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Comparison on Morphological and Anatomical Characteristics of Byu Species Found in Bogalay Township, Ayeyawady Region

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ဧရာဝတီတိုင်းဒေသကြီး၊ ဘိုကလေးမြို့နယ်နှင့် ပုသိမ်မြို့နယ်များတွင်ပေါက်ရောက်သောဗြူးအုပ်စုဝင်အပင်များ၏ပြင်ပရုပ်သွင်နှင့်သစ်အင်္ဂါဗေဒ လက္ခဏာများအားနှိုင်းယှဉ်လေ့လာခြင်း

ကျော်ဝင်းမောင်၊ လက်ထောက်သုတေသနအရာရှိ၊ သစ်တောသုတေသနဌာန
ဒေါက်တာကြူကြူသင်း၊ လက်ထောက်ကထိက၊ သစ်တောတက္ကသိုလ်

စာတမ်းအကျဉ်း

ဤစာတမ်းတွင်မြန်မာအမည်ဗြူးဖြင့်စတင်သောအပင်(၅)ပင်၏ပြင်ပရုပ်သွင်နှင့်သစ်အင်္ဂါဗေဒ လက္ခဏာရပ်များကိုနှိုင်းယှဉ်လေ့လာထားပါသည်။၎င်းအပင်များမှာဗြူးအုပ်ဆောင်း(*Bruguieragym norhiza*) ဗြူးရွှေဝါ(*Bruguierasexangula*) ဗြူးဘိုင်းဒေါင့် (*Kandelia candle*) ဗြူးချေထောက်အဖို(*Rhizophoraapiculata*)နှင့် ဗြူးချေထောက်အမ(*Rhizophoramucronata*) တို့ ဖြစ်ပါသည်။ ၎င်းအပင်များကို အလွယ်တကူခွဲခြားနိုင်သော အဓိကပြင်ပရုပ်သွင် လက္ခဏာများမှာ လေရှူမြစ်အမျိုးအစား၊ အမြစ်လောင်း၏ အရွယ်အစားနှင့် ပုံသဏ္ဍာန်တို့ဖြစ်ပါသည်။ လေရှူမြစ်နှင့် ကိုင်းထောက်မြစ်များကို ဗြူးဘိုင်းဒေါင့်နှင့် ဗြူးချေထောက်မျိုးစိတ်နှစ်ပင်တွင် တွေ့ရှိရပါသည်။ ဒူးပုံသဏ္ဍာန်လေရှူမြစ်နှင့် ပါးပျဉ်းမြစ်တို့ကို *Bruguiera* မျိုးစိတ်နှစ်ခုတွင် တွေ့ရှိရပါသည်။ *Bruguiera* မျိုးစိတ်နှစ်ခု၏ အမြစ်လောင်းများမှာ ဆေးပေါ့လိပ်ပုံတွေ့ရပြီး ကျန်အပင်များမှာ ရှည်လျားသည့် ဆလင်ဒါပုံကိုတွေ့ရပါသည်။ Vessels ခေါ်ရေကြောဆဲလ်များ၏ perforation plate ခေါ်ထိပ်ဝအကန့်နံရံများမှာ အပင်အားလုံးတွင် Scalariform ဖြစ်ပါသည်။ လေ့လာခဲ့သော အပင်အားလုံး၏ Fibers နံရံမှာထူသော်လည်း ဗြူးဘိုင်းဒေါင့်၏ နံရံမှာပါးသည်ကို တွေ့ရှိရပါသည်။ အကန့်ပါသည့် Fibers များကိုဗြူးဘိုင်းဒေါင့်၊ ဗြူးချေထောက်အဖိုနှင့် ဗြူးချေထောက်အမတို့တွင် တွေ့ရှိရပါသည်။ လေ့လာခဲ့သောအပင်အားလုံးတွင် Axial parenchyma အနည်းငယ်သာ တွေ့ရပါသည်။ ဗြူးဘိုင်းဒေါင့်တွင် Ray cells ခေါ်ရောင်ခြည်ဆဲလ်၏ ကန့်လန့်ဖြတ် အကျယ်မှာ ဆဲလ်(၇)လုံးတန်းအထိ တွေ့ရသော်လည်းဗြူးရွှေဝါတွင်(၄)လုံးနှင့် ကျန်အပင်များတွင်(၅)လုံးတန်း ရှိသော ရောင်ခြည်ဆဲလ်များကို တွေ့ရှိရပါသည်။ သို့ရာတွင် လေ့လာခဲ့သော အပင်များ၌ အတော်အသင့် ကျဉ်းသော ရောင်ခြည်ဆဲလ်များနှင့် အလယ်အလတ်အရွယ်ရှိသော ရောင်ခြည်ဆဲလ်များကို တွေ့ရှိရ ပါသည်။ Tyloses များကိုဗြူးချေထောက်အဖိုနှင့် ဗြူးချေထောက်အမတို့တွင် တွေ့ရှိရပြီး gum deposits များကို ဗြူးဘိုင်းဒေါင့်မှလွဲ၍ လေ့လာခဲ့သောအပင်အားလုံး၌ တွေ့ရှိရပါသည်။

Comparison on morphological and anatomical characteristics of Byuspecies found in Bogalay and Pathein Township, Ayeyawady Region

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Abstract

In the present research morphology and wood anatomical properties of byu species namely *Rhizophoraapiculata*, *R. mucronata*, *Bruguieragymnorhiza*, *B. sexangula* and *Kandelia candle* were studied. Type of aerial roots, shape and size of hypocotyls are main character to easily distinguish species in the field.Aerial roots and stilt roots in *Kandelia candle* (L.) Druce and two *Rhizophora*species. Knee like aerial roots and buttress roots are found in two *Bruguiera*species. Hypocotyls of *Bruguiera*species are cigar shaped and those of the remaining species are long cylindrical. The perforations of vessels are scalariform in all species studied. Fiber of all species studied are thick walled but thin walled fibers are found in *Kandelia candle* (L.) Druce.Septate fibers are found in *Kandeliacandel*(L.) Druce, *Rhizophoraapiculata*Blume and *R. mucronata* Lam. Axial parenchyma are rare in all species studied. Ray cells are up to 7-seriate in *Kandeliacandel*(L.) Druce, tetraseriate in *Bruguieriasexangula* (Lour.)Poir and pentaseriate in the remaining species. The ray width is moderately fine to medium-sized. Tyloses were found in *Rhizophora*species and gum deposits in all byu species expected in *Kandelia candle* (L.) Druce.

Key words: Byu, *Bruguiera, Rhizophora, Kandelia*, perforation plate, scalariform

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1. Introduction

Myanmar mangrove forests are situated along the coastal regions, particularly inRakhing, Ayeyawady deltaand Tanintharyi. They comprised of plants so called mangrove which are halophytic plants growing in littoral areas. Tomlinson (1986) divided mangroves into true mangrove and associated mangroves. True mangrove species grow only in mangrove environment and do not extend into terrestrial plant community and are morphologically, physiologically and reproductively adapted to saline, waterlogged and anaerobic condition. A total number of 69 species in 27 genera, belonging to 20 families are considered as true mangrove species (Kathiresan&Bringham 2001and Selvam *et al*. 2004). Rhizophoraceae is one of families considered as true mangrove. Although Rhizophoraceae is well known as mangrove family only 4 genera of its total 16 genera are found in mangrove ecosystem.

The principal mangrove genera of Rhizophoracea are *Rhizophora*, *Bruguiera*, *Ceriops* and *Kandelia* and include 16 species. Two species of *Rhizophora*, five species of *Bruguiera*, two species of *Ceriops* and only one species of *Kandelia* are found in Myanmar mangrove. The vernacular name of all these species are started with the word “Byu” except the species of *Ceriops*. Two species of *Rhizopora* are called Byu Che Tauk Apo and Byu Che Tauk Ama. Among five species of *Bruguiera* the vernacular name starting with the word “Byu” were given for only three species and the remaining two species were known by other name without Byu. The vernacular name of *Bruguiera* species are Byu Oksaung, Byu Shwe Wa. Hnan Byu and Byu Wha Kya Lein. Two species namely *B. gymnorhiza* (Byu Oksaung) and *B. sexangular* (Byu Shwe Wa) are cosmopolitan and dominant species in Myanmar mangrove forests. *Kandelia* species is known as Byu Baing Dauk She.

These Byu species produce heavy hardwood that burns with a high calorific value and tannin rich barks. Their woods are therefore highly suitable as fuel wood or for making charcoal. In addition, they are well-suited for constructional use as their woods are strong, durable and rot-resistant. They are in great demand as piles for building and road construction as the poles are extremely resistant to rot under anaerobic conditions. Therefore, these species are widely valued for construction, fuel wood and tannin extraction (Ewel et al., 1994).

