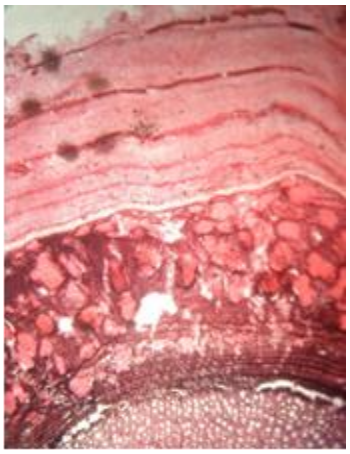
Leaflet No.13/2019

The Republic of the Union of Myanmar

Ministry of Natural Resources and Environmental Conservation

Forest Department

Morphology and Anatomy of Barks and Sapwood of Six Different Myanmar Deciduous Trees



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December, 2019

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မြန်မာ့ရွက်ကြွေတောရှိ သစ်ပင်(ဖ)မျိုး၏အခေါက်၏အတွင်းအပြင်လက္ခဏာများနှင့် အခေါက်နှင့် ဆက်စပ်လျက်ရှိသော သစ်သားကိုလေ့လာခြင်း

ကြည်ကြည်ခိုင်၊ သုတေသနလက်ထောက် -၂
သစ်တောသုတေသနဌာန၊ ရေဆင်း

စာတမ်းအကျဉ်း

သစ်တောသုတေသနဝင်း သစ်ပင်ကြီးများ ဥယျာဉ် (Arboretum) အတွင်းရှိ မြန်မာ့ရွက်ကြွေ တောဝင် မျိုးစိတ်(ဖ)မျိုးတို့ကိုစုဆောင်း၍ မျိုးမည်ဖော်ပြီး လေ့လာပါသည်။ အခေါက်နှင့်သစ်သားကို Sliding Microtime၊ Rotary Microtime တို့နှင့် အလွှာပါးများဖြတ်ပြီး Johansen's (1940) နည်း အတိုင်းဆေးဆိုးပါမည်။ ၎င်းတို့၏ အခေါက်၊ အစာ ရေကြော အသားတိုးလွှာနှင့် သစ်အကာသား တို့၏ အပင်ခန္ဓာဗေဒ လက္ခဏာများကိုပုံများနှင့်တကွ ဆွေးနွေးတင်ပြထားပါသည်။ သစ်အကာသား များ (ဖ)မျိုး စလုံးသည် ဖက်သန်း(*Fernandoa adenophylla*) မှအပ၊ diffuse-porous ဖြစ်သည်။ နဘဲ (*Lannea coromandelica*)မှ အပ၊ ရေကြော ရောင်ခြည်ဆဲလ်များသည် homogeneous ဖြစ်သည်။ ရေကြောဖိုက်ဘာများသည် နဘဲမှအပ၊ အကန့် နံရံမဲ့ဖြစ်သည်။ နဘဲ၊ သစ်ဥငုံးတ၊ ပိတောက် သစ်သား တို့တွင် Tyloses များပါဝင် သည်။ နဘဲ(*Lannea coromandelica*)၊ ပိတောက် (*Pterocarpus macrocarpus*) နှင့်ပျဉ်းကတိုး(*Xylia xylocarpa*) သစ်သားတို့တွင် ကော်စေးများပါဝင်သည်။ နဘဲ၊ ဖက်သန်းတို့၏ အခေါက်နှင့်သစ်သားအကြားတွင်ရှိ အစာရေကြော အသားတိုးလွှာတွင် ထပ်ကြပ် ဆင်းဆဲလ် များသည် အလွှာများစွာရှိသည်။ မျိုးစိတ်(ဖ)မျိုးစလုံး၏ အခေါက်တွင် ဆန်ကာပြွန်ဆဲလ်များ (sieve tubes)သည် ဘေးနံရံ၌ ဆန်ကာကွက် နေရာများပါသည်။ နဘဲတွင်မူ ဘေးနံရံ များကို ကွန်ယက်များ ကဲ့သို့တွေ့ရသည်။ ကွန်ယက်များ ကဲ့သို့ နံရံထူနေသည်ကို ဖက်သန်း(*Fernandoa adenophylla*) နှင့် သစ်ဥငုံးတ *(Heterophragma sulfureum*) တို့၏ ဆန်ကာပြွန်ဆဲလ်များ ထိပ်ပိတ်နံရံတွင်တွေ့ရသည်။ ပျဉ်းကတိုး၏ *ဆန်ကာပြွန် ဆဲလ်များ၏ ထိပ်ပိတ်*နံရံတွင်၊ ဆန်ကာ ပြင်များ (sieve plates) စုပေါင်းနေပြီး ဆန်ကာပြင်တစ်ခုစီသည် ကြီးနေသည်ကိုတွေ့ရသည်။ ဖက်သန်း အခေါက်နှင့် သစ်လင်းတအခေါက်တို့တွင် spiral thickenings ရှိသော ဖိုက်ဘာ နှင့်တူသော ဆဲလ်များကိုတွေ့ရသည်။ ထို့ပြင် ဤနှစ်ပင်၏ ပေရင်ခိုင်မာ ဆဲလ်များတွင် တုတ်ချောင်းပုံ အစာ ပစည်းကို တွေ့ရသည်။ နဘဲပင်အခေါက်တွင် စစ်ထုတ်ပြွန်များရှိသည်။

ၵင်းတို့သည်အတွင်းနံရံကို ပေရင်ခိုင်မာဆဲလ်များဖြင့် ဝန်းရံထားသည်။ ထို့ပြင်စစ်ထုတ်ပြွန်များကို multiseriate phloem ray များတွင်လည်းတွေ့ရသည်။ ပိတောက်တွင် စစ်ထုတ်ဆဲလ်များကို တစ်ခုချင်းဖြစ်စေ၊ အုပ်စုလိုက် ဖြစ်စေ တွေ့ရသည်။ ပျဉ်းကတိုး၏ အခေါက်အပြင်လွှာတွင် sclereids ခေါ် ဆဲလ်များ အလွှာလိုက်၊ ပြင်လိုက်တွေ့ရသည်။ ဤအပင်ခန္ဓာဗေဒ ဝိသေသလက္ခဏာများကို သိရခြင်းသည် သစ်ပင် မျိုးစိတ်တို့၏အပင်ခန္ဓာဗေဒကို ထပ်ဖြည့်ပေးနိုင်သည်။ ထို့ပြင် ဤသစ်သား ပိုင်းနှင့် အခေါက် တို့၏ ဝိသေသလက္ခဏာများကိုသိရခြင်းသည် မြန်မာနိုင်ငံရှိ မြန်မာ့ရွက်ကြွေတောဝင် သစ်ပင်မျိုးစိတ်များကို မျိုးမည်ဖော်ရာ၌ အသုံးဝင်ပါသည်။

Morphology and Anatomy of Barks and Sapwood of Six Different Myanmar Deciduous Trees

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Abstract

Specimens of six species of the deciduous tree were collected from arboretum in the compound of Forest Research Institute, Yezin, identified and studied. The bark and wood were cut into thin section by using Rotary Microtome and Sliding Microtome. The section were stained according to Johansen's (1940). The anatomical characteristics of their bark, vascular cambium and sap wood of stems were described, discussed, and presented with their photographs and photomicrographs. The sapwoods of the six species studied were diffuse-porous except in *Fernandoa adenophylla*. Xylem rays were homogeneous in all species except in *Lannea coromandelica* and xylem fibers were non-septate except in *L. coromandelica*. Tyloses were found in *L. coromandelica*, *Heterophragma sulfureum* and *Pterocarpus macrocarpus.* Gum deposits were present in the wood of *Lannea coromandelica, Pterocarpus macrocarpus* and *Xylia xylocarpa.* In the bark of *Lannea coromandelica* and *Fernandoa adenophylla*, vascular cambium showed many layers of immediate derivatives. In all of the six species, sieve tubes were with many sieve area on the lateral wall, but, that of *Lannea coromandelica* was reticulated thickenings at the lateral wall. Reticulated thickenings were found at the end wall of *Fernandoa adenophylla* and *Heterophragma sulfureum.* In the bark of *Xylia xylocarpa*, end wall of sieve tube was with compound sieve plates and each sieve plate was large. In the bark of *Fernandoa adenophylla* and *Heterophragma sulfureum*, fiber-like cells were with spiral thickenings. In the bark of *Fernandoa adenophylla* and *Heterophragma sulfureum*, rod-shape food particles were abundantly present in the parenchymatous cells. In the bark of *Lannea coromandelica***,** secretory ducts were present and they were bounded by epithelial layer of parenchymatous cells. Moreover, secretory ducts were also present in multiseriate phloem ray. In *Pterocarpus macrocarpus*, single or group of large secretory cells were present. In the bark of *Xylia xylocarpa* groups of a few to many layers of sclereids was forming a thick column, The knowledge of anatomical characteristics of stem wood and bark of six species fulfilled the anatomy of the tree species. Moreover, these characteristics are useful in identification of the deciduous tree species of Myanmar.

Morphology and Anatomy of Barks and Sapwood of Six Different Myanmar Deciduous Trees

1. Introduction

Barks of trees are varied in appearance, however, some of them are slightly similar to each other, and their morphological characteristics are important in identification of the plants especially in deciduous season in Myanmar. In summer, trees in deciduous forest are not bearing leaves and no inflorescences are observed when it is not flowering time. In such case, external features and anatomical characteristics of the barks can be mainly considered to identify the trees and anatomical characteristics of the wood can also support in identification.

The barks consisted of outer bark and inner bark. The outer bark is an older portion of the bark and it may consist of epidermis or ruptured epidermis, periderm which is protective layer of the inner tissue of the stem or root, cortex, primary phloem and older parts of secondary phloem which is nonconductive layer, and the inner bark consisted of conductive secondary phloem tissue which can transport food materials throughout the whole plant body.

As the girth of stem or root becomes larger while the process of its growth forms because of the activity of its secondary meristem known as vascular cambium, the epidermal cells might not be stretched or divided enough to form cells and some of the parenchymatous cells near the epidermis becomes meristematic. As a result, a covering layer forms around the epidermis completely or partially, in some cases many layers form to cover the inner tissue of stem or root. This layer functions as a protective layer and known as periderm.

Periderm usually forms from the epidermis, cortical cells or even from the phloem tissues (Esau 1965) by the secondary meristematic tissue and this meristem laterally lying in the stem or root is known as phellogen or cork cambium. The periderms could also detrmine the appearance of the bark and morphological characteristics depended partially on the periderm formation.

A few researchers studied and described anatomy of tree barks. In Myanmar, Khin Myint Maw (2007) studied bark anatomy of 20 Myanmar species of Fabaceae and gave a brief account on healing of the barks. Khin Lay Nwe (2012) studied twelve clones of *Hevea brasiliensis* (Willd. ex A.Juss.) Mull. Arg. and described the latex rings in the bark of four selected *H, brasiliensis* clones BPM 24, PB 235, GT 1 and PB 5/63 in transverse section. She found sieve tubes as latex rings in the bark of four clones in transverse section. Description of anatomical characteristics of barks of tree species are still lesser and use of bark anatomy in identification is almost lacking in Myanmar.

In this paper, six timber species of Myanmar growing wild are selected and morphology and internal structures of their barks and associated wood (sapwood) are studied and described with the aims of providing knowledge of morphology and anatomy of bark and wood to support in identification of the trees especially in deciduous condition.

2. Literature Review

The bark of Lannea coromandelica (Houtt.) Merr. contained tannins to use for the impregnation of fishnets. Jingan gum was obtained from its stem and it was a soluble resin and use dfro calico printing. The bark yielded a coarse cordage fibre and the heartwood was light red when freshly cut, turning reddish-brown on exposure. The wood was moderately hard, close-grained and it was used for spear shafts, scabbards, wheel-spokes, oil presses, grain pounders etc. (Fern 2019).

The bark of Lannea coromandelica (Houtt.) Merr. was brownish gray to gray, 10 cm thick; outer bark on all or most of the trunk; fur-round longitudinally and transversely, shed in thin irregular round flakes from the stems and branches, leaving a smooth brown surface as mention by Thein Kywe & Kyaw Soe. 1983.

The bark of Dalbergia oliveri Gamble ex Prain was blackish bright yellow, 8 – 10 mm thick; outer dead bark persistent over the whole of the trunk and larger branches, rough, irregularly shallow furrowed, scaly plates separated by shallow fissures as mentioned by Thein Kywe & Kyaw Soe (1983).

The wood colour of Haplophragma adenophyllum (synonyms of Fernandoa adenophylla) was found to be pale yellow to brownish yellow as mentioned by Soe Myint et.al (1997). Gamble (1922) stated that the wood colour of H. adenophyllum was light yellow to orange yellow with occasionally darker streaks. Watt (1890) also described that yellowish white and orange or yellow in colour. Rodger (1963) described that yellowish white and orange or yellow in colour. Gamble (1922) described that vessel pores of H. aplophragma adenophyllum are moderate-sized and filled with yellowish resinous materials.

Thein Kywe (1983) stated that sap wood colour of Dalbergia oliveri was white or yellow-wish white and the barks of the trees, within limits, were found to be useful as an aid in identification of the trees.

Pearson & Brown (1932) described that (xylia dolabriformis Benth.) Pyinkado was one of the species of the family Leguminosae. It was known in trade as ‘Pyinkado’ . Seven local names listed. It was a very large tree and was found growing at its best in the Pegu Yoma, where the boles of the trees are straight and fairly cylindrical. They were found in association with Teak in all the lower hill forests of Burma and certain localties in the Arakan State. Pyinkado was apart from Teak, the most important timber in Myanmar for constructional purposes, especially as posts for bridges and houses.

Bennet and Bahadur (1978) stated that Xylia trees were found in India, Burma, Indo-China, Singapore and the Philippines. Rao and Purkayastha (1972) offered a description of the wood, which was, in general.

To a very large extent, many of the physical properties of hardwoods are related to the relative proportions of vessels, fibers and parenchyma present in the wood. The anatomical characteristics of fiber length, cell diameter, cell wall thickness and proportion of cell type varied in accordance with the environmental factors such as temperature, precipitation and wind. In addition, such factors as age and position of the material in the stem influenced these anatomical characteristics (Wangaard 1981).

The bark of the trees, within limits, were found to be useful as an aid in identification of the trees. Microscopic characteristics of the wood such as pore distribution, type of

perforation, abundance and pattern of parenchyma, resin canals and tyloses (as seen in transverse section); types, nature of component cells, the height and cell inclusions of the rays (as seen in tangential longitudinal section) were found to much dependable characters for identification (Thein Kywe 1983).

Evert (2006) described that development of the secretory ducts in Anacardiaceae apparently varied among plant parts and from species to species. In *Lannea coromandelica*, development of the ducts in the primary phloem of the stem reportedly was schizogenous, whereas that of their counterparts in the secondary phloem and phelloderm was lysigenous.

3. Materials and Methods

The samples of bark and stem wood of six different deciduous trees species were collected from the forest near Aye-Nyein-Chan-Thar Pagoda, Forest Research Institute Arboretum, Yezin, [19.840° North Latitude; 96.285° East Longitude (Google Earth)] in the year of 2018 to 2019. Small portions of bark and wood of stem near at the breast height level were taken.

The specimens were killed and fixed in 50% ethyl alcohol for further study. The specimens killed and fixed were washed in the running water overnight and the specimens were dehydrated through a series of tertiary butyl alcohol solutions. Then the totally dehydrated specimens were infiltrated in a series of paraffin wax of which melting points were 49° C, 55° C and 60° C respectively. The specimens were then embedded in the 60° C paraffin wax and cut into 16 – 19 □m thick sections by using a rotary microtome, model AO 820.

These thin sections were mounted on a clean glass slide by Mayer's albumen and immersed in xylol solution to remove paraffin. Then they were double-stained in the combination of safranin and fast green solutions according to Johenson (1940). After staining, the sections were permanently mounted under a cover slip by using Canada balsam in xylol and kept dried for a few days on a slide tray in the room temperature. The killing and fixation, dehydration, infiltration, embedding, staining and mounting were made according to Johansen's (1940) Method.

Some of the stem blocks were boiled in water for 12 hours and cut into 25 – 30 □m thick sections at the transverse, tangential longitudinal and radial longitudinal plane respectively by using a sliding microtome. These sections were stained with haematoxilin and safranin combination according to Johansen (1940). After staining, the sections were dehydrated and permanently mounted under a cover slip with Canada balsam in xylol and kept dried for a few days on a slide tray. The sections were examined under Biological microscope (MT 4300H) attached to a laptop by a camera.

The parts of stem bark and stem wood were macerated separately by warming in a mixture of two parts of hydrogen peroxide solution and one part of glacial acetic acid solution according to Franklin's method (modified) (Berlyn and Mikshe 1976). The macerated elements were studied under Biological microscope (MT 4300H) and the vessel elements and fibers were measured and recorded by a digital camera.

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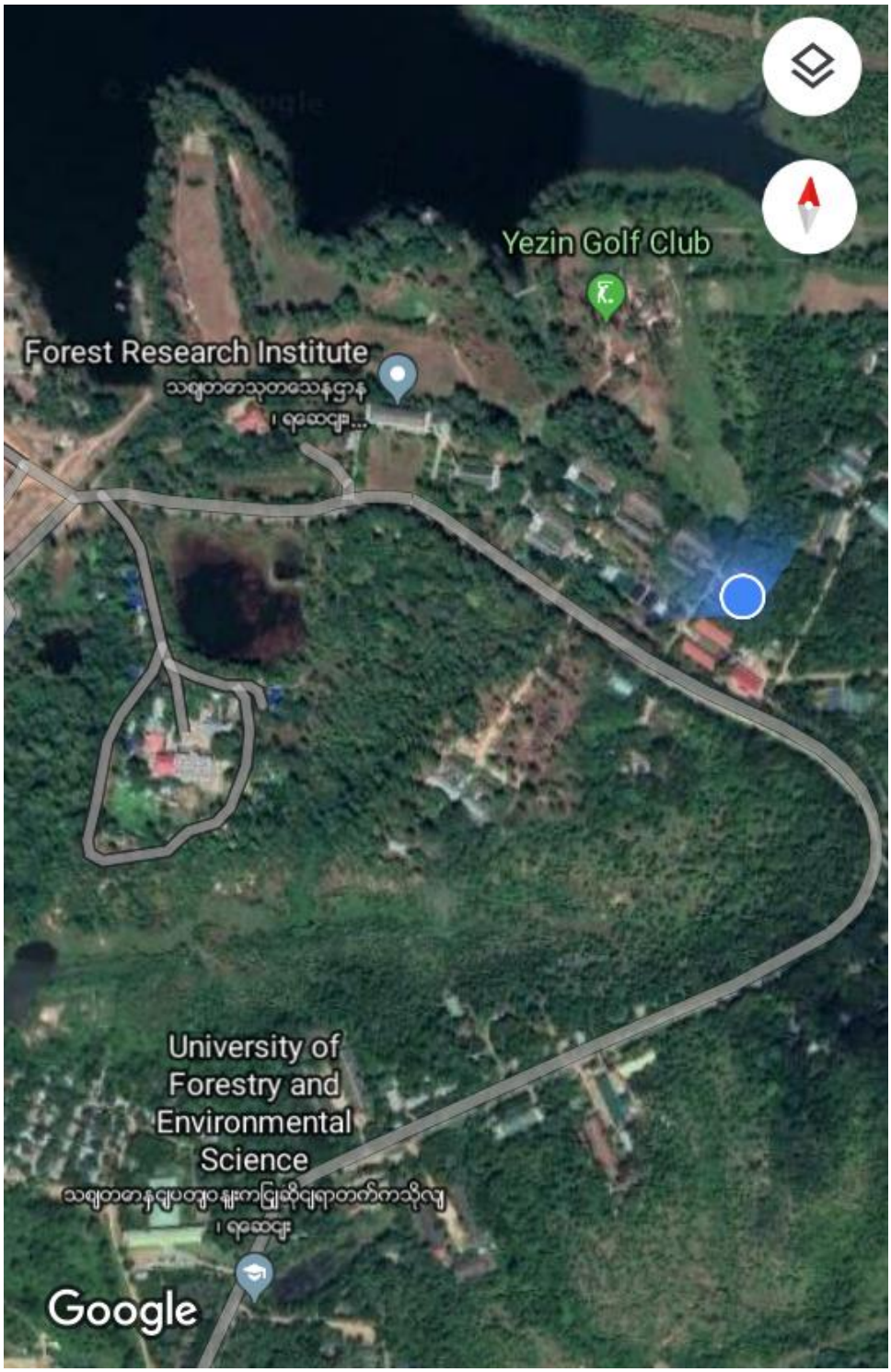


Figure 3.1 Location map of Arboretum (collection site) of Forest Research Institute, Yezin

4. Results

4.1 *Lannea coromandelica* (Houtt.) Merr.

Botanical name***: Lannea coromandelica*** **(**Houtt.) Merr. J. Arnold Arbor. 19(4): 353 1938.

Synonyms: *Calesium grande* Kuntze
Dialium coromandelicum Houtt.
Haberlia grandis Dennst.
Lannea grandis Engl.
Lannea wodier (Roxb.) Adelb.
Lannea wodier (Roxb.) Parker
Odina pinnata Rottler
Odina wodier Roxb.
Rhus odina Buch.

