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A Study on the Morphology and Wood Anatomy of Some Myanmar Species of the Genus *Quercus*

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မြန်မာနိုင်ငံရှိ ညံ၊ ညံဖို မျိုးစုဝင် အပင်များ၏ ပြင်ပရုပ်သွင် နှင့် သစ်အင်္ဂါဗေဒ လက္ခဏာများအား စူးစမ်းလေ့လာခြင်း

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လက်ထောက်ညွှန်ကြားရေးမှူး၊
သစ်တောသုတေသနဌာန၊ ရေဆင်း။

စာတမ်းအကျဉ်းချုပ်

မြန်မာနိုင်ငံ၊ ပြင်ဦးလွင် မြို့နယ်တွင် အထူးသဖြင့် ပေါက်ရောက်သော ညံ၊ ညံဖို မျိုးစုဝင် သစ်ပင် (၉) ပင်၏ပြင်ပရုပ်သွင် နှင့် သစ်အင်္ဂါဗေဒ များကို လေ့လာတင်ပြ ထားပါသည်။ ၎င်းတို့၏ ပင်ပိုင်းနှင့် မျိုးပွားပိုင်း တို့၏ပြင်ပရုပ်သွင် များကိုလည်းကောင်း၊ ပင်စည်မှ ထွက်သော သစ်သားတို့၏ သစ်အင်္ဂါဗေဒ လက္ခဏာများကို လည်းကောင်း တင်ပြထားပါသည်။ တင်ပြထားသော အပင်များမှာ- *Quercus brandisiana* Kurz.(ဖလပ်), *Quercus dealbata* Hook. f. & Thoms (ကြွက်စာနီ), *Quercus fenestrata* Roxb. (ကမျဉ်း), *Quercus griffithii* Hook. f. & Thoms. (ညံဖို), *Quercus helferiana* A.Dc. (ရင့်ဂူအကြီး) , *Quercus lindleyana* Wall. (ဖက်ကြမ်း), *Quercus mespilifolia* Wall. (ရင့်ဂူအသေး) , *Quercus serrata* Thunb, (ညံ) နှင့် *Quercus truncata* King. (ကြွက်စာနက်) တို့ဖြစ်ပါသည်။ မျိုးစိတ်တို့၏ ထင်ရှားသော လက္ခဏာများနှင့်၊ ၎င်းတို့၏ သစ်သားများအသုံးဝင်ပုံ၊ သစ်သားတို့၏ အရေးပါသော ရုက္ခဗေဒဆိုင်ရာ တွေ့ရှိချက်များကို တင်ပြ ဆွေးနွေးထား ပါသည်။

A Study on the Morphology and Wood Anatomy of Some Myanmar Species of the Genus *Quercus*

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Abstract

A study on the morphology and anatomy of *Quercus* species especially found in the Pyinoolwin Township of Myanmar has been undertaken. The morphology of vegetative and reproductive parts and the anatomy of wood of the stems of nine species have been studied. The species observed in this research were *Quercus brandisiana* Kurz, *Quercus dealbata* Hook. f. & Thoms., *Quercus fenestrata* Roxb., *Quercus griffithii* Hook. f. & Thoms., *Quercu fenestrata* Roxb., *Quercus griffithii* Hook. f. & Thoms., *Quercus helferiana* A.DC., *Quercus lidleyana* Wall., *Quercus mespilifolia* Wall., *Quercus serrata* Thunb. and *Quercus truncata* King. The outstanding characteristics of the species and important botanical observation in reference to their wood utilization have been discussed.

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1. Introduction

Thirty species of the large genus **Quercus** belonged to the family Fagaceae, the English name " Oaks" (Foxworthy, 1972) are also distributed through out Myanmar at the elevations of 2,000-8,000 ft., mostly in the hill forests, but also in the plains Upper Myanmar.

Oak was one of the most important of the hardwoods and stands in fourth place among all the woods. Not only the timber was important but the oaks were the largest and finest of the hardwood trees of the forest. Oak wood was hard, tough , durable, resilient, and elastic. Its great strength and ability to resist heavy strains render it valuable for ship-building and all types of heavy construction (Hill, 1952).

Their bark was often rich in tannin and was used for tanning leather, and all species produced wood valuable for fuel and in the manufacture of charcoal. The nut or acorns were very nutritious and are eaten by many animals as well as by man in other countries from prehistoric times (Hill, 1952). The bark of a few species has also been employed in medicine (Bailey, 1939). Besides, the use of cork for stoppers of all sorts is well known and in the manufacture of linoleums, shoe insoles, cigarette tips and etc. (Pearson & Brown, 1932).

A review of literature has revealed that very little work has been made so far on the wood anatomy of this genus. A comparative study on the morphology and anatomy of this genus in Myanmar, has been totally lacking.

