

Leaflet No. 15/2018

**The Republic of the Union of Myanmar
Ministry of Natural Resources and Environmental Conservation
Forest Department**



**Wood Anatomical characteristics and uses of woody species
utilized by indigenous people in Zeyadam Village, Putao
Township, Kachin State**

Kyaw Win Maung, Assistant Research Officer, Wood Anatomy Section, FRI
Dr. Kyu Kyu Thin, Lecturer (Head of Botany Department), Hakha College, Chin
State

Mr. Yunhong Tan, Professor, XTBG, CAS

Mr. Shishun ZHOU, XTBG, CAS

December, 2018

Contents

စာတမ်းအကျဉ်း	i
Abstract	ii
1. Introduction	1
2. Objectives	1
3. Materials and Methods	1
4. Results and Discussion	5
5. Conclusion	6
6. Acknowledgements	6
References	7

ကချင်ပြည်နယ်၊ပူတာအိုမြို့နယ်၊ ဇီယာဒမ်းရွာမှ ဒေသခံများ အသုံးပြုသော သစ်မျိုးများ၏
သစ်အင်္ဂါဗေဒလက္ခဏာနှင့် အသုံးပြုပုံများအားလေ့လာခြင်း

ဦးကျော်ဝင်းမောင်၊ လက်ထောက်သုတေသနအရာရှိ၊ သစ်အင်္ဂါဗေဒဌာနစိတ်
ဒေါက်တာကြူကြူသင်း၊ ကထိက၊ ဌာနမှူး၊ ရုက္ခဗေဒဌာန၊ ဟားခါးကောလိပ်၊ ချင်းပြည်နယ်

Mr. Yunhong Tan, Professor, XTBG, CAS

Mr. Shishun ZHOU, XTBG, CAS

စာတမ်းအကျဉ်း

မြန်မာနိုင်ငံမြောက်ဖျားပိုင်း၊ ကချင်ပြည်နယ်၊ ပူတာအိုမြို့နယ်အတွင်းရှိ ဒေသခံ
တိုင်းရင်းသားများက နေ့စဉ်နေထိုင်မှုအတွက် အသုံးပြုသည့်သစ်မျိုး(၁၄)မျိုး၏ အသုံးပြုပုံ နှင့်
သစ်အင်္ဂါဗေဒလက္ခဏာများကိုလေ့လာတင်ပြထားပါသည်။ ဤသုတေသနစာတမ်းတွင် လေ့လာ
တင်ပြထားသော အပင်များမှာ *Alnus nepalensis* D.Don, *Evodia trichotoma* (Lour.)
Pierre, *Garcinia stipulata* T.Anders, *Glochidion daltoni* Kurz, *Juglans sigillata* Dode,
kydia calycina Roxb., *Macaranga peltata* (Roxb.) Mueller, *Mallotus tetracocas*
(Kurz.) Roxb, *Meliosma arnottiana* Walp, , *Meliosma thomsonii* King ex Brandis,
Machelia champaca L, *Shorea assamica*, Dyer, *Symplocos cochichinensis* Wall ex
G.Don *Toona ciliate* M.Roem. သစ်မျိုးများဖြစ်ပါသည်။ ၎င်းသစ်မျိုးများကို ဒေသခံ
တိုင်းရင်းသားများက များသောအား ဖြင့်ထင်းနှင့် အိမ်ကြမ်းခင်း အဖြစ်အသုံးပြုကြပါ သည်။
Machelia champaca (စကားဝါ)နှင့် *Shorea assamica* (ကြေးလံ) သစ်မျိုးများကို ကြမ်းခင်း
အပြင် အိမ်တိုင်၊ ထုတ်၊ ယောက်နှင့် ပရိဘောဂအဖြစ် အသုံးပြုကြပါသည်။ သစ်မျိုး (၁၄)မျိုး၏
သစ်အင်္ဂါဗေဒလက္ခဏာများကို လေ့လာရာတွင် *Machelia champaca* (စကားဝါ) သည် fine
to medium texture ဖြစ်ပြီး *Sorea assamica* (Kyilan) သည် fine to coarse texture
ဖြစ်ပါသည်။ ၎င်းမျိုးစိတ် နှစ်မျိုး၏ fiber နံရံများသည်ပါးပါသည်။ *Garcinia stipulata*၏ fiber
နံရံများသည် ထူ၍ fine texture ဖြစ်သော ကြောင့် လေ့လာထားသော သစ်(၁၄) မျိုး တွင်
အလေး ဆုံးသစ် ဖြစ်ပါသည်။ ၎င်းသစ်၏ သစ်ကြောမှာ သစ်ကြောယှက်ဖြစ်သဖြင့် အလွယ်
တကူကွဲအက်ခြင်း မရှိပါ။ *Garcinia stipulata* ၏အထက်ဖော်ပြပါ လက္ခဏာများ အရ
၎င်းသစ်သည် လမ်း၊ တံတား၊ အဆောက် အဦများ ဆောက်လုပ်ရန် သင့်တော်ပါသည်။
ဇီယာဒမ်းရွာရှိ ဒေသခံများ ကလည်း ၎င်းသစ်မျိုး ကို အိမ်တိုင်များ၊ စိုက်ပျိုးရေး လုပ်ငန်းသုံး
ပစ္စည်းများ၊ ကြမ်းခင်းများ အဖြစ် လည်းကောင်း၊ အိမ်၊ တံတား စသည်တို့ ဆောက်လုပ် ရာတွင်
အသုံးပြုကြပါသည်။ ယခုလေ့လာထားသော သစ်မျိုးများ၏ runkle ratio အရ
စက္ကူပျော့ဖတ်အတွက် သင့်တော်သည်ဟု ကောက်ချက် ချနိုင်သော်လည်း လက်တွေ့တွင်မူ
အချို့သစ်မျိုးများသည် ၎င်းတို့၏ lignin ပါဝင်မှုနှင့် flexibility ratio အရ စက္ကူ ပျော့ဖတ်
အတွက် မကောင်းပါ။ ထို့ကြောင့် သစ်မျိုးတစ်မျိုး၏ အသုံးချနိုင်မှုအလားအလာကို ဆုံးဖြတ်
ရာတွင် မှားယွင်း ခန့်မှန်းခြင်းကို ရှောင်နိုင်ရန်အတွက် ၎င်းသစ်မျိုး၏ သစ်အင်္ဂါဗေဒ
လက္ခဏာရပ်အားလုံးကို ထည့်သွင်းစဉ်းစား တွက်ချက်ရန် လိုအပ်ပါသည်။