Common name: Indian ash tree, Moya, Wodier, Jhingangummi

Local name: Nabe

Trade name: Nabe

Family: Anacardiaceae

Wood of stem

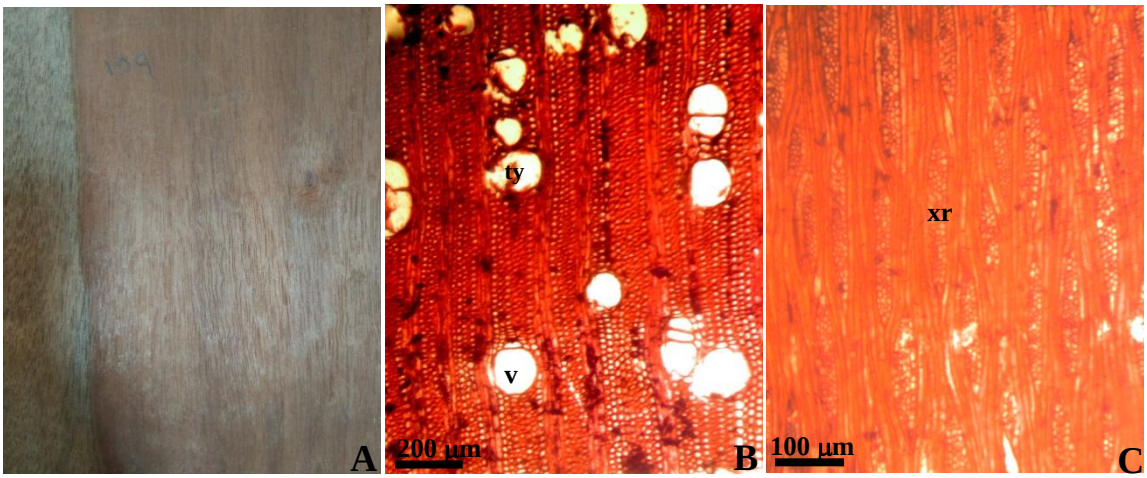
General characteristics and properties of the wood

Sapwood of stem of *Lannea coromandelica* (Houtt.) Merr. studied is pale yellow and heartwood light pinkish-red to light red, turning darker brownish red with age; its odour and taste not distinct. It is light wood, straight-grained, and very fine-textured to medium textured. The wood is diffuse-porous and its growth ring is not distinct. Tyloses abundant in the vessels. Crystal present.

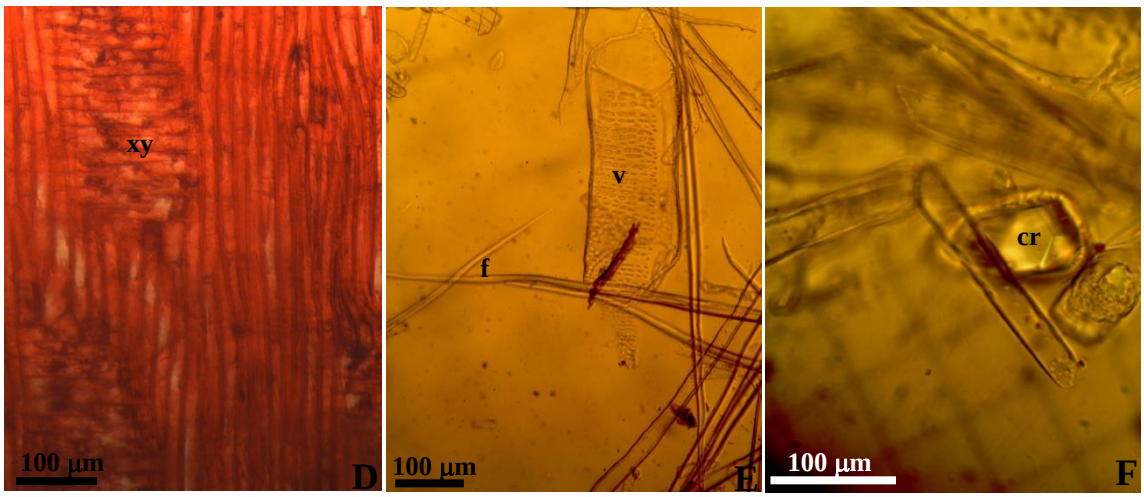
Microscopic characteristics

Vessel elements: Diffuse-porous, pores moderately small to medium-sized, tangential diameter 70 – 160 μm (mean 115.3 μm), very fine-textured to medium textured; number per square mm moderately few to moderately numerous (range 6 – 14); pore solitary, radial multiples of 2 – 4, occasionally pore clusters; pore circular or oval in cross section; thin-walled; perforation plate simple; end walls oblique, tailed at one end or both ends; intervessel pits alternate, crowded; vessel element very short to medium-sized; 200 – 650 μm (mean 441.7 μm) long; tyloses present, pale yellow gum present in parenchyma.

Fibres : Non-libriform, very short to moderately long, 650 – 1650 μm (mean 1310.7 μm) long and 5 – 10 μm (mean 7.9 μm) wide, wall 2 - 5 μm (mean 3.2 μm) thick, thin-walled, size of pits small, simple, slit-like; lumen 3 – 6 μm (mean 4.6 μm) thick, septate, with tapering ends;



A. T.S of a portion of wood of stem as seen. **B.** T.S of a portion of wood of stem showing solitary, radial multiple and group of vessels and xylem parenchyma cells. **C.** T.L.S of a portion of wood of stem showing multiseriate rays. (v – vessel, ty – tyloses, xr – xylem ray.)



D. R.L.S of a portion of wood of stem showing multiseriate rays. **E.** Macerated elements showing vessel element and fibers. **F.** Macerated elements showing prismatic crystal in a sclereid. (v – vessel element, f – fiber, cr – crystal.)

Figure 4.1. Internal structure and macerated elements of stem wood of *Lannea coromandelica* (Houtt.) Merr.

Rays: Heterogeneous, 1 – 5 seriate (mostly 2 – 4) cell wide, 4.7 (range 6 – 10) per mm tangentially, moderately numerous to numerous; multiseriate rays 230 – 700 µm (mean 457.7 µm) in height, 7 – 33 cells high; very fine to medium-sized; 20 – 70 µm (mean 58.3 µm) in width; ray parenchyma cell contain gum deposits. Multiseriate rays sometimes consist of gum canals. Cell size is small and parenchyma cell few.

Axial parenchyma : Apotracheal parenchyma diffuse.

Bark of stem

General characteristics and properties of the bark

Bark of old stem of *Lannea coromandelica* (Houtt.) Merr. studied is brownish gray to grey with many white patches of lichen, 2.0 – 2.2 cm thick, with many vertical lines of warty structure, 2 – 3 vertical lines per 5 cm square, forming slightly ridges and furrows, slightly

lenticels-like warty structures lying on the ridges; outer bark 0.1 – 0.3 cm thick, inner bark 1.2 – 1.4 cm; whitish pale red, fibrous, soft; odour and taste not distinct.

Microscopic characteristics

The older bark of the stem can be distinguished into protective layer, outer zone and inner conductive zone.

Protective layer is outer-most zone of the stem. Epidermal cells damaged and no trace of cells left in old barks as the girth of stem grows. Periderm formed twice or more around the stem at the outer part of cortex to protect the inner tissues.

Periderm: Periderm formed under a few layers of cortex at the outer part forming as a continuous ring around the cortex. Periderm formed twice or more and outer periderm formed lenticels. Individual periderm 21.8 – 33.8 µm thick. Each periderm composed of phellogen or cork cambium, phellem or cork, and phelloderm. (Fig. 4.2 B, C, D & F).

Phellogen lying between cork and phelloderm, one layered, parenchymatous, rectangular in shape, tangentially flattened, meristematic, gives rise to phellem or cork outside and to phelloderm inside; nucleus usually present, colourless.

Phellem or cork derived from phellogen or cork cambium, lying outside the phellogen, parenchymatous, rectangular in shape, tangentially flattened, many layered, cork cells of about ten layers of upper potion cutinized or suberinized, deeply stained.

Phelloderm derived from phellogen or cork cambium, lying inside the phellogen, three or four layered, parenchymatous, rectangular, polygonal or tangentially flattened, sometimes formed into sclereids later, prismatic crystal present in some cells.

Outer zone of the bark: Composed of periderms, cortex, primary phloem and nonconductive secondary phloem cells. Cortex lying outermost, parenchymatous, groups of sclereids present, cells polygonal, tangentially elongated or irregular in shape, prismatic crystals and druses present.

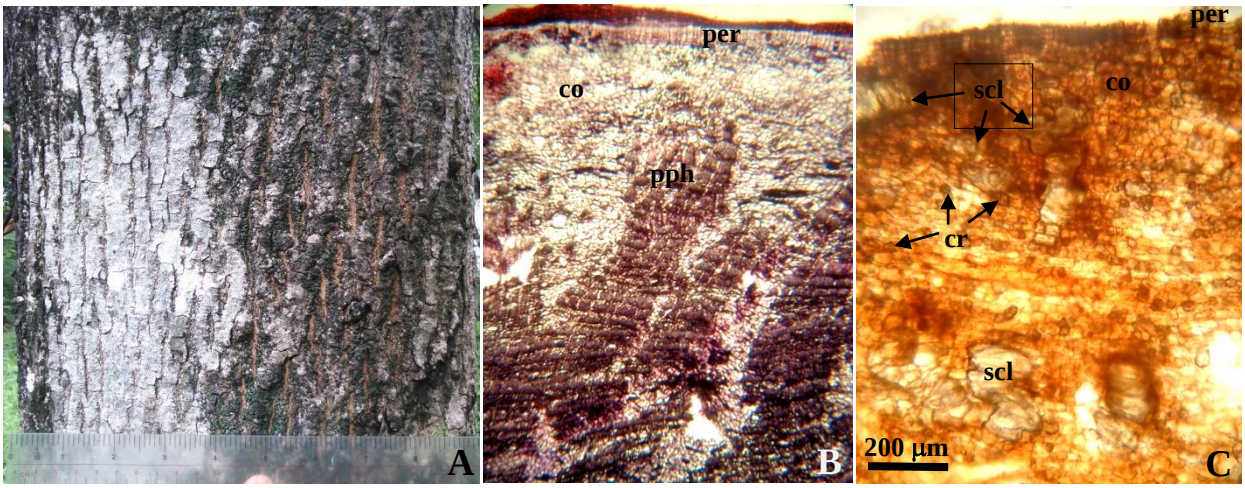
Primary phloem cells lying internal to the cortex, usually overlapped the cortex area, mostly parenchymatous, cells rectangular, elongated, prismatic crystals present, single sclereid or group of a few sclereids present, group of stretched sieve tubes present, companion cell not distinct, phloem fibers thick-walled; phloem ray cells distinct.

Inner zone of the bark: Composed of non-conductive and conductive phloem. Many layers of phloem fibers present and forming discontinuous rings interrupted by phloem rays, cells thick-walled; phloem parenchyma and sieve tubes lying between the phloem fiber layers, sieve tubes observed with reticulated thickenings in tangentially longitudinal section, nucleus found in some sieve tubes, some cells brown coloured and tanniferous, some sieve tubes forming stretched cells; companion cells usually not distinct in transverse section, distinct in tangential longitudinal section and nucleus present, cells radially elongated; many secretory ducts present, bounded by epithelial layer of parenchymatous cells; phloem rays mostly 2-seriate to 7-seriate, cells parenchymatous and radially elongated, secretory ducts present in multiseriate phloem ray.

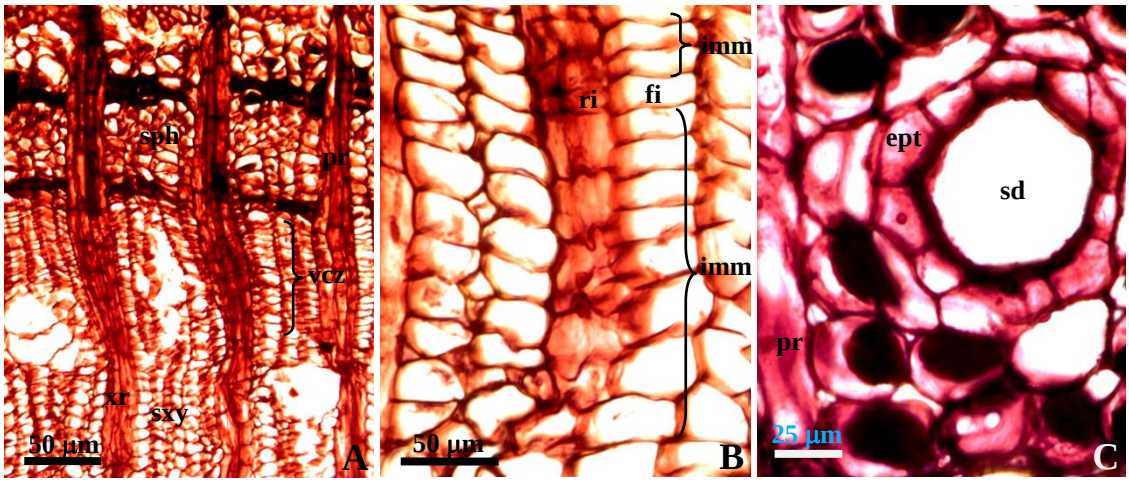
Vascular cambium: Lying phloem and xylem. Cambial cells one-layered, parenchymatous, meristematic, tangentially flattened, rectangular, colourless, differentiated into ray initial and

fusiform initial; immediate derivatives many layered, tangentially flattened, rectangular, colourless; ray initial gives rise to phloem ray outside and to xylem ray inside; fusiform initial gives rise to secondary phloem outside and to secondary xylem inside.

Secondary phloem: Lying outside the vascular cambium, consisted of sieve tubes and companion cells, phloem parenchyma, ray parenchyma and phloem fibers. Sieve tubes near the cambium conductive, older sieve tubes non-conductive. Phloem fibers moderately short to very long, 800 – 2800µm (mean 2009 µm) long and 10 – 25 µm (mean 17.41 µm) wide, wall 2.5 – 17.5 µm (mean 5.75µm) thick, lumen 2.5 – 20 □m (mean 11.58 µm) thick.

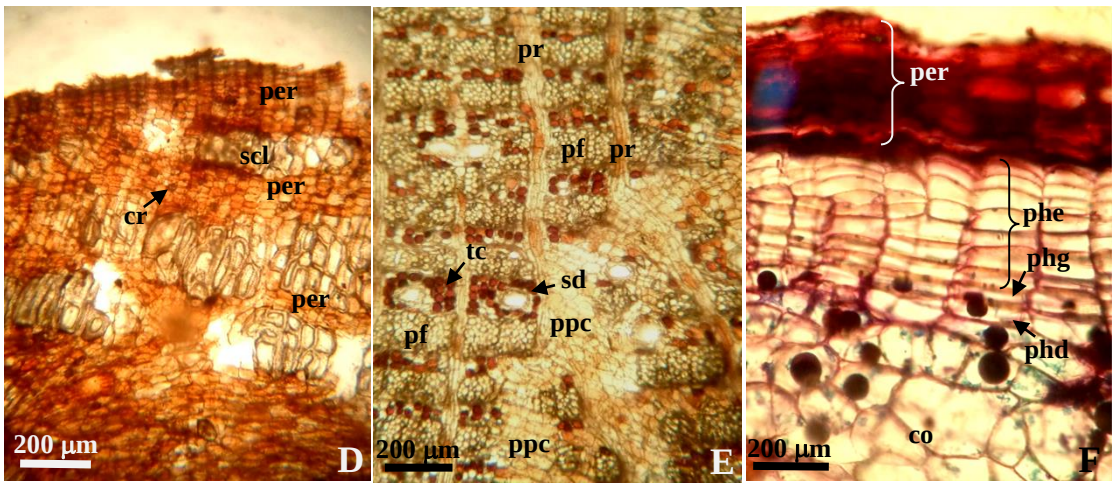


A. A portion of bark of stem as seen.
B. T.S of a portion of bark of stem showing outer bark.
C. T.S of a portion of outer bark of stem showing periderm, sclereids and crystals.
(per – periderm, co –cortex, pph – primary phloem, scl – sclereids, cr – crystals.)

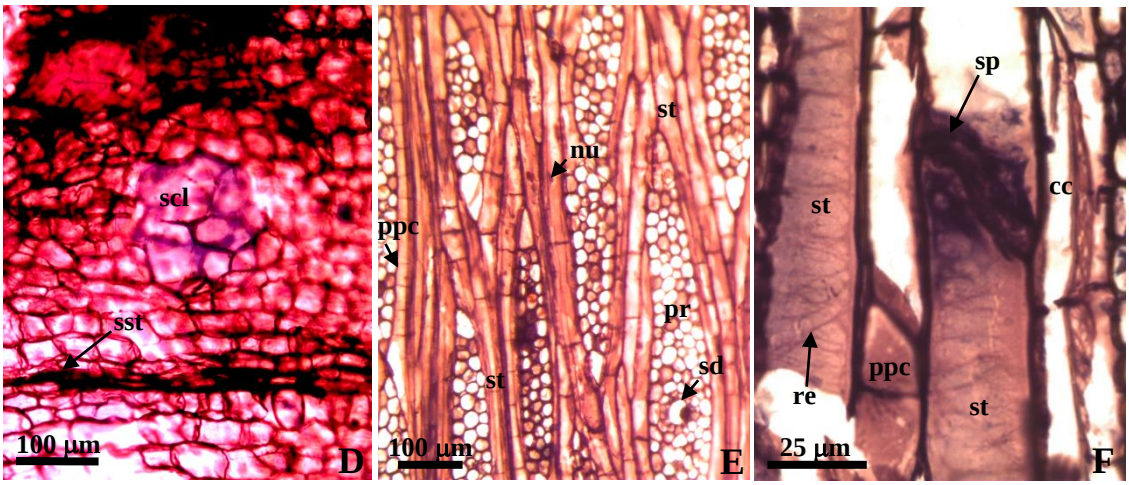


D. T.S of a portion bark showing periderm and sclereids.
E. T.S of a portion of inner bark showing ring of phloem fiber, phloem ray, secretory cells and tannin cells.
F. T.S of a portion of bark of stem showing repeatedly formed periderm.
(per – periderm, scl – scereids, cr – crystals, pf – phloem fiber, pr – phloem ray, ppc – phloem parenchyma, sg – secretory gland, tc – tannin cells, co – cortex, phg – phellogen, phe – phellem or cork, phd – phelloderm.)

Figure 4.2. Bark of stem of *Lannea coromandelica* (Houtt.) Merr.

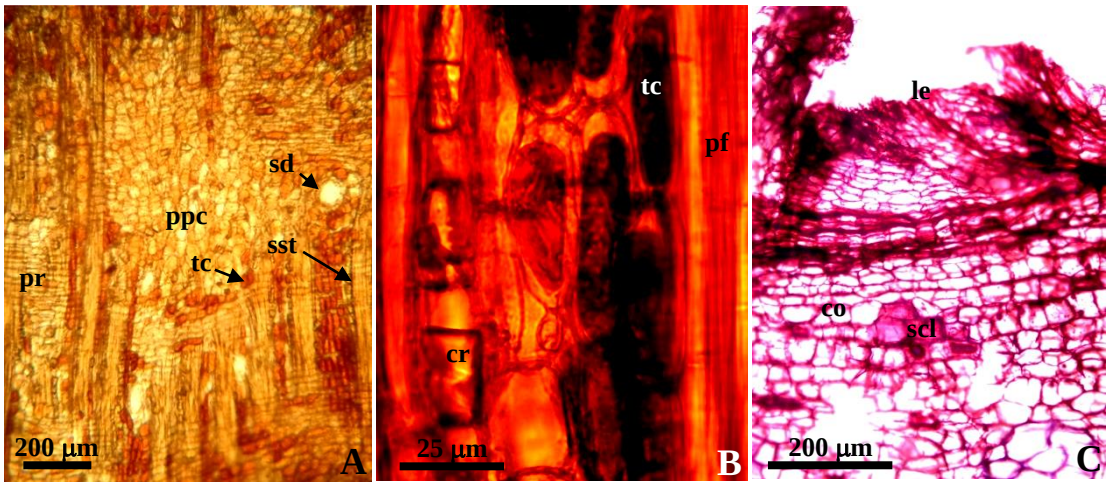


A. T.S of a portion of stem showing vascular cambial zone, secondary phloem and secondary xylem.
B. T.S of a portion of stem showing vascular cambium and its derivatives.
C. T.S of a portion of bark of stem showing secretory duct.
(vcz – vascular cambial zone, sph – secondary phloem, sxy – secondary xylem, pr – phloem ray, xr – xylem ray, ri – ray initial, fi – fusiform initial, imm – immediate derivativews, sd – secretory duct, ept – epithelial layer.)