Ecologically these species furnished the plenty of benefits to marine lives and costal people. Byu species have prop roots or stilt roots descending from the trunk and branches and knee roots emerging as a root loop from the underground root system. Their specialized aerial root system provide habitat for marine organisms, especially for shrimps larvae. Despite Byu species are ecologically and economically important, the information for them are difficult to be available. Especially anatomical data are very rare. In this paper, five byu species found in Bogalay Township was investigated anatomically and morphologically. In particular wood anatomical properties of byu species were studied in the present research. The byu species studied are *Bruguiera gymnorhiza*, *B. sexangula*,*Kandelia candle*,*Rhizophora apiculata* and*R. mucronata*.

2. Objectives

The objectives of this paper are to identify the byu species found in Bogalay and Pathein Townshipand to investigate the wood anatomical features of byu species and highlight the wood anatomical features relating to processing and utilization potential.

3. Literature review

Rhizophoraceae was a small pan tropical family (Macnae & Fosberg 1981 and Tomlinson 1986) but widespread in tropical regions especially in the tidal forest (Hou 1970). It consisted of about 17 genera and 70 species (Lawrence 1964), 20 species (Ridley 1967) and about 16 genera and 120 species (Tomlinson 1986). Several genera of that family were characteristic mangrove vegetation growing in muddy tidal flats and shore line of the world (Lawrence 1964, Tomlinson 1986). Macnae & Fosberg (1981) reported that Rhizophoraceae was grouped into two tribes: Rhizophoraeae and Legnotideae. Tribe Rhizophoraeae with 4 genera occurred in mangrove swamp and tidal forests and tribe legnotideae comprised the inland genera.

Aerial roots were the roots that were exposed to air at least during part of the day or sometimes all day in relating to the tide. Aerial roots were one of the important characters in identifying mangrove species in the field (Kitamura *et al*.1997 and Selvam *et al*. 2004). There were four different types of aerial roots found in mangrove tree species. These are stilt root or prop root, pneumatophore, buttress root and knee root (Selvam *et al*. 2004). Stilt roots diverged from the tree trunk as much as 2 to 3 m above ground and penetrated the soil some distance away from the main stem. They also developed from lower branches of the tree. Because of their appearance and their functions providing main physical support of the trunk, these aerial roots were often called as stilt roots. Sometimes roots of this type were known as prop root. On reaching the soil, absorptive roots grew from the stilt roots vertically downward into the soil (Selvam *et al*. 2004). Stilt roots were typical characters of the genus *Rhizophora* (Macnae & Fosberg 1981, Tomlinson 1986, Kitamura *et al*.1997, Kathiresan & Bingham 2001, Selvam *et al*. 2004 and Giesen *et al.* 2007). Very conspicuous arching stiltroots were found in *R.apiculata* Blume(Giesen *et al.*2007).Stilt roots descending from all levels were pronounced in *R. mucronata* Lam. (Macnae & Fosberg 1981, Kitamura *et al.* 1997 and Giesen *et al.* 2007).

Knee roots were horizontal roots reorienting upward through the soil. In these roots tip of the upward extension formed pronounced loop. At the site of the loop, there was a blunt, knoblike structure raising above the soil surface and these roots. As this structure looked alike the knee and these root type was called knee root. These roots type was classical to *Bruguiera cylindrical* and often found in *Ceriops* and*Bruguiera* species including *B.gymnorhiza* (L.) Savigny. (Selvam *et al*. 2004).

Apart from the type of aerial roots, species general characteristics such as size shape and color of leaves, flowers, fruits and viviparous propagules facilitated to easily identify the mangrove species.*Bruguiera sexangula* (Lour.) Poir. was characterized by single flowers with 10 – 12 lobed yellow to yellowish brown calyx, petals with blunt tip with 1 – 2 short bristle or hairless (Giesen *et al*. 2007). The outstanding features of *Kandelia candel* (L.) Druce. were stipulate elliptic to narrow elliptic or obovate-oblong leaves, flowers with linear and reflexed calyx and fruits with terete hypocotyls (Hou 1970). *Rhizophoraapiculata* Blume was important and conspicuous mangrove tree along tidal river banks and creeks and seaward in Thailand (Aksornkoae *et al.* 1992).Two bisexual flowers on stalk in axil of leaf scar and 4 persistent sepals occurring in a recurved form on the end of fruits were identification features for this species (Giesen *et al.* 2007). *R. mucronata* Lam. was characterized by leaves with long mucro at acute apex, 4 – 8 flowered dichotomous cymes, white petals with densely hairy margin and 8 stamens (Macnae & Fosberg 1981, Kitamura *et al.* 1997 and Giesen *et al.* 2007). Bark was used for dye and tannin (Giesen *et al.* 2007 and Win Myint & Stanley 2011) while fruit were eaten (Win Myint and Stanley 2011).

Mangrove trees were a source of timber, fuel, railroad ties and tannin in the tropics. Mangrove wood was dense and resistant to rot and termites. The durability of the wood made it popular as a source of poles used in buildings, boats and fish-traps. In Asia, commercial mangrove wood production was necessary for the construction of boats, houses and furniture (ITTO 2012). According to Guebas *et al*. (2000) the largest and most significant uses of mangrove wood was in the form of poles used for house construction in Kenya and certain species particularly used for framework of a house were *Rhizophora mucronata* Lam. and *Bruguiera gymnorhiza* (L.) Lam. The wood of *Rhizophoraapiculata* Blume was used for foundation piles, beams, interior timber, furniture and charcoal making as recorded by Giesen *et al.* (2007) and Win Myint & Stanley (2011). Wood of *R. mucronata* Lam. was used for construction, fish traps, house frames, pilling and poles (Win Myint and Stanley 2011). Giesen*et al.* (2007) stated that it was for fuel and charcoal.

4. Materials and methods

Five mangrove studiedspecies in this paper were collected from Byone hmwe kyun, Bogale Township and chaung thar reserved forest, Pathein Township, Ayeyarwady Region. The studied species are Byu ok saung (*Bruguiera gymnorhiza* L.(Lamk.), Byu shwe wa (*Bruguiera sexangula*(Lour.) Poir.), Byu baing dauk (*Kandelia candel* (L.) Druce.) , Byuchidauk-apo (*Rhizophora apiculata* Bl.) and Byuchidauk-ama (*Rhizophora mucronata* Lamk.). For morphological studies and identification, the collected vegetative and reproductive are pressed and taken photos. Fresh specimens were used for identification and morphological description. The wood specimens for wood anatomy studied were taken from 1.3 meter height of stem from the ground. From the collected wood samples, three blocks of 1 × 1 × 2 cm were prepared as transverse, tangential and radial sections. These blocks were boiled in water for 24 hours and immersed in equal volume of 50% alcohol and 50 % glycerin for five days to be softened. The softened blocks were sliced in thickness of 25 to 30 µm by using sliding microtome. For staining these wood slices were immersed in ferric ammonium sulphate for 10 to 15 seconds and rinsed in water 2 to 3 times for discoloration. Then the wood slices were immersed in hematoxylin for 5 to 10 seconds and rinse off excess hematoxylin in water 2 to 3 times. After that the wood slices were put in safranin over night. For destaining and dehydration the wood slices were transferred from safranin to series of alcohol representing 50 %, 70 %, 90 %, 95%respectively. Then the wood slides were cleaned in at least two change of xylene and washed with clove oil for further cleaning. Finally three wood slices containing transverse, radial longitudinal and tangential longitudinal section were placed on same slide and mounted with Canada balsam to make microslide. For observation and measurement of individual elements wood samples were chipped and boiled in mixture of equal volume of 50% hydrogen peroxide and 50 % glacial acetic acid until detach individually according to Jeffery (1917).

After that macerated tissues were washed in water and finally stored in equal volume of solution of 50% alcohol and glycerin with 2 to 3 drops of safranin solution.

Measurements of wood anatomical features were made with MT 4300H Microscope attach with digital camera and computer.Means minimum and maximum are based on fifty individual measurements for each feature. Fiber morphology such as length, diameter, lumen diameter and wall thickness as well as length and perforation characters of vessel elements were determined from macerated samples. Terms for description and determination of quantitative values followed the recommendations of an IAWA Committee (1989). Photomicrographs were taken by biological light microscope connected to an image analysis system.