Wood Anatomical characteristics and uses of woody species utilized by indigenous people in Zeyadam Village, Putao Township, Kachin State

Kyaw Win Maung, Assistant Research Officer, Wood Anatomy Section, FRI
 Dr. Kyu Kyu Thin, Lecturer (Head of Botany Department), Hakha College, Chin State
 Mr. Yunhong Tan, Professor, XTBG, CAS
 Mr. Shishun ZHOU, XTBG, CAS

Wood Anatomical characteristics and uses of woody species utilized by indigenous people in Zeyadam Village, Putao Township, Kachin State

Kyaw Win Maung, Assistant Research Officer, Wood Anatomy Section, FRI
 Dr. Kyu Kyu Thin, Lecturer (Head of Botany Department), Hakha College, Chin State
 Mr. Yunhong Tan, Professor, XTBG, CAS
 Mr. Shishun ZHOU, XTBG, CAS

Abstract

A study on anatomical characters and local uses of (14) tree species utilized by indigenous people in Zeyadam village, Putao Township, Kachin State has been undertaken. The species observed in this research were *Alnus nepalensis* D. Don, *Evodia trichotoma* (Lour.) Pierre, *Garcinia stipulata* T. Anders, *Glochidion daltoni* Kurz, *Juglans sigillata* Dode, *Kydia calycina* Roxb, *Macaranga peltata* (Roxb.) Mueller, *Mallotus tetracocas* (Kurz.) Roxb, *Meliosma arnottiana* Walp, *Meliosma thomsonii* King ex Brandis, *Machelia champaca* L, *Shorea assamica* Dyer, *Symplocos cochinchinensis* Wall ex G. Don and *Toona ciliata* M. Roem. Indigenous people living in Zeyadam Village generally utilize these tree species as fuel wood and floor in house building. Among these species *Machelia champaca* (Sagawa) and *Shorea assamica* (Kyilan) are also used as pile, beam, plank and furniture. In the study on anatomical characteristics, the wood of *Machelia champaca* (Sagawa) is fine to medium texture and of *Shorea assamica* (Kyilan) is fine to coarse. The fiber wall thickness of these two species is thin. Among the species study *Garcinia stipulata* T. Anders is heaviest in weight because the fiber wall thickness of this species is thick and wood texture is fine. Its grain is interlocked which is resistant to splitting. The above anatomical properties make this species suitability in heavy construction. The local people in Zeyadam village utilize this species as posts, agriculture implements and in flooring, house building and bridge construction. According to value of runkle ratio it can conclude that all species except *Garcinia stipulata* T. Anders is suitable for pulp and paper. However, some species are found to be not good for pulp and paper in practices because of their other anatomical characteristics such as lignin content, flexibility ratio etc. therefore it is important to consider all anatomical characteristics in determining the utilization potential to avoid misappraisal.

