

THE MORPHOLOGICAL AND ANATOMICAL CHARACTERISTICS OF SOME MANGROVES TREE SPECIES

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ABSTRACT

The morphology of vegetative and reproductive parts, and the wood anatomy of (6) tree species growing in mangrove forest has been studied. They are Byu-utalon (*Bruguiera gynorhiza* (L.) Savigny.), Kambala (*Sonneratia apetala* Buch.), Laba (*Sonneratia griffithii* Kurz.), Lamu (*Sonneratia caseolaris* (Linn.) Endl.), Pinle-on (*Xylocarpus granatum* (J. Kong.) Alston.) and Thame (*Avicennia officinalis* Linn.). The important macroscopic and microscopic characteristics of species and their wood utilization also has been discussed.

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1. INTRODUCTION

Mangrove species are restrictly distributed species because they can not be occurred any area without tidal influence. And then the mangrove species are belonged to several unrelated families but they possess similar physiological characteristics and structural adaptation with similar habitat preference. For instance, to be resistance to the tidal influence their roots are modified as pneumatophores or stilt roots or prop roots. Moreover the small vessel with high frequency are found in most of the mangrove wood. Scholander et.al 1964,1965 stated that the high density (frequency) of narrow (small) vessel can be related on theoretical grounds to the fact that high tensions have been measured in the xylem of mangrove stem. This high value are related to high osmotic potential of sea water.

The mangrove species are important ecologically and economically. The erosion of coastal areas are protected by mangrove species which provide various resources for human. Mangrove wood are locally utilized in construction purposes and fishery works. They are also used as fire woods. Some species such as *Byu* is suitable for charcoal making. The bark of some species is main resources for tanning utilized in South East Asia especially in Malaysia, Philippines and Indonesia.

Among the valuable mangrove species or mentioned above, some tree species were observed in morphological and wood anatomical point of view in this research. Although many research works on mangrove in various aspect such as conservation, management, reforestation etc, the wood anatomical studies are very little. In Myanmar it is totally lacking. This work is a basic research but it is valuable for wood identification. The correct identification of wood is necessary to promote conservation for threatened and endangered species (Djanaloedin soerjoha dikoesoemo, 1994). Therefore we sincerely hope that this paper will provide valuable data for wood identification and to study the related properties of wood of some mangrove tree species.

2. MATERIALS AND METHODS

2.1. Materials

For morphological and anatomical studies, all specimens were collected in mangrove forest from Pyinalan reserved forest, Laputta township and Byone-hmwe-Kyun, Kadonkani reserved forest, Bogalay township, Ayeyarwady division. The six species were Byu-u-talon (*Bruguiera gynorhiza*(L.) Savigny.), Kambala (*Sonneratia apetala* Buch.), Laba (*Sonneratia griffithii* Kurz.), Lamu (*Sonneratia caseolaris* (Linn.) Endl.), Pinle-on (*Xylocarpus grannatum* (J.Kong.)Alston.), Thame (*Avicennia officinalis* Linn.). The wood specimens for wood anatomical studies were taken from 4'6" height of stem. It was prepared as wood sample included the bark, sapwood and a portion of heartwood, and measured 8"x 6"x1" .

2.2. Methods

Only heartwood portion as small wood blocks (1 cm x 1 cm x 2 cm) were used in microslides preparation in which follow by the method of Jeffery (1917) with slightly modification. The wood specimens were prepared and chipped into fine match- sized splints for maceration. It is using Franklin's methods (1946) for the study of individual element. The splints were macerated using equal parts of 60% glacial acetic acid and 30% hydrogen peroxide until they turned whitish. The solution was then removed and the splints were washed repeatedly with water until acid free. The fibres were stained with safranin 0, to facilitate fibres measurements. 50 vessel elements, pores, rays, fibres were measured for each species. Other diagnostics features like presence of gum deposits, crystals and silica were also observed. Photomicrographs of the wood were transverse section, tangential and longitudinal section and radial and longitudinal section. The photomicrographs were taken by use of the olympus universal research microscope, vanox model.

In this study, the terminology used for microscopic description was as given by Chattaway (1932) and Wheeler, Bass and Gasson (1939).

