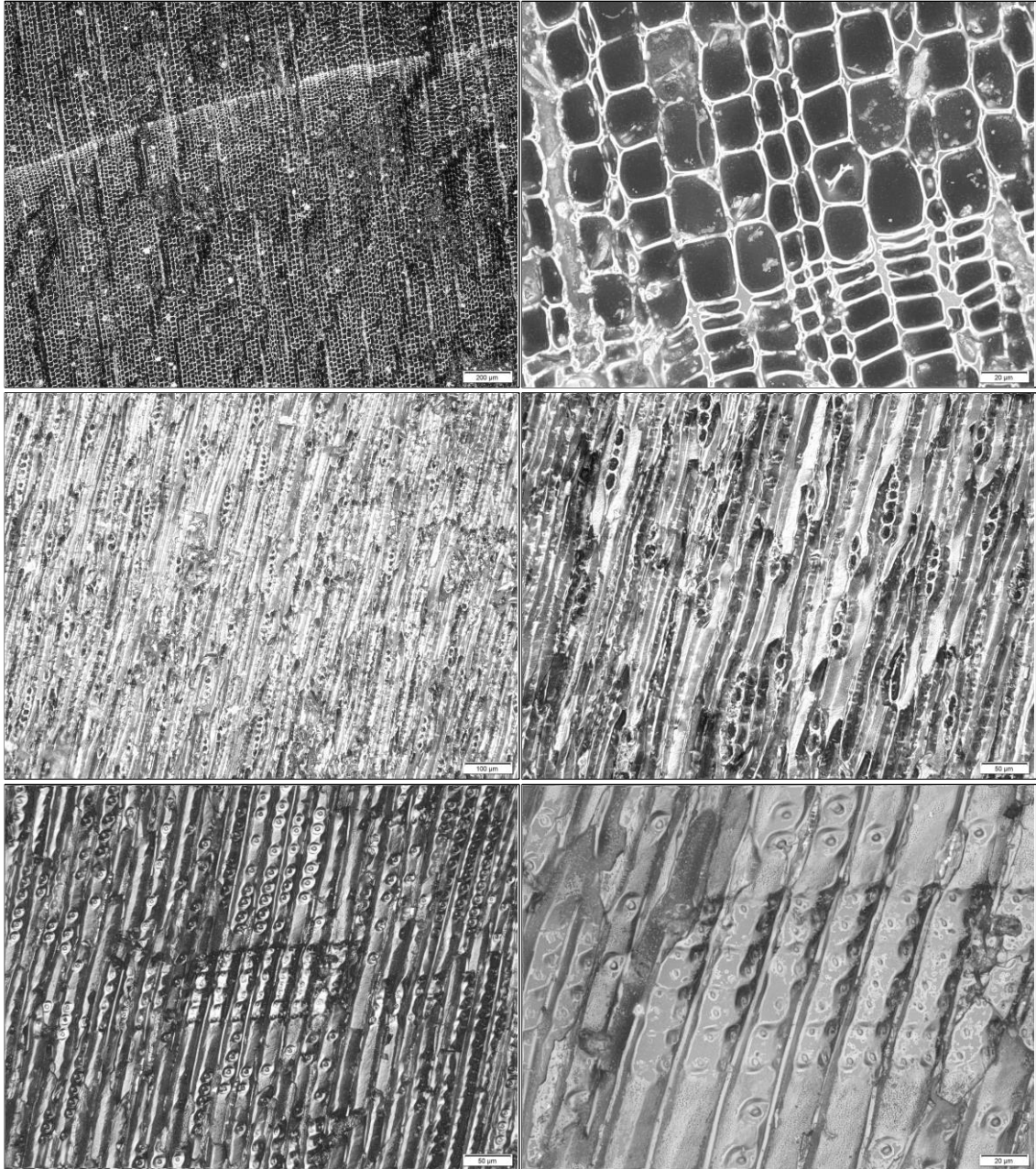
*Juniperus macropoda.*

Growth rings distinct. Transition from early- to latewood abrupt. Tracheid pitting uniseriate. Intercellular spaces between tracheids present. Warty layer present.

Axial parenchyma scarce or absent.

Rays exclusively uniseriate, mostly up to 4 cells high, rarely 5-15 cells. Ray tracheids absent. Cross field pits 2-4 per field, cupressoid.

Resin canals absent.



**EBENACEAE**

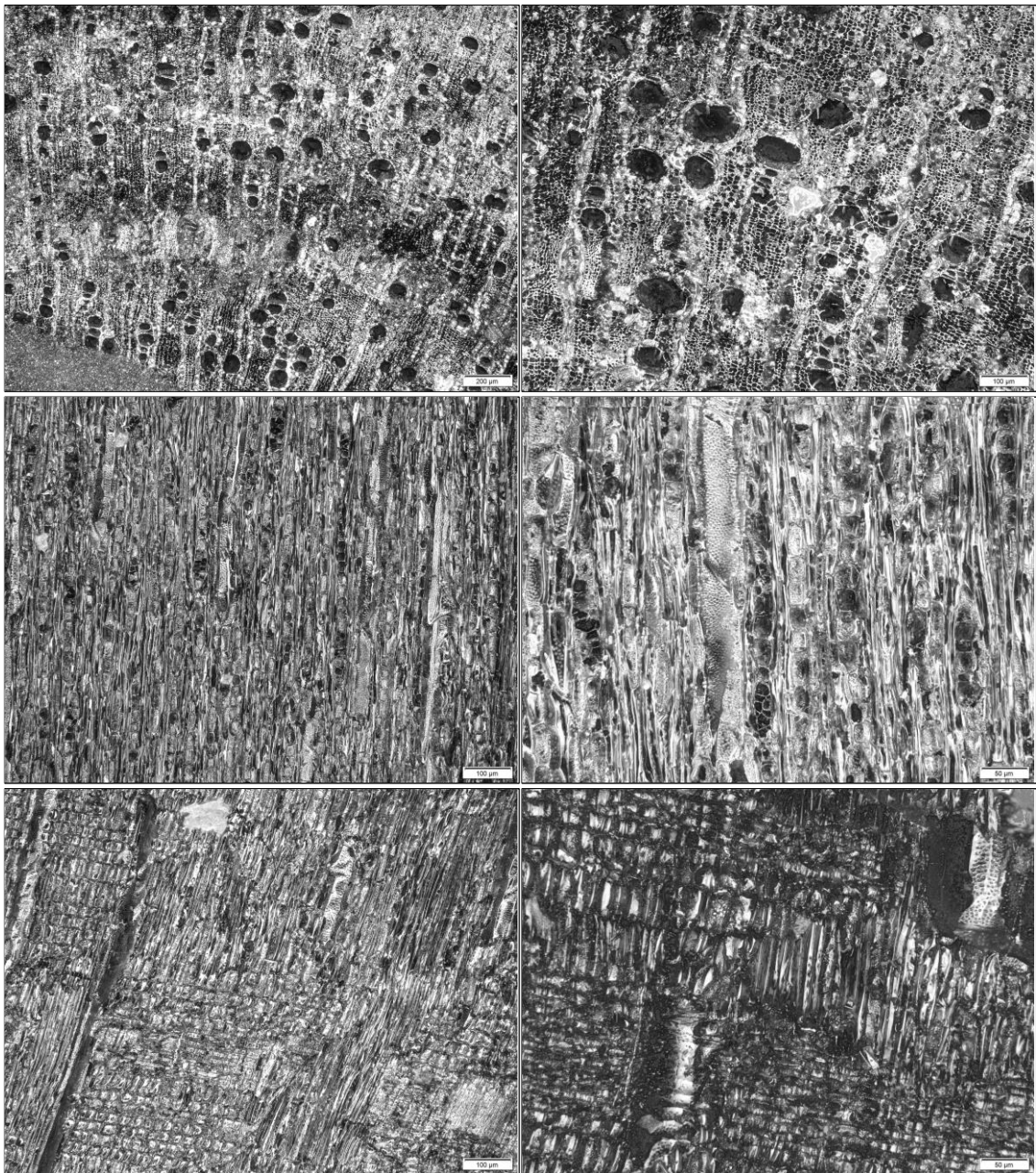
*Diospyros lotus.*

Growth rings indistinct or absent. Wood diffuse-porous. Vessels mid-sized, sometimes solitary, sometimes in radial groups of 2-4, featuring a radial distribution. Solitary vessel outline tends to angular. Perforation plates simple. Intervessel pits alternate, usually minute. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse-in-aggregates, paratracheal scanty, vasicentric. Parenchyma bands present, tangential narrow, up to three cells.

Rays 1-3 seriate, with multiseriate portions as wide as the uniseriates. Heterocellular, sometimes with ray body cells procumbent and 1-4 rows of square/upright cells, sometimes with all cell types mixed.

Fibre pitting common. Crystals absent. Storied structure: all elements storied.