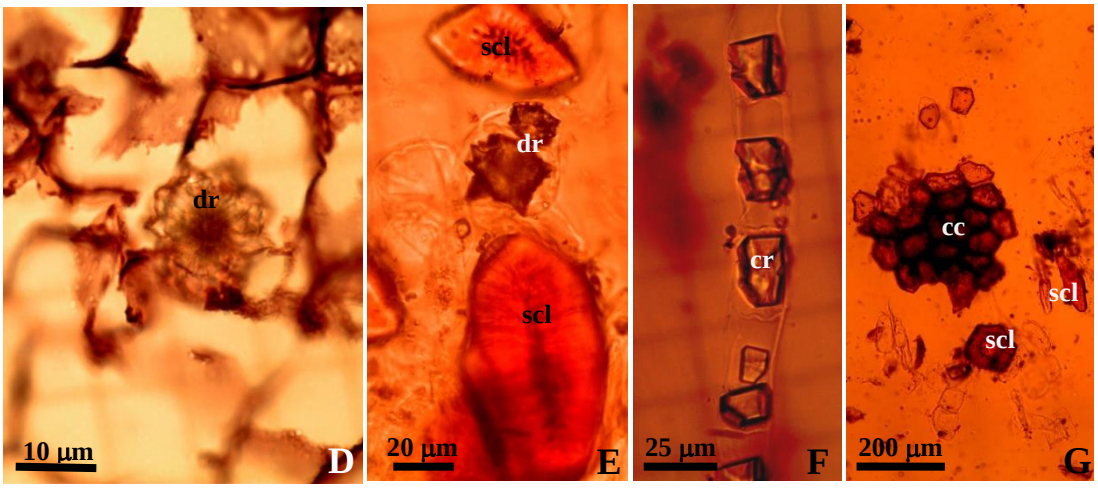


D. T.S of a portion of outer bark of stem showing stretched sieve tubes and sclereides.
E. T.L.S of bark of stem showing phloem ray, sieve tube, and secretory duct.
F. T.L.S of bark of stem showing sieve tube with reticulated thickenings.
(sst – stretched sieve tubes, scl – sclereids, pr – phloem ray, ppc – phloem parenchyma, st – sieve tube, pr – phloem ray, nu – nucleus, sd – secretory duct, sp – sieve plate, re – reticulated thickening.)

Figure 4.3 Internal structure of bark of stem of *Lannea coromandelica* (Houtt.) Merr.



A. R.L.S of outer bark of stem showing tannin cells, secretory duct and stretched sieve tubes.
B. R.L.S of bark of stem showing phloem fibers, tannin cells and row of crystals.
C. T.S of a portion of outer bark showing lenticel.
(sst – stretched sieve tubes, pr – phloem ray, ppc – phloem parenchyma, tc – tannin cells, sd – seretory duct, pf – phloem fiber, cr – crystal, co – cortex, scl – sclereids, le - lenticel.)



D. T.S of bark of stem showing druses. (dr – druses.)
E. Macerated element of bark of stem showing sclereid and druses.
F. Macerated element of bark of stem showing prismatic crystals.
G. Macerated element of bark of stem showing sclereid and cork cells.
(dr – druses, scl – sclereids, cr – crystal, cc – cork cells.)

Figure 4.4 Internal structure and macerated elements of bark of stem of *Lannea coromandelica* (Houtt.) Merr.

4.2 *Fernandoa adenophylla* (Wall. ex G.Don) Steenis

Botanical name: *Fernandoa adenophylla* (Wall. ex G.Don) Steenis, Blumea 23: 135. 1976.
Synonyms:

Bignonia adenophylla Wall. ex G.Don
Haplophragma adenophyllum (Wall. ex G.Don) Dop;
Heterophragma adenophyllum (Wall. ex G.Don) Seem. ex Benth. & Hook.f.;
Spathodea adenophylla A.DC.

Common name: Katsagon Tree
Local name: Phetthan
Trade name: Petthan (ITTO), Karen wood
Family: Bignoniaceae

Wood of stem

General characteristics and properties of the wood

Sapwood of stem of *Fernandoa adenophylla* (Wall. ex G.Don) Steenis studied is pale brownish yellow and heartwood pale yellowish brownish; its odour and taste not distinct. Growth ring is present, hard, straight-grained and very fine to fine textured. The wood is ring-porous.

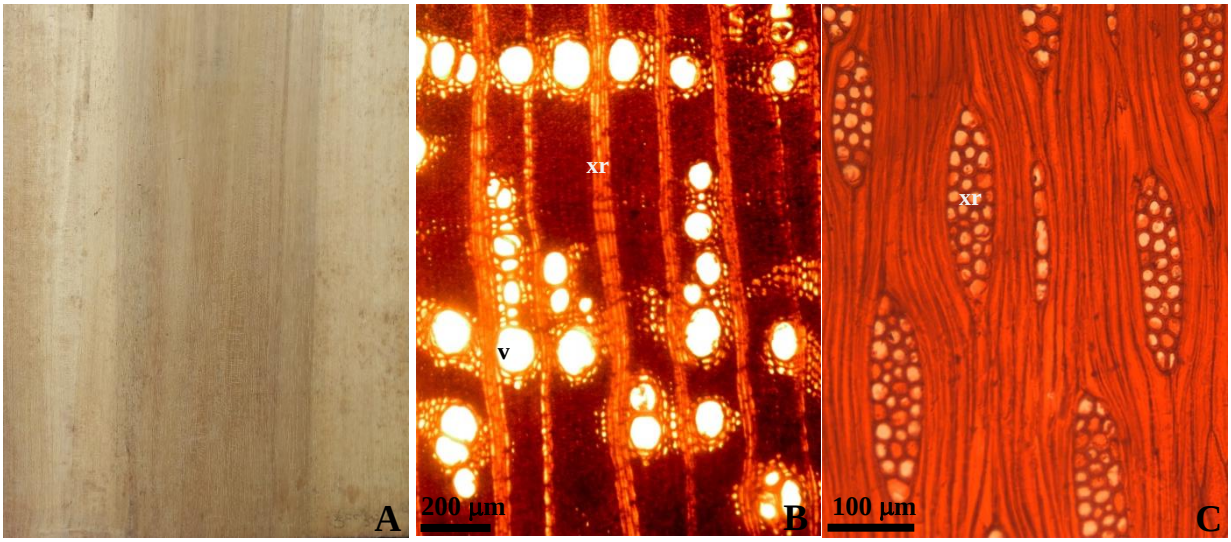
Microscopic characteristics

Vessel elements: Ring-porous, pores very small to medium-sized, tangential diameter 40 – 130 µm (mean 95.38 µm), very fine to fine textured; number per square mm numerous (range 10 – 31), moderately few to numerous; pore solitary, radial multiples 2 – 5, sometime pore cluster; pore circular or oval in cross section, filled with yellowish resinous materials; perforation plate simple; end walls of element transverse or oblique, tailed at one end, truncate; intervessel pits alternate, circular or oval; vessel element extremely short to moderately short; 150 – 320 µm (mean 245.33 µm) long.

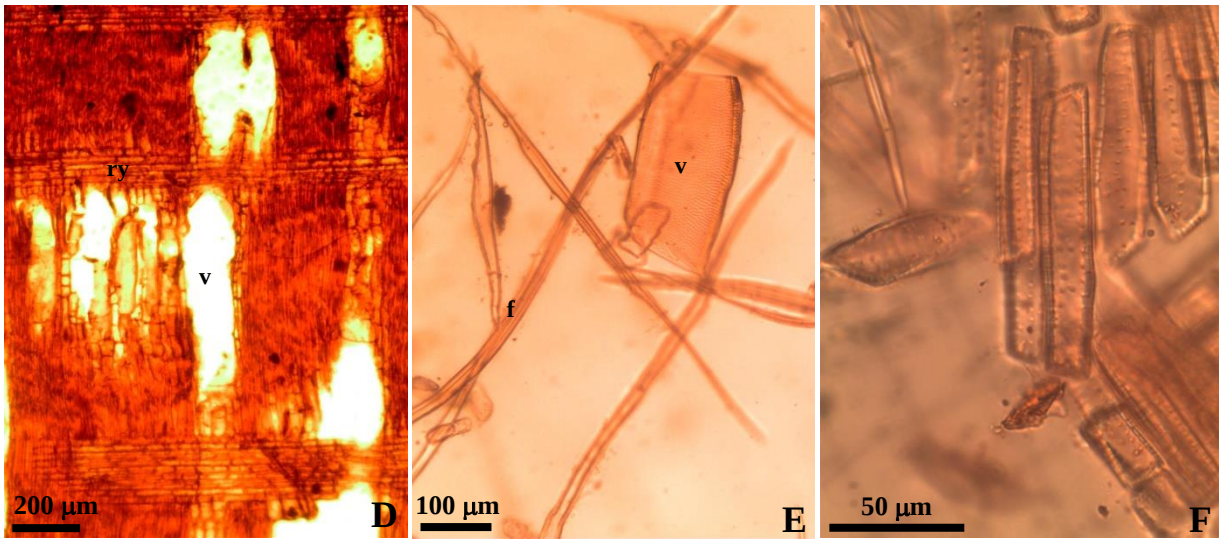
Fibres : Libriform, non-septate; extremely short to medium-sized, 450 – 920 µm (mean 793.3 µm) long and 4– 8 µm (mean 6.0 µm) wide, wall 2 - 5 µm (mean 3.56 µm) thick, thin-walled, size of pits small; lumen 1 – 5 □m (mean 2.4 µm) thick, with tapering ends; interfibre pits minute, simple, slit-like.

Rays: Homogeneous, 1- to 4-seriate, rarely uniseriate and mostly triseriate; 6.8 (range 5 – 9) per mm tangentially, moderately numerous to numerous; multiseriate rays 70 – 300 µm (mean 208 µm) in height, 6 – 15 cells high; moderately fine to medium-sized, 30 – 70 µm (mean 54 µm) in width; multiseriate rays, ray vessel pits similar to intervascular pits.

Axial parenchyma : Paratracheal, vasicentric, aliform or aliform confluent.



A. T.S of a portion of wood of stem as seen. **B.** T.S of a portion of wood of stem showing solitary, radial multiple and group of vessels and xylem parenchyma cells. **C.** T.L.S of a portion of wood of stem showing uniseriate and multiseriate rays. (v – vessel element, xr – xylem ray.)



D. R.L.S of a portion of wood of stem showing vessel and rays. **E.** Macerated elements showing vessel element and fibers. **F.** Macerated elements showing ray parenchyma. (v – vessel, f – fiber, xr – xylem ray.)

Figure 4.5 Internal structure and macerated elements of stem wood of *Fernandoa adenophylla* (Wall. ex G.Don) Steenis

Bark of stem

General characteristics and properties of the bark

Bark of old stem of *Fernandoa adenophylla* (Wall. ex G.Don) Steenis studied is yellowish-brown with many white patches of lichen, 1.1 – 1.5 cm thick, with a few vertical lines and warty structure, 1 – 3 vertical lines per 5 cm square; inner bark 0.4 – 1.0 cm thick; grayish yellow, fibrous, soft; odour and taste not distinct.

Microscopic characteristics

The older bark of the stem can be distinguished into protective layer, outer zone and inner conductive zone.

Protective layer is outer-most zone of the stem. Epidermal cells damaged and no trace of cells left in old barks as the girth of stem grows. Periderm formed in the cortex as well as inner part of phloem twice or more.

Periderm: Periderm formed under a few layers of cortex at the outer part forming as a continuous ring around the cortex as well as formed in the inner part of phloem, it occurs repeatedly to form multiple periderm. Outer periderm formed lenticels. Some lenticels formed beneath the outer periderm and closed. Individual periderm 72.5 – 147.5 µm thick. Each periderm composed of phellogen or cork cambium, phellem or cork, and phelloderm (Fig. 4.6 C & F).

Phellogen lying between cork and phelloderm, one layered, parenchymatous, rectangular in shape, tangentially flattened, meristematic, gives rise to phellem or cork outside and gives rise to phelloderm inside; nucleus usually present, colourless.

Phellem or cork derived from phellogen or cork cambium, lying outside the phellogen, parenchymatous, rectangular in shape, many layered, some cells formed into sclereids, prismatic crystal present.

Phelloderm derived from phellogen or cork cambium, lying inside the phellogen, one to three or more layered, parenchymatous, some cells formed into sclereids, rectangular in shape, prismatic crystal present in some cells.

Outer zone of the bark: Composed of cortex, primary phloem and nonconductive phloem cells. Cortex lying outermost, parenchymatous, groups of sclereids present, cells polygonal, tangentially elongated and irregular in shape, many layers of rings of phloem fibers present, prismatic crystals present.

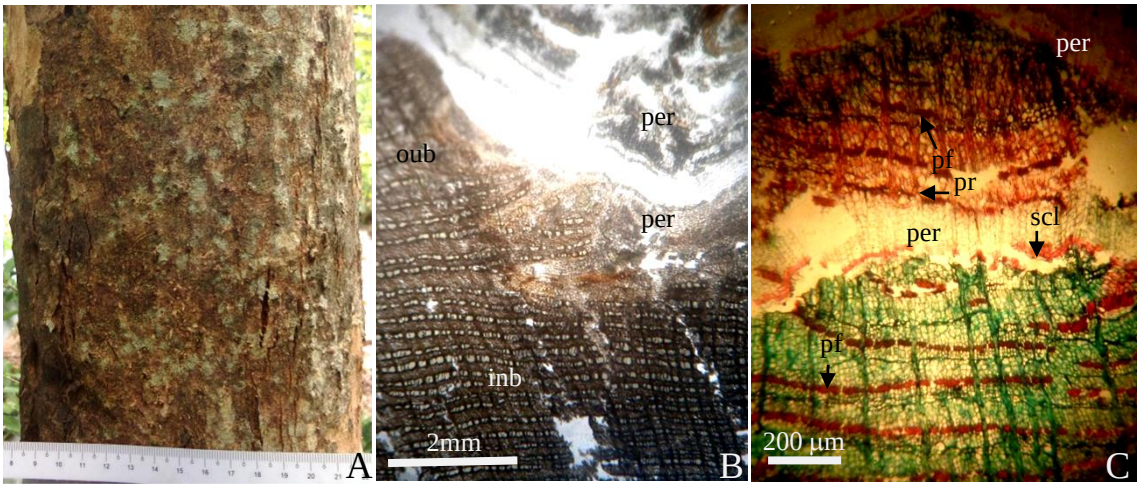
Primary phloem cells lying inside the cortex, usually overlapped the cortex, mostly parenchymatous, cells rectangular, polygonal in shape, prismatic crystals present, single sclereid or group of a few sclereids present, group of stretched sieve tubes present, companion cell not distinct; phloem fibers forming a discontinuous ring, many rings present, cells thick-walled, polygonal in shape; phloem ray cells distinct, bi- to tetra-seriate, radially elongated.

Inner zone of the bark: Composed of secondary phloem, outer layers of secondary phloem non-conductive, inner layers of secondary phloem near vascular cambium conductive, group of stretched sieve tubes forming like a ring, companion cell not distinct; phloem fibers forming many discontinuous rings, cells thick-walled, polygonal in shape, phloem fiber-like cells with spiral thickenings present; phloem parenchyma cells polygonal,

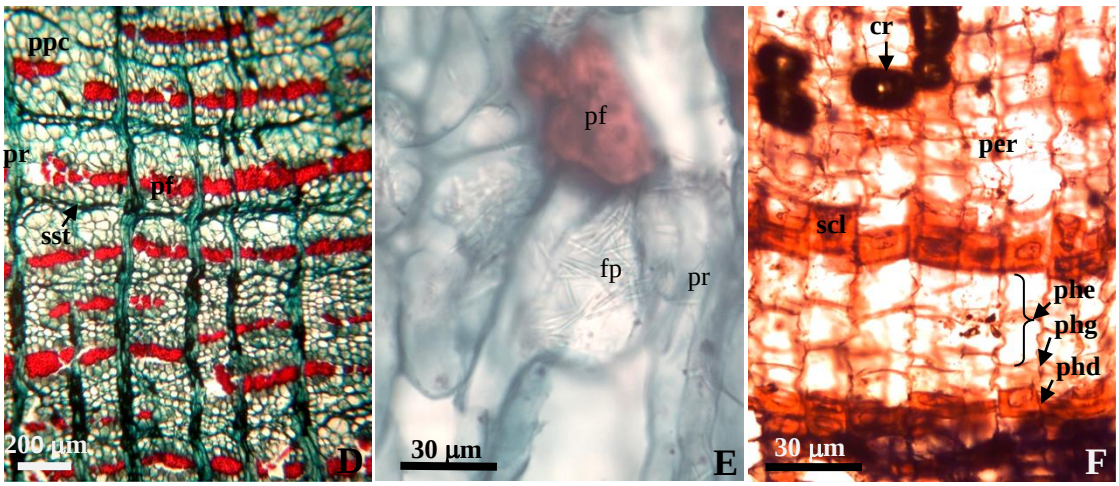
elongated or irregular in shape, rod-shape food particles abundantly present; phloem ray cells distinct, bi- to tetra-seriate, radially elongated in transverse section; prismatic crystals present.

Vascular cambium: Lying phloem and xylem. Cambial zone cells 10 or more-layered, parenchymatous, meristematic, tangentially flattened, rectangular, colourless, immediate derivatives many layered, tangentially flattened, rectangular, colourless; ray initial gives rise to phloem ray outside and to xylem ray inside; fusiform initial gives rise to secondary phloem outside and to secondary xylem inside.

Secondary phloem: Lying outside the vascular cambium, consisted of sieve tubes and companion cells, phloem parenchyma, ray parenchyma and phloem fibers. Sieve tubes near the cambium conductive, older sieve tubes non-conductive. Phloem fibers very short to moderately short, 590 – 880 µm (mean 764.66 µm) long and 12.5 – 25.0 µm (mean 19.75 µm) wide, wall 5.0 – 17.5 µm (mean 6.25µm) thick, lumen 2.5 – 20.0 µm (mean 13.5µm) thick.

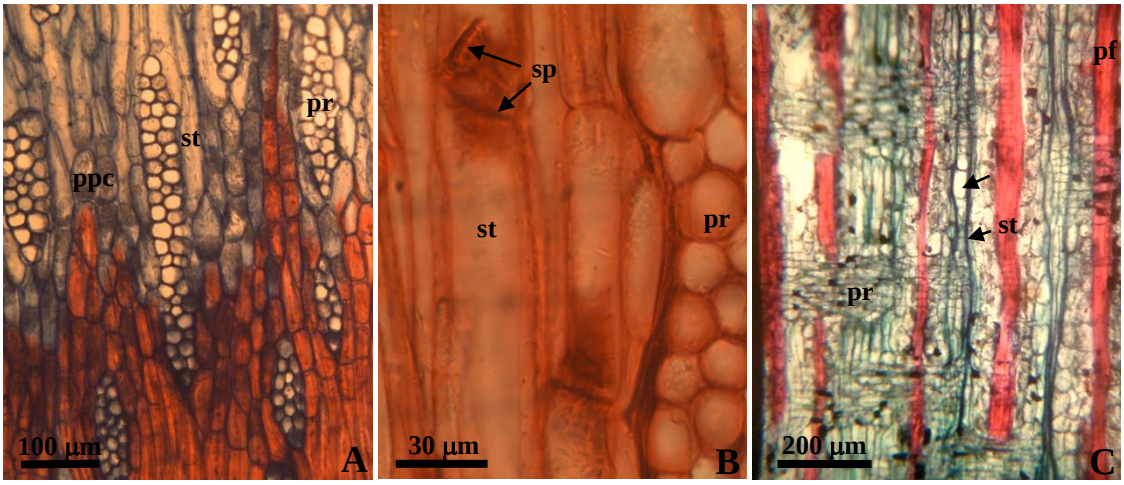


A. A portion of bark of stem as seen. **B.** T.S of a portion of bark of stem showing outer and inner bark. **C.** T.S of a portion of outer bark of stem showing many periderm layers, phloem ray and phloem fibers. (oub – outer bark, inb – inner bark, per – periderm, scl – sclereids, pf – phloem fiber, pr – phloem ray.)

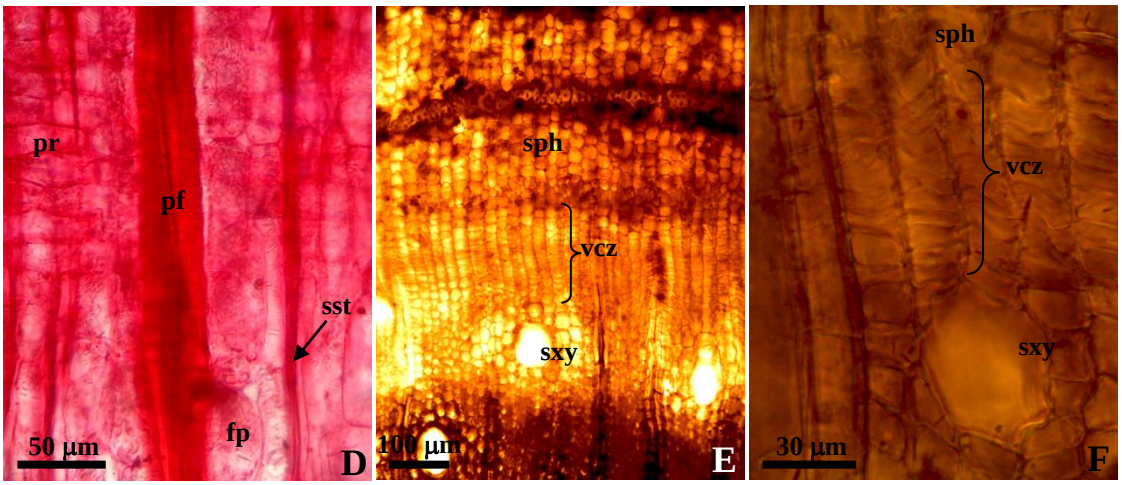


D. T.S of a portion inner bark showing stretched sieve tube, phloem fiber and phloem ray.
E. T.S of a portion of bark of stem showing phloem fiber, phloem ray and phloem parenchyma cell with food particles.
F. T.S of a portion inner bark showing two adjacent periderm layers. (ppc – phloem parenchyma, pr – phloem ray, pf – phloem fiber, sst – stretched sieve tube, fp – food particles, per – periderm, scl – scereids, cr – crystals, phg – phellogen, phe – phellem or cork, phd – phelloderm,)

Figure 4.6 Bark of stem of *Fernandoa adenophylla* (Wall. ex G.Don) Steenis

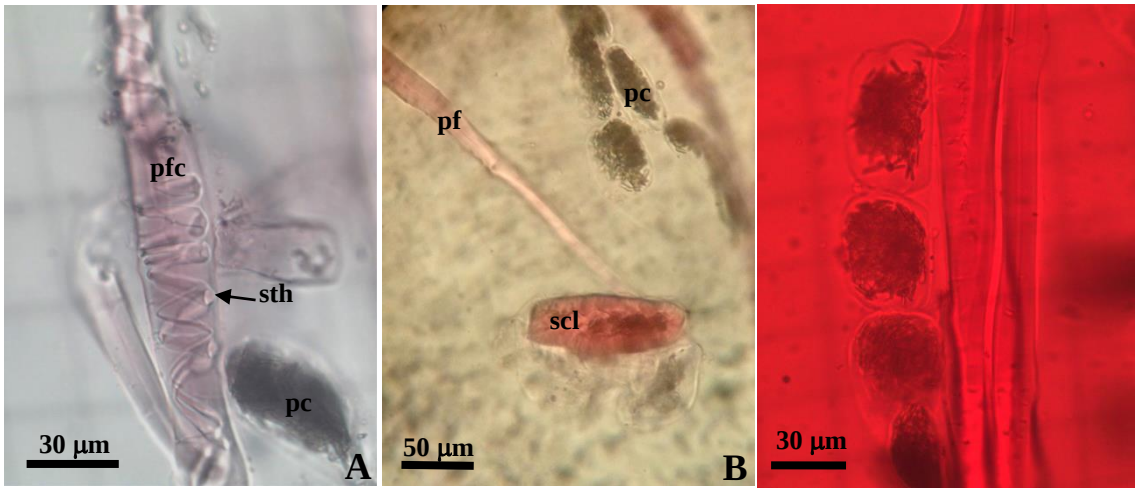


A. T.L.S of bark of stem showing phloem ray and sieve tube.
B. T.L.S of bark of stem showing phloem ray, sieve tube and sieve plate.
C. R.L.S of a portion of bark of stem showing phloem ray cells, phloem fiber, phloem parenchyma and sieve tubes. (st – sieve tube, pr – phloem ray, sp – sieve plate, ppc – phloem parenchyma, pf – phloem ray.)