**3. ARTIFICIAL KEY TO THE SPECIES
(MORPHOLOGICAL CHARACTERS)**

1. Radicle present on tree, leaves stipulate, calyx lobes more than 10, petal divided into 2 lobe at the tip, long bristle in sinus of petal lobes-----*Bruguiera gynorhiza*
1. Radicle absent on tree, leaves exstipulate, calyx lobes less than 10, petal not divided into 2 lobes at the tip, without long bristle in sinus of petal lobes-----2
2. Leaves compound, flowers unisexual, staminal tube present, woody fruit-----*Xylocarpus granatum*
2. Leaves simple, flowers bisexual, staminal tube absent, non- woody fruit-----3
3. Calyx deciduous and free, stamen 4, epipetalous, stigma simple, fruit heart-shaped-----*Avicennia officinalis*
3. Calyx persistent and gamosepalous, stamen numerous, stigma capitate, fruitbowl-shaped-----4
4. Pneumatophores sometimes forked at end, flowers red to pinkish-red, petal present-----*Sonneratia caseolaris*
4. Pneumatophores never forked at end, flowers white, petal absent-----5
5. Aerial root fine point, inflorescence panicle, calyx 4 lobes, capitate stigma like mushroom-----*Sonneratia apetala*
5. Aerial root stout and swollen to nail-shaped at end, inflorescence solitary, calyx 6 lobes, capitate stigma not like mushroom-----
-----*Sonneratia griffithii*

**4. ARTIFICIAL KEY TO THE SPECIES
(WOOD ANATOMICAL CHARACTERS)**

1. Growth rings distinct, fine texture-----2
1. Growth rings indistinct, fine to medium coarse texture-----3
 2. Fibre septate, included phloem absent, stone cells absent in the axial parenchyma, crystals and gum deposits present in the ray cells-----
----- *Xylocarpus granatum*
 2. Fibre non-septate, included phloem present, stone cells present in the axial parenchyma as conjunctive parenchyma, crystals and gum deposits absent in the ray cells----- *Avicennia officinalis*
3. Vessel pores without tyloses, vessel perforation plate scalariform, axial parenchyma scanty, silica bodies present in the ray cells-----
----- *Bruguiera gynorhiza*
3. Vessel pores with tyloses, vessel perforation plate simple, axial parenchyma absent, silica bodies absent in the ray cells-----4
 4. Pores solitary percentage less than 40%, septate fibre, maximum ray frequency less than 20----- *Sonneratia griffithii*
 - 4 . Pores solitary percentage more than 40%, septate fibre, maximum ray frequency more than 20----- 5
5. Wood lustrous, maximum ray cells height less than 800 μm , fork fibre present-- -----*Sonneratia apetala*
5. Wood dull, maximum ray cells height more than 800 μm , fork fibre absent---- ----- *Sonneratia caseolaris*

5. OBSERVATION

BYU-U-TALON

Scientific Name-----*Bruguiera gynorhiza* (L.) Savigny.

Family -----Rhizophoraceae

Morphological characters;

Medium-sized tree, buttress. Bark reddish brown, rough, with reddish yellow lenticle. Leaves simple, opposite and decussate, stipulate, oblong to elliptic oblong, acuminate at the the tip, cuneate at the base, entire margin, glabrous, coriaceous, green, glossy, petiole green, covered with white wax, shorter than leaf blade, stipule 2, oblong, obtuse at the tip, cream colour flushed with pink, enclose the young leaves, fall of when the young leaves developed. Inflorescences solitary, axillary. Flower medium- sized, sub-sessile, outer red, yellow inner, disfragrant; calyx tubular, yellowish red to red, lobe and tube same in length, lobes 12-14, linear, coriaceous, fleshy, persistent; corolla free, 12-14, linear to linear oblong, divided into 2 lobes at the tip, acute at the tip of each lobe with 3-4 bristle, red, caduous. Stamen 2 times of petals, petal enclosed a pair of stamens, filament filiform, red, anther linear, dosifixed. Ovary embedded in calyx tube, style stout, persistent, stigma 3-lobed. Fruit is variable in length, radicle stout, cigar-shaped, dark green, smooth, angular. It have knee-like pneumatophores, stout, numerous lenticles, develop from the base of the tree.

General characteristics of the wood;

Sapwood yellowish-brown, heartwood red, hard, slightly lustrous, fine and even texture, straight or slightly interlock grained, odour and taste absent, diffuse porous, growth rings indistinct, pores small, hardly visible to the naked eye, distinct with a handlen, rays visible to the naked eye, broad.