**EBENACEAE**

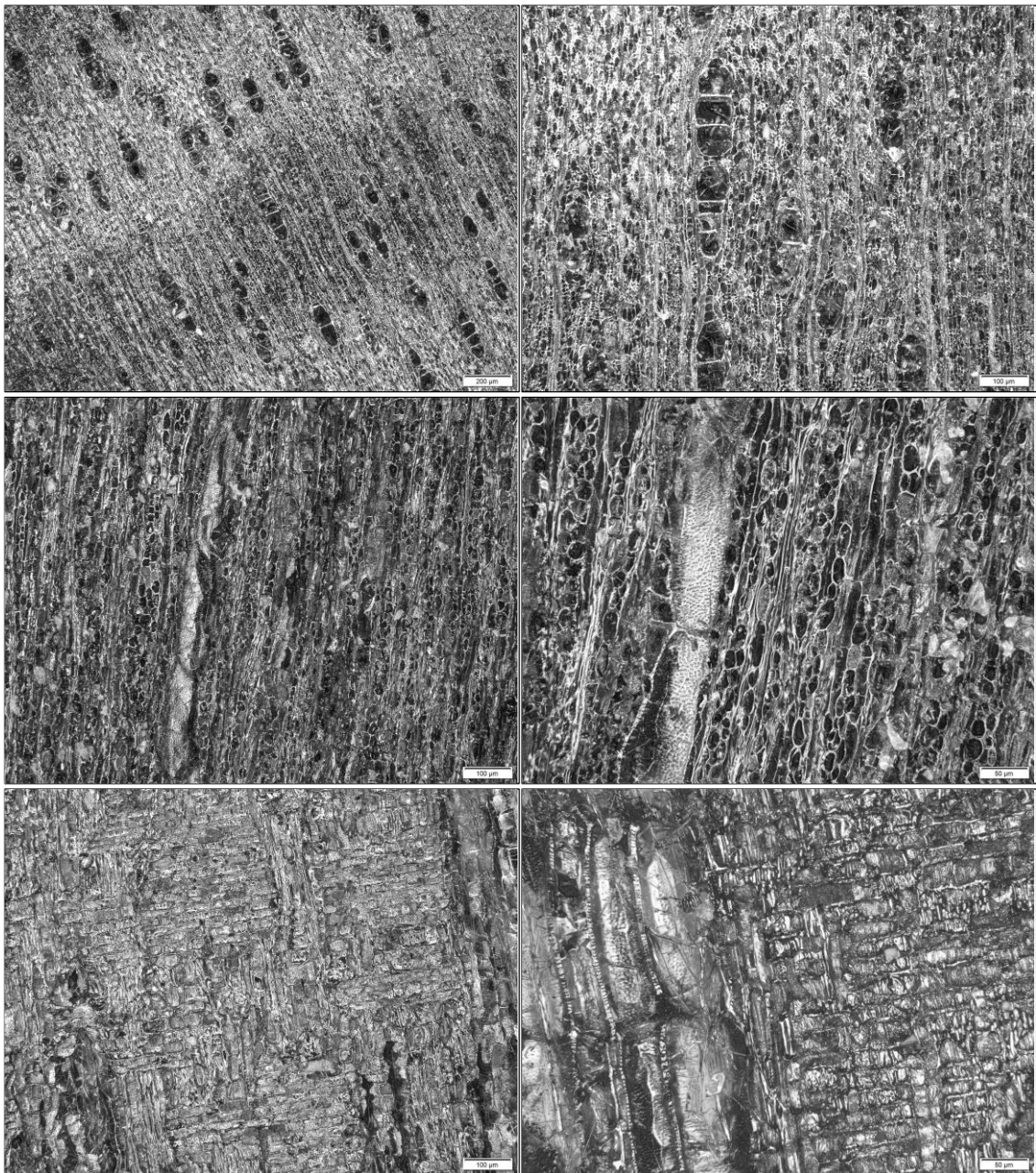
*Euclea racemosa.*

Growth rings indistinct or absent. Wood diffuse-porous. Small vessels, generally in radial groups of 4 or more, featuring a radial distribution. Perforation plates simple. Intervessel pits alternate. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal, diffuse-in-aggregates. 4 or more cells per strand.

Rays generally uniseriate, rarely 2-3seriates. Heterocellular, with body ray cells procumbent and 1-3 rows of square/upright cells.

Prismatic crystals present, mainly in ray cells but also in chambered parenchyma cells.



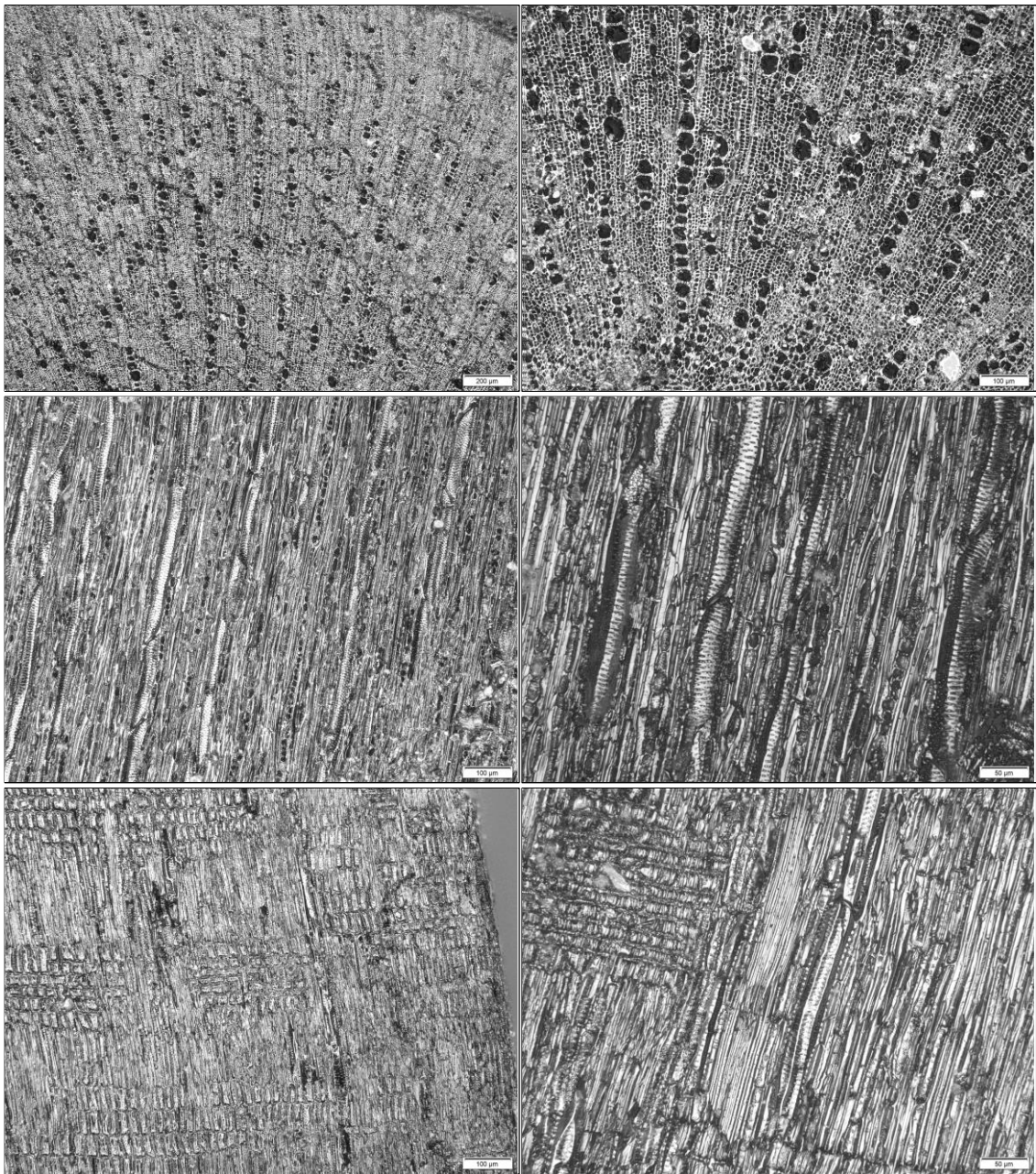
**EUPHORBIACEAE***Croton alnifolius*

Growth rings indistinct or absent. Wood diffuse-porous. Small vessels, generally in radial groups of 2-4 or more. Perforation plates simple. Intervessel pits alternate. Vessel-ray pits with distinct borders, bigger than intervessel pits but similar in shape.

Axial parenchyma apotracheal diffuse, paratracheal scanty. 4 or more cells per strand.

Rays mostly uniseriate, rarely 2-3seriates. Heterocellular, with body ray cells procumbent and 1-4 rows of square/upright cells.

Libriform fibres present. Prismatic crystals present in ray cells.



