Morphological and wood anatomical characteristics of three *Sonneratia* species growing in Mangroves at Bogalay Township

Kyu Kyu Thin[1]

Abstract

Three *Sonneratia* species growing in mangroves at Bogalay Township are *S. apetala* Ham. Buch. (Kambala), *S. caseolaris* (L.f.) Engl. (Lamu) and *S. griffithii* Kz. (Laba). The morphological and wood anatomical investigation was conducted on wood samples and herbarium specimens of the *Sonneratia* species collected from Compartment No. 7 and 11 of Mainmahla wildlife sanctuary and ByoneHmewKyun. Artificial keys based on morphological and anatomical characteristics were constructed. The key diagnostic morphological features for species identification are aerial root shape, flower sizes and color, presence or absence of petal. Aerial root type of all species studied is pneumatophore. Flowers bloom in the early morning and ephemeral in all species observed in this research. In wood anatomical investigation, the porosity of all species studied is diffuse porous. The fibers are septate in *S. apetala* Ham. Buch. and *S. griffithii* Kz. but non-septate in *S. caseolaris* (L.f.) Engl.. The rays of the *Sonneratia* species studied are exclusively uniseriate except *S. apetala* in which rays are uniseriate to biseriate. Morphological characteristics are valuable to be authenticated species in identification. Wood anatomical characteristics are also indispensable for species confirmation as well as for estimation of potential uses of their timber.

Keywords: **Mangrove; *Sonneratia*species; artificial key; morphological characteristics; wood anatomical characteristics;**

Introduction

The genus *Sonneratia* grows in mangrove habitat and includes true mangrove tree species confined to the mangrove communities in the tropical regions (Qinet al. 2007). Although this genus was placed under Sonneratiaceae recent phylogenetic studies treated this genus as a member of Lytheracea (Shi et al. 2002; APG IV 2016). Duck and Schmitt (2015) recorded that this genus comprise of nine identified species including natural hybrid species on the world. In Myanmar, there are four *Sonneratia* species which are trees of mangrove swamp and intertidal regions (Kress et al. 2003).

[1] Lecturer, Department of Botany, Hakha College

Three *Sonneratia* species namely *S. apetala* (Kambala), *S. caeolaris* (Lamu) and *S. griffithii* (Laba) are found in mangroves of Bogalay Township. From three species *S. apetala* and *S. caeolaris* are used as plantation species in mangrove restoration programme of Myanmar. *S. caeolaris*is most popular species among local people by itsmulti-purposely uses such as eatingyoung fruits and utilizing timber as fuelwood, poles and furniture etc. *S. griffithii* is listed under the IUCN category of critically endangered.

All three *Sonneratia* species produce timber and commonly used as fuelwood by local people. The timbers of *S. apetala* and *S. caeolaris* are used for construction as well. The quality and potential utilization of wood can be predictable by wood anatomical characteristics because the wood anatomical structure is responsible for physical and mechanical properties governing wood procession and utilization.In order to improve the wood utilization, it is indispensable to understand the wood anatomical structure and properties. The previous studies on correlation between the wood structure and properties (Wu *et al*. 2006, Gryc 2008, Junior *et al*. 2009, Schulgasser& Witztum 2011 and Moya *et al*. 2012) documented that some anatomical attributes commonly used to predict timber properties are fiber wall thickness, porosity pattern, fiber length, tissue proportions, microfibril angle and grain pattern. Among these features, the thickness of the fiber cell wall is the major factor governing density and strength in wood (Adeniyi *et al*. 2013).

The species of genus *Sonneratia* has common reproductive and vegetative features such as showy flowers with numerous ephemeral stamens and different shape of pneumatophore adapting to mangrove environment. Although there are many studies on morphological characteristics of *Sonneratia* species wood anatomical studies are very rare. In this study morphological and wood anatomical characteristics of the *Sonneratia* species found in mangrove of Bogalay Township are investigated. The aim of this study provides the morphological and wood anatomical information of three *Sonneratia* species for taxonomically species confirmation and for the exploration of wood properties and potential utilization. The specific objectives of this research are to identify the morphologically diagnostic features, to identify the macroscopic and microscopic characteristics of wood and to compare the morphological and wood anatomical characteristics of three *Sonneratia* species.

Materials and Methods

All specimens examined in this study were collected from Kadonkani reserved forest compartment no. 49, Byone Hmwe Kyun and forest compartment no. 6,7 and 11 of Mainmahla reserved forest, Bogalay Township. For taxonomical identification and morphological observation twigs with flowers and fruits were collected during the flowering time and fruiting time. Some herbarium specimens were sent to the herbarium of Forest Research Institute to get herbarium register number for authentication. Identification was carried out with the assistance of literature (Hou 1970; Cronquist 1981; Tomlinson 1986; Kitamura 1997, Heywood *et al*. 2007).