5. Observations

5.1. Scientific name----------*Bruguiera gymnorhiza* (L.) Lamk.
Family--------------------Rhizophoraceae
Myanmar name----------Byuoaksaung

Morphological characters

The tree is 10 m to 20 m height; 15 cm in diameter; buttressed; knee roots or pneumatophore at the base of the trunk.Bark is dark grey in colour, and has numerous lenticles.Leaves are simple, opposite,leathery, elliptic with pointed tips, clustering towards the end of the branch. Flowers are bright red colour. The petals have 2-3 white bristles at the tip of each petal lobe, and one conspicuous bristle in the notch.Hypocotyls arecigar-shaped, thick, blunt narrowed apex.

Macroscopic characters of wood

Sapwood palebrown, heartwood pinkish-red; odour and taste not distinct; hard; fine texture; interlock grained; diffuse porous wood; growth rings not distinct.

Microscopic characters of wood

Vessel elements: Diffuse porous;mean tangential diameter 122.37µm (range 60.14-169.80 µm), moderately small to medium-sized, mean radial diameter 142 µm (range 48.27-204.69 µm); very small to moderately large, number per sq.mm 19 (range 11-31), moderately numerous to numerous; average solitary pores 46% (range26%-70%); pores solitary or as radial pore multiples of 2 to 4, sometimes cluster; circular or oval in transverse section;tylosesabsent; perforation plates scalariform, end walls of elements oblique, tail one end or both ends or truncate; inter vessels pits opposite to scalariform, elliptical, chamber with mean tangential diameter 14.37 µm(range 7.5-20)µm), medium-sized to very large, vessel elements mean length 765.67µm(range 471.5-1045.5 µm). Medium-sized to moderately long;gum deposits present; silica bodies absent; crystal absent.

Fibers: Libriform, mean length 1189.68µm (range 645.75-1640µm),very short to moderately long, non-septate; mean fiber width 22.83 µm (range 17.5-30 µm), mean fiber wall thickness 6.83µm (range 5-10µm), thick-walled; interfiber pits minute, simple simple, slit-like.

Rays: Heterogeneous, 2-5 seriate, 6-9 per mm tangentially, normally spaced or moderately numerous to numerous; multiseriate rays mean height 1136µm (range 358.75-2460µm), extremely low to rather low, 14-75 cells high, mean width 58.76 µm(range 30.75-102.5µm), medium-sized to moderately broad; ray vessel pitting opposite, oval or elliptical in shape,10 µm(7.5-12.5µm) in diameter, medium-sized to large; gum deposits present, silica bodies absent, crystals absent.

Axial parenchyma: Apotracheal diffuse, paratracheal scanty.

Figure 5.1.A Morphological characters of *Bruguiera gymnorhiza* (L.) Lamk.

A. Habit
B. Stem base with slightly buttress and knee root or pneumatophore
C. Bark showing with lenticels
D. Flower showing bristle at the apex of corolla lobe and stamens
E. Matures fruits with long dark green cigar shaped hypocotyls

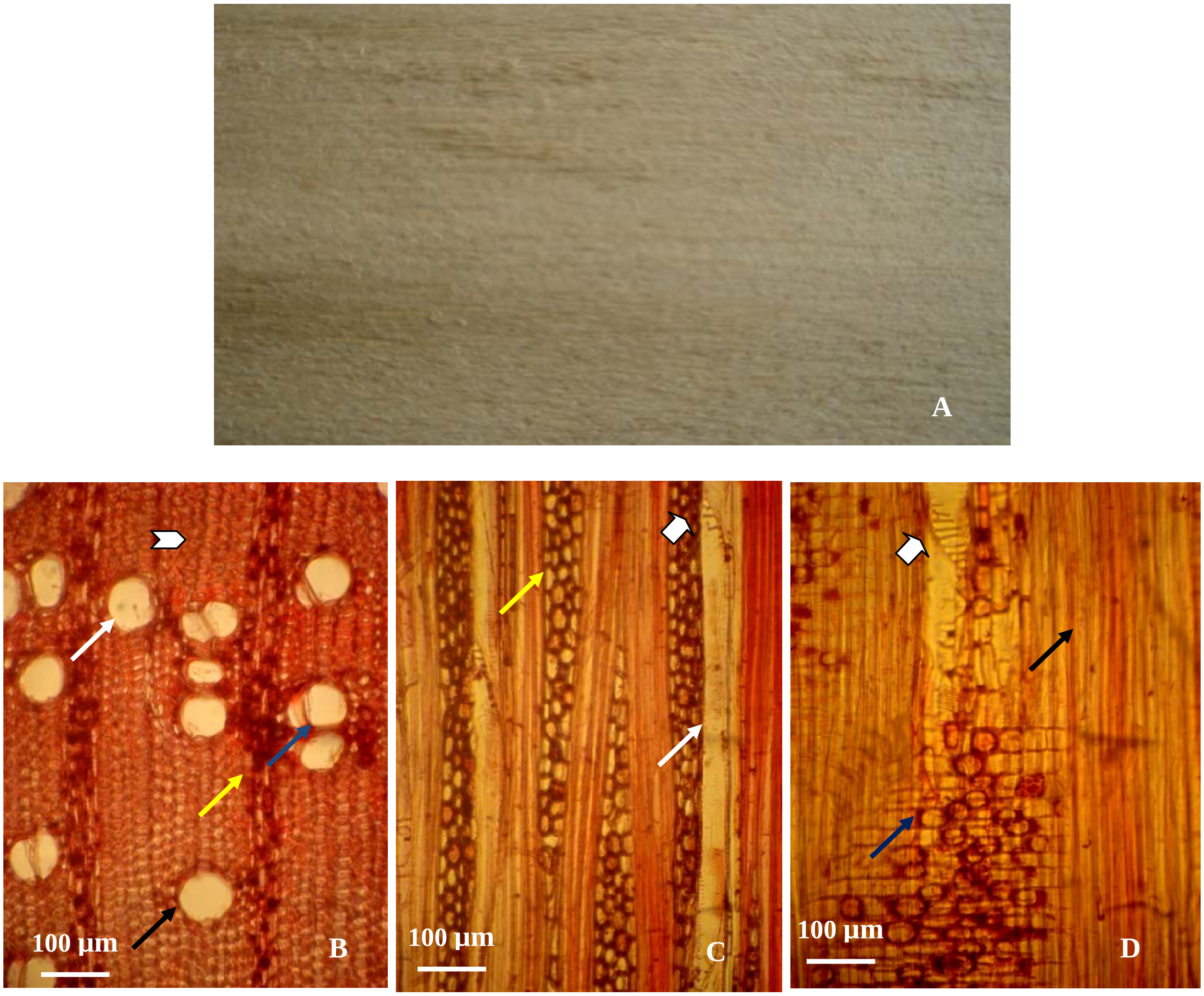

Figure 5.1.B Wood anatomy structure of *Bruguiera gymnorhiza* (L.) Lamk.

A. Wood section showing tangential surface.
B. Transverse section showing solitary pore (white arrow), pores cluster (blue arrow), ray parenchyma cells (yellow arrow), axial parenchyma cells (black arrow) and thick-walled fiber (white arrow head)
C. Tangential longitudinal section showing multiseriate rays (yellow arrow), vessel element (white arrow) and scalariform perforation plate (white arrow head)
D. Radial longitudinal section showing ray parenchyma cells with gum deposits (blue arrow), non-septate fiber (black arrow) and scalariform perforation plate (white arrow head)

5.2.Scientific name----------*Bruguiera sexangula* (Lour.) Poir.
Family--------------------Rhizophoraceae
Myanmar name----------Byushwewa

Morphological characters

Tree is 12m to 15 m in height and 12 cm in diameter; buttress; knee roots or pneumatophores at the base of the trunkBark is pale brown to grey in colour, and has longitudinal fissure. Leaves are simple, opposite, glossy green, narrow elliptic to elliptic oblong with pointed tip; clustering towards the end of the branch. Flowers are pale yellowish-green in colour. The petals lack bristles on each apex but one conspicuous bristle is found in the sinus Hypocotyls are cigar-shaped.

Macroscopic characters of wood

Sapwood yellowish- white, heartwood pinkish-red; odour and taste not distinct; hard; fine texture; interlock grained; diffuse porous wood; growth rings not distinct.