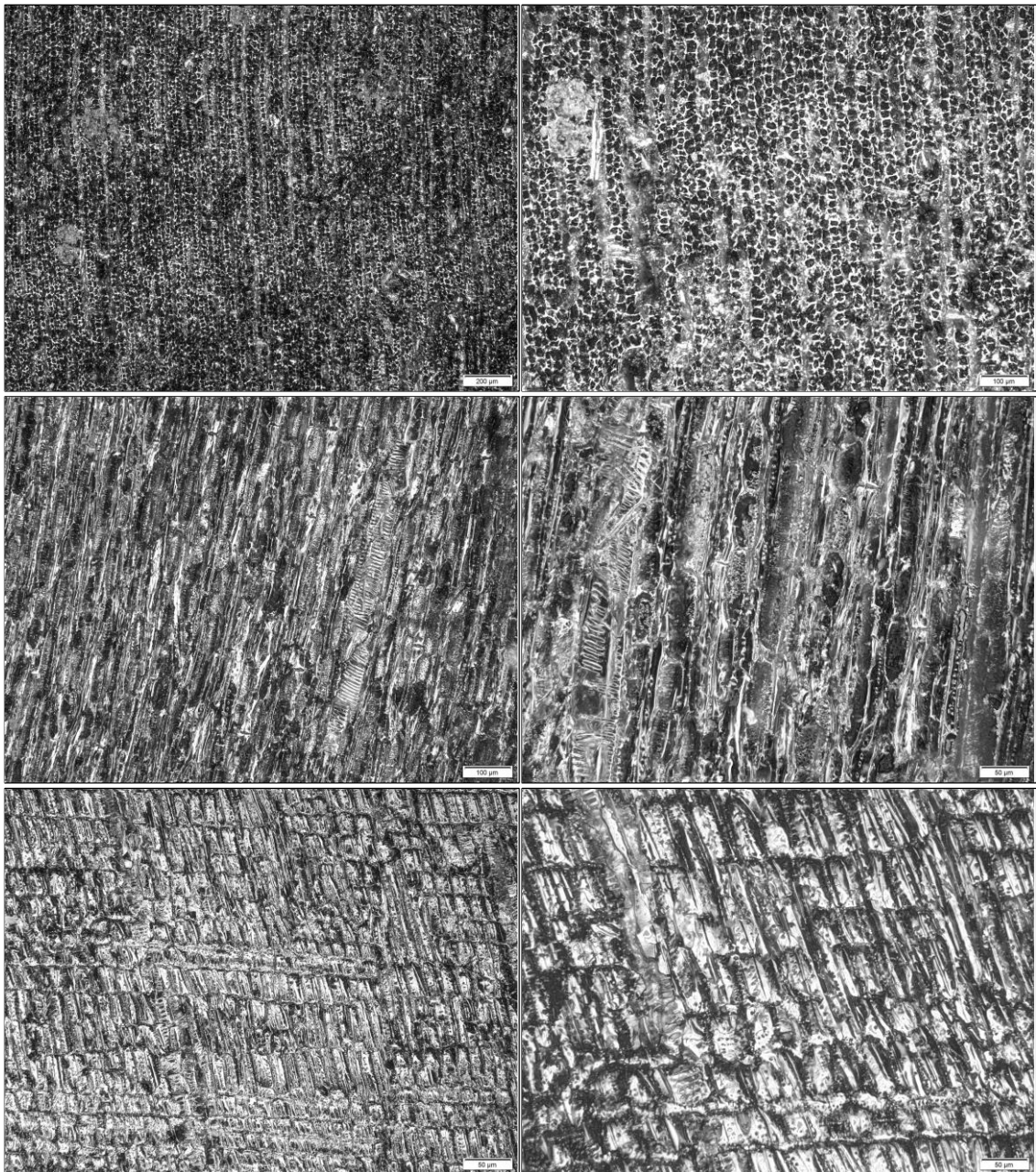
**EUPHORBIACEAE***Euphorbia* sp.

Growth rings indistinct or absent. Wood diffuse-porous, with a low vessel density. Small vessels. Solitary vessel outline angular. Perforation plates simple. Intervessel pits alternate. Vessel-ray pits sometimes with much reduced borders to apparently simple, pits horizontal-scalariform to vertical-palisade; sometimes with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse. 2-4 cells per strand.

Rays exclusively uniseriate. Heterocellular, with procumbent, square and upright cells mixed.

Crystals absent.





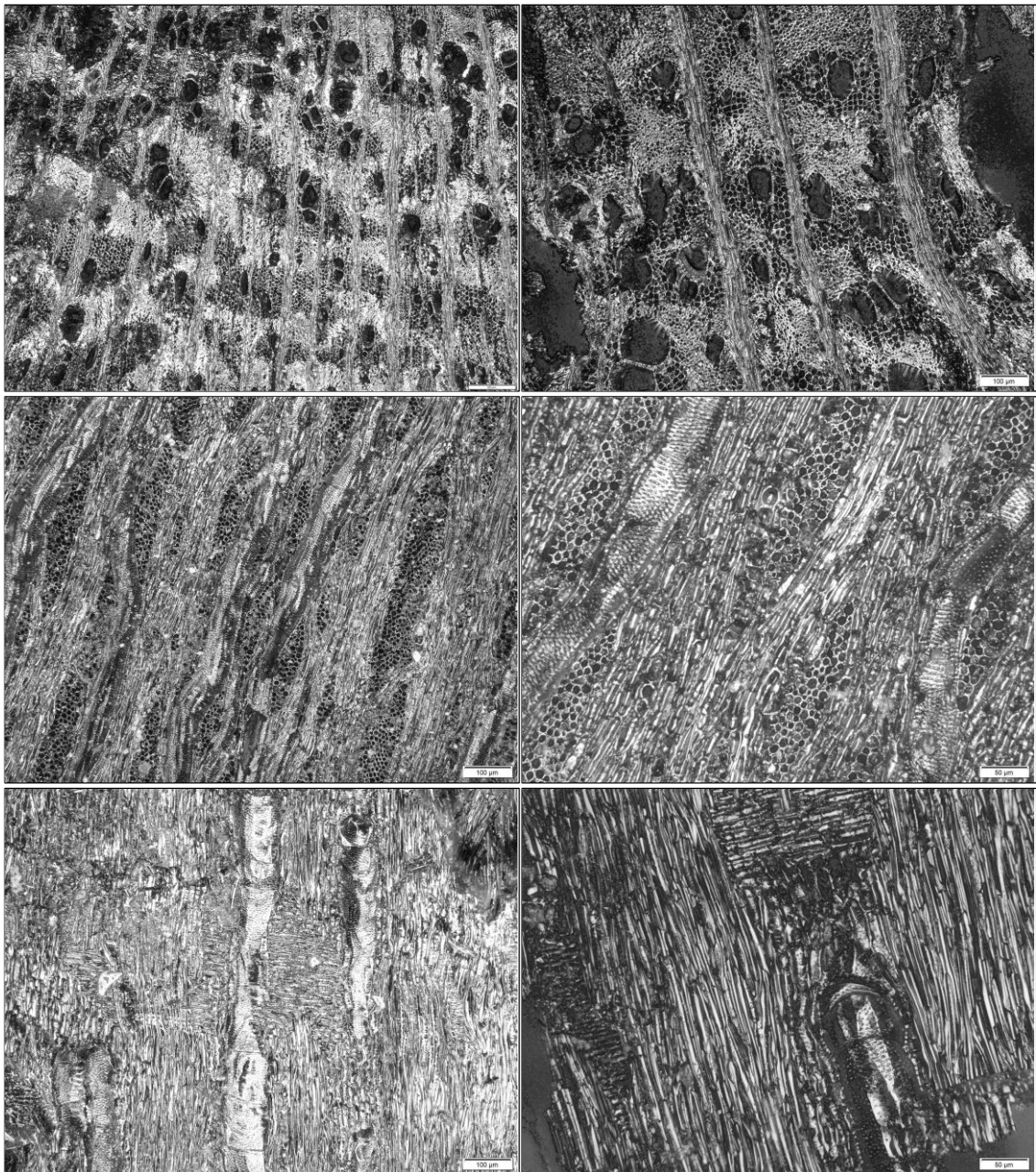
**FABACEAE***Acacia mellifera*

Growth rings indistinct or absent. Wood diffuse-porous. Vessels mid-sized, usually in radial groups of 2-4 or forming clusters. Perforation plates simple. Intervessel pits alternate, vestured, with polygonal shape. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma paratracheal vasicentric, aliform, sometimes confluent forming bands. 2-4 cells per strand.

Rays usually large, 4-8seriates, with some few 2-4seriates. Homocellular, all cells procumbent.

Prismatic crystals present, both in fibres and chambered axial parenchyma cells.



**MALVACEAE**

*Gossypium* sp.