D. R.L.S of bark of stem showing phloem ray, phloem fiber, stretched sieve tube and food particles.
E. T.S of young branch showing vascular cambial zone.
F. T.S of a portion of young branch showing vascular cambial zone, secondary phloem and secondary xylem. (pf – phloem fiber, sst – stretched sieve tube, pr – phloem ray, fp – food particles, vcz – vascular cambial zone, sph – secondary phloem, sxy – secondary xylem.)

Figure 4.7 Internal structure of bark of stem of *Fernandoa adenophylla* (Wall. ex G.Don) Steenis



A. Macerated elements showing spiral thickening of phloem fiber-like cell.
B. Macerated elements showing parenchyma cells containing food , sclereid and a portion of phloem fiber.
C. Macerated elements showing sieve tubes and parenchyma cells. (pfc – phloem fiber-like cell, sth – spiral thickening, pc – parenchyma, f – phloem fiber, scl – sclereids, st – sieve tubes.)

D. Macerated element of bark of stem showing phloem fiber. (f – phloem fiber)

Figure 4.8 Macerated elements of bark of stem of *Fernandoa adenophylla* (Wall. ex G.Don) Steenis

4.3 *Heterophragma sulfureum* **Kurz**

Botranical name**:** *Heterophragma sulfureum* Kurz, *J. Asiat. Soc. Bengal, Pt. 2, 42(2): 90 1873.*

Synonym:

Haplophragma sulfureum (Kurz) Pichon

Heterophragma vestitum Dop

Common name: Unknown

Local name: Thitlinda

Trade name: Unknown

Family: Bignoniaceae

Wood anatomy

General characteristics and properties of the wood

Sapwood of stem of *Heterophragma sulfureum* Kurz studied is pale yellow and heartwood yellowish brownish; its odour and taste not distinct. It is light wood, straight-grained, and very fine to fine textured. The wood is diffuse porous and its growth ring is not distinct. Tyloses present in the vessels element of the heartwood. Crystals present.

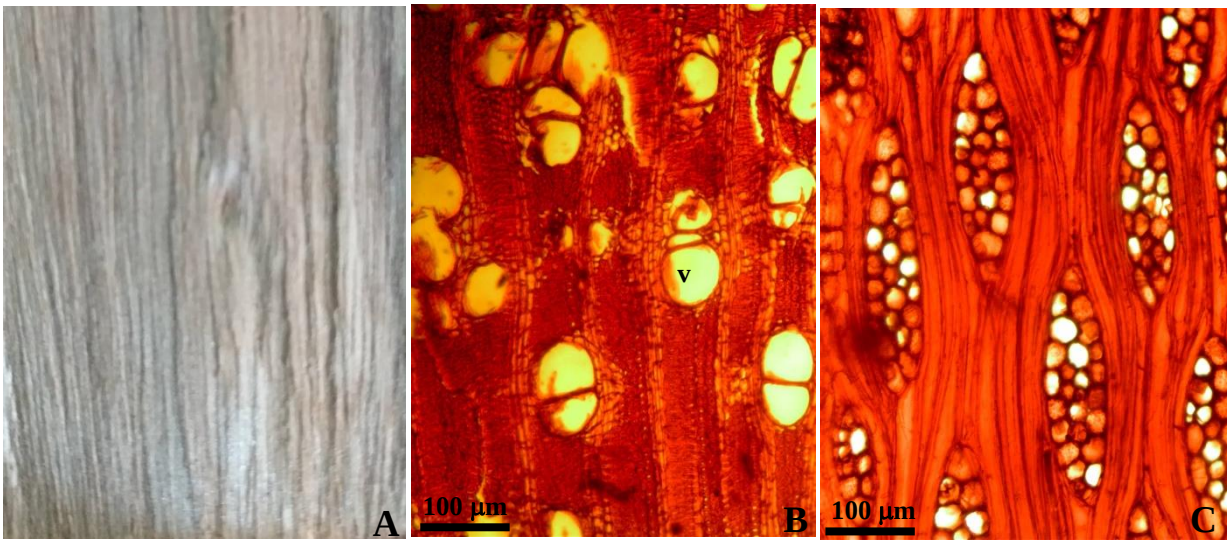
Microscopic characteristics

Vessel elements: Diffuse porous, paratracheal aliform confluent , pores very small to moderately small, tangential diameter 40 – 90 µm (mean 6.17 µm), very fine to fine textured; number per square mm numerous (range 5 – 15); moderately few to moderately numerous; pore solitary, radial multiples 2 – 3, sometime pore cluster; pore oval in cross section, sometime yellowish resinous materials in vessel element; perforation plate simple; tailed at two ends, circular or oval; vessel element very short to medium-sized; 180 – 420 µm (mean 291.0 µm) long.

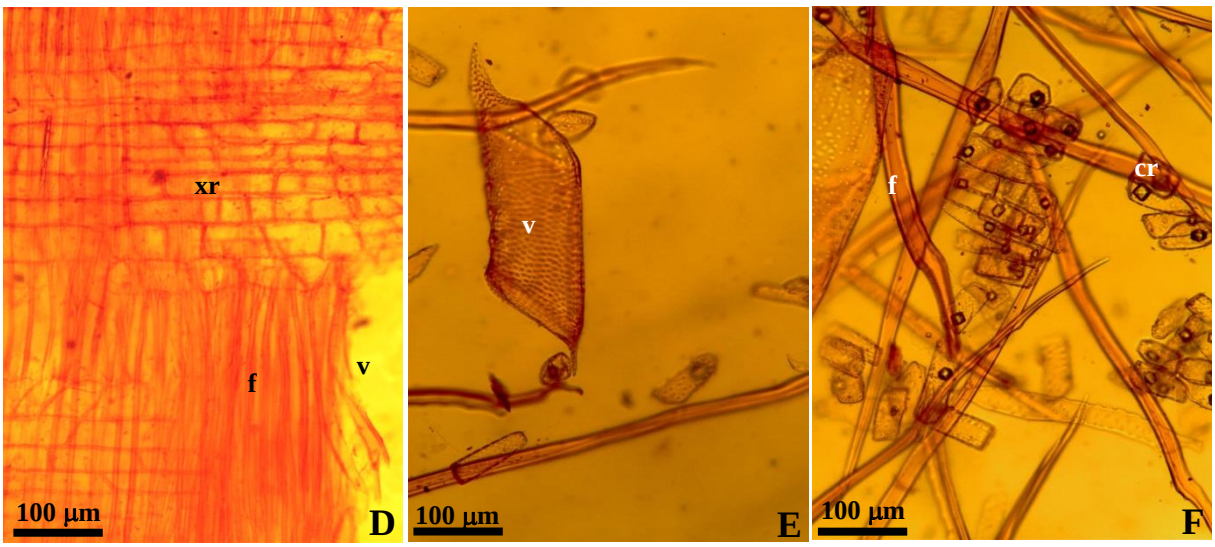
Fibres : Libriform, non-septate; extremely short to medium-sized, 470 – 1350 µm (mean 893.3 µm) long and 3 – 10 µm (mean 6.77 µm) wide, wall 2 – 6 µm (mean 3.73 µm) thick, thin-wall, lumen 1 – 5 µm (mean 3.03 µm) thick, with tapering ends; interfibre pits minute, simple, slit-like.

Rays: Homogeneous, 1 – 5 seriate, rarely uniseriate and mostly triseriate, 7.3 (range 5 – 10) per mm tangentially, few to moderately few; biseriate rays, 140 – 260 µm (mean 204.7 µm) in height, 4 – 9 cells high; moderately fine, 30 – 50 µm (mean 47.7 µm) in width; multiseriate rays, 230 – 470 µm (mean 308.3 µm) in height, 7 – 18 cells high; medium-sized, 60 – 90 µm (mean 78.7 µm) in width; circular or oval in shape.

Axial parenchyma : Paratracheal, vasicentric, aliform or aliform confluent and apotracheal diffuse.



A. T.S of a portion of wood of stem as seen. **B.** T.S of a portion of wood of stem showing solitary, radial multiple and group of vessels. **C.** T.L.S of a portion of wood of stem showing uniseriate and multiseriate rays. (v – vessel element, xr – xylem ray.)



D. R.L.S of a portion of wood of stem showing vessel, rays and fibers. **E.** Macerated elements showing vessel element and fibers. **F.** Macerated elements showing fibers and crystals. (v – vessel element, f – fiber, xr – xylem ray.)

Figure 4.9 Internal structure and macerated elements of stem wood of *Heterophragma sulfureum* Kurz

Bark of stem

General characteristics and properties of the bark of stem

Bark of old stem of *Heterophragma sulfureum* Kurz studied is deep grayish with vertical deep or shallow and long cracks, a few horizontal small cracks are present, very few patches of lichens may also found; 9 – 18 cm thick, 1 – 3 vertical lines per 5 cm square, forming ridges and furrows, lenticels-like structures lying on the ridges; inner bark 4 – 12 cm thick; grayish yellow, fibrous, soft; odour and taste not distinct.

Microscopic characteristics

The older bark of the stem can be distinguished into protective layer, outer zone and inner conductive zone.

Protective layer: It is outer-most zone of the stem. Epidermal cells damaged and no trace of cells left in old barks as the girth of stem grows. Periderm formed twice or more around the stem at the outer part of cortex to protect the inner tissues, lenticels present,some lenticels closed and lying in the cortex.

Periderm: Periderm formed under a few layers of cortex at the outer part forming as a continuous ring around the cortex, it occurs repeatedly to form multiple periderm. Outer periderm formed lenticels. Some lenticels formed beneath the outer periderm and closed. Individual periderm 247.8 – 320.8 µm thick. Each periderm composed of phellogen or cork cambium, phellem or cork, and phelloderm (Fig. 4.10 B, C, D & E).

Phellogen lying between cork and phelloderm, one layered, parenchymatous, rectangular in shape, tangentially flattened, meristematic, usually with nucleus, gives rise to phellem or cork outside and gives rise to phelloderm inside; nucleus usually present, colourless.

Phellem or cork derived from phellogen or cork cambium, lying outside the phellogen, parenchymatous, rectangular in shape, many layered.

Phelloderm derived from phellogen or cork cambium, lying inside the phellogen, one to three or more layered, parenchymatous, some cells formed into sclereids, rectangular or polygonal in shape.

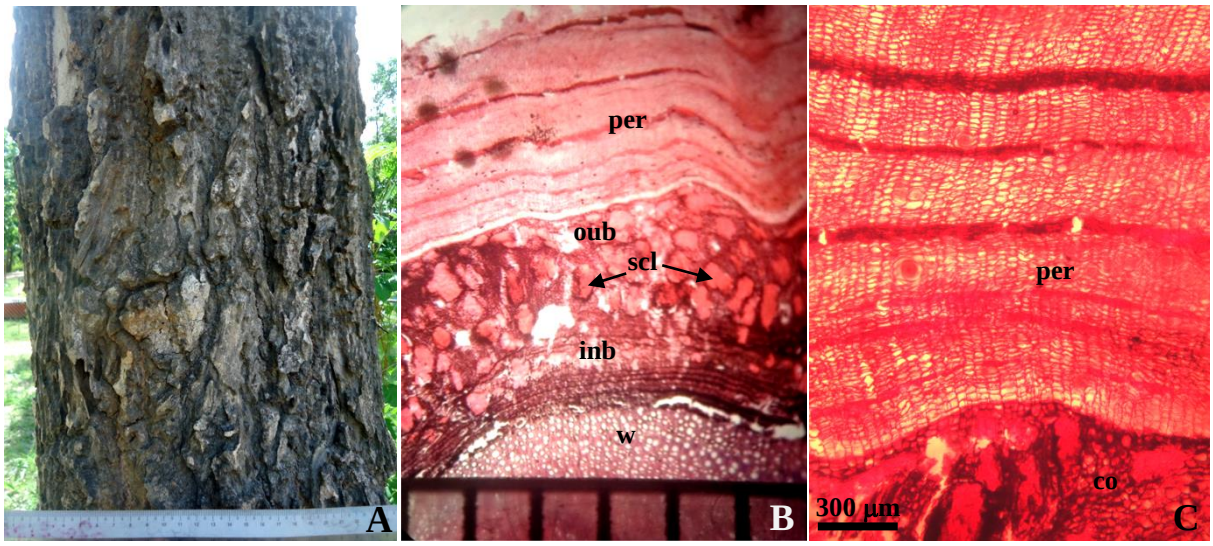
Outer zone of the bark: Composed of cortex, primary phloem and nonconductive phloem cells. Cortex lying outermost, parenchymatous, cells polygonal, tangentially elongated and irregular in shape, rings of stretched sieve tube present, many large groups of sclereids present.

Primary phloem cells lying inside the cortex, usually overlapped the cortex, mostly parenchymatous, cells rectangular, tangentially flattened, polygonal or irregular in shape, group of a few sclereids present, group of stretched sieve tubes present, companion cell not distinct; phloem fibers in groups forming discontinuous ring, cells thick-walled, polygonal in shape.

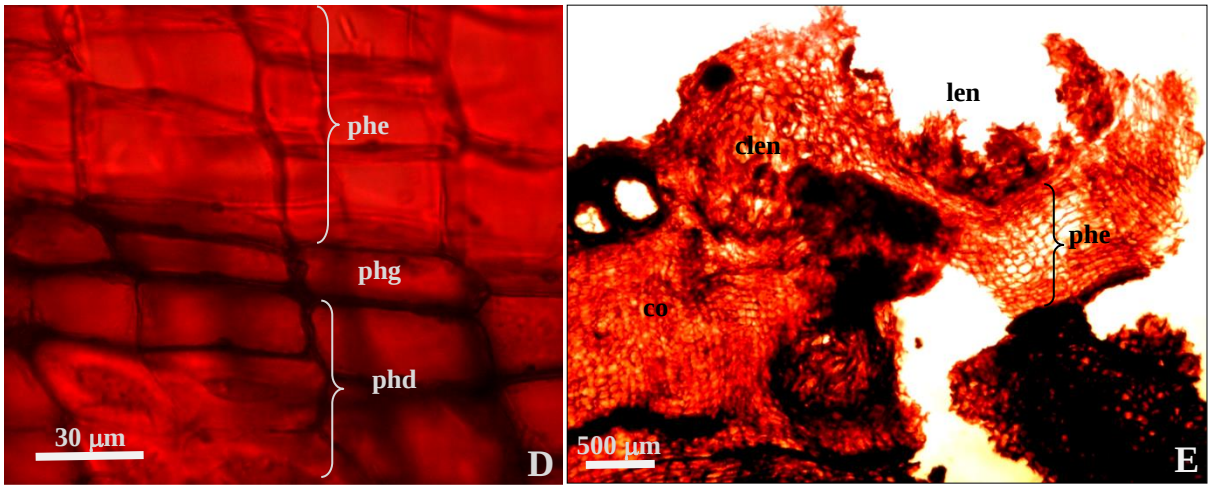
Inner zone of the bark: composed of secondary phloem, outer layers of non-conductive secondary phloem, inner layers of conductive secondary phloem near vascular cambium, group of stretched sieve tubes forming like a ring, companion cell not distinct; sieve tubes with many sieve areas at the lateral walls, reticulated thickenings at the end wall; phloem fibers forming many discontinuous rings, cells thick-walled, polygonal in shape, phloem fiber-like cells with spiral thickenings present; phloem parenchyma cells polygonal, elongated or irregular in shape, rod-shaped food particles abundantly present; phloem ray cells distinct, bi- to tetra-seriate, radially elongated in transverse section.

Vascular cambium: Lying between phloem and xylem. Vascular cambium one-layered, parenchymatous, meristematic, tangentially flattened, rectangular, colourless, differentiated into ray initial and fusiform initial; ray initial gives rise to phloem ray outside and to xylem ray inside; fusiform initial gives rise to secondary phloem outside and to secondary xylem inside.

Secondary phloem: Lying outside the vascular cambium, consisted of sieve tubes and companion cells, phloem parenchyma, ray parenchyma and phloem fibers. Sieve tubes near the cambium conductive, older sieve tubes non-conductive. Phloem fibers medium-sized to moderately long, 1000 – 1650 µm (mean 1270 µm) long and 17.5 – 30 µm (mean 22.25 µm) wide, wall 12.5 – 27.5 µm (mean 18.75µm) thick, lumen 2.5 – 5 µm (mean 3.25µm) thick.

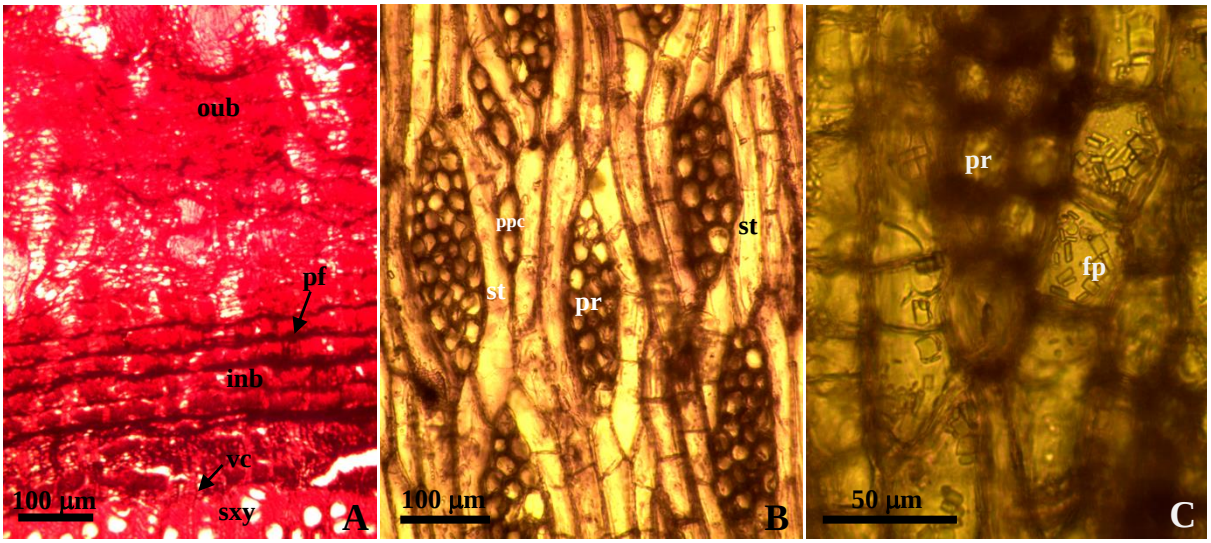


A. A portion of stem showing bark.
B. T.S of a portion of bark of stem showing outer, inner bark and groups of sclereids (1 division = 1 mm).
C. T.S of a portion of outer bark of stem showing many periderm layers and outer portion of cortex.
(oub – outer bark, inb – inner bark, per – periderm, w – wood, co – cortex.)