Microscopic characters of wood

Vessel elements: Diffuse porous;mean tangential diameter 114.41µm (range 22.20-179.41 µm), extremely small to very short, mean radial diameter 131.01 µm (range 41.86-201.70 µm); very small to moderately large , number per sq.mm 19 (range 11-27), moderately numerous to numerous; average solitary pores 46% (range11%-77%); pores solitary or as radial pore multiples of 2 to 8, sometimes cluster; circular or oval in transverse section; tyloses absent; perforation plates scalariform, end walls of elements oblique, tail one end or both ends or truncate; inter vessels pits opposite to scalariform, elliptical, chamber with mean tangential diameter 8.75µm(range 6.25-12.5µm); small to large; mean vessel elements length 702.8 µm(range 338.25-1025 µm), moderately short to moderately long; gum deposits present; silica bodies absent; crystal absent.

Fibers: Libriform, mean length 1140.14µm (range 717.5-1691.25µm), moderately short to moderately long, non-septate; mean fiber width 23.33 µm (range 17.5-27.5 µm), mean fiber walled thickness 8.91µm (range 7.5-10µm), thick-walled; interfiber pits minute, simple simple, slit-like.

Rays: Heterogeneous, 2-5 seriate, 7-10 per mm tangentially, normally spaced to fairly close or numerous; multiseriate rays mean height 816.24µm (range 246-2050µm), extremely low to rather low, 8-67 cells high, mean width 97.03 µm(range 20.5-92.25µm), very fine to medium-sized; ray vessel pitting opposite, oval or elliptical in shape, 7.91µm (6.25-10µm) in diameter, small to medium-sized; gum deposits present, silica bodies absent, crystals absent.

Axial parenchyma: Apotracheal diffuse, diffuse in aggregate, paratracheal scanty; gum deposits present.

Figure 5.2.A Morphological characters of *Bruguiera sexangula* (Lour.) Poir.

A. Habit

B. Stem base with slightly buttress and knee root or pneumatophore

C. Bark showing with lenticels

D. Flower showing lack bristle on each apex but one conspicuous bristle is found in the sinus

E. Matures fruits with dark green cigar shape hypocotyls

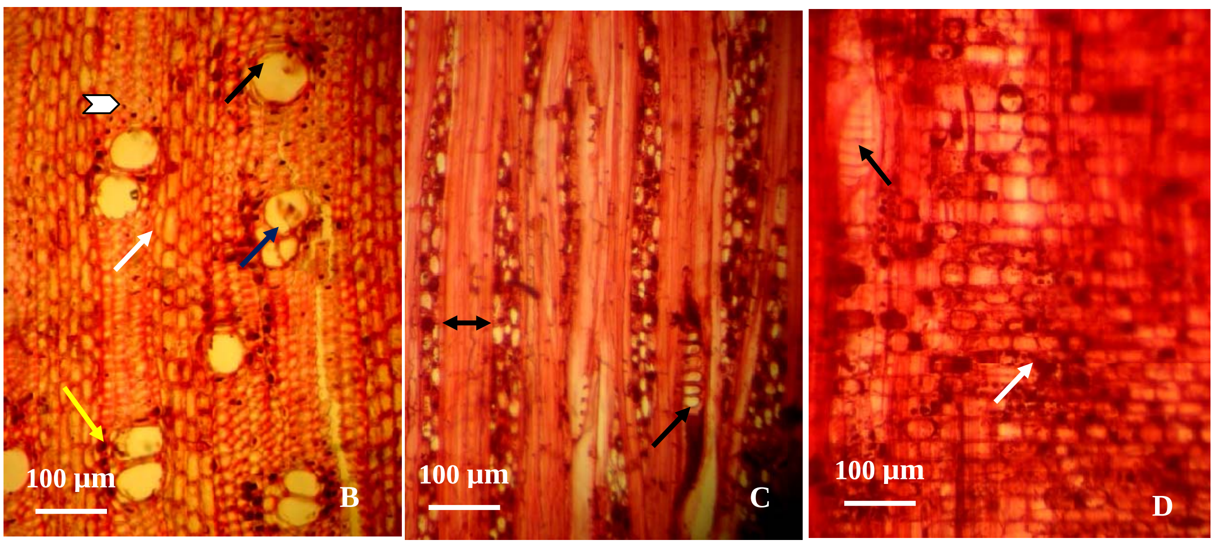

Figure 5.2.B Wood anatomy structure of *Bruguiera sexangula* (Lour.) Poir.

A. Wood section showing tangential surface.
B. Transverse section showing solitary pore (black arrow), pores cluster (blue arrow), ray parenchyma cells (white arrow),axial parenchyma cells (yellow arrow) and thick-walled fiber (white arrow head)
C. Tangential longitudinal section showing multiseriate rays (double head arrow) and scalariform perforation plate (black arrow)
D. Radial longitudinal section showing ray parenchyma cells with gum deposits (white arrow) and scalariform perforation plate (black arrow)

5.3 Scientific name--------*Kandelia candel* (L.) Druce.

Family-------------------Rhizophoraceae

Myanmar name----------Byubaingdauk

Morphological characters

Tree is 7 m to 10 m in height and 10 cm in diameter; stilt root and buttress at the base of the trunk. Bark is grayish brown to pinkish brown, smooth, slightly fissured and has lenticels. Leaves are simple, opposite and distichous, coriaceous, yellowish green, glabrous. Flowers are greenish-yellow in colour and have scale like bracts. Hypocotyls are oblongoid with blunt tip,glabrous, rusty brown.

Macroscopic characters of wood

Sapwood and, heartwood pale yellowish-brown; odour and taste not distinct; fine texture; straight grained; diffuse porous wood; growth rings not distinct.

Microscopic characters of wood

Vessel elements: Diffuse porous;mean tangential diameter 123.73µm (range 68.66-173.10 µm), moderately small to medium-sized, mean radial diameter 190.57 µm (range 4101.21-281.33 µm); medium-sized, number per sq.mm 18 (range 13-25), moderately numerous to numerous; average solitary pores 64% (range50%-92%); pores solitary or as radial pore multiples of 2 to 4, sometimes cluster; circular or oval in transverse section; tyloses absent; perforation plates scalariform, end walls of elements oblique, tail one end or both ends or truncate; inter vessels pits opposite to scalariform, elliptical, chamber with mean tangential diameter 12.5µm(range 7.5-17.5 µm);medium-sized to very large;mean vessel elements length 481.4µm(range 294-625.25 µm), moderately short to medium-sized; gum deposits absent; silica bodies absent; crystal absent.

Fibers: Libriform, mean length 982.97µm (range 512.5-1332.5µm), very short to medium-sized, septate; mean fiber width 22.66 µm (range 12.5-30 µm), mean fiber walled thickness 6µm (range 2.5-10µm), Thin to thick-walled; interfiber pits minute, simple simple, slit-like.

Rays: Heterogeneous, 3-7 seriate, 8-13 per mm tangentially, normally spaced to fairly close or numerous to very numerous; multiseriate rays mean height 1076.25µm (range 225.5-3433.75µm), extremely low to rather low, 9-108 cells high, mean width 80.97 µm(range 51.25-123µm), medium-sized to moderately broad; ray vessel pitting opposite,elliptical in shape, 7.91(range 6.25-10 µm) in diameter, medium-sized; gum deposits present, silica bodies absent, crystals absent.

Axial parenchyma: Apotracheal diffuse, paratracheal scanty, banded confluent.

Figure 5.3.A Morphological characters of *Kandelia candel* (L.) Druce.