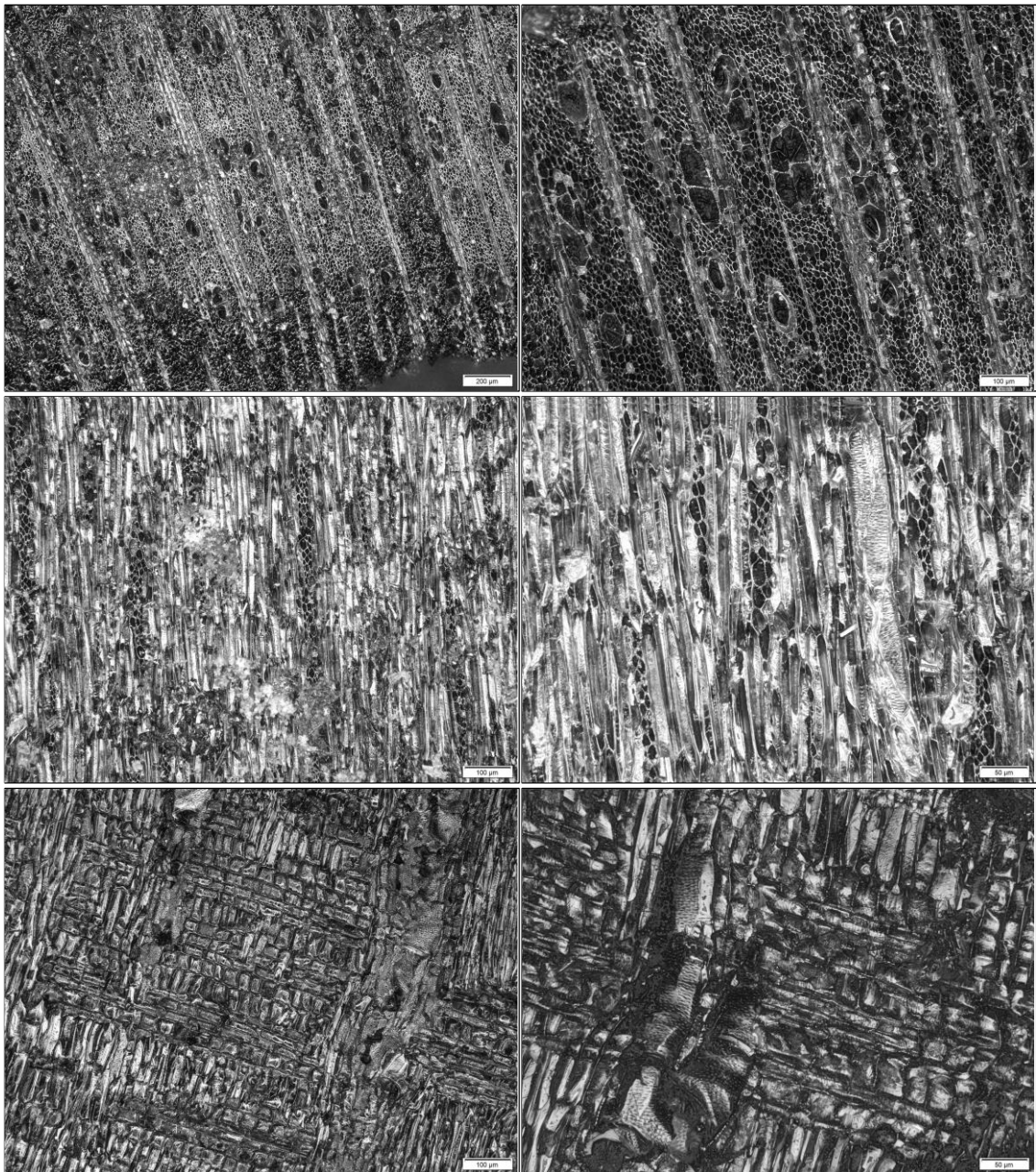
Growth rings indistinct or absent. Wood diffuse-porous. Small vessels, in radial groups of 2-4, usually forming clusters. Solitary vessel outline angular. Perforation plates are simple. Intervessel pits alternate, minute. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse.

Rays 1-4-seriates, very long. Heterocellular, body ray cells procumbent with 1-2 rows of square/upright cells. Sheat cells present.

Crystals absent.

Storied structure: axial parenchyma and vessel elements storied, fibres storied.



**MALVACEAE**

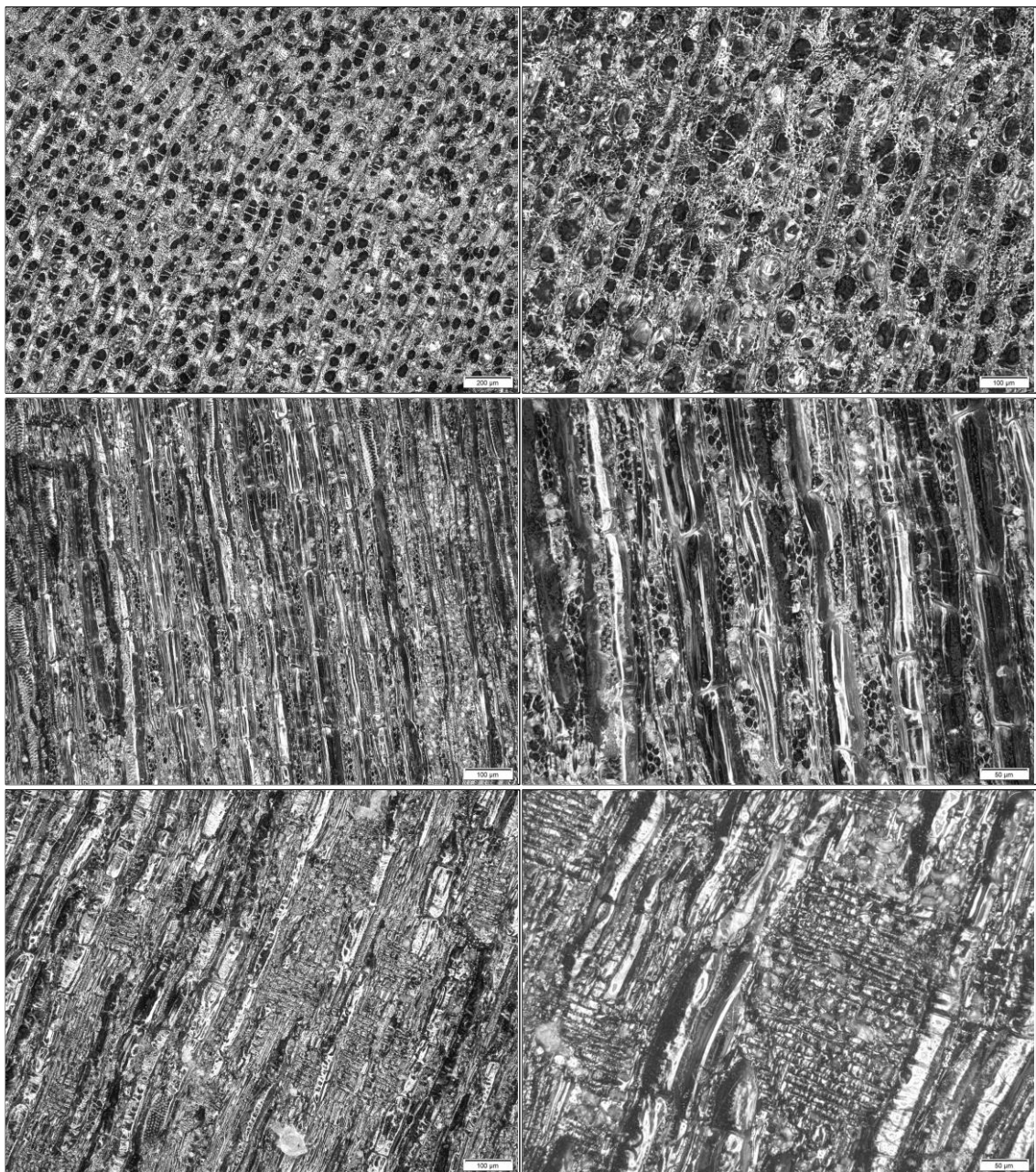
*Grewia* sp.

Growth rings indistinct or absent. Wood semi-ring-porous, with high vessel density. Small vessels, generally in radial groups of 4 or more, forming clusters, but also some solitary vessels. Simple perforation plates. Intervessel pits alternate. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse and diffuse-in-aggregates, paratracheal scanty. 4 or more cells per strand.

Rays 1-3seriates, with bigger terminal cells. Heterocellular, body ray cells procumbent with 1-3 rows of square/upright cells, but also all mixed sometimes. Sheat cells present. Tile cells present.

Tyloses common. Prismatic crystals present in ray cells.