Microscopic characters;

Growth-rings indistinct or scarcely distinct. Vessels diffuse, 10-27/mm², moderately numerous to numerous, solitary 51 %, in radial multiples of 2-4 and 47%, with few clusters, solitary pores rounded or oval, mean tangential diameter

63µm, (range 31-92 µm), very small to moderately small, mean length of vessel elements 706µm, (range 369-1005 µm), medium-sized to moderately long, perforation plates scalariform, oblique, wider opening, intervessel pits scalariform, ray vessel pits also scalariform, tyloses absent, reddish-brown gum deposits present. Fibres very short to medium- sized, mean length 1139 µm, (range 666-1589 µm), mean fibre width 23 µm, (range 13-33 µm), mean fibre walled thickness 6 µm, (range 3-10 µm), thick-walled, septate, libriform, slit-like. Axial parenchyma sparse, scanty. Rays heterogeneous, 5-10/ mm, widely space to fairly close, uniseriate to multiseriate, 7-64 cells high, 1-5 cells wide, mean height 1077 µm, (range 215-2583 µm), extremely low to very high, mean width 65 µm, (range 10-103 µm), extremely fine to moderately broad, crystal and silica body present.

Uses;

The wood is hard, used for house-post, harrow-teeth and for husking paddy. The bark is suitable for tanning leather and fishing nets. It is used for also as condiment and adhesive, and as an astringent medicine against diarrhoea and sometimes malaria. The timber is used for firewood and charcoal, less so for piles, house posts, rafters, fishing stakes, heavy construction, beams, door frames, tool handle and telegraph poles. The fruits are sometimes used as and astringent in betel quid. They are suitable as an eye medicine, too. The leaves and peeled hypocotyls are eaten in times of scarcity in the moluccas after having been soaked in water and boiled.

KAMBALA

Scientific Name-----*Sonneratia apetala* Buch.

Family-----Lythraceae

Morphological characters;

Medium to large-sized tree. Bark greyish-brown, smooth, with horizontal oval lenticles. Leaves simple, opposite, exstipulate, obovate to lanceolate, acute at the tip, cuneate at the base, undulate margin, glabrous, coriaceous, dull green, petiole reddish-green, shorter than the leaf blade. Inflorescence panicle, axillary. Flower medium-sized, pedicellate, white, apetalous, fragrant; calyx campanulate, pale yellow to greenish-yellow outer, pale yellow inner, glabrous, lobe 4, ovate, acute at the tip, coriaceous, persistent, stamen numerous, inserted, filament white, flat, anther small, brown, horse-shoe shaped, dorsifixed. Ovary flat, pale green, style stout, pale green, persistent, joint near the base of stigma. Stigma capitate like mushroom, pale green. Fruit globose, rounded, flat dorsiventrally, pale green, berry, indehiscent. Radicle absent. It gives slender upright root processes and the top of the aerial root is fine point.

General characteristics of the wood;

Sapwood yellowish-grey, heartwood yellowish-brown, lustrous, fine texture, straight grained, odour and taste absent, diffuse porous, growth ring distinct, pore small to medium sized, visible with handlens, rays indistinct, visible with a handlen.

Microscopic characters;

Growth-rings present but inconspicuous. Vessels diffuse, evenly distributed, 13-32 /mm², moderately numerous to numerous, solitary 43 %, in radial multiples of 2-3 (-9) and 53% and with few clusters, solitary pores mostly oval, mean tangential diameter 80µm, (range 31-133 µm), very small to medium-sized, mean length of vessel elements 518µm, (range 215-759 µm), very short to medium-sized, perforation plates simple, oblique to transverse, tailed one end or both end, intervessel pits alternate, small, vestured, vessel ray pits similar to intervessel pits, tyloses present, occasionally gum deposits present. Fibres extremely short to medium-

sized, mean length 918 μm , (range 369-1343 μm) mean fibre width 26 μm , (range 13-35 μm), mean fibre walled thickness 5 μm , (range 3-8 μm), very thin-walled, septate, libriform, occasionally fork fibres present, slit-like. Axial parenchyma lack. Rays heterogeneous, 16-26 / mm, close to extremely close, 1 (-2) seriate, mostly uniseriate, 3-30 cells high, mean height 360 μm , (range 51-779 μm), extremely low to very low, mean width 12 μm , (range 10-20 μm), extremely fine to very fine, gum deposits present, crystal abundant.

Uses;

The wood is used for house-building, packing box, planks, furniture and parts of boats as well as for fuel.

LABA

Scientific Name-----*Sonneratia griffithii* Kurz.

Family -----Lythraceae

Morphological characters;

Medium to large sized tree, not buttressed. Bark brownish-grey, smooth. Leaves simple, opposite and decussate, exstipulate, ovate to suborbicular, broadly rounded at the tip, rounded at the base, entire margin, glabrous, fleshy and brittle, dark green upper, pale beneath, petiole green and green midrib, very short. Inflorescence solitary, axillary. Flowers large, showy, pedicellate, white. Calyx tube campanulate, green outer, pale green inner, lobes 6, lanceolate, acute at the tip, coriaceous, persistent, corolla absent, stamen numerous, caduous, filament filiform, long, exserted, white, anther horse shoe-shaped, dorsifixed. Ovary bowl-shaped, green, glabrous, style long, stout, green, stigma capitate, persistent. Fruits bowl-shaped, green, berry, indehiscent. It produce prominent pneumatophore which is stout, and swollen to nailed-shaped at end.