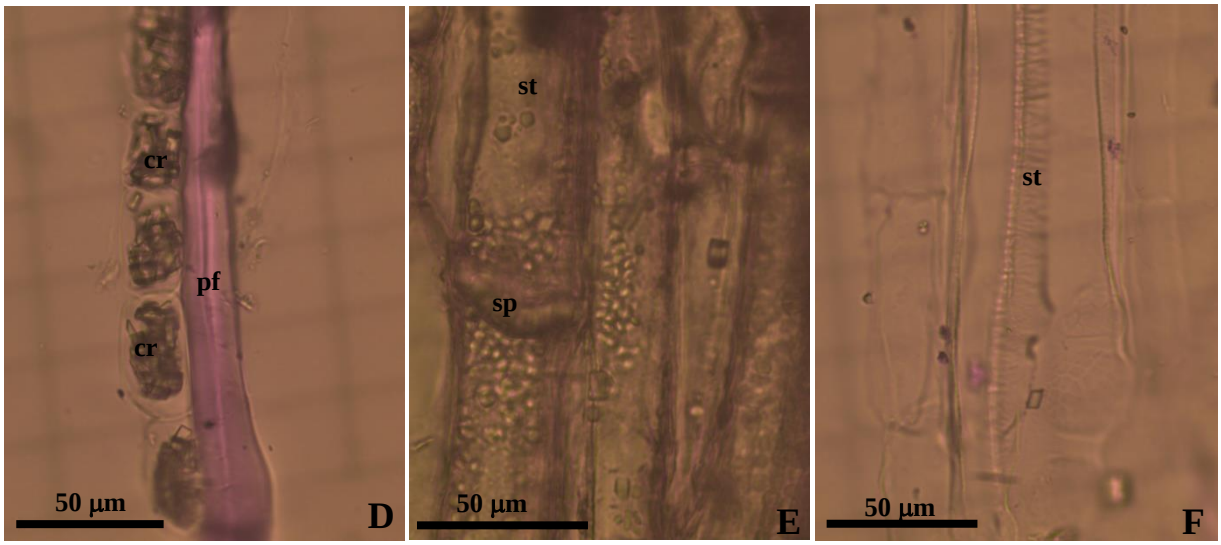


D. T.S of a portion of bark of stem showing periderm.
E. T.S of a portion outer bark showing lenticels.
(phg – phellogen, phe – phellem or cork, phd – phelloderm, len – lenticels, clen – closed lenticel.)

Figure 4.10. Internal structure of Bark of stem of *Heterophragma sulfureum* Kurz

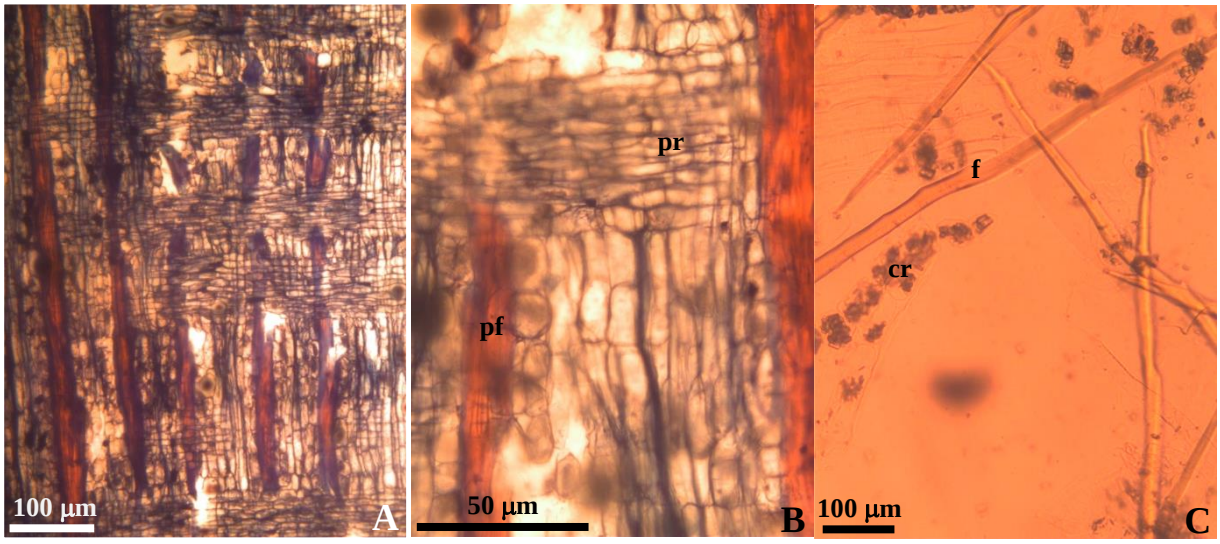


A. A portion of bark of stem showing inner bark, outer bark and vascular cambium.
B. T.L.S of a portion of bark of stem showing sieve tube, uniseriate ray and multiseriate rays.
C. T.L.S of a portion of bark of stem showing phloem ray and food particles in phloem parenchyma cells. (oub – outer bark, inb – inner bark, f – phloem fiber, pr – phloem ray, st – sieve tube, fp –food particles, ppc – phloem parenchyma.)



D. Macerated elements showing crystal chain and phloem fiber.
E. T.L.S of bark of stem showing phloem ray, sieve tube and sieve plate.
F. Macerated elements showing stem inner bark sieve tube with reticulated thickenings. (cr – crystals, pf – phloem fiber, st –sieve tube, sp –sieve plate)

Figure 4.11 Macerated elements of bark of stem of *Heterophragma sulfureum* Kurz



A. R.L.S of bark of stem showing phloem ray and fiber.
B. R.L.S of bark of stem showing phloem ray and fiber.
C. Macerated elements showing fibers and crystals. (pf – phloem fiber, pr – phloem ray, cr – crystal)

Figure 4.12 Internal structure and macerated elements of bark of stem of *Heterophragma sulfureum* Kurz

4.4 Dalbergia oliveri Gamble ex Prain

Botanical name: **Dalbergia oliveri Gamble ex Prain, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 66: 451 (1897).**

Synonym: *Dalbergia laccifera* Laness
Dalbergia prazeri Prain
Dalbergia bariensis **Pierre**
Dalbergia dongnaiensis Pierre
Dalbergia mammosa Pierre
Dalbergia duperreana Pierr

Common name: Burma Tulipwood, Pinkwood, Tamalan Tree

Local name: Tamalan

Trade name: Tamalan, Burmese rosewood, Laos rosewood, Asian rosewood.

Family: Fabaceae

Wood of stem

General characteristics and properties of the wood

Sapwood of stem of *Dalbergia oliveri* Gamble ex Prain studied is white or yellowish white; heart wood reddish yellow to reddish-brown with distinctly darker lines; without distinct odour and taste; straight or slightly inter-locked-grained, very fine textured to fine textured; pleasant odour and without distinct taste; very hard, wood is diffuse-porous. Growth ring distinct.

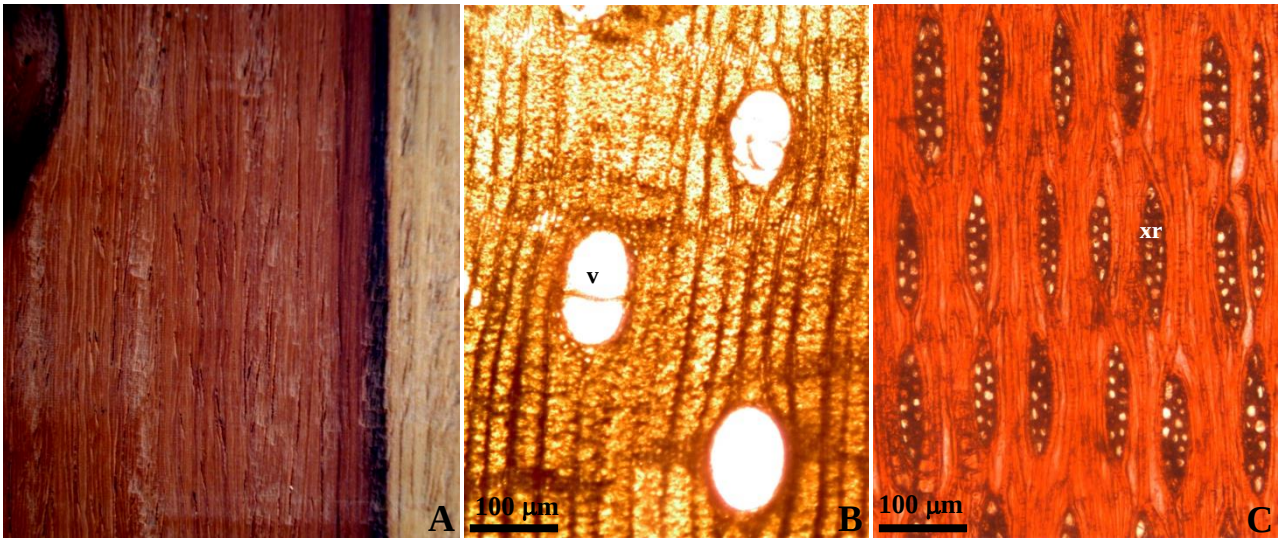
Microscopic characteristics

Vessel elements: Diffuse-porous; pore moderately small to moderately large, tangential diameter 80 – 220 µm (mean 166.3 µm), very fine textured to fine-textured; number per square mm few to moderately numerous (range 2 – 11); pore solitary, radial multiples 2 – 3 (mostly 1 or 2), sometime clustered (3 – 9); pore oval in cross section; perforation plate simple; intervessel pits alternate, crowded, moderately small to very large; vessel element very short to medium-sized, 170 – 380 µm (mean 251.2 µm)

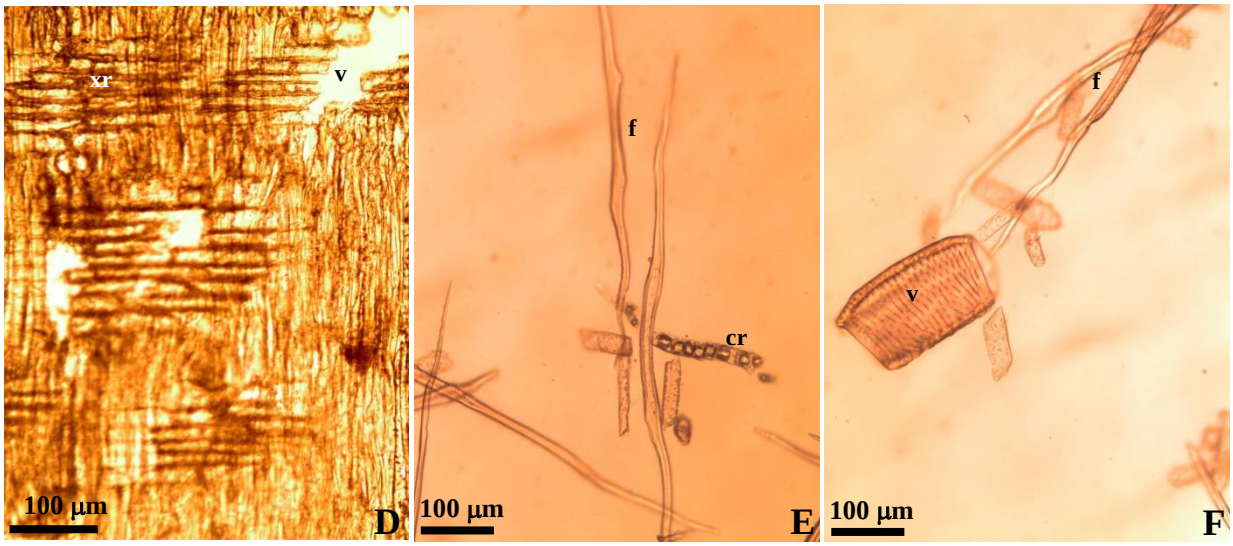
Fibres : Libriform, nonseptate; very short to medium-sized, 660 – 1110 µm (mean 888.8 µm) long and 12.5 – 25.0 µm (mean 19.3 µm) wide, wall 10 – 20 µm (mean 13.45 µm) thick, thick-walled, lumen 2.5 – 12.5 µm (mean 5.7 µm) thick, with tapering ends; chain of prismatic crystals present between the fiber cells.

Rays: Homogeneous, 1 – 3 seriate bands (mostly 2) cell wide; 6 – 14 per mm tangentially, moderately numerous to very numerous; multiseriate rays 80.0 – 210.0 µm (mean 145.3 µm) in height, 5 – 9 cells high; very fine to moderately fine, 20 – 40 µm (mean 28 µm) in width; pits between ray cells and other parenchyma cells few and size of pits small.

Axial parenchyma : Relatively abundant, paratracheal parenchyma confluent, aliform to aliform confluent, tangential bands, prismatic crystals present.



A. T.S of a portion of wood of stem as seen.
B. T.S of a portion of wood of stem showing solitary and radial multiple.
C. T.L.S of a portion of wood of stem showing uniseriate and multiseriate rays.
(v – vessel element, xr – xylem ray.)



D. R.L.S of a portion of wood of stem showing vessel and rays. **E.** Macerated elements showing crystals and fibers. **F.** Macerated elements showing vessel. (v – vessel, f – fiber, xr – xylem ray, cr – crystal.)

Figure 4. 13 Internal structure and macerated elements of stem wood of *Dalbergia oliveri Gamble ex Prain*

Bark of stem

General characteristics and properties of the bark

Bark of old stem of *Dalbergia oliveri* Gamble ex Prain studied is yellowish-gray, 1.2 – 1.6 cm thick, with longitudinal and horizontal deep cracks, irregular bark flakes present, old barks very hard, small lenticels and warty structures present; 1 – 4 vertical lines per 5 cm square; inner bark 1.0 – 1 .2 cm thick; yellowish brown, fibrous, soft; odour and taste not distinct.

Microscopic characteristics

The older bark of the stem can be distinguished into protective layer, outer zone and inner conductive zone.

Protective layer: It is outer-most zone of the stem. Epidermal cells damaged and no trace of cells left in old barks as the girth of stem grows. Periderm formed twice or more around the stem at the outer part of cortex to protect the inner tissues. Lenticels present, some lenticels closed and lying in the cortex.

Periderm: Periderm formed under a few layers of cortex at the outer part forming as a continuous ring around the cortex and it occurs repeatedly to form multiple periderm. Outer periderm formed lenticels. Some lenticels formed beneath the outer periderm and still closed. Individual periderm 78.8 – 115.8 µm thick. Each periderm composed of phellogen or cork cambium, phellem or cork, and phelloderm, prismatic crystals present in closed periderm (Fig. 4.14 B, C, D, E & F).

Phellogen lying between cork and phelloderm, one layered, parenchymatous, meristematic; rectangular in shape, tangentially flattened in transverse section, gives rise to phellem or cork outside and to phelloderm inside; nucleus usually present, colourless.

Phellem or cork derived from phellogen or cork cambium, lying outside the phellogen, parenchymatous, rectangular in shape in transverse section, many layered.

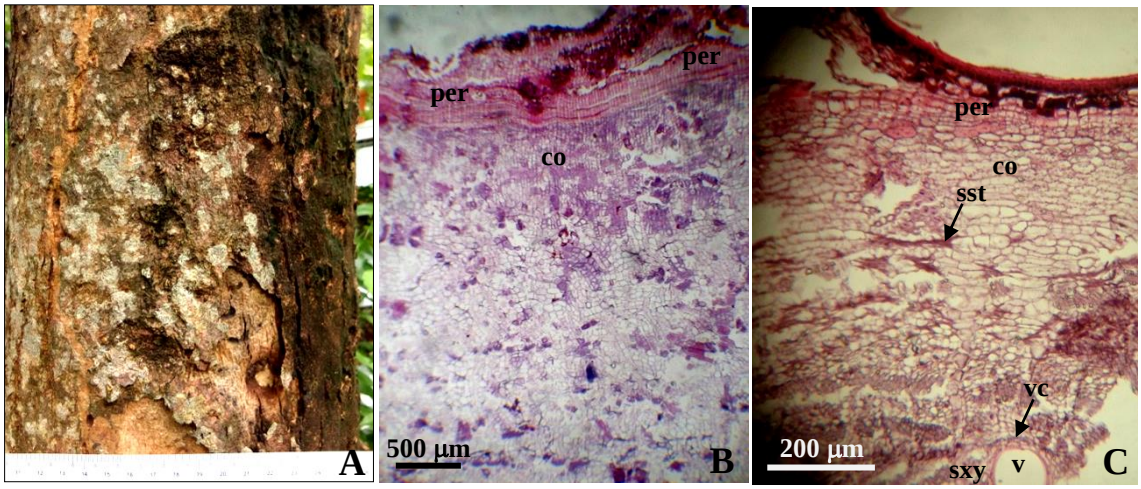
Phelloderm derived from phellogen or cork cambium, lying inside the phellogen, one to three layered, parenchymatous, sometimes formed into sclereids later, rectangular in shape, prismatic crystals present in some cells.

Outer zone of the bark: Composed of cortex, primary phloem and nonconductive phloem cells. Cortex lying outermost, parenchymatous, groups of sclereids present, cells polygonal, tangentially elongated and irregular in shape in transverse section, prismatic crystals present.

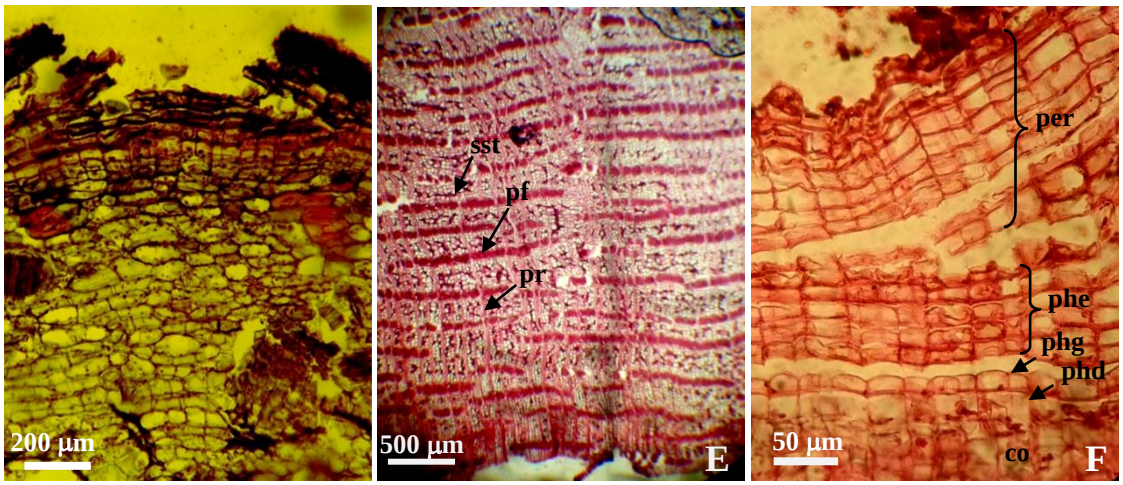
Primary phloem cells lying internal to the cortex, usually overlapped the cortex, mostly parenchymatous, cells rectangular, elongated, prismatic crystals present, single sclereid or group of a few sclereids present, group of stretched sieve tubes present, companion cell not distinct, phloem fibers thick-walled; phloem ray cells distinct.

Inner zone of the bark: Composed of conductive phloem, outer layers of non-conductive secondary phloem, inner layers of conductive secondary phloem near vascular cambium, group of stretched sieve tubes present, companion cell not distinct in transverse section; sieve tubes with many sieve areas at the lateral walls; phloem fibers forming many discontinuous

rings, cells thick-walled, polygonal in shape in transverse section; phloem parenchyma cells oval, rectangular, polygonal, elongated or irregular in shape in transverse section; phloem ray cells distinct, bi- to tetra-seriate, radially elongated in transverse section.

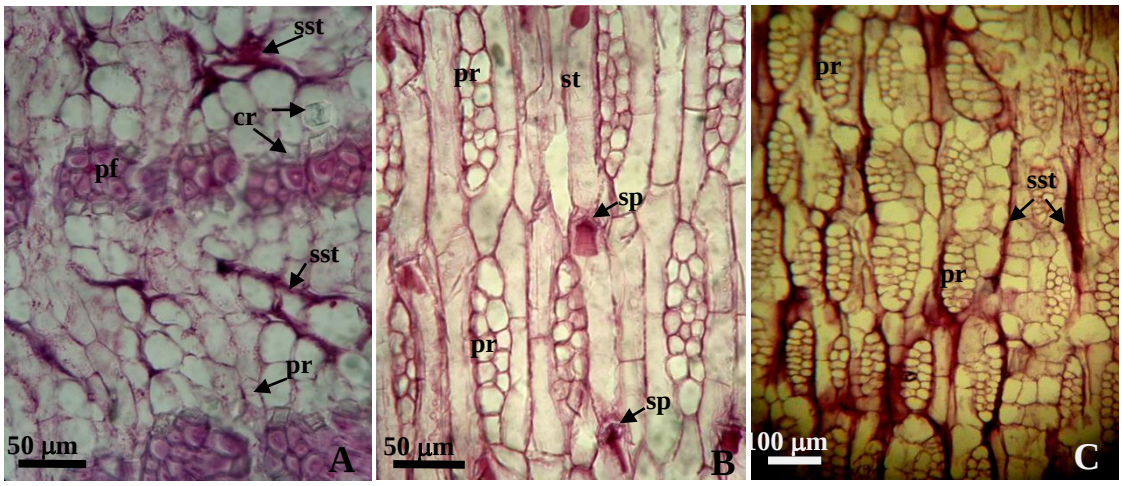


A. A portion of bark of stem as seen.
B**.** T.S of a portion of old stem-bark showing outer bark with periderm.
C. T.S of a portion of young stem-bark showing outer and inner bark.
(per – periderm, co –cortex, vc – vascular cambium, v – vessel element, sxy – secondary xylem, sst – stretched sieve tubes.)