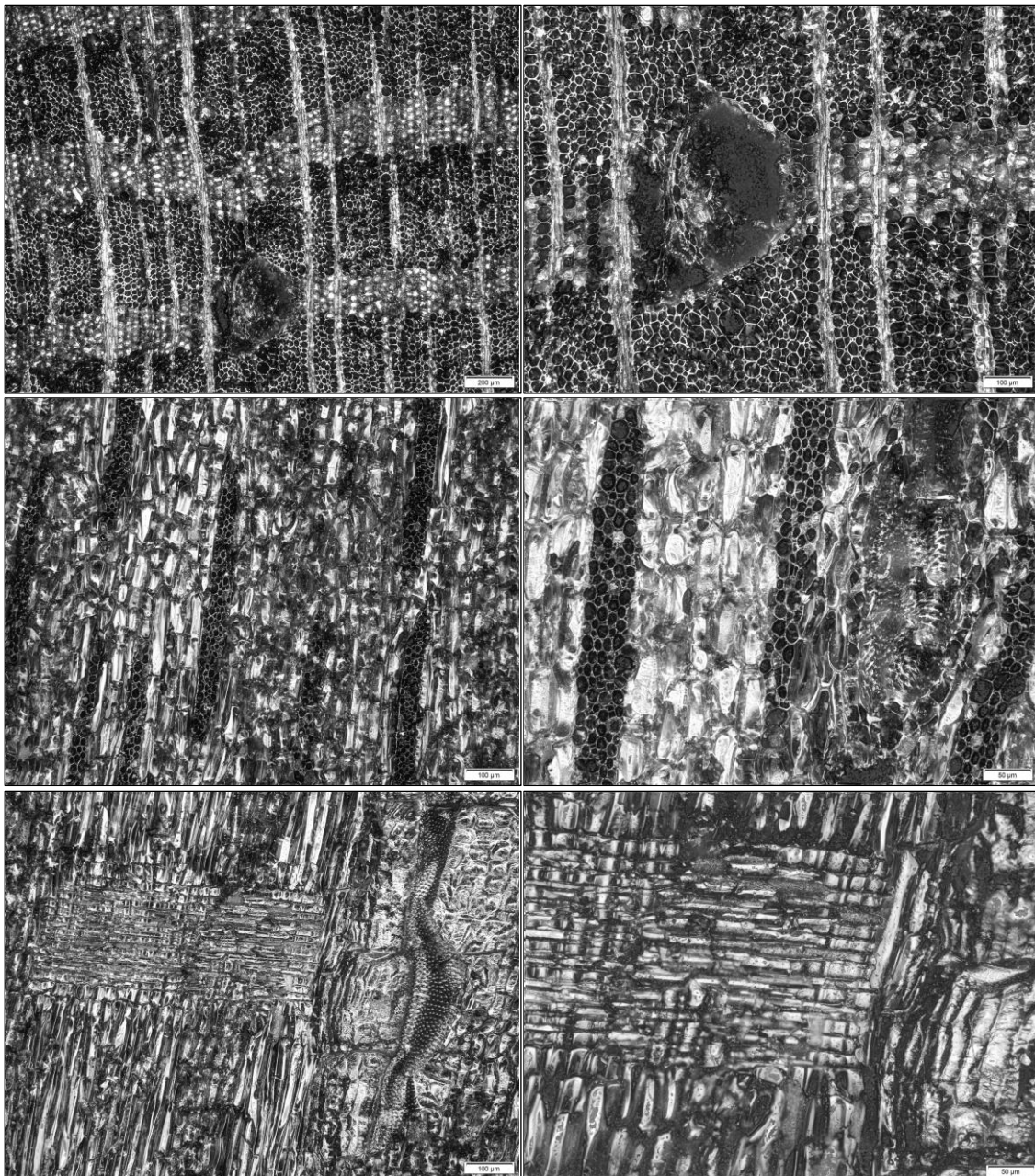
**MORACEAE***Ficus indica*

Growth rings indistinct or absent. Wood diffuse-porous, with low vessel density. Big vessels. Perforation plates simple. Intervessel pits alternate, with a polygonal shape. Vessel-ray pits with much reduced borders to apparently simple, pits horizontal-scalariform to vertical-palisade and/or rounded to angular.

Axial parenchyma paratracheal scanty. Bands of more than 3 cells wide present. 3-4 or more cells per strand.

Rays 4-6seriates, very long. Heterocellular, body ray cells procumbent with 2-4 rows of square/upright cells.

Tyloses common. Prismatic crystals present in ray cells.



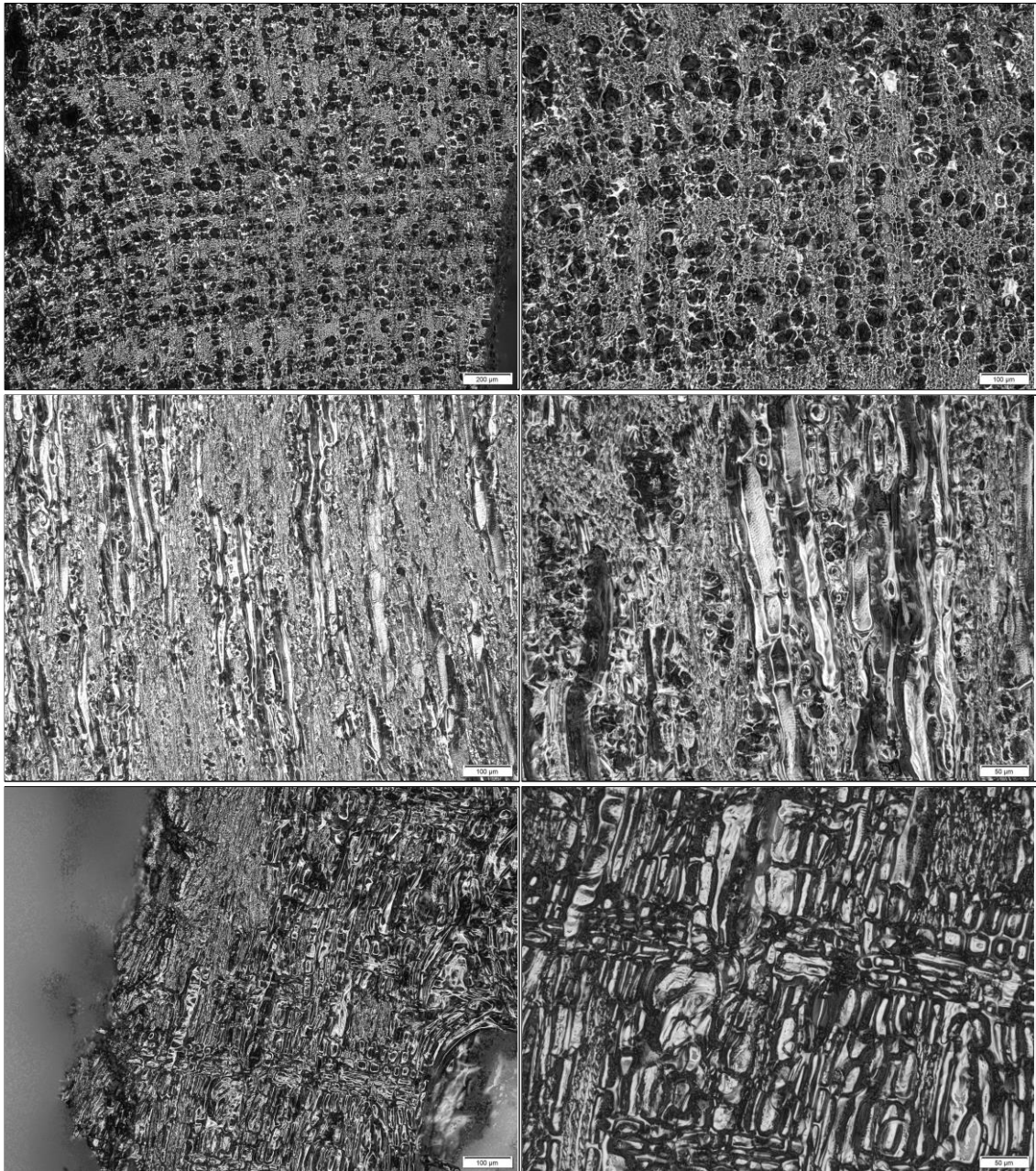
**OLEACEAE**

*Olea europaea.*

Growth rings indistinct or absent. Wood diffuse-porous. Small vessels, in radial multiples of 4 or more. Simple perforation plates. Intervessel pits alternate. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse, paratracheal vasicentric, sometimes confluent. Marginal bands present. 4 or more cells per strand.

Rays mostly 2-3seriates, very few uniseriates, with elongated terminal cells. Heterocellular, body ray cells procumbent with 1-4 rows of square/upright cells.