A. Habit

B. Stem base with stilt roots and buttress of trunk

C. Bark showing with lenticels

D. Branchlet showing inflorescence and flower

E. Matures fruits with long cylindrical hypocotyls

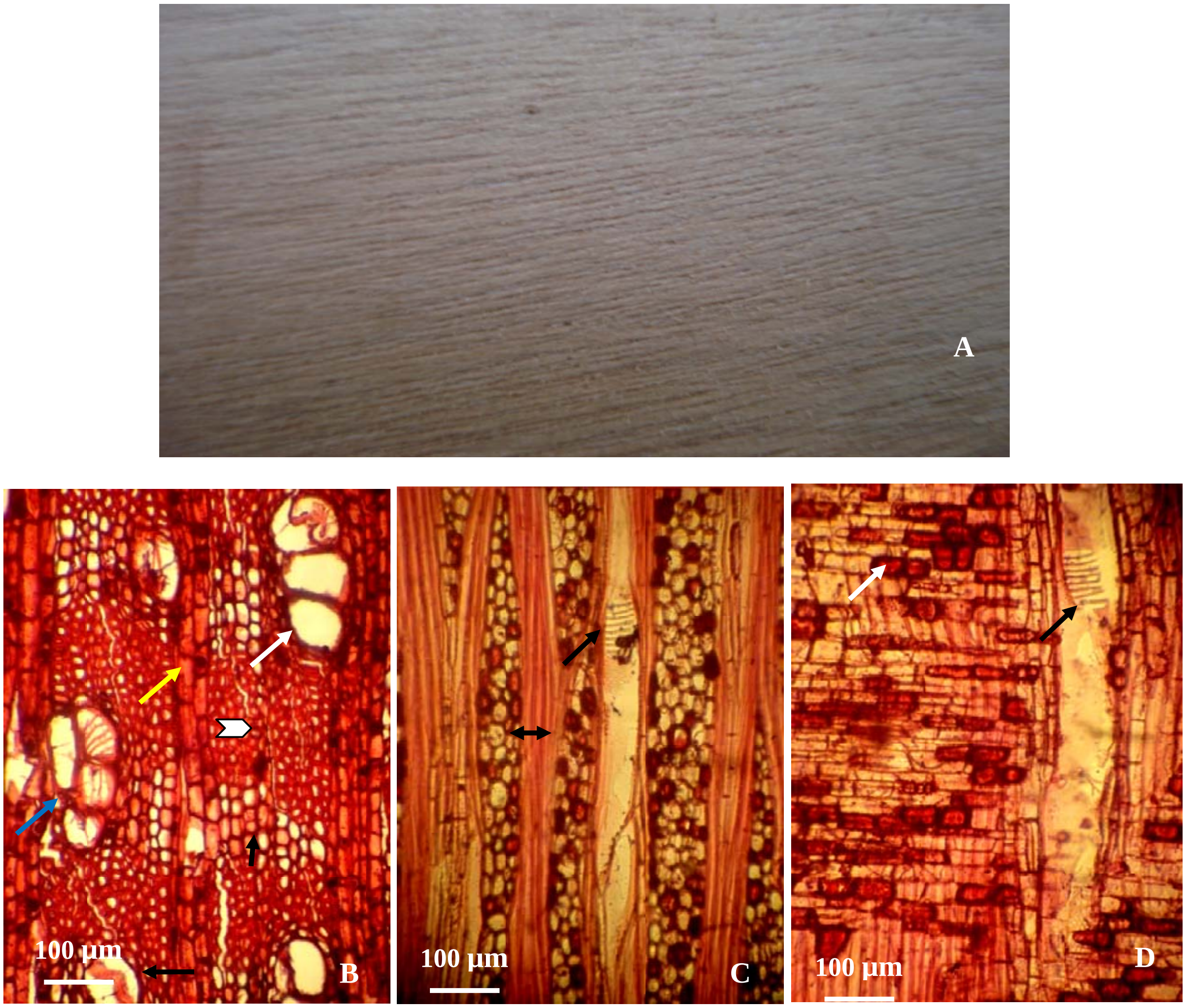

Figure 5.3.B Wood anatomy structure of *Kandelia candel* (L.) Druce.

A. Wood section showing tangential surface.
B. Transverse section showing solitary pore (black arrow), pores multiples (white arrow), pore clusters and scalariform perforation plate (blue arrow), ray parenchyma cells (yellow arrow), axial parenchyma cells (short black arrow) and thin-walled fiber (white arrow head)
C. Tangential longitudinal section showing multiseriate rays (double head arrow) and scalariform perforation plate (black arrow)
D. Radial longitudinal section showing ray parenchyma cells with gum deposits (white arrow) and scalariform perforation plate (black arrow)

5.4. Scientific name---------*Rhizophora apiculata* Bl.
Family--------------------Rhizophoraceae
Myanmar name---------Byuchidauk (Apo)

Morphological characters

Tree is 15 m to 30 m in height and 18 cm in diameter.Stilt roots are pendulous from lower branches. Bark is brownish-grey to whitish-gray in colour and longitudinally fissured. Leaves are simple, opposite and decussate, elliptic in shape, and have tiny black-spots on the lower surface. Flowers are creamy-colour and sessile. Hypocotyls aresmooth, with somewhat rounded tip.

Macroscopic characters of wood

Sapwood pale yellowish-brown, heartwood reddish-brown; odour and taste not distinct; hard; very fine texture; interlock grained; diffuse porous wood; growth rings not distinct.

Microscopic characters of wood

Vessel elements: Diffuse porous;mean tangential diameter 72.88µm (range 34.34-194.2 µm), medium-size, mean radial diameter 117.53µm (range 34.67-259.33µm); very small to moderately large, number per sq.mm 23(range 13-37), moderately numerous to numerous; average solitary pores 84% (range75%-93%); pores solitary or as radial pore multiples of 2 to 4, circular or oval in transverse section; tyloses present; perforation plates scalariform, end walls of elements oblique, tail one end or both ends or truncate; inter vessels pits opposite to scalariform, elliptical, chamber with mean tangential diameter 11.25µm(range 8.75-15µm), medium-sized; vessel elements mean length 634.85µm(range 563.75-1081.5µm). medium-sized to moderately long;gum deposits present; silica bodies absent; crystal absent.

Fibers: Libriform, mean length 1030.12µm (range 367.5-1470µm), extremely short to medium-sized, septate; mean fiber width 21.16µm (range 12.5-30 µm), mean fiber walled thickness 8.08µm (range 5-12.5µm), thick-walled; interfiber pits minute, simple simple, slit-like.

Rays: Heterogeneous, 3-4 seriate, 6-8 per mm tangentially, normally spaced or moderately numerous to numerous; multiseriate rays mean height 1390.91µm (range 234.6-3587.5µm), extremely low to rather low, 14-111 cells high, mean width 47.25 µm(range 21-71.75µm), very fine to medium-sized; ray vessel pitting opposite, oval or elliptical in shape, 9.58µm(range 7.5-12.5µm) in diameter; gum deposits present, silica bodies present, crystals present.

Axial parenchyma: Apotracheal diffuse, paratracheal scanty.

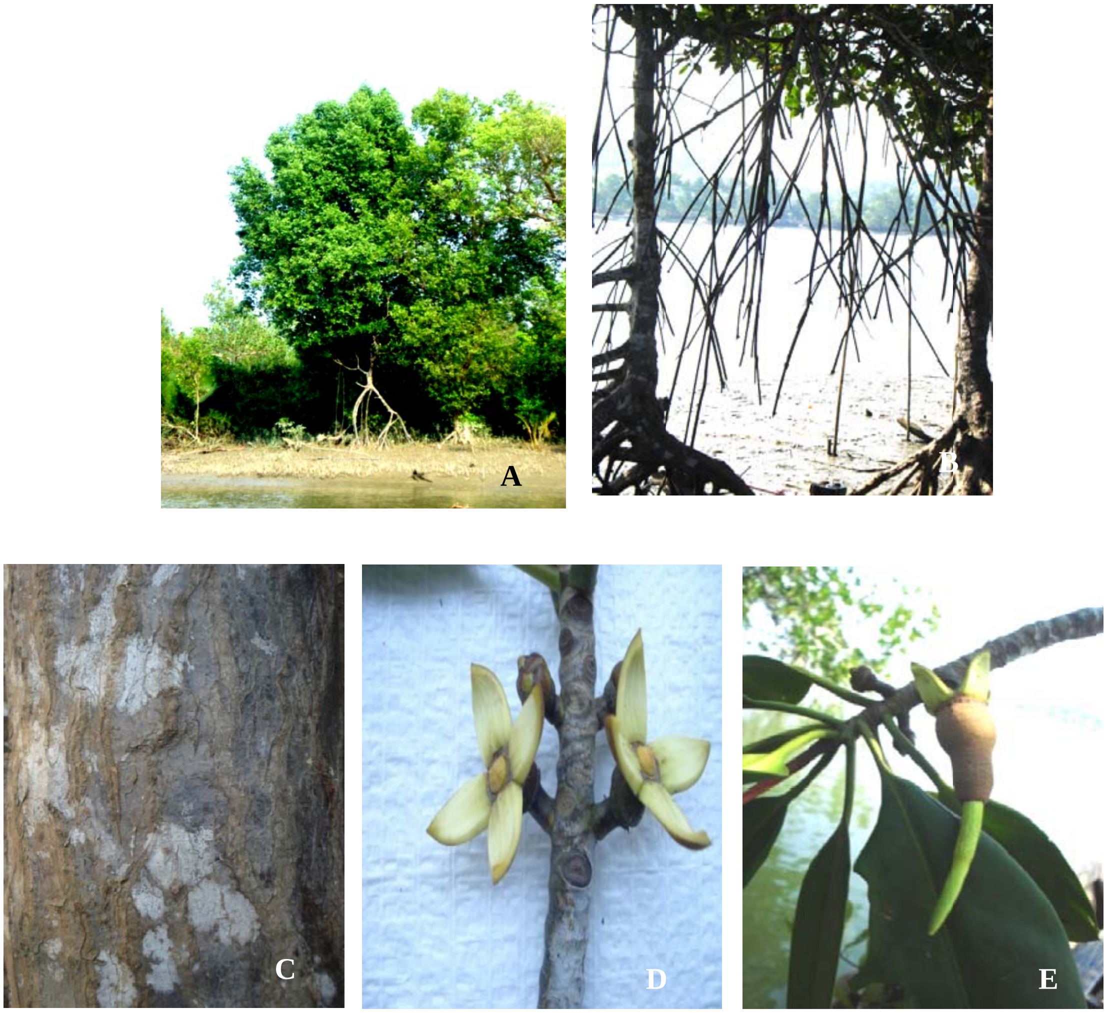

Figure 5.4.A Morphological characters of *Rhizophora apiculata* Bl.