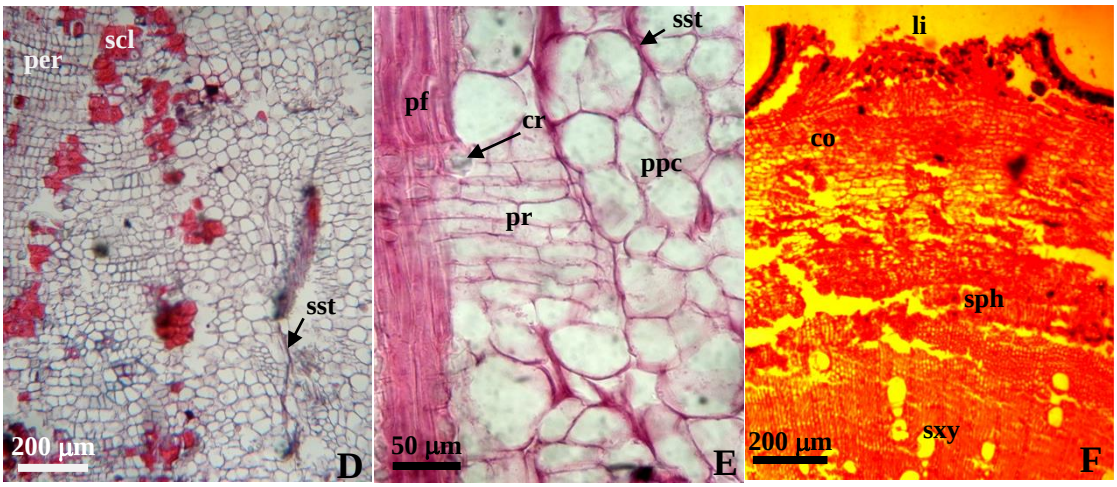


D. T.S of a portion bark showing lenticels and phellogen.
E. T.S of a portion of inner bark showing ring of phloem fiber and phloem ray.
F. T.S of a portion of bark of stem showing repeatedly formed periderm.
(pf – phloem fiber, pr – phloem ray, sst – stretched sieve tubes, per – periderm, co –cortex, phg – phellogen, phe – phellem or cork, phd – phelloderm.)

Figure 4.14 Bark of stem of *Dalbergia oliveri* Gamble ex Prain

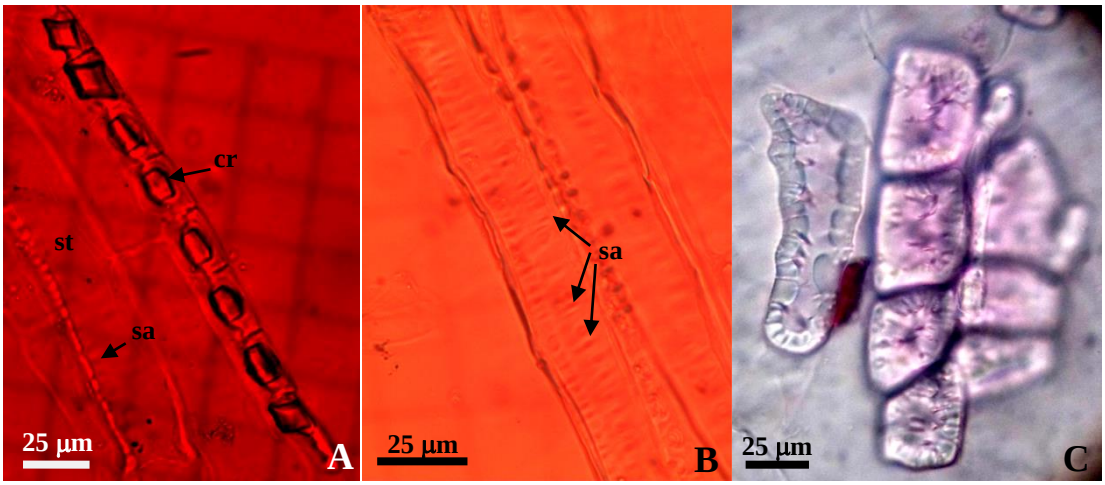


A. T.S of a portion of bark of stem showing phloem fiber and stretched sieve tubes.
B. T.L.S of bark of stem showing phloem ray, sieve tube and sieve plate.
C. T.L.S of bark of stem showing phloem ray and stretched sieve tubes.
(sst – stretched sieve tubes, pf – phloem fiber, pr – phloem ray, st – sieve tube, sp – sieve plate, cr - crystal.)

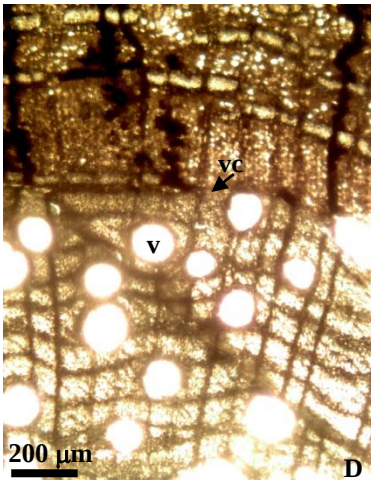


D. R.L.S of outer bark of stem showing sclereids and stretched sieve tubes.
E. R.L.S of bark of stem showing phloem ray, phloem fibers and stretched sieve tubes.
F. T.S of a portion of outer bark showing lenticels.
(per – periderm, sst – stretched sieve tubes, scl – sclereids, ppc – phloem parenchyma, pr – phloem ray, pf – phloem fiber, cr – crystal, co – cortex, sph – secondary phloem, sxy – secondary xylem.)

Figure 4.15 Internal structure of bark of stem of *Dalbergia oliveri* Gamble ex Prain



A. Macerated element of bark of stem showing sieve tubes and row of chambered crystals.
B. Macerated element of bark of stem showing sieve tubes with sieve areas.
C. Macerated element of bark of stem showing sclereids. (sa - sieve area, st – sieve tube, cr – crystal.)



D. T.S of a portion of bark of stem showing vascular cambium and secondary xylem.

Figure 4. 16 Internal structure and macerated elements of bark of stem of *Dalbergia oliveri* Gamble ex Prain

Vascular cambium: Lying between phloem and xylem. Vascular cambium one-layered, parenchymatous, meristematic; cells tangentially flattened, rectangular in transverse section, colourless, differentiated into ray initial and fusiform initial; ray initial gives rise to phloem ray outside and to xylem ray inside; fusiform initial gives rise to secondary phloem outside and to secondary xylem inside.

Secondary phloem: Lying outside the vascular cambium, consisted of sieve tubes and companion cells, phloem parenchyma, ray parenchyma and phloem fibers. Sieve tubes near the cambium conductive, older sieve tubes non-conductive. Phloem fibers very short to medium-sized, 690 – 1200 µm (mean 869 µm) long and 12.5 – 25µm (mean 20.65 µm) wide, wall 5 – 10 µm (mean 6.1µm) thick, lumen 7.5 – 25 µm (mean 14.6µm) thick.

4.5 Pterocarpus macrocarpus Kurz

Botranical name: *Pterocarpus macrocarpus* Kurz, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 43(3): 187 (1874).

Synonym: *Lingoum cambodianum* Pierre

Lingoum glaucinum Pierre

Lingoum gracile Pierre

Lingoum macrocarpum (Kurz) Kuntze

Lingoum oblongum Pierre

Lingoum parvifolium Pierre

Pterocarpus cambodianus (Pierre) Gagnep.

Pterocarpus cambodianus Pierre

Pterocarpus glaucinus Pierre

Pterocarpus gracilis Pierre

Pterocarpus parvifolius (Pierre) Craib

Pterocarpus parvifolius Pierre

Pterocarpus pedatus (Pierre) Gagnep.

Pterocarpus pedatus Pierre

Lingoum pedatum Pierre

Common name: Burma padauk, Padauk,

Local name: Padauk

Trade name: Padauk

Family: Fabaceae

Wood anatomy

General characteristics and properties of the wood

Sapwood of stem of *Pterocarpus macrocarpus* Kurz studied is yellowish-brown to grey and hardwood bright yellowish –red; its odour and taste distinct. It is hard wood, interlocked-grained and very fine-textured to very coarse textured. The wood is diffuse-porous and its growth ring is distinct. Tyloses present in the vessel. Crystal present.

Microscopic characteristics

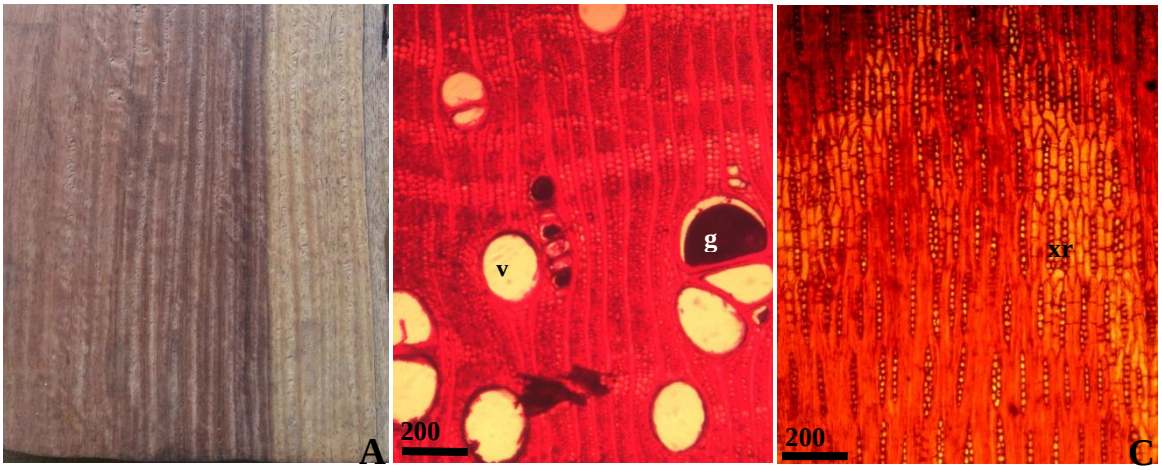
Vessel elements: Semi-ring porous; pore moderately small to moderately large, tangential diameter 70.0 – 260.0 µm (mean 149.3 µm), very fine-textured to very coarse textured; number per square mm few to moderately numerous (range 3 – 12); pore distribution solitary or as radial multiples or clusters, 2 – 6 (mostly 2); pore circular in cross section; perforation plate simple; end walls oblique or transverse; intervessel pits alternate,

crowded, vessel element very short to medium-sized; 190.0 – 470.0 µm (mean 264.5 µm) long.

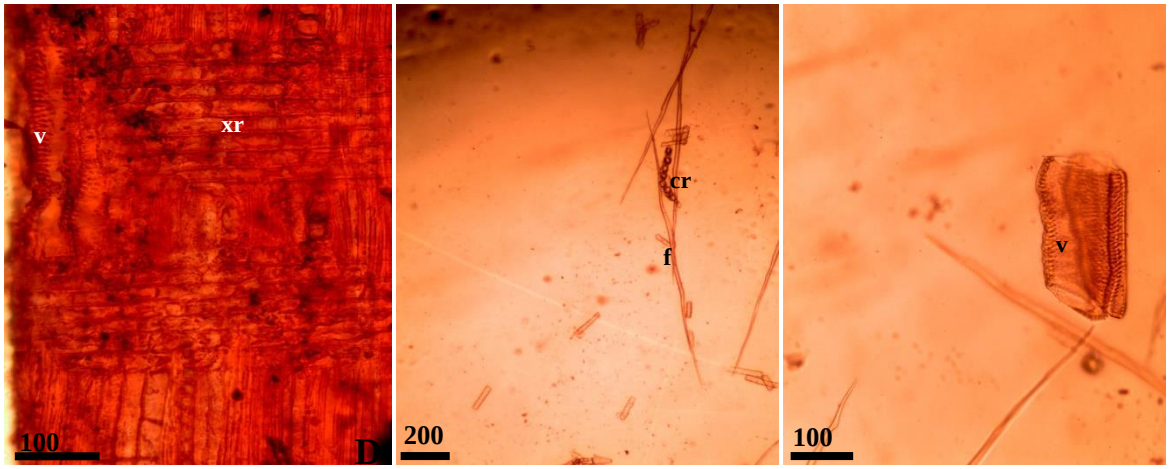
Fibres : Libriform, non-septate; very short to medium-sized, 580.0 – 1220.0 µm (mean 985.67 µm) long and 7.5 – 17.5 µm (mean 14.25 µm) wide, wall 5 –10 µm (mean 8 µm) thick, thin or thick-walled, lumen 2.5 – 10.0 µm (mean 6.1 µm) thick, with tapering ends; chain of prismatic crystals present between the fiber cells.

Rays: Homogeneous, 1 – 2 seriate bands (rare 3) cell wide; 9 – 15 per mm tangentially, numerous to very numerous, uniseriate rays, 140.0 – 220.0 µm (mean 177.67 µm) in height, 3 – 11 cells high; extremely fine to very fine, 10 – 20 µm (mean 14.16 µm) in width; biseriate rays 160.0 – 260.0 µm (mean 193.0 µm) in height, 6 – 11 cells high; very fine to moderately fine, 20 – 40 µm (mean 28.8 µm) in width; pits between ray cells and other parenchyma cells few and size of pits small, gum deposits present.

Axial parenchyma : Paratracheal parenchyma vasicentric, aliform and confluent metatracheal bands.



A. T.S of a portion of wood of stem as seen.
B. T.S of a portion of wood of stem showing solitary and radial multiple.
C. T.L.S of a portion of wood of stem showing uniseriate and biseriate rays.
(v – vessel element, xr – xylem ray, gu – gum.)



D. R.L.S of a portion of wood of stem showing vessel and rays.
E. Macerated elements showing fibers and crystals.
F. Macerated elements showing vessel.
(v – vessel element, f – fiber, xr – xylem ray, cr – crystal.)

Figure 4.17 Internal structure and macerated elements of stem wood of *Pterocarpus macrocarpus* Kurz

Bark of stem

General characteristics and properties of the bark

Bark of old stem of *Pterocarpus macrocarpus* Kurz studied is yellowish in young and grayish black at maturity, 0.5 – 3.2 cm thick, with longitudinal cracks, irregular bark flakes present, old barks hard; 3 – 5 vertical lines per 5 cm square; inner bark 2.5 and outer bark 0.7 cm thick; brownish deep red, fibrous, soft; odour and taste not distinct.

Microscopic characteristics

The older bark of the stem can be distinguished into protective layer, outer zone and inner conductive zone.

Protective layer: It is outer-most zone of the stem. Epidermal cells damaged and no trace of cells left in old barks as the girth of stem grows. Periderm formed around the stem at the outer part of cortex to protect the inner tissues. Lenticels present.

Periderm: Periderm formed at the outer part of cortex, forming as a continuous ring around the cortex. Outer periderm formed lenticels. Periderm 137.4 – 680.8 µm thick. Periderm composed of phellogen or cork cambium, phellem or cork, and phelloderm, prismatic crystals present (Fig. 4.18 B & F).

Phellogen lying between cork and phelloderm, one layered, parenchymatous, meristematic, rectangular in shape, tangentially flattened in transverse section, colourless, gives rise to phellem or cork outside and to phelloderm inside.

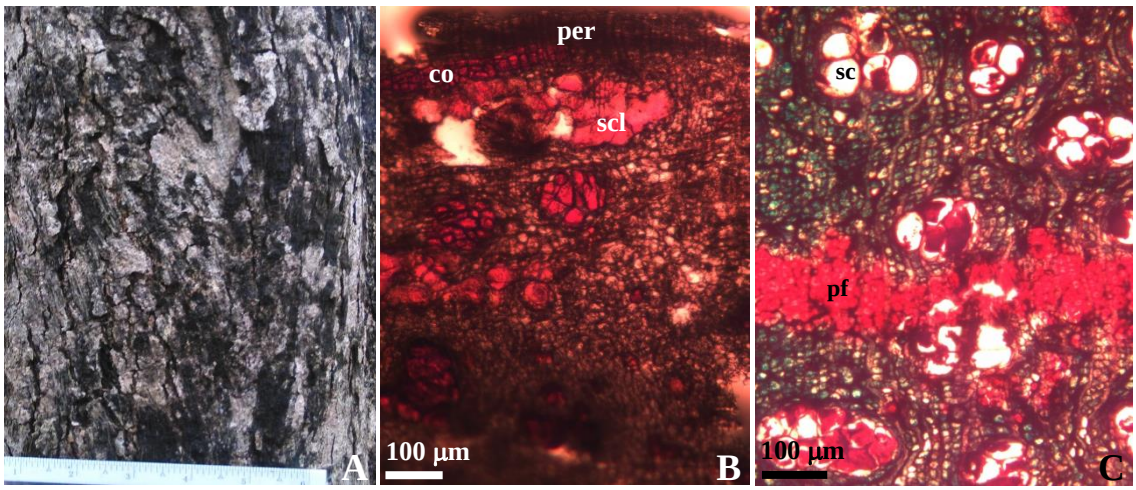
Phellem or cork derived from phellogen or cork cambium, lying outside the phellogen, parenchymatous, rectangular in shape in transverse section, tangentially flattened, a few layered.

Phelloderm derived from phellogen or cork cambium, lying inside the phellogen, one to three layered, parenchymatous, rectangular in shape, tangentially flattened, prismatic crystals present in some cells.

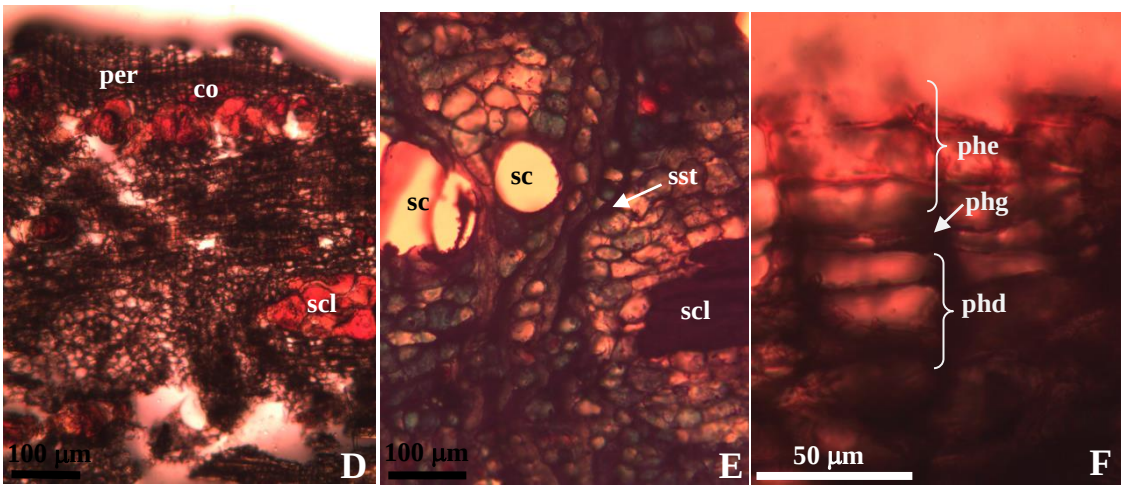
Outer zone of the bark: Composed of cortex, primary phloem and nonconductive phloem cells. Cortex lying outermost, parenchymatous, groups of sclereids present, cells polygonal, tangentially elongated and irregular in shape in transverse section, prismatic crystals present.

Primary phloem cells lying internal to the cortex, usually overlapped the cortex, mostly parenchymatous, cells rectangular, elongated, prismatic crystals present, single sclereid or group of a few sclereids present, stretched sieve tubes present, companion cell not distinct, phloem fibers thick-walled; phloem ray cells distinct; group of secretory cells present, cells large, sometime single secretory cell present.

Inner zone of the bark: Composed of conductive phloem, outer layers of non-conductive secondary phloem and inner layers of conductive secondary phloem near vascular cambium; group of stretched sieve tubes present, companion cell not distinct in transverse section; sieve tubes with many sieve areas at the lateral walls; phloem fibers forming discontinuous rings, cells thick-walled, polygonal in shape in transverse section; phloem parenchyma cells oval, rectangular, polygonal, elongated or irregular in shape in transverse section; phloem ray cells distinct, uni- to tri-seriate, mostly uniseriate, rarely triseriate, radially elongated in transverse section.