Keywords: Woody species, Anatomical characteristics, Zeyadam village, Local utilization

Wood Anatomical characteristics and uses of woody species utilized by Indigenous people in Zeyadam village, Putao Township, Kachin State

1. Introduction

Putato Township is northernmost region of Myanmar and situated in Kachin State. Zeyadam Village is a village within the Putato Township and the nearest village to Hponkanrazi wildlife sanctuary. This village is also designated as Rawang village because the most of villagers are Rawang race. A few Lisu and Lisu-Rawang national races are also found in this village. The livelihood of Zeyadam villagers is mainly cultivation, hunting and collection of non-wood forest product including medicinal plants. Hence the villagers depend on the thick evergreen hardwood forest surrounding their village for their subsistence. Their houses are also constructed by wood, bamboo and bamboo products. Moreover, the majority of their household utensils are made up of timber and bamboo.

The hardwood species growing in forest surrounding in their village are utilized for construction, furniture, household utensils and various purposes. The mostly utilized hardwood species are *Alnus nepalensis*, *Evodia trichotoma*, *Garcinia stipulata*, *Glochidion daltoni*, *Juglans sigillata*, *kydia calycina*, *Macaranga peltata*, *Mallotus tetracocas*, *Meliosma arnottiana*, *Meliosma thomsonii*, *Machelia champaca*, *Shorea assamica*, *Symplocos cochichinensis* and *Toona ciliata*. The anatomical characteristics of woods are indispensable for wood identification and estimation of wood properties as well. The studies on anatomical characteristics of woods utilized by the Rawang and Lisu communities are very limited. In this research the wood of 14 woody species growing in forest surrounding in Zeyadam village are investigated to identify their anatomical characteristics and to record local uses of 14 woody species in Zeyadam village according to oral information of indigenous people. The aim of this study is to contribute the anatomical information which is indispensable to improve wood quality by wood technology such as seasoning, preservation and etc. This study also attends to develop the potential uses of these 14 woody species based on their anatomical characteristics.

2. Objectives

To identify anatomical characteristics of 14 woody species utilized by indigenous people in Zeyadam village

To record the local uses of 14 woody species utilized by indigenous people in Zeyadam village

To appraisal the utilization potential based on anatomical characteristics

3. Materials and Methods

The specimens of (14) tree species taken in this research were collected from forest surrounding in Zeyadam Village, Putao Township, Kachin State. The collected species were *Alnus nepalensis*, *Evodia trichotoma*, *Garcinia stipulate*, *Glochidion daltoni*, *Juglans sigillata*, *kydia calycina*, *Macaranga peltata*, *Mallotus tetracocas*, *Meliosma arnottiana*, *Meliosma thomsonii*, *Machelia champaca*, *Shorea assamica*, *Symplocos cochichinensis*, *Toona ciliate*. The wood specimens for wood anatomical studies were taken from 1.3 m height of stem. It was prepared as wood sample included the bark, sapwood and a portion of heartwood and measured 6"x 4"x1".