A. Habit

B. Stem base with pendulous stilt root

C. Bark showing with longitudinal fissure

D. Flower showing stalkless and creamy white in colourE. Smooth hypocotyl and cylindrical shaped with rounded tip

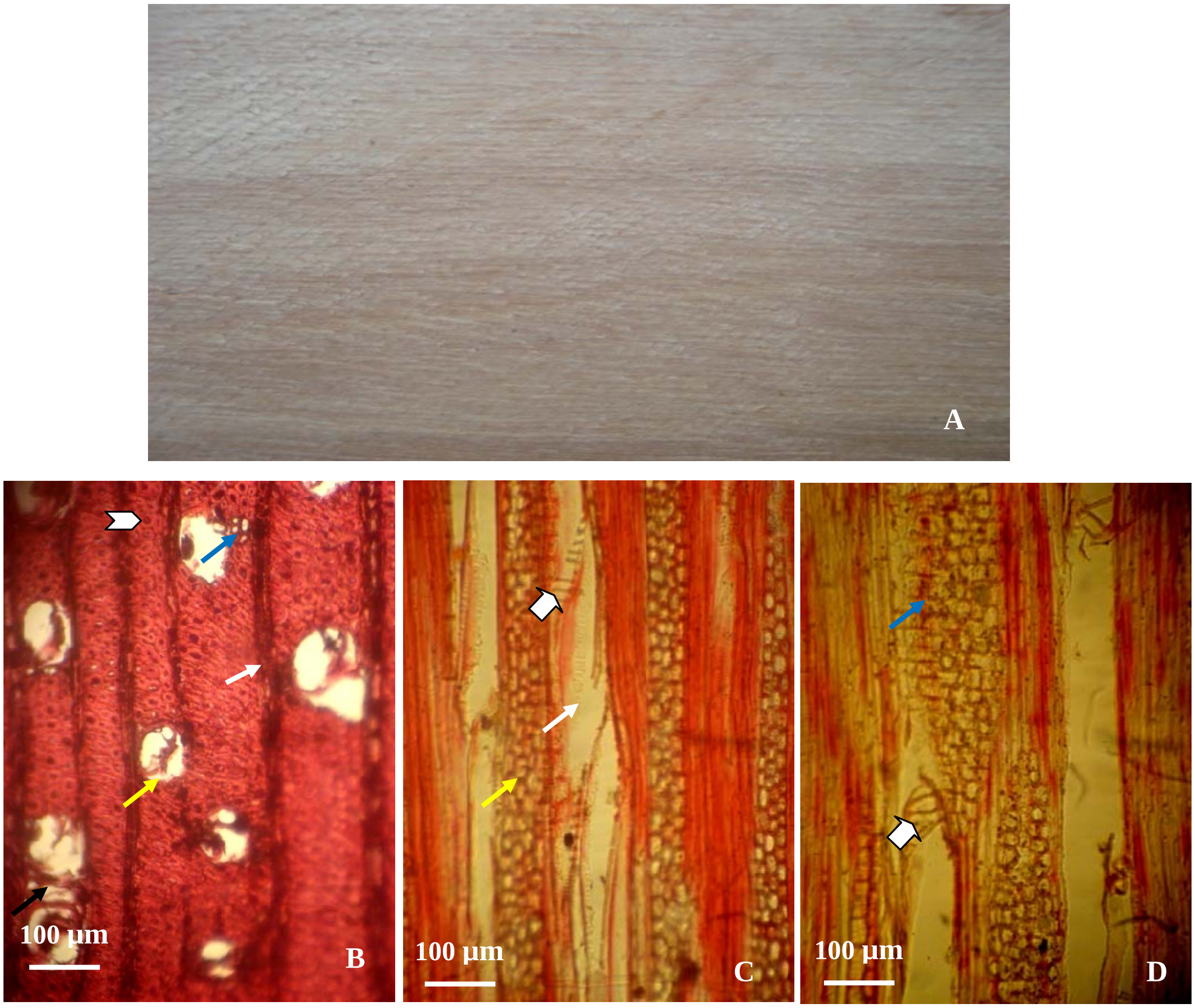

Figure 5.4.B Wood anatomy structure of *Rhizophora apiculata* Bl.

A. Wood section showing tangential surface.
B. Transverse section showing solitary pore (yellow arrow), pores multiples (black arrow), ray parenchyma cells (white arrow), axial parenchyma cells (blue arrow) and thick-walled fiber (white arrow head)
C. Tangential longitudinal section showing multiseriate rays (yellow arrow), vessel element (white arrow) and scalariform perforation plate (white arrow head)
D. Radial longitudinal section showing ray parenchyma cells with gum deposits (blue arrow), scalariform perforation plate (white arrow head)

5.5. Scientific name---------*Rhizophora mucronata* Lamk.
Family--------------------Rhizophoraceae
Myanmar name----------Byuchidauk (Ama)

Morphological characters

Tree is 13 m to 25 m in height and 15 cm in diameter branching arching stilt roots. Bark is brown or blackish-grey, smooth, horizontal fissured. Leaves are opposite, elliptical to oblong in shape, glabrous, and have black-dotson the lower surface. Flowersare pale yellow in colour, bell-shaped and clusteredon axillary infloresence. The hypocotyls are very long cylindrical, up to 60 cm long.

Macroscopic characters

Sapwood pale yellowish-brown, heartwood pale reddish-brown; odour and taste not distinct; hard;finetexture; interlock grained; diffuse porous wood; growth rings not distinct.

Microscopic characters

Vessel elements: Diffuse porous; mean tangential diameter 137.17µm (range 69.07-221.78 µm), moderately small to moderately large, mean radial diameter 173.59µm (range 83.74-226.84µm); moderately small to moderately large, number per sq.mm 28(range 18-37), moderately numerous to numerous; average solitary pores 74% (range60%-90%); pores solitary or as radial pore multiples of 2 to 3, circular or oval in transverse section; tyloses present; perforation plates scalariform, end walls of elements oblique, tail one end or both ends or truncate; inter vessels pits opposite to scalariform, elliptical, chamber with mean tangential diameter 10µm (range 8.75-11.25 µm), medium-sized to large; vessel elements mean length 656.69µm(range 278.75-994.25µm), moderately short to moderately long;gum deposits present; silica bodies present; crystal present.

Fibers: Libriform, mean length 1283.78µm (range 656-1896.25µm), very short to moderately long, septate; mean fiber width 20.75µm (range 12.5-27.5 µm), mean fiber walled thickness 7.25 µm (range 5-10 µm), thick-walled; interfiber pits minute, simple simple, slit-like.

Rays: Heterogeneous, 3-5 seriate, 8-11 per mm tangentially, normally spaced to fairly close or numerous to very numerous; multiseriate rays mean height 1157.9 µm (range 225.5-2952µm), extremely low to rather low, 10-120 cells high, mean width 39.29 µm(range 20.5-61.5µm), very fine to medium-sized; ray vessel pitting opposite, oval or elliptical in shape, 9.58 µm (range 7.5-11.25 µm), in diameter, medium-sized to large; gum deposits present, silica bodies present, crystals present.

Axial parenchyma: Apotracheal diffuse, paratracheal scanty.

Figure 5.5.A Morphological characters of *Rhizophora mucronata* Lamk.