General characteristics of the wood;

Sapwood yellowish-brown, heartwood reddish-brown, dull, texture fine, straight or interlock grained, odour and taste absent, diffuse porous, growth rings present but inconspicuous, pores small to medium-sized, indistinct the naked eye, visible with handlens, rays indistinct but visible with handlens.

Microscopic characters;

Growth-rings present but inconspicuous. Vessels diffuse, 17-28/mm², moderately numerous to numerous, solitary 37 %, in radial multiples of 2-4 and 62%, rare clusters, solitary pores rounded or oval, mean tangential diameter 101µm, (range 41-144 µm), very small to medium-sized, mean length of vessel elements 371µm, (range 205-564 µm), very short to medium-sized, perforation plates simple, oblique to transverse, tailed one end or both end, intervessel pits alternate, small, vested, vessel ray pits alternate, small, gum deposits present, tyloses abundant. Fibres extremely short to medium- sized, mean length 768 µm, (range 205-1128

µm), mean fibre width 28 µm, (range 20-35 µm), mean fibre walled thickness 5µm, (range 3-7 µm), very thin-walled, libriform, septate, slit-like, fork fibres present. Axial parenchyma lack. Rays heterogeneous, 14-19/ mm, close to extremely close, 1 (-2) seriate, mostly uniseriate, 2-23 cells high, mean height 392 µm, (range 41-718 µm), extremely low to very low, mean width 28µm, (range 20-35 µm), very fine to moderately fine, gum deposits present, crystal abundant.

Uses;

The wood is fairly strong and for boat building, construction work, posts and fuel wood.

LAMU

Scientific Name-----*Sonneratia caseolaris* (Linn.)Endl.

Family-----Lythraceae

Morphological characters;

Medium-sized tree. Bark greenish-brown, smooth to irregularly slightly fissured. Twigs drooping. Leaves simple, opposite and decussate, exstipulate, obovate, rounded to slightly notched at the tip, cuneate at the base, entire margin, glabrous, fleshy and brittle, dark green upper, pale beneath, petiole reddish-green, very short, subsessile. Inflorescence solitary axillary. Flower large, showy, pedicellate, red to pinkish-red. Calyx tube campanulate, green outer, pale green inner, lobe 6, lanceolate, acute at the tip, coriaceous, persistent, corolla free, 6-lobed, linear, red to reddish-purple, caducous. Stamens numerous, caducous, filament filiform, long, exerted, white upper portion, red lower portion, anther horse shoe-shaped, dorsifixed, ovary bowl-shaped, green, glabrous, style long, stout, green, stigma capitate, persistent. Fruit bowl-shaped, green, berry, sour, edible, indehiscent. It produces prominent pneumatophores, pointed, long and slender, often forked at the end.

General characteristics of the wood;

Sap wood whitish-yellow, heartwood yellowish-brown, dull, texture fine, straight grained or interlock grained, odour and taste absent, diffuse porous, growth rings present but inconspicuous, pores small to medium-sized, indistinct but visible with hand lens, rays indistinct.

Microscopic characters;

Growth-rings present but inconspicuous. Vessels diffuse, distributed, 22-37/mm², numerous, solitary 51%, in radial multiples of 2-4 and 49%, rare clusters, solitary pores mostly oval, mean tangential diameter 93µm, (range 21-154 µm), extremely small to medium-sized, mean length of vessel elements 488µm, (range 308-666 µm), moderately short to medium-sized, perforation plates simple, oblique to transverse, tailed one end or both end, intervessel pits alternate, small, vestured,

vessel ray pits alternate, vestured, small to medium-sized, tyloses and gum deposits present . Fibres very short to medium- sized, mean length 856 μm , (range 513-1230 μm), mean fibre width 23 μm , (range 13-40 μm), mean fibre walled thickness 4 μm , (range 3-5 μm), very thin-walled, libriform, septate, slit-like. Axial parenchyma lack, very rare, not visible, apparently absent. Rays heterogeneous, 18-29/ mm, close to extremely close, 1 (-2) seriate, mostly uniseriate, 2-40 cells high, mean height 312 μm , (range 31-923 μm), extremely low to very low, mean width 15 μm , (range 10-31 μm), extremely fine to moderately fine, gum deposits present, crystal present.

Uses;

It is suitable for matchwood. It is also used piling, posts, poles, bridge construction, flooring, furniture, cabinet and interior finish. The bark is local used for dying. The aerial roots are soft and cocky, it used for fishing net floats and as bottle stoppers.