Only heartwood portion as small wood blocks (1 cm x 1 cm x 2 cm) were prepared for microslides preparation in serial of transverse section, tangential longitudinal section and radial longitudinal 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. These sample blocks were cut 20-25 µm in thickness by sliding microtome. In this work, the microslides of the wood samples were prepared according to the methods as given by Jeffery (1917) with slightly modification. To prepare the permanent miccroslices, these sections were fixed with ferric ammonium sulphate and hamaltoxylin 15 seconds respectively. These sections were stained with safranin for overnight and then dehydrated with serial 50%, 70%, 90%, 95% of ethanol and two changes of xylene. Then sections were cleaned with clove oil and mounted with Canada balsam. These microslides were observed under light microscope and photomicrographed by using Meji biological microscope model: MT 4300H attached with camera and computer. Photomicrographs of the wood were transverse section, tangential and longitudinal section and radial and longitudinal section. And then wood specimens were chipped into fine match- sized splints for maceration. The maceration was prepared by 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. All wood elements were stained with safranin 0, to facilitate measurements of each element. 50 vessel elements, pores, rays and fibres were randomly measured for each species. Other diagnostics features like presence of gum deposits, crystals and silica were also observed. In this study, the terminology used for microscopic description was as given by Wheeler, Bass and Gasson (1939).

Table 1. Macroscopic and microscopic characteristics of (14) tree species from Hponkanrazi wildlife sanctuary Kachin

Macroscopic Characters	Species													
	<i>Alnus nepalensis</i>	<i>Evodia Trichotoma</i>	<i>Garcinia Stipulate</i>	<i>Glochidion daltoni</i>	<i>Juglans sigillata</i>	<i>Kydia calycina</i>	<i>Macaranga peltata</i>	<i>Mallotus tetracocas</i>	<i>Meliosma armottiana</i>	<i>Meliosma thomsonii</i>	<i>Michelia champaca</i>	<i>Shorea assamica</i>	<i>Symplocos cochinchinensis</i>	<i>Toona ciliata</i>
Growth rings	X	√	X	X	√	X	X	√	√	√	√	√	√	√
Texture	F	FC	F	F	F	F	F	FM	F	FM	FM	FC	F	FC
Grain	S	S	I	S	S	S	S	I	S	S	S	S	I	S
Odour&Taste	–	–	–	–	–	–	–	–	–	–	-	–	–	+
Porosity	◆	◆	◆	◆	▲	◆	◆	▲	▲	◆	◆	◆	◆	▲
Perforation plate	Sf	S	S	S	S	S	S	S	S	Sf	Sf	S	Sf	S
Fiber Type	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Fiber septation	◆	◆	■	■	◆	◆	■	◆	◆	◆	◆	■	■	◆
Ray Type	Ho	Ht	Ht	Ht	Ht	Ht	Ht	Ht	Ht	Ht	Ht	Ht	Ht	Ht
Aggregate Ray	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Axial parenchyma	●	●	●▽	●	●	●▽□	●	●▽▼	●	●□	●□	●▼	●	●□
Tyloses	–	+	–	–	–	–	+	+	–	-	-	+	–	–
Gum deposits	+v,r	–	+v, r	+r	+v	+ v,,p	+v,r,p	+v,r	+v,r	+ r,p	+vrp	+v,r	+vr	+v,r
Silica bodies	–	–	+r	–	–	–	–	–	–	-	-	–	+r	+r
Crystals	–	–	–	–	–	–	–	–	–	-	-	–	–	–
Resin canals	–	–	–	–	–	–	–	–	–	–	-	+	–	–

√=Distinct, X=Not distinct, F=Fine to very fine, FC=Very fine to coarse, FM=very fine to medium, S=Straight grained, I=Interlock grained, +=Present, – = Absent, ▲=Semi rings porous,

◆=Diffuse porous, S=Simple, Sf=Scalariform, L=Libriform, ◆=Non-septate, ■=Septate, , Ht=Heterogeneous, Ho=Homogeneous, ●=Diffuse, ▼= Diffuse in aggregate, □=Scanty,

Table 2. Quantitative characteristics of (14) woody species utilized by indigenous people in Zeyadam Village