A. Habit

B. Stem base with branching arching stilt root

C. Bark showing with horizontal fissures

D. Flower showing with bell shape

E. Cylindrical shaped hypocotylswith warty on the surface

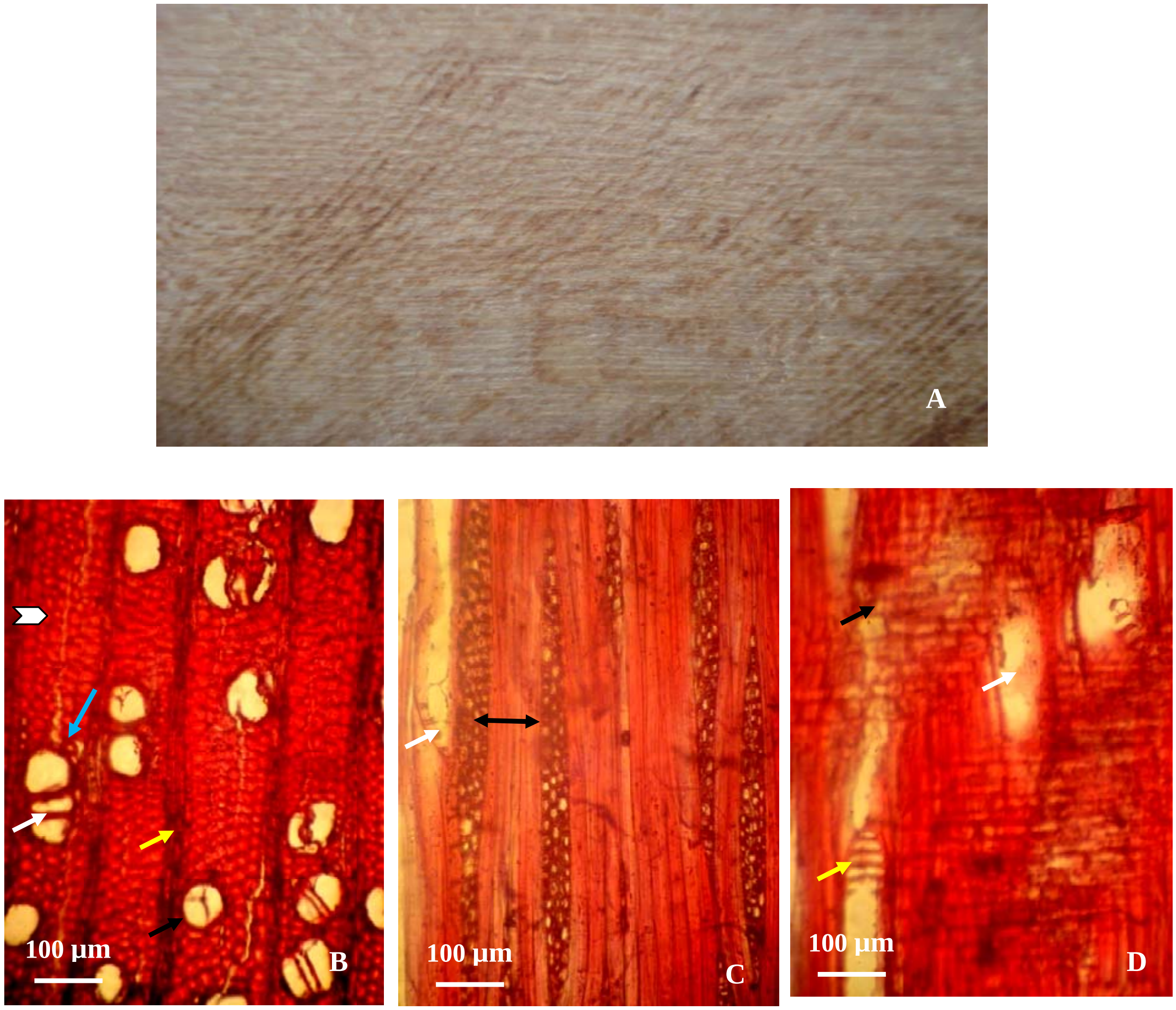

Figure 5.5.B Wood anatomy structure of *Rhizophora mucronata* Lamk.

E. Wood section showing tangential surface.
F. Transverse section showing solitary pore (black arrow), pores multiples (white arrow), ray parenchyma cells (yellow arrow), axial parenchyma cells (blue arrow) and thick-walled fiber (white arrow head)
G. Tangential longitudinal section showing multiseriate rays (double black arrow) and scalariform perforation plate (white arrow)
H. Radial longitudinal section showing ray parenchyma cells with gum deposits (black arrow), scalariform perforation plate (yellow arrow) and vessel element (white arrow)

Table 1 comparison on morphological characters of vegetative parts of five mangrove tree species

Vegetative parts	Species				
	Bruguiera gymnorhiza	***Bruguiera sexangula***	***Kendelia candel***	***Rhizophora apiculata***	***Rhizophora mucronata***
Bark	Dark grey, numerous lenticles	Pale brown to grey, longitudinal fissure	Bark grayish brown to pinkish brown, smooth, slightly fissured, lenticels	Brownish-grey to whitish-gray, longitudinally fissured.	Brown or blackish-grey, smooth, horizontal fissures.
Aerial root system	Buttress roots at the base of the trunk. Forming knee roots, pneumatophores.	Buttress roots at the base of the trunk. Forming knee roots or pneumatophores.	Stilt root and buttress at the base of the trunk, lenticels.	Stilt roots pendulous.	Branching arching stilt roots.
Leaf	Simple, opposite, leathery, elliptic with pointed tips, clustering towards the end of the branch.	Simple, opposite, glossy green, narrow elliptic to elliptic- oblong with pointed tip; clustering towards the end of the branch	Leaves simple, opposite and distichous, coriaceous, yellowish green, glabrous.	Simple, opposite and decussate, Leaf blades elliptic, tiny black-spotted below.	Opposite, elliptical to oblong, acute, entire, without visible veins, thick, leathery, glabrous, black-dotted beneath
Flowers	Large, bright red colour, 2-3 white bristals at the tip of each petal lobe, and one conspicuous bristal in the notch.	Bristles on each apex and 1 conspicuous bristle in the sinus (indentation between the petal lobes) that is shorter than the petal lobes.	Flowered, greenish-yellow, glabrous; bracts scale like	Creamy-coloured	Pale yellow ,clusters, bell-shaped
Hypocotyls.	Thick and cigar shaped	Cigar-shaped	Oblongoid with blunt tip	Smooth, and cylindrical shaped with rounded tip	Cylindrical shaped with warty on the surface

Table 2 Macroscopic characters of five mangrove tree species

Macroscopic characters	**Species**				
	Bruguiera gymnorhiza	***Bruguiera sexangula***	***Kendelia candel***	***Rhizophora apiculata***	***Rhizophora mucronata***
Growth rings	Not distinct.	Not distinct.	Not distinct.	Not distinct.	Not distinct.
Texture	Fine	Fine	Fine	Very fine	Fine
Grain	Interlock	Interlock	Straight	Interlock	Interlock
Odour&taste	Absent	Absent	Absent	Absent	Absent
Porosity	Diffuse	Diffuse	Diffuse	Diffuse	Diffuse
Perforation plate	Scalariform	Scalariform	Scalariform	Scalariform	Scalariform
Fiber type	Libriform	Libriform	Libriform	Libriform	Libriform
Fiber septation	Non-septate	Non-septate	Septate	Septate	Septate
Ray type	Heterogeneous	Heterogeneous	Heterogeneous	Heterogeneous	Heterogeneous
Axial parenchyma	Apotracheal diffuse, paratracheal scanty.	Apotracheal diffuse, diffuse in aggregate, paratracheal scanty; gum	Apotracheal diffuse, paratracheal scanty, banded confluent.	Apotracheal diffuse, paratracheal scanty.	Apotracheal diffuse, paratracheal scanty.
Tyloses	Absent	Absent	Absent	Present	Present
Gum deposits	Present in vessels and rays	Present in vessels, rays and axial parenchyma	Present in rays	Present in vessels and rays	Present in vessels and rays
Silica bodies	Absent	Absent	Absent	Present in rays	Present in vessels and rays
Crystals	Absent	Absent	Absent	Present in rays	Present in vessels and rays