**PITTOSPORACEAE**

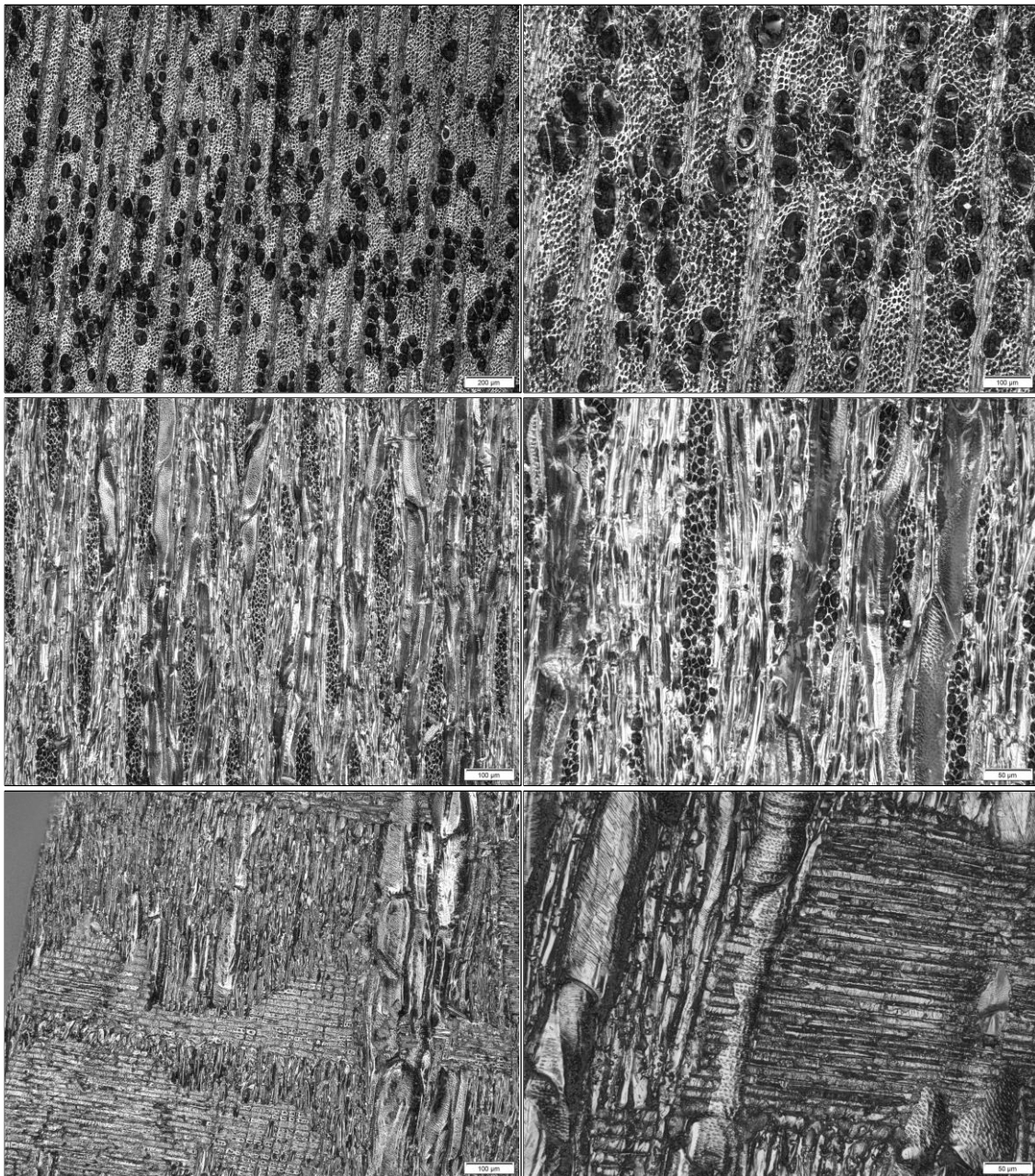
*Pittosporum abyssinicum*

Growth rings indistinct or absent. Wood diffuse-porous. Vessels mid-sized, usually forming clusters. Solitary vessel outline angular. Perforation plates simple. Intervessel pits alternate, with a polygonal shape. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse, paratracheal scanty. 4 or more cells per strand.

Rays 3-6seriates, with elongated terminal cells. Homocellular, all cells procumbent, but sometimes heterocellular, with 1-2 rows of square/upright cells.

Fibre pitting common. Septate fibres present. Prismatic crystals present in ray cells. Crystals in enlarged cells.



**PODOCARPACEAE**

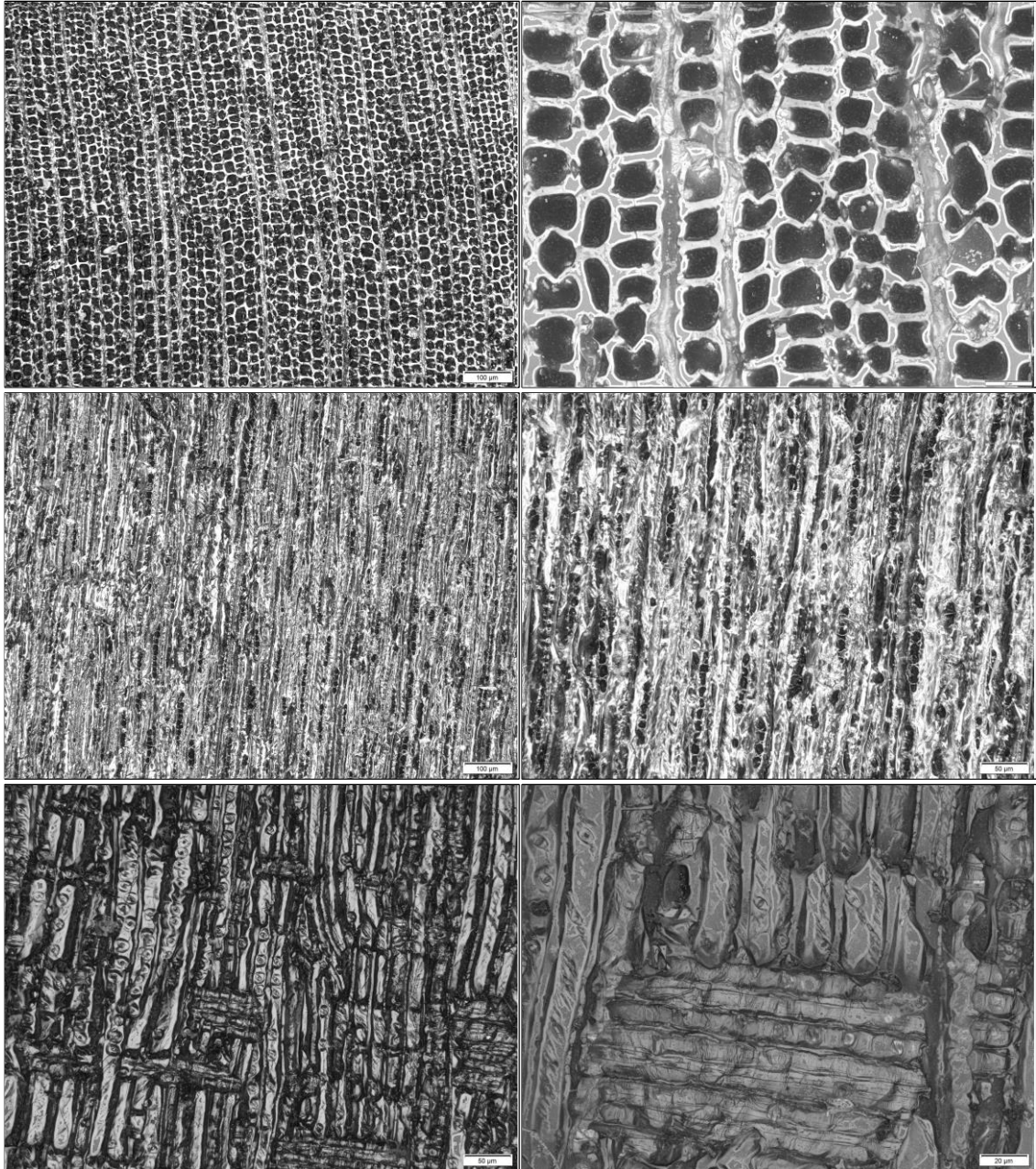
*Podocarpus elongatus*

Growth rings indistinct or absent. Transition from early- to latewood gradual. Tracheid pitting uniseriate.

Axial parenchyma scarce or absent.

Rays exclusively uniseriate, 5-15 cells long. Ray tracheids absent. Cross field pits 1 per field, taxodioid.

Resin canals absent.