Macroscopic Characters	Species													
	<i>Alnus nepalensis</i>	<i>Evodia trichotoma</i>	<i>Garcinia Stipulate</i>	<i>Glochidion daltoni</i>	<i>Juglans sigillata</i>	<i>kydia calycina</i>	<i>Macaranga peltata</i>	<i>Mallotus tetracocos</i>	<i>Meliosma arnotiana</i>	<i>Meliosma thomsonii</i>	<i>Michelia champaca</i>	<i>Shorea assimica</i>	<i>Symplocos cochinchinensis</i>	<i>Toona ciliata</i>
Mean Vessel length (µm)	665.43	481.75	726.11	685.72	399.21	361.12	731.86	519.16	755.08	1023.77	953.93	543.93	999.99	359.98
Mean Tangential vessel dia(µm)	67.54	99.93	78	116.54	98.21	153.64	89.58	87.63	128.94	90.91	120.95	141.86	39.74	99.42
Mean No/mm2	26	9	27	12	5	3	8	10	5	12	10	7	52	3
Mean solitary pores (%)	63	61	37	54	70	98	72	53	39	36	36	79	99	57
Mean fiber length (µm)	841.05	1111.7	1848.88	1425.16	977.85	1156.23	1322.15	1035.45	1382.5	1314.66	1524.38	1447.3	1376.57	792.12
Mean fiber dia (µm)	29.08	31.83	19.75	34.5	32.58	32.58	27.91	24.5	44	27.91	28.12	26.16	28.41	24.25
Mean fiber wall thickness (µm)	2.83	3.0	8.12	5.91	2.58	3.83	3.33	3.25	3.5	6.25	4.25	5.08	5.83	2.66
Mean Ray height (µm)	284.78	412.66	1371.86	1250.29	346.65	386.79	356.49	337.45	1439.3	2025.55	411.85	506.76	469.45	288.23
Mean Ray width (µm)	28.7	41.6	59.79	67.75	31.94	40.07	26.9	37.92	107.31	77.59	43.56	46.63	40.25	39.97
Ray seriate	1-2	1-5	1-4	1-5	1-4	1-4	1-2	1-3	1-10	1-4	1-4	1-5	1-5	1-5
Ray/mm tangentially	20(16-23)	6(3-8)	10(7-13)	10(8-13)	11(8-13)	11(7-13)	13 (8-16)	14 (11-16)	7(4-10)	7(5-9)	8(6-9)	7(5-9)	13(7-18)	13 (11-15)
Runkle ratio	0.23	0.23	4.64	0.54	0.19	0.3	0.31	0.32	0.18	0.79	0.79	0.63	0.69	0.27

4. Results and Discussion

The wood anatomy studied was mainly of those growing wild in evergreen forests in surrounding area of Zeyadam village. The trees studied were moderate to large sized. All the trees studied have been regarded as economically important. Fourteen species of trees studied in this work were members of the (11) families and their woods are utilized as house building, furniture and fuel wood by people living in Putao Township. The anatomical structure of wood is not same in all species in this study as Adeniyi *et al* (2013) proposed that variation in anatomical characteristics of wood is not only observed from one species to other but also within same species; within a tree. The variation in anatomical characteristics is highly facilitate for wood identification and influence on working properties governing the utilization potential.

Macroscopic and microscopic characteristics of wood of all species studied are presented in Table 1. Table 2 shows the quantitative characteristics of wood cells of each species. Desch (1973) proposed that interlock grained timbers provide resistance to splitting and straight grained ones split more readily in radial direction. In this study interlock grained woody species include *Garcinia stipulate*, *Mallotus tetracocas* and *Symplocos cochichinensis*, the remaining species are straight grained.

Adeniyi *et al* (2013) recorded that fine texture species are suitable for flooring, tool handle, sculpture and heavy construction. The coarse texture species are suitable for light construction, furniture, packing box and particle boards. In the present research the wood of all species are very fine to fine texture except *Evodia trichotoma*, , *Shorea assamica*, *Toona ciliate*. *Evodia trichotoma*, *Shorea assamica* and *Toona ciliata* are very fine to coarse texture and *Mallotus tetracocas*, *Meliosma thomsonii* and *Machelia champaca* are very fine to medium.