For wood anatomical investigation wood samples were collected from the stem at 1.3 m high. From the collected wood samples, three blocks of 1 × 1 × 2 cm were prepared at transverse, radial and tangential sections. The micro slides preparation was followed to the methods using by the wood anatomical section of FRI, Yezin. For observation and measurement of individual elements, wood samples were macerated according to Jeffery (1917) with slight modification. The macerated tissues were washed in water and finally stored in 50/50 solution of 50% alcohol and glycerin with 2 to 3 drops of safranin solution.

Measurements of wood anatomical features were made with Olympus light microscope. Means, minimum and maximum were 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 a digital camera attached to Olympus light microscope.

Results

Morphological observations

The comparison of the diagnostic morphological characteristics of three *Sonneritia*species is presented in Table.1.

Table 1.Comparison on the diagnostic morphological characteristics of three *Sonneratia* species

Morphological characteristics	***S. apetala*** **(Kambala)**	***S. caseolaris*** **(Lamu)**	***S.griffithii*** **(Laba)**
Pneumatophore	 stout, conical shaped, pointed tip	 thin, pencil like, spreading about 1 m surrounding the base of trunk	 knee like, stout, flattened, swollen at the base
Leaf shape	 lanceolate	 obovate to oblong bovate	 orbicular to obovate
Inflorescence	 terminal and axillary, cymes, 1- to 2-flowered	 terminal, solitary cymes	 terminal, cymes, 3- to 5-flowered
Flower	 whitish green to pale green,apetalous, 1.6 – 1.8 cm across	 red or purplish red with 6 petals, 10.2 – 11.0 cm across	 white, 10.8 – 9.0 cm across
Stigma	 mushroom shaped	 discoid	 discoid
Fruit	 globoid with flattened tip, 2.1 – 2.3 cm by 2.5 – 2.6 cm, dark green	 globoid with flattened tip, 1.8 – 2.3 cm by 4.2 – 4.6 cm,	 globoid with flattened tip,1.9 – 2.4 by 4.1 – 4.7 cm, dark green with rusty brown patches

Wood anatomical observation

Sonneratia apetala Buch.-Ham.

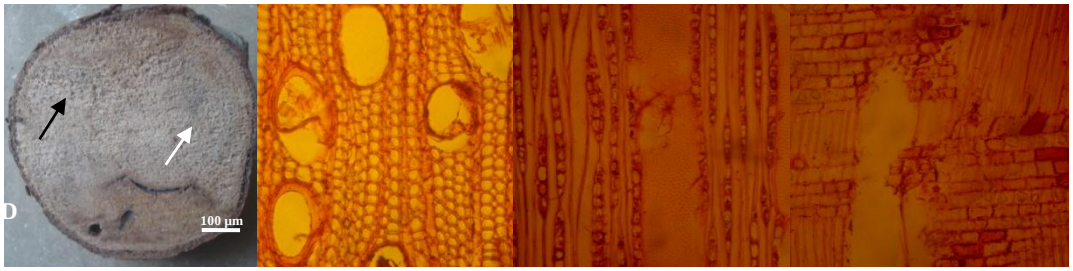


Fig. A. Wood section showing indistinct growth layer before sanding, B. Transverse section showing vessel grouping with solitary pore (black arrow) and uniseriate ray (white arrow), C. Tangential longitudinal section showing uniserate rays (white arrow) and vessel elements with inter vessel pits (black arrow), D. Radial longitudinal section showing vessel elements (black arrow) and crystal in some ray parenchyma (white arrow).

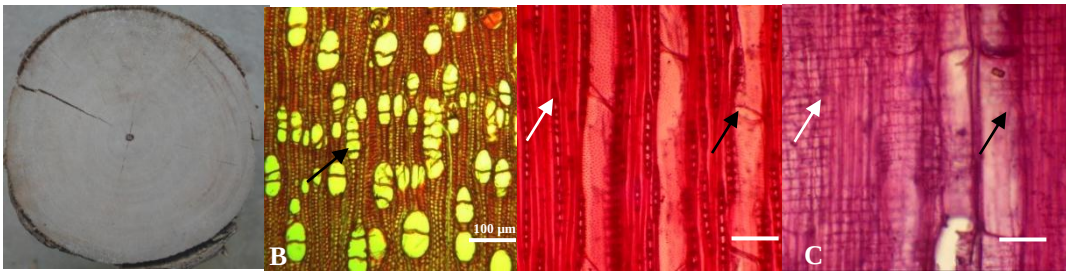
Macroscopic characteristics of the wood

Sapwood yellowish brown, heartwood not distinct; odour and taste not distinct, hard; very fine textured; straight grained, diffuse porous wood; growth ring not distinct.