PINLE-ON

Scientific Name-----*Xylocarpus granatum* (J.Kong.) Alston.

Family-----Meliaceae

Morphological characters;

Medium-sized tree with small buttress. Bark grayish-brown, thin, smooth with irregularly rounded flakes. Leaves unipinnate compound, with 2-4 or 6 leaflets, exstipulate, leaflet obovate-oblong to oblong, rounded at the tip, cuneate at the base, entire margin, glabrous, leathery, rachid golden-brown. Inflorescence cymose, axillary, with 3-4 unisexual flowers. Male and female flowers are borne on same inflorescence and has same shape, size and structure. But they are different in presence of staminode in female and rudimentary ovary in male flower. Flowers are fragrant, creamy white, pedicellate. Calyx 4- lobes, free, rounded-oblong, concave inside, pale green to creamy colour. Staminal tube short, urceolate with 8 short and rounded teeth, anther 8, on the edge of tube. Ovary globose, style short, stigma capitate. Fruit globose, golden-yellow, woody, 4-20 seeded. Aerial roots arise from well-developed buttresses. They are narrow, undulating ribbon-like extensions of the surface root system.

General characteristics of the wood;

Sapwood pale brownish-yellow, heartwood reddish- brown, lustrous, fine to medium- coarse texture, straight to slightly interlock grained, odour and taste absent, diffuse porous, growth rings distinct, pores small to medium-sized, distinct with a hand lens, rays indistinct but distinct with a hand lens.

Microscopic characters;

Growth-rings distinct. Vessels diffuse, 18-28/ mm², moderately numerous to numerous, solitary 75 %, in radial multiples of 2-3 (-4) and 24%, rare clusters, solitary pores rounded or oval, mean tangential diameter 57 µm, (range 21-92 µm), extremely small to moderately small, mean length of vessel elements 358µm, (range 205-472 µm), very short to medium-sized, perforation plates simple, oblique to

transverse, tailed one end, intervessel pits alternate, small to medium-sized, ray vessel pits similar to intervessel pits, tyloses absent, gum deposits present. Fibres extremely short to moderately short, mean length 724 μm , (range 441-964 μm), mean fibre width 21 μm , (range 18-25 μm), mean fibre walled thickness 4 μm , (range 3-5 μm), very thin-walled, septate, slit-like, libriform, forkfibre present. Axial parenchyma concentric, 2-6 cells wide. Gum deposits present. Rays heterogeneous, 10-19/mm, fairly close to close, uniseriate to multiseriate, (mostly multiseriate), 6-27 cells high, 1-4 cells wide, mean height 350 μm , (range 174-666 μm), extremely low to very low, mean width 34 μm , (range 10-51 μm), extremely fine to medium-sized, crystal and gum deposits present.

Uses;

The wood is used mainly for high quality furniture and cabinet work, carving, light construction, bridge building, interior finished, panelling, flooring, doors, posts, joist, beams, rafters, mouldings, ship and boat building, fence post, salt-water piling, gun stocks, billiard tables and billiard cue butts, tool handles, tobacco pipes, wooden pins and sliced has been used as an illuminant and as hair oil.

THAME

Scientific Name-----*Avicennia officinalis* Linn.

Family----- *Avicenniaceae*

Morphological characters;

Medium-sized tree. Bark greyish-brown, thin, smooth, lenticelate. Leaves simple, opposite and decussate, exstipulate, obovate to broadly elliptic, rounded at the tip, cuneate at the base, entire margin, glabrous upper, puberulous beneath, coriaceous, green upper, greenish-yellow beneath, petiole pale green, shorter than the leaf blade. Inflorescence panicle, terminal and axillary. Flower small, sub-sessile, yellow to orange yellow, bracteate, bracteolate. Calyx free, 5 lobes, ovate, acute at the tip, reddish-brown, brown hairs along the margin, tuft brown hair base of the upper surface, corolla campanulate, pale green outside, yellow to orange-yellow inside, densely hairs outside, glabrous inside, 4 lobes, ovate, rounded at the tip, unequal in size, one petal slightly large than others. Stamen 4, epipetalous, alternate to the petal filament filiform short reflexed, anther ovoid, basifixed. Ovary ovoid, yellowish-green to pale green, with densely hairs, style short with densely hairs, stigma simple. Fruits heart shaped, beak short, straight. In this species there are sometimes slender stilt roots.

General characteristics of the wood;

Sapwood whitish-yellow, heartwood greyish-brown, dull, fine to coarse texture, interlock grained, odour and taste absent, diffuse porous, growth ring distinct, pore small to medium-sized, indistinct to distinct to the eye, but visible with hand lens, rays inconspicuous but visible with a handlen.