**RHAMNACEAE**

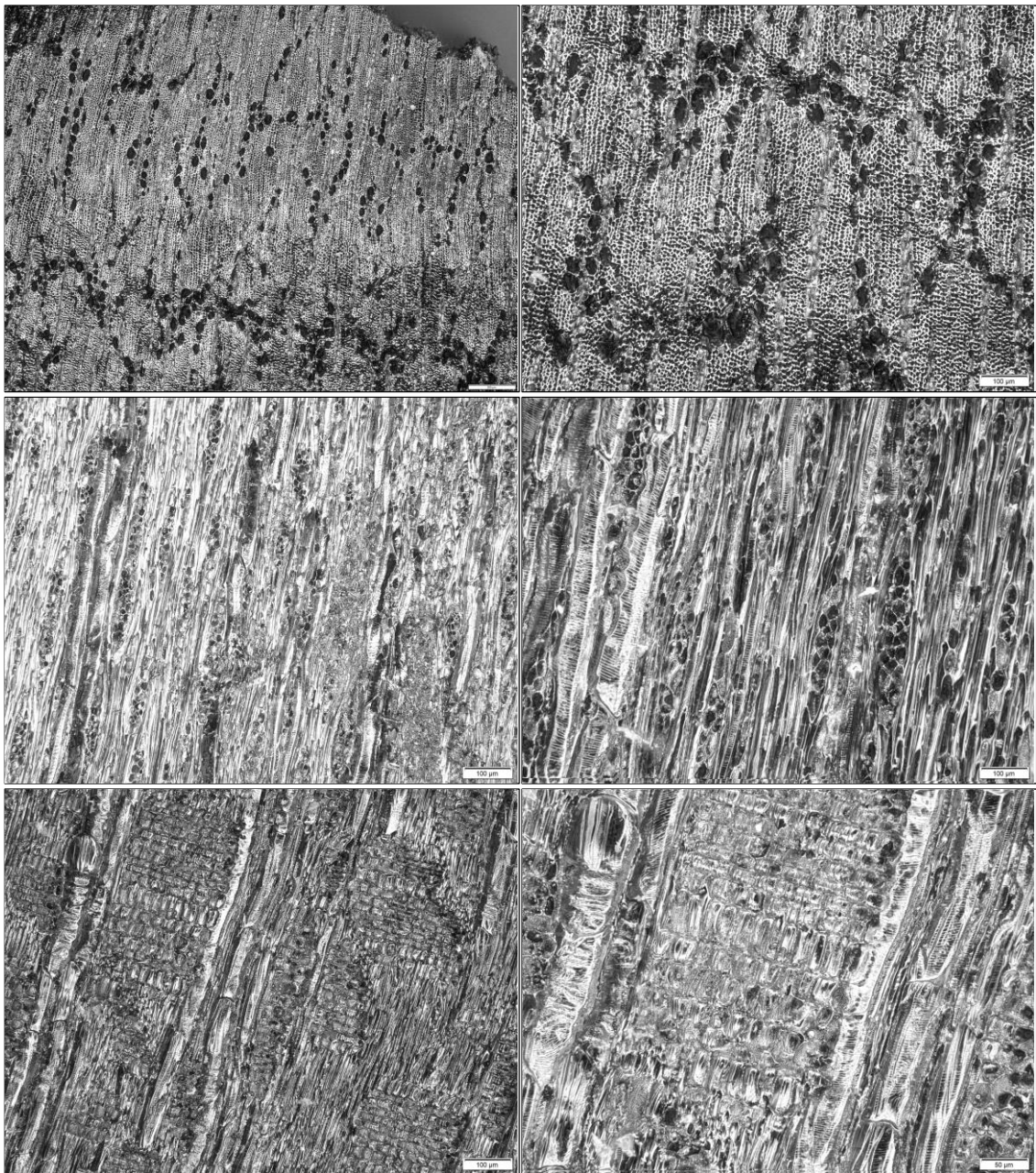
*Rhamnus pauciflora.*

Growth rings distinct. Wood semi-ring-porous. Small vessels, usually forming clusters, featuring a dendritic distribution. Solitary vessel outline angular. Perforation plates simple. Intervessel pits alternate. Helical thickenings present. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma absent.

Rays 1-3seriates. Heterocellular, body ray cells procumbent with 1 row of square/upright cells, but sometimes homocellular, all cells procumbent.

Libriform fibres.





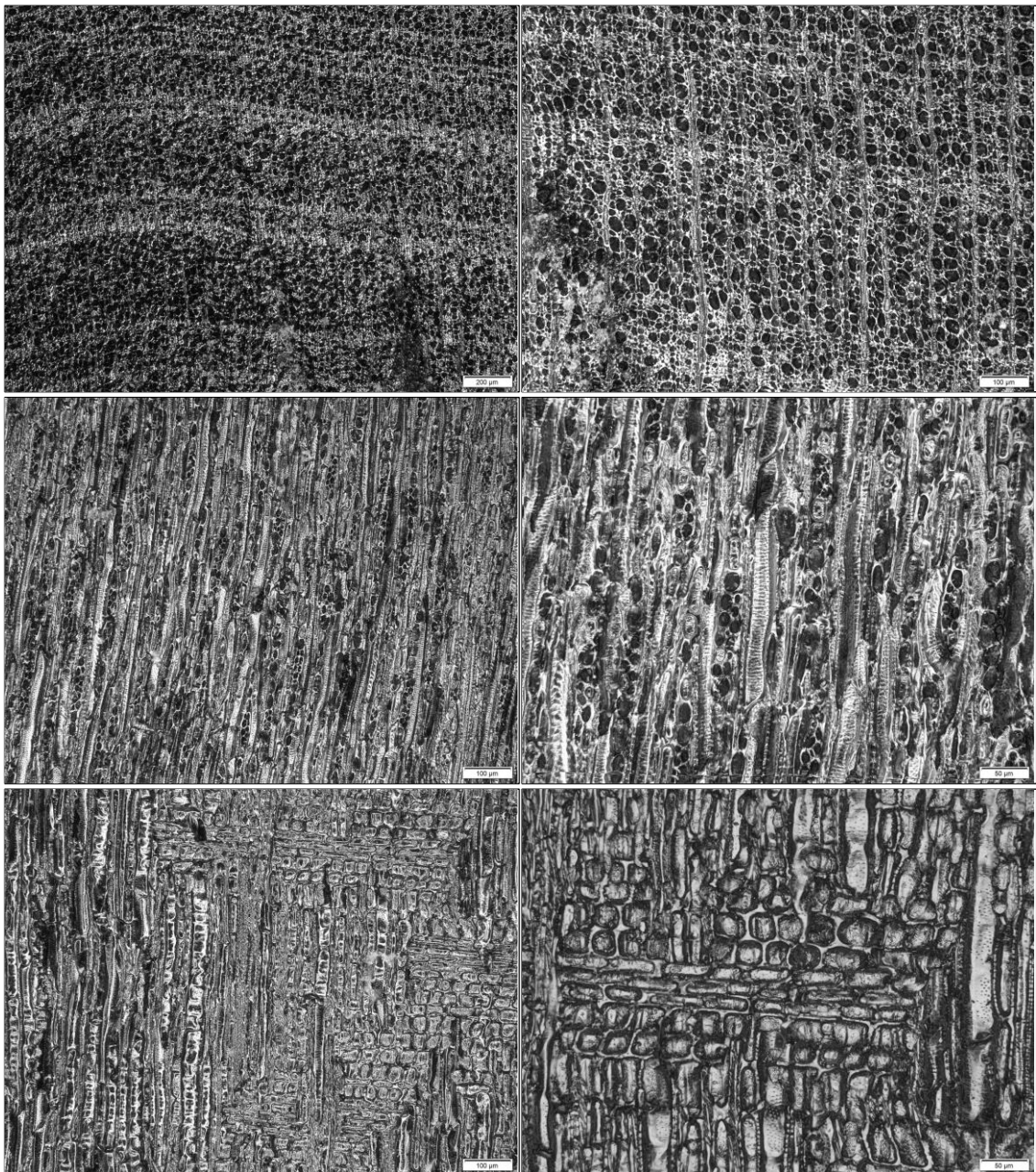
**RUBIACEAE***Canthium schimperiana.*

Growth rings indistinct or absent. Wood diffuse-porous, with high vessel density. Small vessels, mostly isolated. Solitary vessel outline angular. Perforation plates simple. Intervessel pits alternate, vestured, with a polygonal shape. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse. Narrow bands up to 3 cells present. 5-8 or more cells per strand.

Rays are 1-3-seriates, with multiseriate portions as wide as the uniseriates and elongated terminal cells. Heterocellular, body ray cells procumbent with 1-3 rows of upright/square cells.

Fibre pitting common.