In this study the longest average length of vessel elements is found in *Meliosma thomsonii* and the shortest one in *Toona ciliate*. The vessel pores of, *Evodia trichotoma*, *Macaranga peltata*, *Mallotus tetracocas* and *Shorea assamica* consist of tyloses and of remaing species lack tyloses. Gum deposits are found in vessels of all species except *Glochidion daltoni*, *Evodia trichotoma*. Resin canal was found in only *Shorea assamica*. Silica bodies were found in *Garcinia stipulate*, *Symplocos cochichinensis* and *Toona ciliate*. Scalariform perforation plate are found in, *Alnus nepalensis*, *Meliosma thomsonii* , *Machelia champaca*, *Symplocos cochichinensis* and the remaining species have simple perforation plate. Some species also contain various types of paratracheal parenchyma although apotracheal diffuse parenchyma are found in all species. The paratracheal parenchyma of *kydia calycina* is scanty, diffuse in aggregate, of *Mallotus tetracocas* is diffuse, diffuse in aggregate, vasicentric and of *Garcinia stipulata* is diffuse, diffuse in aggregate . Crystal and gum deposits are absent in axial parenchyma of all species.

The rays of all species are uniseriate to multiseriate . The highest ray frequency between (16- 23) per mm are found in *Alnus nepalensis* and the lowest frequency (3 – 8) per mm tangentially) in *Evodia trichotoma*. The longest average length of fibers is found in *Garcinia stipulata* and shortest one in *Toona ciliata*.

In this study fibers of all species observed are libriform which agree with Pearson and Brown (1932) and Metcalfe and Chalk (1985). The fibers of *Garcinia stipulate*, *Glochidion*

daltoni, *Macaranga peltata*, *Shorea assamica*, *Symplocos cochichinensis*, are septate and that of the *Alnus nepalensis*, *Evodia trichotoma*, *Juglans sigillata*, *kydia calycina*, *Mallotus tetracocas* *Meliosma arnottiana*, *Meliosma thomsonii*, *Michelia champaca*, *Toona ciliate*, are non-septate. Adeniyi *et al* (2013) reported that the species with thick walled fibers have a high density and strength and are useful in heavy construction. In this study the wood of *Garcinia stipulata* is heavy than the remaining because fiber wall of *Garcinia stipulata* is thick and the remaining species has thin walled fiber. Therefore the wood of *Garcinia stipulata* is suitable for heavy construction. The local people use this species as posts, floor and agricultural implements as well as in house building and bridge construction.

All species of runkel ratio are less than 1 except *Garcinia stipulata* which is more than 1. If the species with the runkel ratio which is less than 1 is good for pulp and paper (Jang&Seth 1998) it can consider that all species except *Garcinia stipulata* are good for pulp and paper. However some species are not good for pulp and paper in practices because of their cell inclusion such as silica bodies, gum deposits and other obstacle characteristics such as high lignin content, flexibility ratio etc.

5. Conclusion

The woods of tree species utilized by indigenous people in Zeyadam village possess different anatomical properties because they are belonging to unrelated families. The difference in anatomical characteristics is indispensable for wood identification. The major characteristics are type of perforation plate, axial parenchyma type, ray seriate, porosity and fiber separation. Fiber wall thickness is responsible for wood density. In this study only one species namely *Garcinia stipulata* have thick walled fiber. Therefore it is heaviest among species studied. Each anatomical characteristics influence on particular wood properties and end uses. However the potential utilization may be misappraisal by determining based on only one characteristic. Therefore it is important to consider all anatomical characteristics of a particular species to appraisal the potential utilization.

6. Acknowledgements

Authors would like to express our special thanks to Director General, Forest Department and Director, Forest Research Institute, Yezin for their permission for this research. We are also thankful to U Myint Zaw, Forester and U Kyaw Swar, Forester, Hponkanzarazi Wildlife Sanctuary, Putato for their valuable assistance.

References

- Adeniyi, I.M., C.A Adebago, F.M. Oladapo and G. Ayetan. 2013. Utilization of Some Selected Wood Species in Relation to their Anatomical Features. Vol. 13(9):21 -27.
- Desch, H.E. 1973 Timber: Its structure and properties. Macmillan.
- Jang, H.F. and R.S. Seth 1998 Using confocal microscopy to characterize the collapse behavior of fibers. Tappi J., 81:167-174
- Metcalf, C.R. and L. Chalk. 1989. Anatomy of the dicotyledons. Vol. 2.2nd ed. Oxford University Press. New York.
- Pearson, R.S. & H.P. Brown. 1932. Commercial timbers of India. Vol. 1 and 2. Calcutta, Government of India Central Publication Branch, India.
- Wheeler E.A, P. Bass, P.E. Gasson. 1998. IAWA list of microscopic features for hardwood identification. IAWA Bull 10: 219-332