Microscopic characters;

Growth-rings distinct. Vessels diffuse porous, 7-22/mm², moderately few to numerous, solitary 32% , in radial multiples of 2-4 (-10) and 60%, with few clusters, solitary pores rounded or oval, mean tangential diameter 91 µm (range 31-144 µm), very small to medium-sized, mean length of vessel elements 252 µm,(range 113-349µm), extremely short to moderately short, perforation plates simple, transverse to

oblique, tailed one end, intervessel pits alternate, small, numerous, reddish-brown gum deposits present, tyloses absent, included phloem of the concentric type. Fibres very extremely short to medium-sized, mean length 887 μm , (range 431-1302 μm), mean fibres width 16 μm , (range 10-25 μm), fibre walled thickness 6 μm , (range 4-8 μm), thick-walled, non-septate, slit-like, libriform. Axial parenchyma vasicentric and banded with 1-several seriate, conjunctive parenchyma containing a band of stone cells. Rays heterogeneous, 10-15/mm, fairly close to close, uniseriate to multiseriate, mostly multiseriate, 7-10 cells high, 1-6 cells wide, mean height 745 μm , (range 154-2255 μm), extremely low to rather low, mean width 16 μm , (range 10- 25 μm), extremely fine to very fine, gum deposits absent, crystals absent.

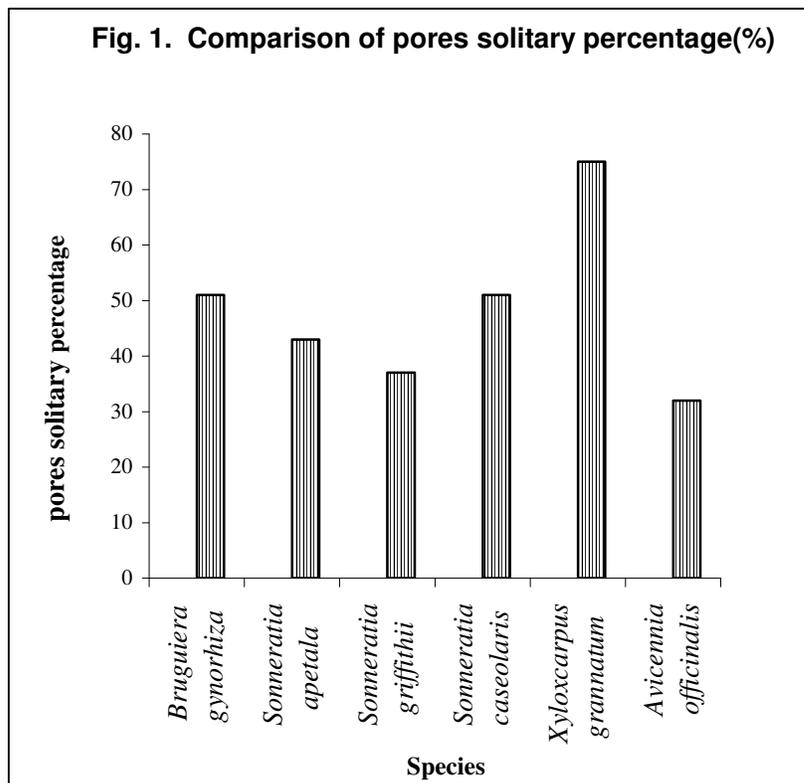
Uses;

The wood is brittle. Used locally for post and fuel, mills for husking paddy, rice-pounder, and oil mills.

6. DISCUSSION

The literatures mentioned for the anatomical characteristics of the species studied in this paper are very rare. Therefore the characters of some species can be examined by comparison with the general characteristics of families which possess the species observed in this paper. The quantitative data of secondary xylem of six mangrove tree species which is important for identification for authentication of wood are mentioned in table 1. In this study although the species examined are belong to different families, their qualitative microscopic characteristics is found to be slightly different as shown in table 2.