**SAPINDACEAE**

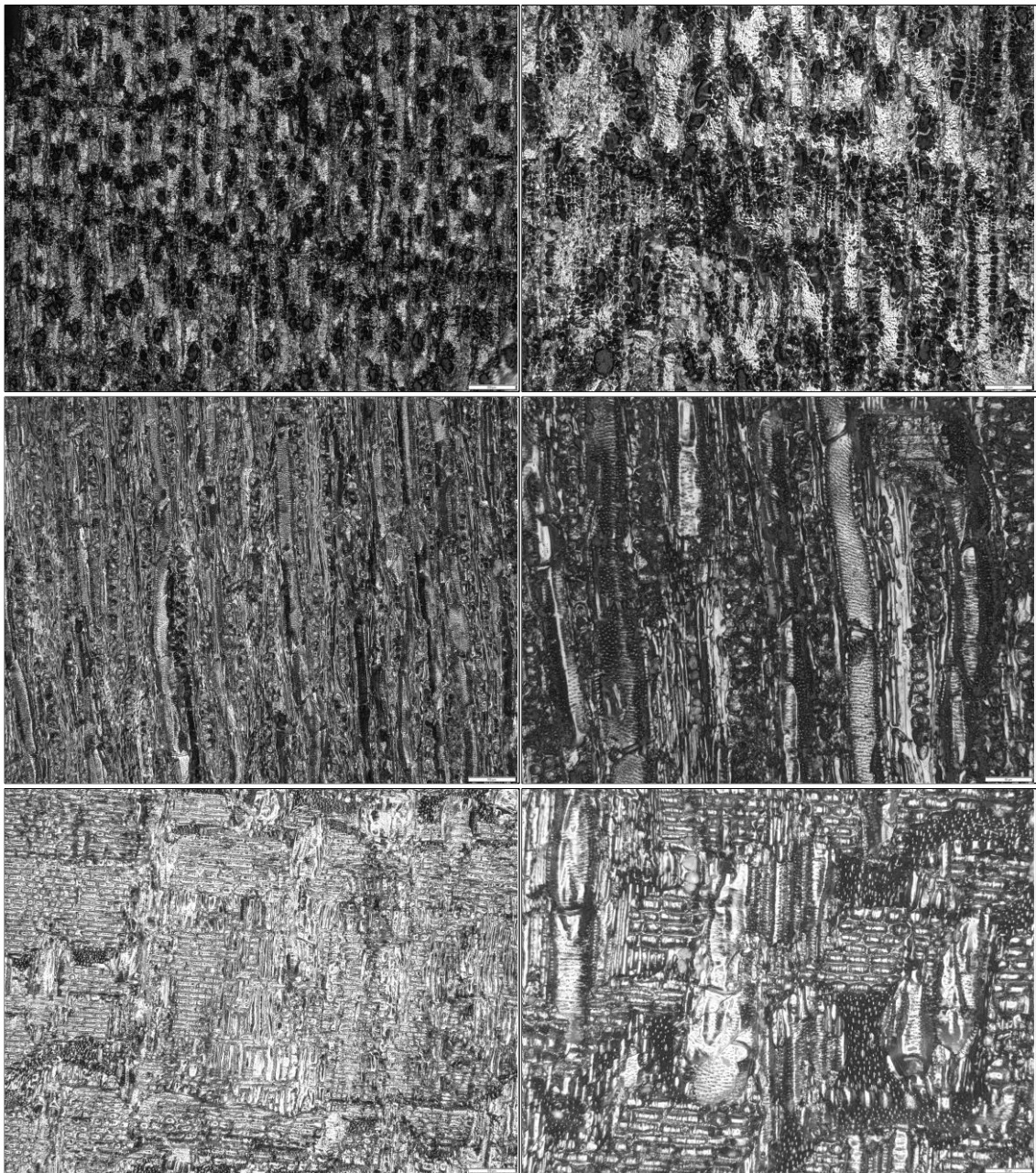
*Dodonaea viscosa.*

Growth rings indistinct or absent. Wood diffuse-porous. Small vessels in radial groups of 2-3. Perforation plates simple. Intervessel pits alternate, with a polygonal shape. Helical thickenings present. Vessel-ray pits with distinct borders, similar to intervessel pits in size and shape.

Axial parenchyma apotracheal diffuse, scanty paratracheal to vasicentric. Narrow horizontal and marginal radial bands present. 2-4 or more cells per strand.

Rays 1-3seriates, tending to square outline in tangential section. Homocellular, all cells procumbent, rarely heterocellular, body ray cells procumbent with 1-2 rows of upright/square cells.

Prismatic crystals present in chambered axial parenchyma cells.



**STILBACEAE**

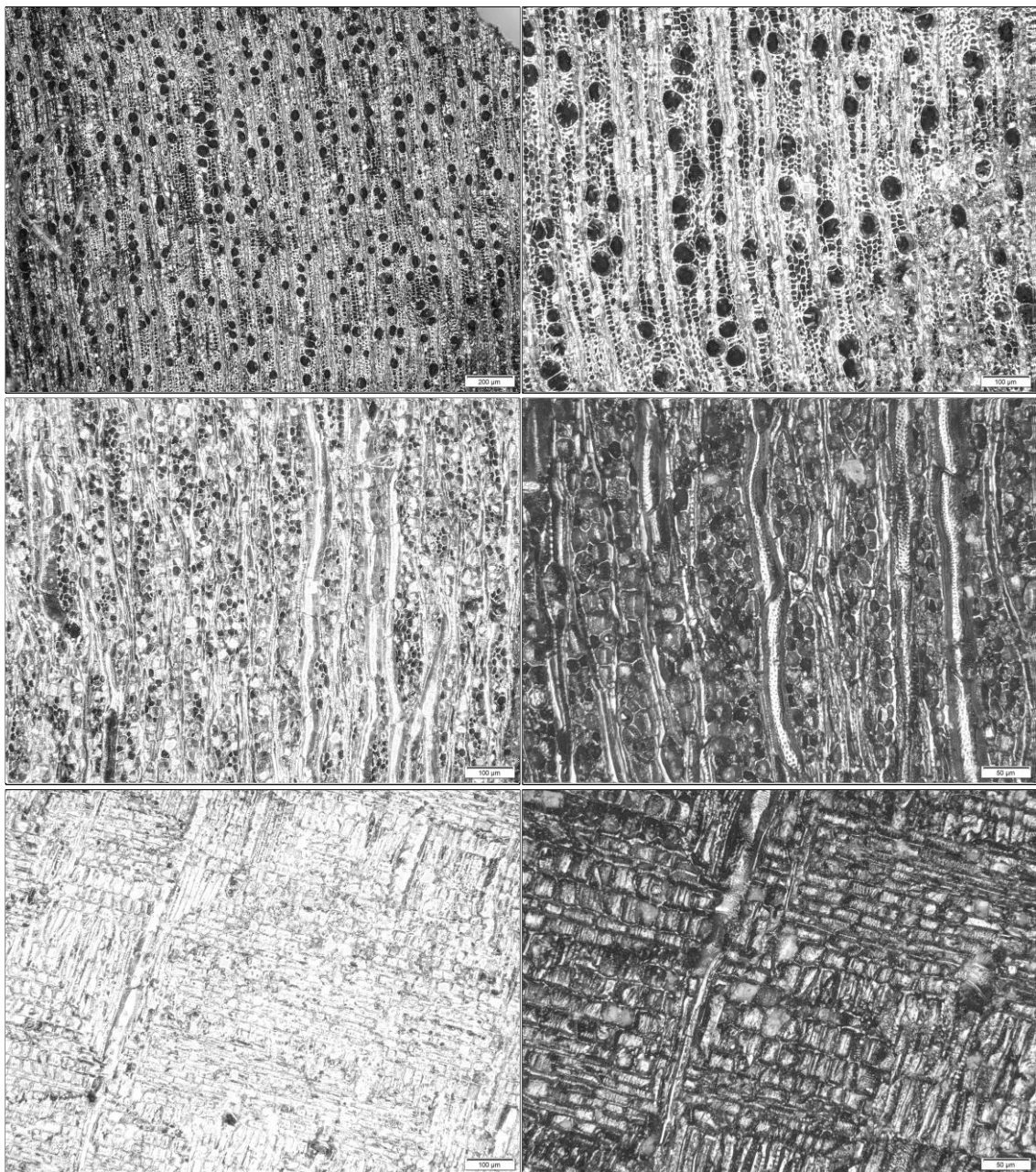
*Nuxia floribunda*

Growth rings indistinct or absent. Wood diffuse-porous. Small vessels, sometimes solitary, sometimes in radial groups of 2-4 or more cells. Solitary vessel outline sometimes angular. Perforation plates simple. Intervessel pits alternate, minute. Vessel-ray pits with distinct borders, usually bigger than intervessel pitting but similar in shape.

Axial parenchyma apotracheal diffuse, paratracheal scanty. 3-4 or more cells per strand.

Rays of two distinct sizes: long 1-4 seriates; and short 4-6 seriates. Heterocellular, sometimes with body ray cells procumbent and over 3 rows of square/upright cells, sometimes all mixed.

Tyloses common. Prismatic crystals present, mainly in ray cells but also in chambered axial parenchyma cells.



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