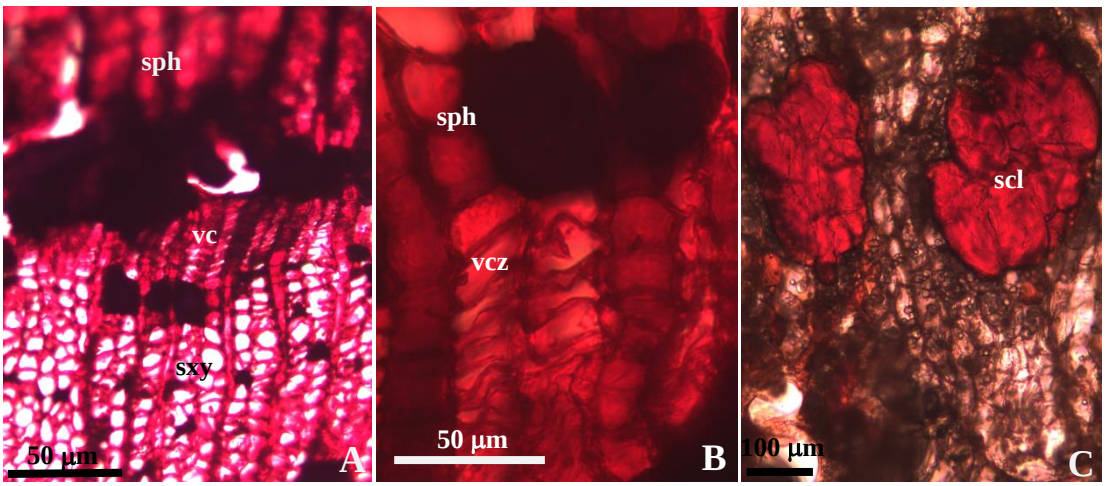


A. A portion of bark of stem as seen.
B. T.S of a portion of old stem-bark showing outer bark with periderm.
C. T.S of a portion of old stem-bark showing phloem fiber and large cell.
(per – periderm, co – cortex, scl – sclereids, sc – secretory cell, pf – phloem fiber)

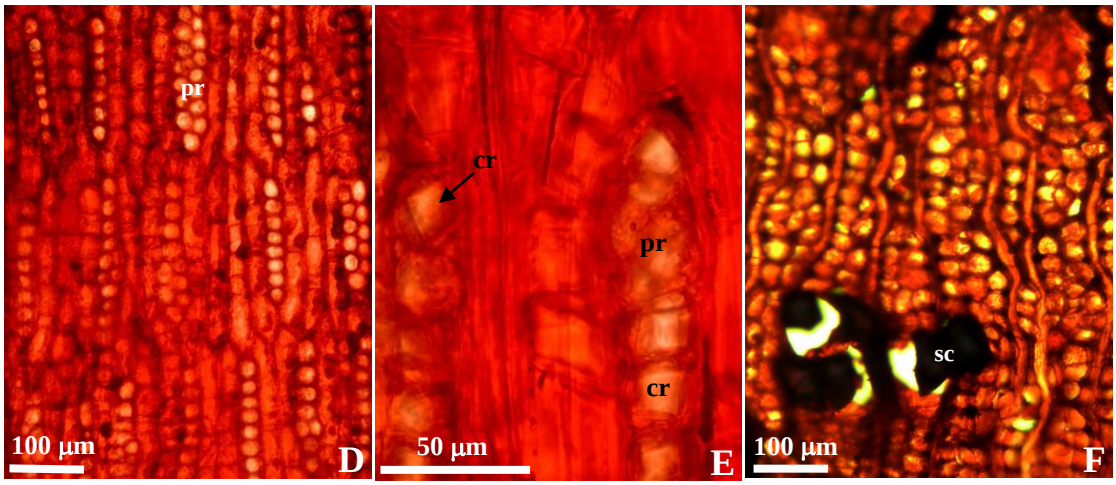


D. R.L.S of a portion bark showing periderm, sclereids and cortex.
E. T.S of a portion bark showing secretory cells, sclereids and stretched sieve tubes.
F. T.S of a portion of bark of stem showing periderm.
(per – periderm, co –cortex, scl – sclereids, sc – secretory cells, sst – stretched sieve tubes, phe – phellem or cork, phg – phellogen, phd – phelloderm.)

Figure 4.18 Internal structure of bark of stem of *Pterocarpus macrocarpus* Kurz

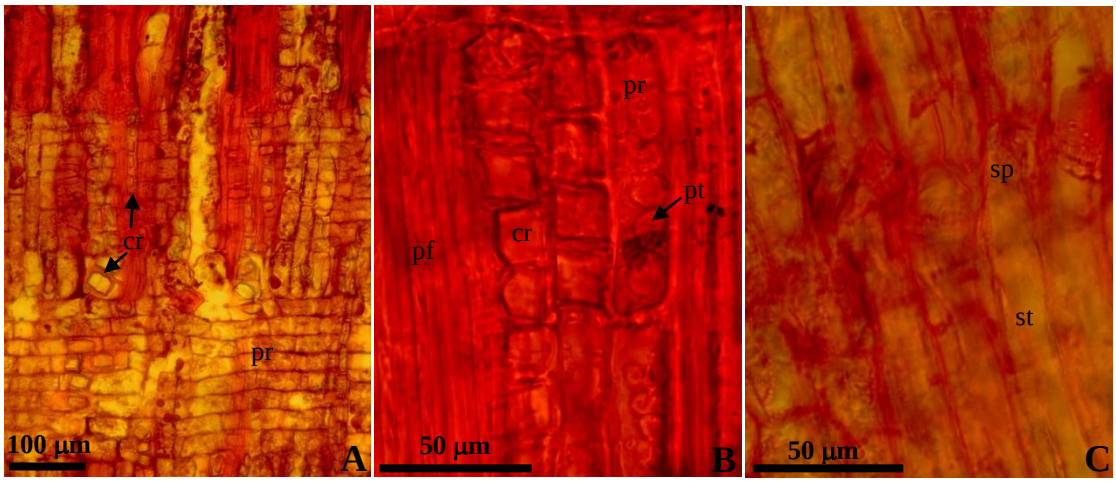


A. T.S of a portion of bark of stem showing vascular cambium, secondary phloem and secondary xylem.
B. T.S of a portion of bark of stem showing vascular cambial zone.
C. T.S of a portion of bark of stem showing groups of sclereids.
(vc – vascular cambium, scl – sclereids, vcz – vascular cambial zone, sph – secondary phloem, sxy – secondary xylem.)

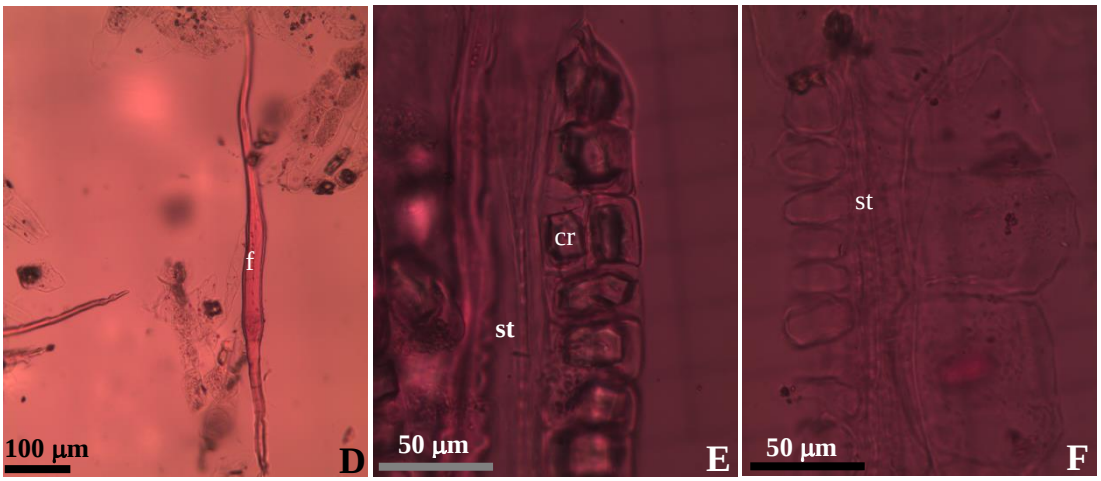


D. T.L.S of bark of stem showing phloem rays.
E. T.L.S of bark of stem showing phloem ray and row of chambered crystals.
F. T.S of bark of stem showing secretory cells.
(pr- phloem ray, f – fiber, sc – secretory cell, cr – crystal.)

Figure 4.19 Internal structure of bark of stem of *Pterocarpus macrocarpus* Kurz



A. R.L.S of bark of stem showing crystal and phloem rays.
B. R.L.S of bark of stem showing phloem fibers, phloem rays, pit and row of crystals.
C. R.L.S of a portion of bark showing sieve plate and sieve tube.
(cr – crystal, pr – phloem ray, pf – phloem fiber, pt – pit, st – sieve tube, sp –sieve plate)



D. Macerated element of bark of stem showing fiber.
E. Macerated element of bark of stem showing sieve tubes and row of chambered crystals.
F. Macerated element of bark of stem showing sieve tubes large cell.
(f – fiber, st – sieve tube, cr – crystal.)

Figure 4.20. Internal structure and macerated elements of bark of stem of *Pterocarpus macrocarpus* Kurz

Vascular cambium: Lying between phloem and xylem. Vascular cambium one-layered, parenchymatous, meristematic; cells tangentially flattened, rectangular in transverse section, colourless, differentiated into ray initial and fusiform initial; ray initial gives rise to phloem ray outside and to xylem ray inside; fusiform initial gives rise to secondary phloem outside and to secondary xylem inside.

Secondary phloem: Lying outside the vascular cambium, consisted of sieve tubes and companion cells, phloem parenchyma, ray parenchyma and phloem fibers. Sieve tubes near the cambium conductive, older sieve tubes non-conductive. Phloem fibers very short to moderately long, 520 – 1900 µm (mean 1171 µm) long and 12.5 – 38µm (mean 20.45 µm) wide, wall 2.5 – 10.0 µm (mean 5.1µm) thick, lumen 7.5 – 33.0 µm (mean 15.6µm) thick.

4.6 *Xylia xylocarpa* (Roxb.) Taub.

Botanical name: *Xylia xylocarpa* (Roxb.) Taub. Bot. Centralbl. 47: 395 (1891, isonym.).

Synonyms: ***Acacia xylocarpa* (Roxb.) Willd.**

Inga xylocarpa (Roxb.) DC.

Mimosa xylocarpa Roxb.

Xylia dolabriformis Benth. **J. Bot. (Hooker)** 4: 417 (1842).

Xylia xylocarpa var. *xylocarpa*

Common name: Burma Ironwood, Ironwood, Pyinkado, Simsapa (Sanskrit)

Local name: Pyinkdo

Trade name: Pyinkado

Family: Fabaceae

Wood anatomy

General characteristics and properties of the wood

Sapwood of stem of *Xylia xylocarpa* studied is pale reddish – white, narrow; hardwood reddish-brown, dull; its odour and taste not distinct. It is hard wood, straight grained, wavy-grain or broadly interlocked –grained and very fine-textured to medium textured. The wood is diffuse-porous it growth ring is distinct.

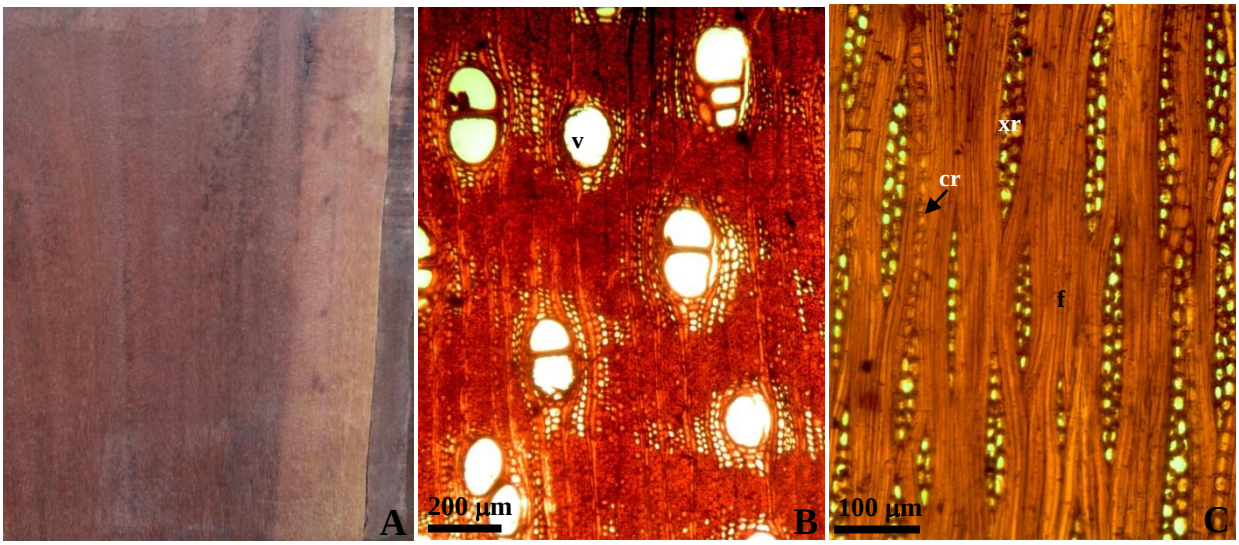
Microscopic characteristics

Vessel elements: Diffuse-porous, pore moderately small to medium-sized, tangential diameter 60.0 – 180.0 µm (mean 101.3 µm), very fine-textured to medium textured; number per square mm moderately few to moderately numerous (range 6 – 14); pore distribution solitary or as radial multiples or clusters, 2 – 7 (mostly 1 or 2); pore oval in cross section; perforation plate simple; end walls oblique or transverse; intervessel pits alternate, crowded, vessel element extremely short to medium-sized; 170.0 – 450.0 µm (mean 307.33 µm) long. Orange brown gum deposit present.

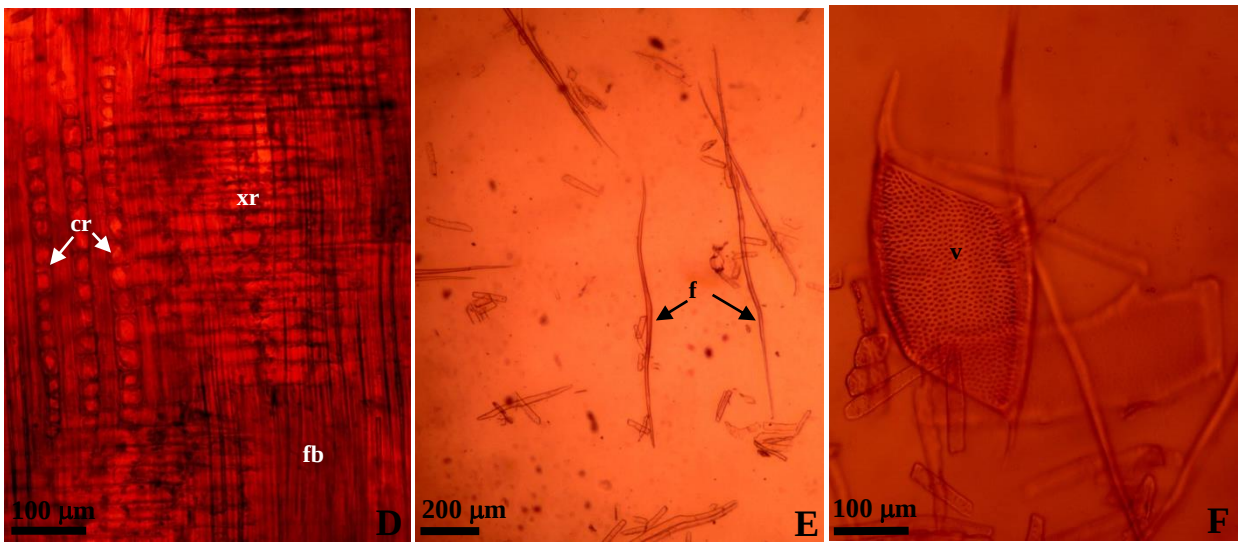
Fibres : Libriform, non-septate; extremely short to moderately long, 320.0 – 1620.0 µm (mean 1076.7 µm) long and 12.5 – 25.0 µm (mean 17 µm) wide, wall 5.0 –17.5 µm (mean 11.5 µm) thick, lumen 2.5 – 10.0 µm (mean 5.6 µm) thick, with tapering ends; chain of prismatic crystals present between the fiber cells.

Rays: Homogeneous, 1 – 2 seriate(rarely 3) cell wide; 5 – 12 per mm tangentially, moderately numerous to very numerous, uniseriate rays, 50.0 – 340.0 µm (mean 186.7 µm) in height, 3 – 15 cells high; extremely fine to very fine, 5.0 – 20.0 µm (mean 10.5 µm) in width; biseriate rays, 80.0 – 860.0 µm (mean 385.7 µm) in height, 6 – 38 cells high; very fine to medium-fine, 20.0 – 40.0 µm (mean 29.83 µm) in width.

Axial parenchyma : Apotracheal parenchyma diffuse in aggregate, paratracheal parenchyma vasicentric, orange brown gummy present, crystals abundant in the parenchyma.



A. Wood of stem as seen. **B.** T. S of stem wood showing solitary and group of vessel, and gum deposits in vessels and some parenchyma cells. C. T.L.S of stem wood showing xylem rays, fibers and chain of crystals. (v – vessel element, xr – xylem ray, cr – crystal.)



D. R. L. S of stem wood showing xylem rays and fibers, crystal chain between fibers. **E.** Macerated element of stem wood showing fibers. **F.** Macerated element of stem wood showing vessel element. (xr – xylem ray, v –vessel element, f – fiber, cr – crystal)

Figure 4.21 Internal structure of stem wood of *Xylia xylocarpa* (Roxb.) Taub.

Bark of stem

General characteristics and properties of the bark

Bark of old stem of *Xylia xylocarpa* (Roxb.) Taub. studied is yellowish in young and deep grayish at maturity, rough, 1.1 – 1.7 cm thick, with longitudinal and horizontal deep cracks, irregular bark flakes present, old barks very hard, lenticels present; 2 – 4 vertical lines per 5 cm square; inner bark 1.1 cm and outerbark 0 . 6 cm thick; pale yellow, fibrous, soft; odour and taste not distinct.

Microscopic characteristics

The older bark of the stem can be distinguished into protective layer, outer zone and inner conductive zone.

Protective layer is outer-most zone of the stem. Epidermal cells damaged and no trace of cells left in old barks as the girth of stem grows. To protect the inner tissues, periderm formed twice or more around the stem at the outer part of cortex.

Periderm: Periderm formed at the outer part of cortex forming a continuous ring around the cortex and it occurs repeatedly under a few layers of the cortex to form multiple periderm. Outer periderm formed lenticels. Some lenticels formed beneath the outer periderm and still closed. Individual periderm 96.8 – 102.4 µm thick. Each periderm composed of phellogen or cork cambium, phellem or cork, and phelloderm.

Phellogen lying between cork and phelloderm, one layered, parenchymatous, rectangular in shape, tangentially flattened, meristematic, gives rise to phellem or cork outside and to phelloderm inside; nucleus usually present, colourless.

Phellem or cork derived from phellogen or cork cambium, lying outside the phellogen, parenchymatous, rectangular in shape, many layered.

Phelloderm derived from phellogen or cork cambium, lying inside the phellogen, one to four layered, parenchymatous, formed into sclereids later, rectangular in shape in transverse section, prismatic crystal present.

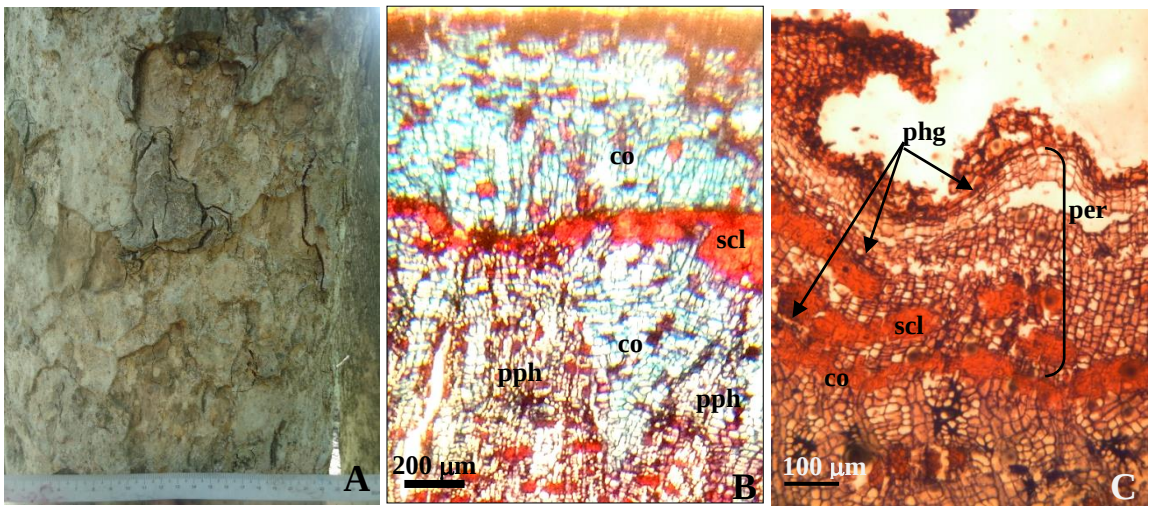
Outer zone of the bark: Composed of cortex, primary phloem and nonconductive secondary phloem cells. Cortex lying outermost, parenchymatous, cells polygonal, tangentially elongated and irregular in shape; groups of a few to many layers of sclereids forming a thick column, cells thick-walled, polygonal in shape; many flattened cells forming tapering columns and overlapping the primry phloem cell columns, prismatic crystals present.

Primary phloem cells lying internal to the cortex, usually overlapped the cortex, mostly parenchymatous, cells rectangular or slightly tangentially flattened in transverse section, prismatic crystals present, single sclereid or group of a few number of sclereids present, stretched sieve tubes present, companion cell not distinct; phloem fibers formimg discontinuous rings, cells thick-walled, polygonal in shape; phloem parenchyma cells elongated, oval or irregular in shape; phloem ray cells radially elongated. Prismatic crystals present.