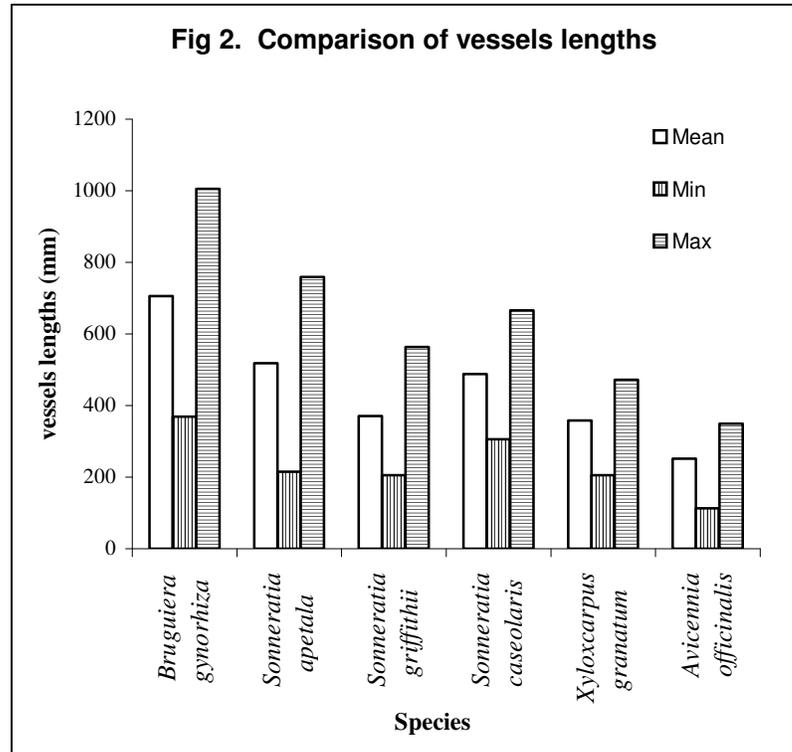
Vessel distribution of all these species are diffuse porous. As observed in the research, the vessel are solitary and in radial multiples, occasionally clusters. The percentage of solitary pore can sometimes be helpful in identification. The highest percentage of solitary pore can be found in *Xylocarpus granatum* and the lowest in *Avicennia grannatum* as shown in figure 1.



All vessel pits are alternate except in *Bruguiera gynorhiza* in which they are scalariform.

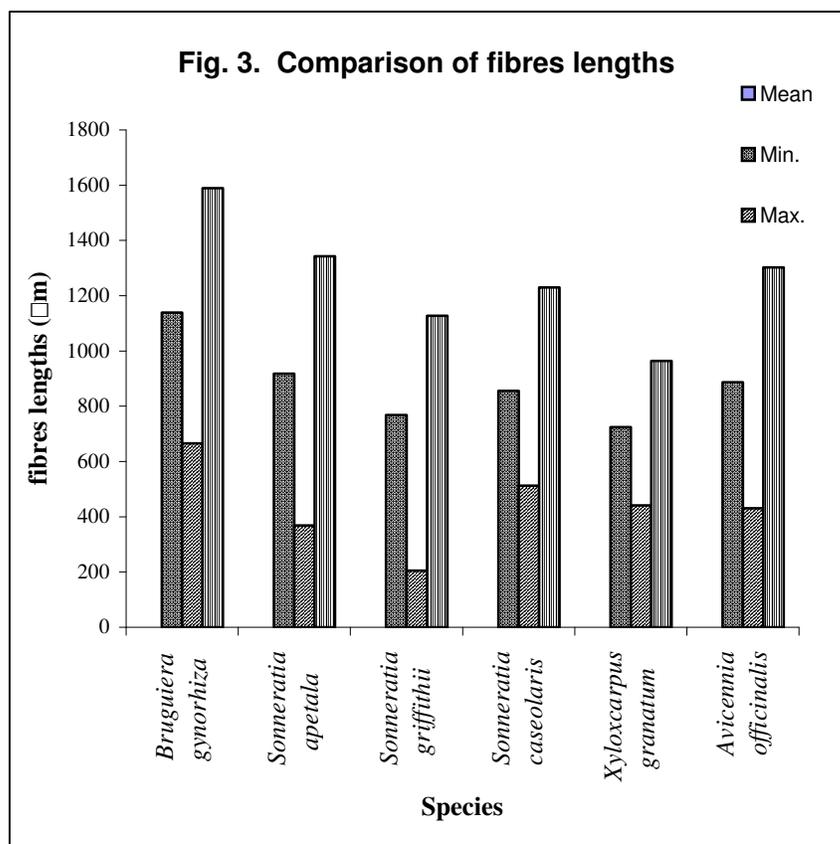
As studied in this work, vessel diameter of species is found to be small to medium-sized except in *Xylocarpus granatum* which is very small to moderately small. The vessel pores of *Sonneratia apetala*, *Sonneratia griffithii* and *Sonneratia caseolaris* are with tyloses and in remainings, tyloses are absent in their vessel pores. In the vessel pores of all species studied the gum deposits are found.

Average vessel length varies from 252 μm in *Avicennia officinalis* to 706 μm in *Bruguiera gynorhiza*. As shown in figure 2, the longest individual vessel element (up to 1005 μm) can be found in *Bruguiera gynorhiza* and the shortest (only 113 μm) in *Avicennia officinalis*.