Microscopic characteristics of the wood

Vessels are average 63 %solitary, radial multiples of 2 – 5 (mostly 2 – 3), rarely cluster pores; number per sq. mm. few to moderately numerous (range 4 – 11); 76.53 µm (range 30.75 – 133.25 µm) in diameter, 455.27 µm (range 276.75 –768.75 µm) in length and contains gum deposits. End walls of vessel elements are oblique or transverse, truncate or tailed at one end or both ends and perforation plateis simple. Intervessel pitting is3.75 – 17.56 µm in diameter, alternate, crowded, elliptical in shape. Ray vessel pitting is2.5 – 3.75 µm in diameter, alternate, circular or oval in shape. Fibers are thin-walled, septate, with minute, simple, slit-like in radial wall. Axial parenchyma is very sparse. Rays are homocellular, 1 – 2 cells wide, 2 – 24 cells high and contain gum deposits and crystals.

***Sonneratiacaseolaris* (L.)Engl.**



A. Wood section showing indistinct growth layer before sanding, B. Transverse section of wood of showing multiple pores (white arrow head)C. Tangential longitudinal section showing uniserate rays (white arrow) and vessel elements with simple perforation (black arrow), D. Radial longitudinal section showing vessel elements (black arrow) and ray parenchyma (white arrow).

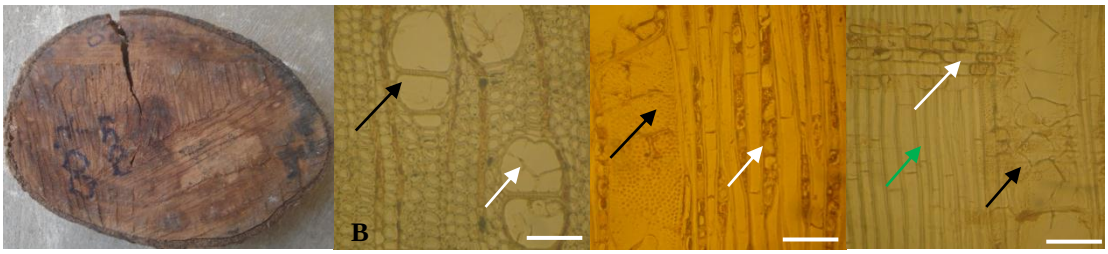
Macroscopic characteristics of the wood

Sapwood whitish brown, heartwood not distinct; odour and taste not distinct, hard; very fine textured; slightly twisted grained, semi-ring to diffuse porous wood; growth ring not distinct.

Microscopic characteristics of the wood

Vessels are average 59 %solitary, radial multiples of 2 – 5 (mostly 2), sometimes cluster pores; number per sq. mm. few to moderately numerous (range 4 – 11); 73.18 µm (rang 30.75 – 123.5 µm) in diameter, 373.1 µm (range 205.0 – 563.75 µm)in length and contains tyloses and silica bodies. End walls of vessel elements are oblique or transverse, truncate or tailed at one end or both ends and perforation plateis simple. Inter vessel pitting is2.5 – 6.25 µm in diameter, alternate, crowded, elliptical in shape.Ray vessel pitting is2.5 – 3.75 µm in diameter, alternate, circular or oval in shape. Fibers are thin-walled, non-septate, with minute, simple, slit-like in radial wall. Axial parenchyma is very sparse. Rays are heterocellular, exclusively uniseriate, 2 – 41 cells high and contain gum deposits.

SonneratiagriffithiiKurz



A. Wood section showing indistinct growth layer before sanding, B. Transverse section showing vessel grouping with radial multiple pore (black arrow), pores occluding thin tyloses (white arrow) C. Tangential longitudinal section showing uniseriate ray with crystal and gum deposits (white arrows), vessel pore with intercellular pits (black arrow) F. Radial longitudinal section showing ray parenchyma with crystal (white arrow), ray vessel pits (black arrow) and septate fiber (green arrow).

Macroscopic characteristics of the wood

Sapwood pale pinkish yellow, heartwood not distinct; odor and taste not distinct, hard; very fine textured; straight grained, diffuse porous wood; growth ring not distinct.