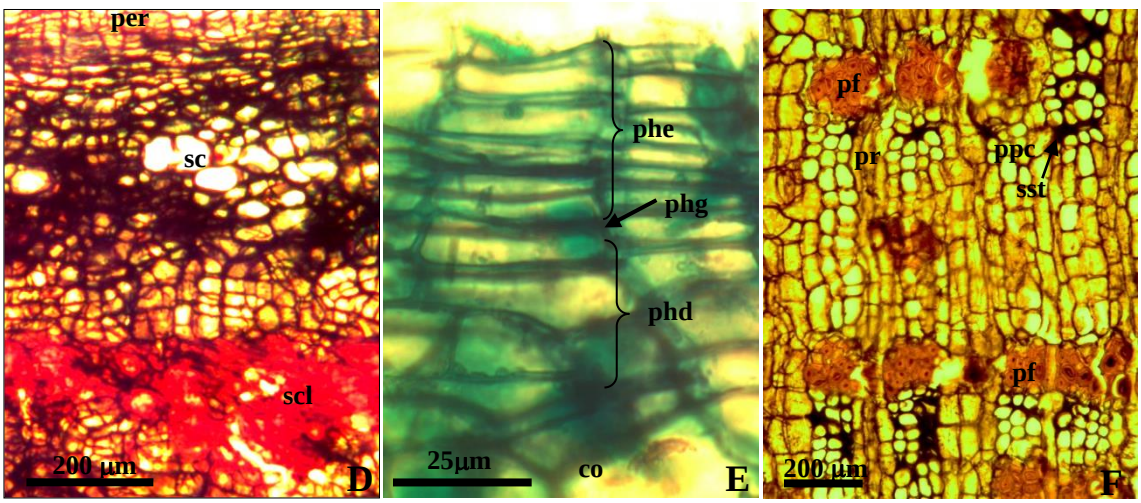
Inner zone of the bark: Composed of outer layers of non-conductive secondary phloem and inner layers of conductive secondary phloem near vascular cambium; group of stretched sieve tubes present, companion cell not distinct in transverse section; sieve tubes with many sieve areas at the lateral walls, end wall of sieve tubes with compound sieve plates, each sieve plate large; phloem fibers forming discontinuous rings, cells thick-walled, polygonal in shape in transverse section; phloem parenchyma cells oval, rectangular, polygonal or elongated in shape in transverse section; phloem ray cells distinct, bi- or tri-seriate, radially elongated in transverse section, prismatic crystals present.

Vascular cambium: Lying between phloem and xylem. Vascular cambium one-layered, parenchymatous, meristematic; cells tangentially flattened, rectangular in transverse section, colourless, differentiated into ray initial and fusiform initial; ray initial gives rise to phloem ray outside and to xylem ray inside; fusiform initial gives rise to secondary phloem outside and to secondary xylem inside.

Secondary phloem: Lying outside the vascular cambium, consisted of sieve tubes and companion cells, phloem parenchyma, ray parenchyma and phloem fibers. Sieve tubes near the cambium conductive, with compound sieve plates, older sieve tubes non-conductive. Phloem fibers very short to medium-sized, 700 – 1350 µm (mean 1075µm) long and 12.5 – 25µm (mean 19.25µm) wide, wall 2.5 – 15 µm (mean 6.83µm) thick, lumen 5 – 20 µm (mean 12.3µm) thick.

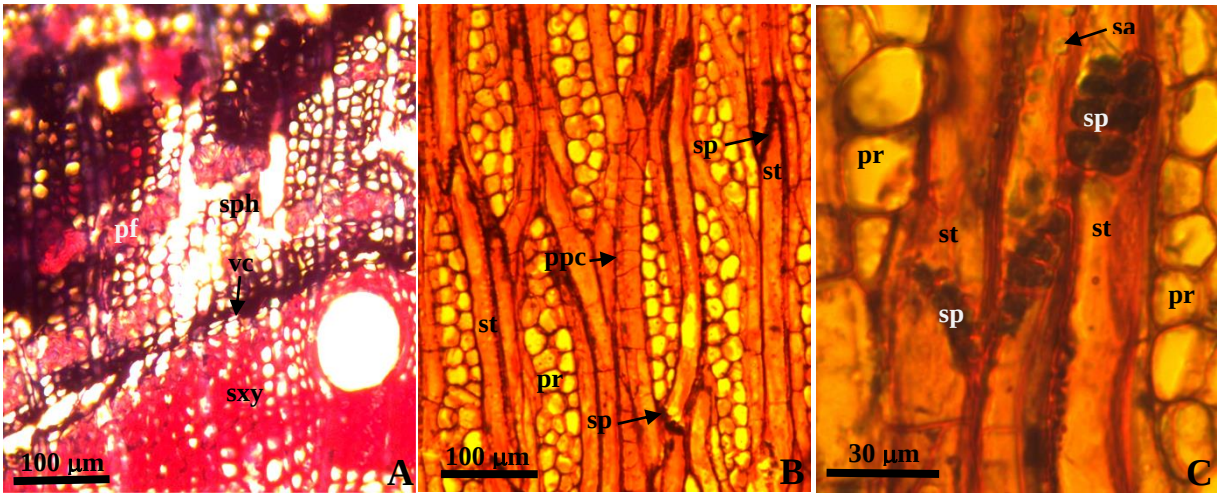


A. A portion of bark of stem as seen. **B.** T.S of a portion of old stem-bark showing outer bark.
C. T.S of a portion of stem-bark showing multiple periderm.
(co –cortex, scl – sclereids, pph – primary phloem, per – periderm, phg – phellogen.)

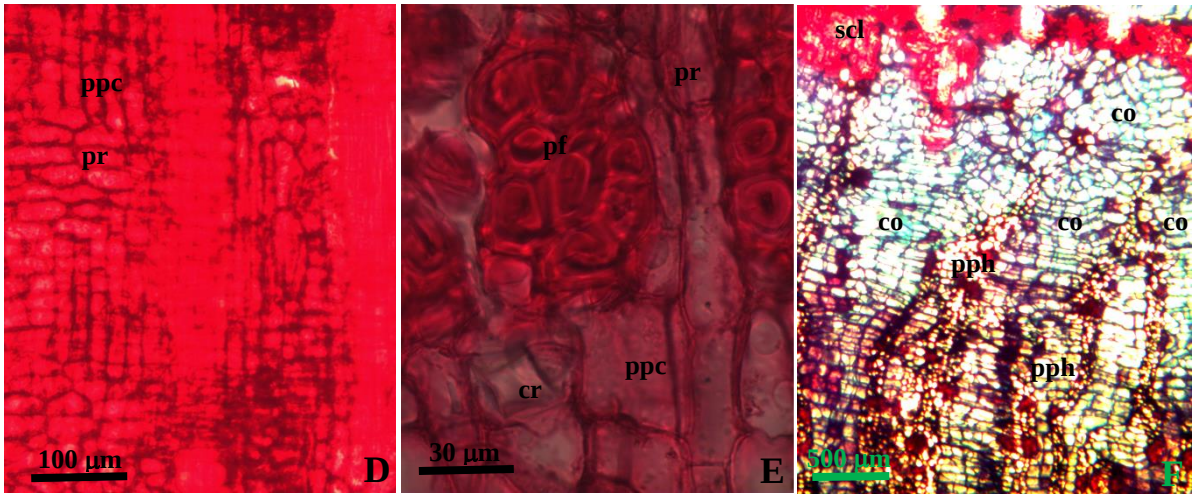


D. T.S of a portion of outer bark showing cortex and thick ring of sclereids. **E.** T.S of a portion of young stem-bark showing peridermn. **F.** T.S of a portion of bark of stem showing discontinuous ring of phloem fibers, phloem ray and stretched sieve tubes.
(sc – secretory cell, scl – sclereids, phg – phellogen, phd – phelloderm, co –cortex, scl – sclereids, pph – primary phloem, pf – phloem fiber, pr – phloem ray, sst – stretched sieve tubes, ppc – phloem parenchyma cells.)

Figure 4.22 Internal structure of bark of stem of *Xylia xylocarpa* (Roxb.) Taub.

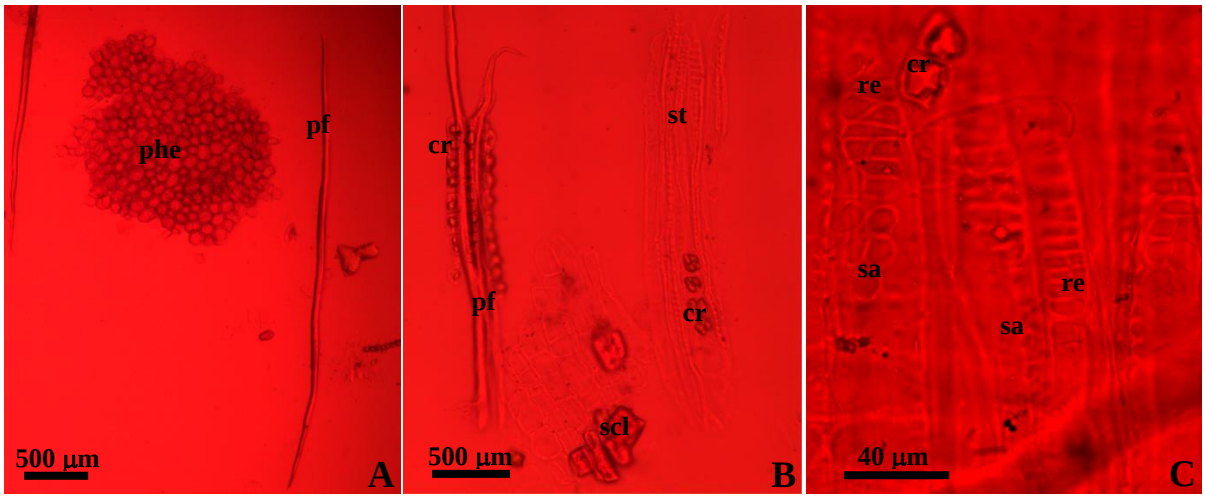


A. A portion of bark of stem showing vascular cambium, **B.** T.L.S of a portion of stem-bark showing phloem ray, sieve tube and sieve plates. **C.** T.S of a portion of stem-bark showing compound sieve plates.
(vc – vascular cambium, sph – secondary phloem, sxy – secondary xylem, sp – sieve plate, st – sieve tube, sa – sieve area, pr – phloem ray, ppc – phloem parenchyma cell.)



D. R.L.S of a portion of young stem-bark showing phloem ray cells.
E. T.S of a portion of inner bark showing phloem fiber, phloem ray and crystal.
F. T.S of a portion of bark showing a thick ring of sclereids of cortex and overlapping of primary phloem and cortex.
(pr – phloem ray, ppc – phloem parenchyma cells, pf – phloem fiber, cr – crystal, scl – sclereids, co – cortex, pph – primary phloem.)

Figure 4. 23 Internal structure of bark of stem of *Xylia xylocarpa* (Roxb.) Taub.



A. Macerated elements bark of stem showing cork cells and phloem fiber.
B. T.L.S of bark of stem showing phloem ray, sieve tube and sieve plate.
C. T.L.S of bark of stem showing phloem ray and sieve tubes.
(phe – phellem or cork, f – phloem fiber, cr – crystal , st – sieve tube, re – reticulate compound sieve plate, sa – sieve area.)

Figure 4. 24 Macerated elements of bark of stem of *Xylia xylocarpa* (Roxb.) Taub.

5. Discussion and conclusion

The six timber species grown in arboretum of Forest Research Institute, Yezin, were selected and anatomical characteristics of sap wood and barks of their stem were studied, described and compared.

Among the six species studied, growth rings of the stem wood are distinct in the transverse section except in each of *Lannea coromandelica* and *Heterophragma sulfureum*. The wood of *Pterocarpus macrocarpus* was found to be very fine to very coarse textured while those of *Lannea coromandelica* and *Xylia xylocarpa* were very fine to medium. However, the rest three species were very fine to fine textured.

The grains of the wood were straight in *Lannea coromandelica*, *Fernandoa adenophylla* and *Heterophragma sulfureum*. *Dalbergia oliveri* was found to be straight or slightly interlocked-grained, but, those of *Pterocarpus macrocarpus* and *Xylia xylocarpa* were found to be interlocked-grained. The odour of wood of *Dalbergia oliveri* was distinct but it was tasteless. The odour of wood of *Pterocarpus macrocarpus* was also distinct, however, those of the rest four species were not distinct.

In all of the species, wood were diffuse porous except in the case of *Fernandoa adenophylla* in which the wood was found to be ring-porous. In *Pterocarpus macrocarpus*,the wood was semi-ring porous. Size of pores was in the range of very small to moderately large and their shape was circular or oval. Perforation of vessel elements of all species studied were found to be simple.

Tyloses were present in the vessels of *Lannea coromandelica*, *Heterophregma sulfureum* and *Pterocarpus macrocarpus*, and abundantly found in *Lannea coromandelica*, but absent in the rest three species studied.

Gum deposits were found in the wood of *Lannea coromandelica*, *Pterocarpus macrocarpus, Dalbergia oliveri* and *Xylia xylocarpa* and absent in the rest two species. Crystals were also present in the wood of all of the species studied except in the case of *Fernandoa adenophylla.* Fibers found in the wood of all species studied were non-septate except in that of *Lannea coromandelica*.

Xylem rays were heterocellular in *Lannea coromandelica* whereas the rest five species were homocellular.

In this study, the pores of *Lannea coromandelica* are found to be solitary, radial multiples of 2 – 4, occasionally pore clusters and this finding was in agreement with those described by ITTO (2000).

The pores of *Fernandoa adenophylla* were found to be very small to medium-sized, very fine to fine textured, vessel elements were extremely short to moderately short; but those were moderate-sized according to Gamble (1932) and the vessel elements were extremely short to medium sized. The wood of fine-texture as mentioned by Soe Myint et.al (1997) and ITTO (2000).

In this study, sapwood of stem of *Fernandoa adenophylla* studied was pale brownish yellow and heartwood pale yellowish brownish. But, Soe Myint et.al (1997) stated that the sapwood was pale yellow and heartwood brownish yellow.

Tangential diameter of the vessel of the six species studied was in the range of 40 – 260 µm i.e., very small to moderately large. The lowest value was found in *Fernandoa*

adenophylla and *Heterophragma sulfureum,* and the highest in *Dalbergia oliveri* and *Pterocarpus macrocarpus.*

Length of vessel elements of the six species studied was found to be in the range of 150 – 650 µm i.e., extremely short to medium-sized. The lowest value was found in *Fernandoa adenophylla*, *Dalbedrgia oliveri* and *Xylia xylocarpa.* The highest value was found in all of the species except in *Fernandoa adenophylla.*

In this paper, vessel element of *Fernandoa adenophyllum* was found to be extremely short to moderately short (mean 245.33 µm). But, Soe Myint et al. described that that of vessel elements was extremely short to medium-sized (mean 307 µm).

In *Dalbergia oliveri*, tangential diameter of vessel ranged 50 – 290 µm and tyloses were absent; perforation plates simple, and length of vessel elements very short to moderately short as mentioned by Thein Kywe & Kyaw Soe (1983).

Length of fiber elements of the six species studied was found to be in the range of 450 – 1650 µm i.e., extremely short to moderately long. The lowest value was found in *Fernandoa adenophylla*, *Heterophragma sulfureum* and *Xylia xylocarpa*. The highest value was found in *Lannea coromandelica* and *Xylia xylocarpa*.

In this paper, fiber of the wood of *Fernandoa adenophyllum* was extremely short to medium-sized (mean 793.3 µm). But, Soe Myint et al. described that the mean length of fiber was 1285 µm i.e., medium-sized.

In this study, the rays of wood of *Lannea coromandelica* were found to be heterogeneous as had been mentioned by Win Kyi (1) et.al (1993) and ITTO (2000). But Thein Kywe & Kyaw Soe (1983) described that rays were found to be homogeneous type II.

In this paper, the rays of wood of *Fernandoa adenophylla* were found to be homogeneous, 1- to 4-seriate, rarely uniseriate and mostly triseriate. Soe Myint et.al (1997) described that xylem rays were uniseriate to triseriate, rarely uniseriate, and homogeneous. ITTO (2000) also described that those were 1 – 4 seriate (mostly 3).

In this paper, inner barks of six species studied were found to be different in colour from each other. The two species were red or reddish and the rest four were yellow or yellowish in colour at the transverse plane.

In the red or reddish group, brownish pale red inner bark was found in *Lannea coromandelica* and brownish deep red in *Pterocarpus macrocarpus*.

In the yellow or yellowish group, grayish yellow was found in *Fernandoa adenophylla*, yellowish brown in *Dalbergia oliveri*, whitish pale yellow in *Heterophragma sulfureum*, and yellowish gray with red colour at the innerparts in *Xylia xlocarpa*.

In this paper, the length of bark fibers of the six species studied were found in the range of 520 to 2800 µm i.e., very short to very long. The highest length was found in *Lannea coromandelica* whereas the lowest was in *Fernandoa adenophylla*, *Pterocarpus macrocarpus, Dalbergia oliveri* and *Xylia xylocarpa.* Fiber width was in the range of 1 to 30 µm.

Periderm formation occurred at the outer portion of the cortex in all species studied in this paper. Periderm formed twice or more in *Lannea coromandelica*. In *Fernandoa adenophylla*, periderm formed under a few layers of cortex at the outer part and in the inner part of phloem, it occurred repeatedly to form multiple periderm. The lenticels were found in the outer periderm. Some lenticels beneath the outer periderm were closed.

In *Heterophragma sulfureum,* periderms occurred repeatedly to form multiple periderm. Outer periderm formed lenticels and some lenticels formed beneath the outer periderm and closed. In *Dalbergia oliveri* and *Pterocarpus macrocarpus*, periderms formed at the outer part of cortex.

In *Xylia xylocarpa,* periderm formed at the outer part of cortex repeatedly to form multiple periderm. Outer periderm formed lenticels and some lenticels still closed.

In the six species studied, vascular cambium showed one layer of meristematic cell between xylem and phloem. In *Lannea coromandelica* and *Fernandoa adenophylla* vascular cambium gave rise to many layers of immediate derivates at first before differentiation. In the rest four species, immediate derivatives were not observed. The differentiation of the immediate derivatives seemed to be in a very short time.

The phloem rays of the bark of six species studied were in the range of uniseriate to 7-seriate. Uniseriate to triseriate phloem rays were found in the bark of *Dalbergia oliveri* and *Pterocarpus macrocarpus.* Biseriate to tetraseriate phloem rays were found in *Fernandoa* adenophylla and Heterophragma sulfureum. Biseriate to 7-seriate phloem rays were found in Lannea coromandelica. However, phloem ray of Xylia xylocarpa was biseriate or triseriate.

Among the six species studied, secretory ducts were found in the multiseriate phloem rays of bark of Lannea coromandelica. Moreover, many secretory ducts were present in cortex, primary and secondary phloem and the ducts were bounded by an epithelial layer of parenchymatous cells. However, Evert (2006) stated that the secretory ducts developed in the primary phloem of the stem in Lannea coromandelica, and they were schizogenous, whereas those of their counterparts in the secondary phloem and phelloderm were lysigenous.In the cortex of the barks of Dalbergia oliveri and Pterocarpus macrocarpus, large secretory cells were found in groups. They were much larger than neighbouring cells in size. Sometime single large secretory cell was found in Pterocarpus macrocarpus.

Rod-shaped food particles were abundant in phloem parenchyma cells of both members of the family Bignoniaceae, Fernandoa adenophylla and Heterophragma sulfureum among the six species. This might be characteristics of members of the family Bignoniaceae.

Prismatic crystals were present in the cortex and phloem of the bark of all species studied in this paper, but prismatic crystals were rarely observed in the bark of *Heterophragma sulfureum*. In the bark of *Lannea coromandelica*, not only the prismatic crystals but also druses were found in the bark. Prismatic crystals might be singly or in rows of parenchymatous cells. Prismatic crystals were also found in closed lenticels of *Dalbergia oliveri*.

In the cortex and phloem of the bark of six species studied, sclereids were common as single cell or group of cells. In *Xylia xylocarpa,* a thick column of groups of a few to many layers of sclereids were found.

In the bark of six species studied, sieve tubes were found to be as stretched structures in group due to aging. In transverse section, groups of stretched sieve tubes were forming ring-like structure in appearance. In tangential longitudinal section, sieve tubes could be seen with many sieve areas at the lateral wall and the end wall were reticulated in some species.

In *Lannea coromandelica*, group of stretched sieve tubes were present. The sieve tubes were observed with reticulated thickenings in tangentially longitudinal section, nucleus found in some sieve tubes,and some cells brown coloured and tanniferous.

In *Fernandoa adenophylla*, group of stretched sieve tubes were forming like a ring, sieve areas at the lateral walls of sieve tube, reticulated thickenings at the end wall. Rarely phloem fiber-like cells were observed with spiral thickenings at the secondary wall.

In *Heterophragma sulfureum*, group of stretched sieve tubes was present and sieve tubes with many sieve areas at the lateral walls, reticulated thickenings at the end wall; fiber-like cells with spiral thickenings.

In *Dalbergia oliveri*, *Pterocarpus macrocarpus* and *Xylia xylocarpa* group of stretched sieve tubes were also found. In *Pterocarpus macrocarpus*, sieve tubes were with many sieve areas at the lateral walls. In *Xylia xylocarpa*, sieve tubes were observed with many sieve areas at the lateral walls, end wall of sieve tubes with compound sieve plates, each sieve plate large.

In this work, anatomical characteristics of sap wood and barks were important and provide the knowledge of anatomy to the flowering plants and useful in identification of the tree species especially in the deciduous season.

Acknowledgements

Ministry of Environmental Conservation and Forestry is acknowledged for providing research grant to carry out this research work.

I am grateful to Dr. Nyi Nyi Kyaw, Director General of Department of Forestry, Ministry of Environmental Conservation and Forestry for allowing me to conduct this research work.

I also thank Dr. Thaung Naing Oo, Director of Forest Research Institute, Yezin for his support and encouragement in doing this work.

I would like to mention my gratitude to U Soe Myint, Rector (Retired), Pakokku University, Pakokku, for his guidance, keen interest and supervision with constructive criticism throughout this research work.

My thanks are also due to all members of the staff of Wood Anatomy section, Library, Medicinal garden and Herbarium, Forest Research Institute, Yezin for their various kinds of help.

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