The scalariform perforation plate can be found in only *Bruguiera gynorhiza* and the rest are simple. The vessel elements of all species examined in this paper have tail at one end or both end.

The fibre of all species are libriform. Septate fibre can be found in *Bruguiera gynorhiza*, *Sonneratia apetala*, *Sonneratia griffithii*, *Sonneratia caseolaris* and *Xylocarpus granatum* and in the rest of a species fibre is non-septate. In present study, fibre of all species have slit-like pits. Forkfibre can be found in, *Sonneratia apetala*, *Sonneratia griffithii* and *Xylocarpus granatum*. The longest fibre (up to 1589 μm) can be found in *Bruguiera gynorhiza* and the shortest fibre (only 205 μm) in *Sonneratia griffithii*, as shown in figure 3.



As observed in the present research, in the species of *Sonneratia*, it is found to be lack of axial parenchyma. All the rest species observed axial parenchyma are concentric banded except in *Bruguiera gynorhiza* which have scanty axial parenchyma. The rays of all species are heterogeneous. The gum deposits are observed in the ray cells of all species studied except in *Bruguiera gynorhiza* and *Avicennia officinalis*. The ray cells of all species observed contain the crystal except in *Avicennia officinalis*. The silica bodies can be observed in ray cells of *Bruguiera gynorhiza* only.

Table (1) Quantitative characteristics of microscopic wood structure for six mangrove tree species

Sr. No	Species Observed	<i>Bruguiera gynorhiza</i>	<i>Sonneratia apetala</i>	<i>Sonneratia griffithii</i>	<i>Sonneratia caseolaris</i>	<i>Xylocarpus granatum</i>	<i>Avicennia officinalis</i>
	Quantitative Characters						
1.	Pore frequency (per sq. mm)	10-27	13-32	17-28	22-37	18-28	7-22
2.	Pore solitary Percentage (%)	51	43	37	51	75	32
3.	Vessel diameter (μm)	63 31-92	80 31-133	101 41-144	93 21-154	57 21-92	91 31-144
4.	Vessel length (μm)	706 369-1005	518 215-759	371 205-564	488 306-666	358 205-472	252 113-349
5.	Fibre width (μm)	23 13-33	26 13-35	28 20-35	23 13-40	21 18-25	16 10-25
6.	Fibre length (μm)	1139 666-1589	918 369-1343	768 205-1128	856 513-1230	724 441-964	887 431-1302
7.	Fibre walled Thickness (μm)	6 3-10	5 3-8	5 3-7	4 3-5	4 3-5	6 4-8
8.	Ray frequency (per mm)	5-10	16-26	14-19	18-29	10-29	10-15
9.	Ray width (μm)	65 10-103	12 10-20	28 20-35	15 10-31	34 10-51	16 10-25
10.	Ray height (μm)	1077 215-2583	360 51-779	392 41-718	312 31-923	350 174-666	745 154-2255

Sr. No	Qualitative characters	Species observed					
		<i>Bruguiera gynorhiza</i>	<i>Sonneratia apetala</i>	<i>Sonneratia griffithii</i>	<i>Sonneratia caseolaris</i>	<i>Xylocarpus granatum</i>	<i>Avicennia officinalis</i>
9.	Fibre septation	Septate	Septate	Septate	Septate	Septate	Non-septate
10.	Spacing of ray	Widely space to fairly close	Close to extremely close	Close to extremely close	Close to extremely close	Fairly close to close	Fairly close to close
11.	Ray type	Heterogeneous	Heterogeneous	Heterogeneous	Heterogeneous	Heterogeneous	Heterogeneous
12.	Axial parenchyma	Sparse, scanty	Lack	Lack	Lack	Concentric	Banded, vasicentric
13.	Tyloses	Absent	Present	Present	Present	Absent	Absent
14.	Gum deposits	Present in vessels	Present in vessels & rays	Present in vessels & rays	Present in vessels & rays	Present in vessels & rays	Present in vessels
15.	Crystals	Present in rays	Abundant in rays	Abundant in rays	Present in rays	Present in rays	Absent
16.	Silica body	Present in rays	Absent	Absent	Absent	Absent	Absent

7. CONCLUSION

In this study, the morphological characteristics, general characteristics and microscopic characteristics of wood and their uses are presented. Moreover qualitative and quantitative data of secondary xylem which is helpful in identification of wood are also presented. The artificial dichotomous key to the species are also mentioned. It is hoped that the observation and results of the present research may contribute the knowledge to a certain extent in examination and studies of some mangrove tree species.

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