Microscopic characteristics of the wood

Vessels are average 49 % solitary,radial multiples of 2 – 11 (mostly 2 – 3), rarely cluster pores;number per sq. mm. few to moderately numerous (range 16 – 33); 79.78 µm (rang 30.75 – 123.0 µm) in diameter, 490.12 µm (range 174.25 – 215.25 µm) in length and contains tyloses and gum deposits. End walls of vessel elements are oblique or transverse, truncate or tailed at one end or both ends and perforation plateis

simple. Intervessel pitting is 2.5 – 6.25 µm in diameter, alternate, crowded, elliptical in shape.Ray vessel pitting is2.5 – 3.75 µm in diameter, alternate, circular or oval in shape. Fibers are thin-walled, septate, with minute, simple, slit-like in radial wall. Axial parenchyma is very sparse. Rays are heterocellular, exclusively uniseriate, 2 – 33 cells high and contain gum deposits.

Key to the species

1. Tyloses absent in vessel pores; Ray uniseriate to biseriate, homocellular; Crystals present in ray parenchyma cells ---------- *S. apetala*

1. Tyloses present in vessel pores; Ray exclusively uniseriate, heterocellular; Crystals absent in ray parenchyma cells ---------- 2

2. Wood color whitish brown; Fiber non-septate; Intervessel pits vestured; Gum deposits absent in vessel pores ---------- *S. caesolaris*

2. Wood color pale pinkish yellow; Fiber septate; Intervessel pits not vestured; Gum deposits present in vessel pores ---------- *S. griffithii*

Table 2. Macroscopic and qualitative characteristics of three *Sonneratia* species

Macroscopic and qualitative characteristics	***S. apetala***	***S. caseolaris***	***S. griffithii***
Color	yellowish brown	whitish brown	pale pinkish yellow
Grain	straight	slightly twisted	Straight
Texture	very fine	very fine	very fine
Odor and taste	not distinct	not distinct	not distinct
Porosity	diffuse porous	semi-ring to diffuse porous	diffuse porous
Perforation plate	simple	Simple	Simple
Axial parenchyma	very sparse	very sparse	very sparse
Fiber type	septate	non-septate	Septate
Ray seriate	uni to biseriate	Uniseriate	Uniseriate
Gum deposits	+ in vessel and ray	+ in ray	+ in vessel and ray
Tyloses	absent	+ (st)	+ (rarely)
Crystal	+ in ray	Absent	absent

* + = present; st = sometimes

Table 3.Quantitative characteristics of three *Sonneratia* species

Mean value of Quantitative characteristics	***S. apetala***	***S. caseolaris***	***S. griffithii***
Vessel diameter (µm)	76.53	73.18	79.78
Solitary pore percentage (%)	63	59	49
Vessel length (µm)	455..27	373.1	490.12
Vessel frequency (per sq.mm)	7	44	24
Fiber length	802.92	616.02	738.68
Fiber diameter (µm)	22.87	23.6	26.56
Fiber wall thickness	5.0	3.7	4.6
Ray width	23.75	15.37	21.43
Uniseriate ray height (µm)	327.32	275.52	272.31
Ray frequency (per mm)	16	24	25

Discussion and Conclusion

Sonneratia species are true mangrove tree species and restrict to mangrove environment. Although the *Sonneratia* species have common morphological characters they can be distinguished by the shape of pneumatophore, leaf shape, flower color and size. Their flowers bloom in the early morning and their stamen are ephemeral. The calyx of all species is persistent and enlarges with fruit development. Some diagnostic features of the *Sonneratia* species studied are compared in table 1. Pneumatophore shape is the most distinct character in the identification of *Sonneratia* species observed in this study. The pneumatophore of *S. apetala* is the conical shape and of *S. caesolaris* is pincle like whereas of *S. griffithii* is knee like. The leaf shape varies with species as shown in table 1. The flower color is designated by their stamen color. The flowers are whitish green or pale green in *S. apetala*, red or purplish red in *S. caesolaris* and white in *S. griffithii*. The mushroom shaped stigma is the most outstanding character of *S. apetala*.

Variation in anatomical characteristics of wood is not only observed from one species to others but also within the same species; within a tree (Adeniyi *et al*. 2013). This variation influences on the wood properties and reflects in wood utilization. The anatomical characteristics of wood are designated by arrangement, distribution and size of wood cell as well as the presence of cell inclusions such as gum deposits,

crystals, silica body, etc. The anatomical characteristics are not the same for every wood. The cell wall thickness is different in all species. This variability is very important in wood identification and utilization (Alex and Regis 2000).