Table3comparison on wood anatomical characters of five mangrove tree species

Anatomical character	*Bruguiera gymnorhiza*	*Bruguiera sexangula*	*Kendelia candel*	*Rhizophora apiculata*	*Rhizophora mucronata*
Vessel length	765.67µm (471.5-1045.5 µm)	702.8 µm (338.25-1025 µm)	481.4µm (294- 625.25 µm)	634.85µm (563.75-1081.5µm)	656.69µm (278.75-994.25µm)
Tangential vessel diameter (µm)	122.37µm (60.14-169.80 µm)	114.41µm (22.20-179.41 µm)	123.73µm (68.66-173.10 µm)	72.88µm (34.34-194.2 µm)	137.17µm (69.07-221.78 µm)
Number per mm2	19 (11-31)	19 (11-27)	18 (13-25)	23 (13-37)	28 (18-37)
Solitary pore %	46%	46%	64%	84%	74%
Perforation plate	Scalariform	Scalariform	Scalariform	Scalariform	Scalariform
Intervessel pit diameter (µm)	14.37 µm (7.5-20 µm)	8.75µm (6.25-12.5µm)	12.5µm (7.5-17.5 µm)	11.25µm (8.75-15 µm)	10µm (8.75-11.25 µm)
Fiber length (µm)	1189.68 µm (645.75-1640µm)	1140.14 µm (717.5-1691.25µm)	982.97µm (512.5-1332.5µm)	1030.12µm (367.5-1470µm)	1283.78µm (656-1896.25µm)
Fiber diameter (µm)	22.83 µm (17.5-30 µm)	23.33 µm (17.5-27.5 µm)	22.66 µm (12.5-30 µm)	21.16µm (12.5-30 µm)	20.75µm (12.5-27.5 µm)
Fiber wall thickness (µm)	6.83 µm (5-10 µm) Thick-walled	8.91µm (7.5-10 µm) Thick-walled	6µm (2.5-10 µm) Thin to thick-walled	8.08 µm (5-12.5 µm) Thick-walled	7.25 µm (5-10 µm) Thick-walled
Ray height (µm)	1136 µm (358.75-2460 µm)	816.24µm (246-2050 µm)	1076.25µm (225.5-3433.75 µm)	1390.91 µm (234.6-3587.5 µm)	1157.9 µm (225.5-2952µm)
Ray width (µm)	58.76 µm (30.75-102.5 µm)	97.03 µm (20.5-92.25 µm)	80.97 µm (51.25-123 µm)	47.25 µm (21-71.75µm)	39.29 µm (20.5-61.5µm)
Ray vessel pit diameter (µm)	10 µm (7.5-12.5 µm)	7.91µm (6.25-10µm)	7.91 (6.25-10 µm)	9.58µm (7.5-12.5µm)	9.58 µm (7.5-11.25 µm)
Ray per mm	6-9	7-10	8-13	6-8	8-11

6.Discussion

All studied species have aerial root system which varies with species. Two species of *Bruguieria* have buttress roots and knee roots and the aerial root system of the remaining species are stilt roots. The flowers of *Bruguieria*species are solitary and have 12 – 14 calyx lobes and petals. The bristle on the apex and sinus of petals are key characteristics to distinguish two species of *Bruguieria*. Although one conspicuous bristle is found in sinus of petals of two species, bristle on the apex of petals are found in *Bruguieria gymnorhiza* and lack in *Bruguieria sexangula*.*Kandelia candle* has dichasium cymose inflorescence with many white flowers. *Rhizophora apiculata* possess two sessile flowered cymose inflorescence and dichasium cymose inflorescence bearing 4 – 8 flowers in *Rhizophora mucronata*. The flowers of *Rhizophora apiculata* are larger than those of *Rhizophora mucronata*.show as shown in Table 6.1.

The general anatomical characteristics of the studied mangrove tree species in this research are fit well to Metcalfe and Chalk (1985). Interlockgrained timbers provide resistance to splitting and straight grained ones split more readily in radial direction (Desch 1973). Interlock grained is found in *Bruguieria gymnorhiza* (L.) Lam., *Bruguiera sexangula* (Lour.) Poir. *Rhizophora apiculata* Blume, and *Rhizophora mucronata* Lam but straight grained in *Kandelia candel* (L.) Druce.

The wood of all studied species are fine texture except *Rhizophora apiculata* Blume in which wood texture is very fine. The vessel pores of *Rhizophora apiculata* Blume, and *Rhizophora mucronata* consist of tyloses athough Pearson and Brown (1932) found tyloses in *Bruguieria gymnorhiza* (L.) Lam., *Rhizophora mucronata* Lam.Gum deposits are found in vessel in all species studied with exception of *Kandelia candel* (L.) Druce as shown in Table 6.2.Very dense wood with very fine texture may commonly be very hard and valuable for paving blocks, flooring, bearings and other similar purposes (Desch 1973).

The parenchyma cells distributed in broad layers provide planes of weakness along which the timber will shear. However, axial parenchyma are rare in all species studied. In all species axial parenchyma are diffuse apotracheal and scanty paratracheal. Banded confluent parenchyma is also found in *Kandelia candle* and diffuse in aggregate apotracheal parenchyma are sometimes in *Bruguieria sexangula*. Gum deposits and crystal are absent in axial parenchyma of all species except in *Kandelia candle* in which gum deposits are found in some axial parenchyma cells.

Average ray height of all species is found to be above 1000 µm and average width varies with species.In this study, the rays of all species are medium sized. Ray cells are up to 7-seriate in *Kandelia candel* (L.) Druce, tetraseriate in *Bruguieria sexangula* (Lour.) Poir and pentaseriate in the remaining species. However, average ray width of all species studied is between 39.29 µm and 97.03 µm. Therefore, the rays of studied species are moderately fine to medium-sized. The wood with broad rays readily split in practical application in some circumstance as the broad rays provide plane of weakness in radial direction. Such high cleavage is very desirable asset for fire wood and materials for manufacture of tight barrels, charcoal, and hand-split shingles (Desch 1973). Among studied species, the rays of two

Rhizophora speciesare moderately fineand those of the remaining species are medium-sized. Although average ray width is broadest in *Bruguieria sexangula*, maximum ray width of *Kandelia candle*is broadest. Ray frequency are between 6 and 13 and the lowest frequency (6 – 8 per mm tangentially) is found in *Rhizophora apiculata*. The highest frequency is 8 – 13 and found in *Kandelia candle*.

The longest average length of vessel elements is found in *Bruguieria gymnorhiza* (L.) Lam. and the shortest one in *Kandelia candel* (L.) Druce. Scalariform perforation plates are found in all species.The longest average length of fibers is found in *Rhizophora mucronata* Lam. and shortest one in *Kandelia candel* (L.) Druce. If the cell walls are thicker in one wood sample, the specific gravity will be higher. Besides, specific gravity will be higher if the proportion of fiber is greater in one wood sample (Desch 1973). Therefore, the wood having high percentage of fiber with thick walls is denser than the one with many thin walled fibers (Nair 1989). Especially, in hardwoods, thickness of fiber walls and their physico-chemical nature are the most important factors determining the strength, shrinkage and working properties of a timber (Desch 1973).

In this study, fiber walls of all species are found to be thick except *Kandelia candel* of which fiber walls are thin to thick.In this study fibers of *Bruguieria gymnorhiza* (L.) Lam., *Bruguiera sexangula* (Lour.) Poir *Rhizophora apiculata* Blume and *R. mucronata* Lam.are thick-walled and of*Kandelia candel* (L.) Druceare thin to thick-walled.as shown in Table 6.3. Therefore, the wood of *Kandelia candel* (L.) Druce is slightly lighter than the remanings.Fibers are libriform in all species observed which agree with Pearson and Brown (1932) and Metcalfe and Chalk (1985). The fibers of *Kandelia candel* (L.) Druce, *Rhizophora apiculata* Blume and *R. mucronata* Lam are septate and that of the *Bruguieria gymnorhiza* (L.) Lam., *Bruguiera sexangula* (Lour.) Poir.are non-septate

Tyloses and gum deposits are obstacle in timber seasoning and preservation process because tyloses reduce the permeabilityof wood (Nair 1989). Tyloses were found in *Rhizophora* species and gum deposits in all byu species expected in *Kandelia candle* (L.) Druce. Therefore, the woods of all species studied may not easy to be seasoned.

7. Conclusion

Aerial roots are stilt roots in *Kandelia candle* (L.) Druce and two *Rhizophora* species. Knee like aerial roots and buttress roots are found in two *Bruguieria*species. Hypocotyls of *Bruguieria* species are cigar shaped and those of the remaining species are long cylindrical. The perforations of vessels are scalariform in all species studied. Except *Kandelia candel* (L.) Druce,fibersare found to be thick walled in all species and hence the wood of these species are heavier than *Kandelia candel* (L.) Druce. Septate fibers are found in *Kandelia candel* (L.) Druce, *Rhizophora apiculata* Blume and *R. mucronata* Lam. Axial parenchyma are rare in all species studied and hence the wood of all species studied will be less in shear. The two *Bruguieria*and *Kandelia* species may be more split in practical application than the two *Rhizophora* species because the ray width oftwo *Bruguieria* and *Kandelia* species is broader than that of the two *Rhizophora* species.

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