In this study, the wood anatomical characteristics are found to be not the same in three *Sonneratia* species although the species are under the same genus. As shown in table 2 and table 3 some characteristics are quite different in each species. In macroscopic characters, the wood color of each species is different. The wood color is yellowish brown in *S. apetala*, whitish brown in *S. caesolaris* and pale pinkish yellow in *S.griffithii*. The wood grain of *S. caesolaris* is slightly twisted but straight in the remaining species. The vessel pore distribution is known as porosity of wood. The porosity of all species is diffuse porous although semi-ring porous is sometimes found in *S. caesolaris*. Non-septate fiber is found in *S. caesolaris* and septate fiber in others. In *S. caesolaris* and *S. griffithii* rays are exclusively uniseriate and uniseriate to biseriate in *S. apetala*. Gum deposits are observed in vessel and ray of *S. apetala* and *S.griffithii* and in ray of *S. caesolaris*. Tyloses are sometimes found in *S. caesolaris*and rarely found in *S. griffithii*. Crystals are observed in rays of *S. apetala* only. The qualitative characters discussed above are highly valuable in wood identification.

Mean value of Quantitative characteristics of three *Sonneratia* species is compared in table 3. As shown in table 3. The mean of vessel diameter of all *Sonneratia* species observed are found to be under 80 µm which indicates that such species have small pores. The wood texture is determined by pore size. According to IAWA standard, small pores bestow the fine or very fine texture. Fiber wall thickness is a major governing the density and strength of wood. The species with thin walled fiber have low density and strength and is ,therefore, suitable for light construction purpose (Adeniyi*et al*. 2013). Mean value of fiber wall thickness and fiber diameter of all *Sonneratia* species in this study are under 6 µm and 30 µm respectively. As presented in IAWA standard all are species with thin walled fiber which are more preferred to light construction, light furniture (Adeniyi*et al*. 2013). The fiber length and vessel length ratio is a good index to pulp and paper making. In this study average vessel length of all species is in the range from 370 µm to 490 µm and average fiber length ranges from 610 µm 802 µm.

Adeniyi *et al*. 2013 propose that vessel diameter, cell wall thickness and other indices such as gum deposits are an important area of consideration before wood

utilization. Understanding of anatomical characteristics provides to improve the wood utilization. Therefore anatomical characteristics are very important in both wood identification and utilization. In this study, the macroscopic and qualitative characters such as wood color and grain, ray seriate and type, fiber type and cell inclusions are used to distinguish the *Sonneratia* species. The quantitative characteristics of wood are important indices to appraise the properties and utilization potential of *Sonneratia* species.

References

Adeniyi, I.M., C.A Adebagbo, F.M. Oladapo and G. Ayetan. 2013. Utilization of Some Selected Wood Species in Relation to their Anatomical Features.Vol. 13(9):21 -27.

Alex C. Wiedenhoeft and Regis B. Miller. 2000. Structure and Function of Wood. USDA, Forest Service, Forest Products Laboratory, Madison, WI

Duck, C. Norman and Schmitt,Klaus. 2015. Mangrove management and assessment and mornitoring. in book: Tropical forest handbook. Springer Berlin Heidelbrrg.Pp.1-29.

Gryc, V., H. Vavrcik, E. Piemyslovska and M. Rybnicek. 2008. The relation between the microscopic structure and the wood density of European beech (*Fagussylvatica*L.) Journal of forest science, 54(4): 170–175.

Hou, Ding. 1970. Rhizophoraceae. Flora of Thailand 2(1): 5 – 15.

IAWA. 1989. IAWA list of microscopic features for hardwood identification. IAWA

Kitamura, Shozo.,AmalyosChaniago, Chairil Anwar & Shigeyuki Baba. 1997. Handbook of mangroves in Indonesia. MEDIT, Tokyo, Japan.

Moya, Róger, Carolina Tenorio and Íris Meyer. **2012.** Influence of wood anatomy on moisture content, shrinkage and during defects in *Vochysiaguatemalensis*Donn Sm. **Sci. For., Piracicaba, 40(94): 249-258.**

Qin Haining , Shirley Graham and Michael G. Gilbert.2007. Sonneratiaceae. Flora of China 13: 286–288.

Schulgasser, K. and Allan Witztum. 2011. How the relationship between wood density and shrinkage depends on the microstructure of the cell wall. power point presentation. Ben-Gurion University of the Negev Beer Sheva, Israel.

Shi, Suhua, Yelin Huang, Fengxiao Tan, Xingjin He and David E. Boufford .2002 .Phylogenetic Analysis of the Sonneratiaceae and its Relationship to Lythraceae Based on ITS Sequences of nrDNA. Journal of Plant research: 113: 253-258.

Tomlinson, P.B. 1986. The botany of mangroves. Cambridge university, U.S.A