In this research, an investigation on the morphology and anatomy of nine species of the genus *Quercus* grown in Pyinoolwin Township was presented.

These nine species are *Quercus brandisiana* Kurz. (Palat), *Q. dealbata* Hook. f & Thoms. (Kywetsa-ni), *Q. fenestrata* Roxb. (Ka-myin), *Q. griffithii* Hook. f & Thoms (Nyanbo), *Q. helferiana* A.DC. (Yingu-akyi), *Q. lindleyana* Wall. (Phetkyan), *Q. mespilifolia* Wall. (Yingu-athe), *Q. serrata* Thunb. (Nyan) and *Q. truncata* King. (Kywetsa-net).

Some Myanmar species of the genus **Quercus** are mostly used as fuel and charcoal and it will be beneficial for the significant value with timber for market of the world as well inland in the near future.

2. Review of the Literature

The genus *Quercus* belongs to the family fagaceae under the order Fagales (Campbell, 1961). Lowson & Sahri (1963) placed the family Fagaceae under the subclass Archichlamydae. Burkill (1935) and Rodger (1963) placed the genus *Quercus* under the family Cupuliferae.

Hooker (1890) reported that the total number of the species of the genus *Quercus* was a about 300 in temperate and tropical region.

Troup (1921) described that about 24 species were found in Myanmar, several of them extended into the eastern Himalaya. However Hundley & Chit Ko Ko (1961) stated that 60 species were found throughout Myanmar.

Myanmar species of **Quercus** were used for lumber and particularly for cabinet wood flooring (Benson, 1957). The main use of the timber was as fuel and in the manufacture of charcoal (Sargent, 1994; street, 1962). Rodger (1963) stated that their wood was fairly hard and split readily, but it was not much used in Myanmar, as most kinds were not durable. They made good fuel, and were also used as times for house-building, boxes, plough, carts and ordinary village purposes.

The nuts were very nutritious, and eaten by many animals as had been stated by Troup (1921), Burkill (1935), Bailey and Bailey (1949), and Benson (1957).

The Morphology and wood anatomy of the genus *Quercus* were described by many workers.

According to Pearson & Brown (1932), the sapwood of the genus *Quercus* was white or greyish-white to reddish-grey, pinkish-or reddish-brown, brown or dark brown, lighter or darker in colour than the heartwood.

The wood was without characteristics odour or taste, moderately heavy to heavy or very heavy, moderately hard to hard or very hard, medium fine-to coarse-and uneven-textured; the growth rings were conspicuous, inconspicuous, or wanting (Pearson & Brown, 1932). Gamble (1902) also described that the wood was brown, very hard to extremely hard, heavy, and annual rings were very distinct.

Vessels of the genus *Quercus* were thin-walled, very large to medium-sized, small, or very small; solitary, irregularly distributed in radial and more or less oblique rows; the wood was ring porous or diffuse porous; perforation was simple; tyloses were abundant sparse, or wanting (Pearson & Brown, 1932). Vessels were solitary, ring porous or dentritic; perforation was scalariform; tyloses and crystals were constantly present (Van Steenis, 1976).

Metcalf and Chalk (1950) also described but the axial parenchyma were apotracheal, typically as scattered cells or irregular uniseriate bands, and the bands more regular land commonly 2 cells wide; chambered crystals were sometimes abundant.

The fibers were non-libriform to libriform and non-septate and non-septate (Pearson & Brown, 1932).

The rays were compound or aggregate, simple or rarely 2- to 3- seriate, and homogenous; the crystals were frequent in the large rays (Pearson & Brown, 1932). The rays were uniseriate or many cells wide, commonly aggregate in the evergreen species, and homogenous (Metcalf & Chalk, 1950).

3. Materials and Methods

All the specimens of the *Quercus* species included in this study were collected from Pyinoolwin Township during the flowering period, from July, 1994 to November, 1995.

For morphological and taxonomic studies, fresh dried and preserved specimens were used, and some were fixed with local ethyl-alcohol for identification.

For anatomical observations, a portion of the stem with bark measured 8" x 6" x 1" was taken at the level of 4 feet high. The wood samples included the bark, the sapwood and a portion of the heartwood. Only the portion of the heartwood was used for microscopic investigation.

The sectioning of the wood were prepared by the use of sliding microtome. The sections were stained with haematoxylin and safranin mounted in Canada balsam.

Macerated wood were prepared by treating plant materials with a mixture of equal volume of 30% hydrogenperoxide and glacial acetic, according to Franklan's method (1946).

General characters of the wood, especially for colour, texture, and grain direction were studied by using wood samples collected.

The photomicrographs were taken by the use of Olympus Universal Research Microscope, Vanox model.

For microscopic descriptions, the terminology was used as had been described by Kribs (1959), and Wheeler, Bass and Gassan (1989).

For the present study, authentication of the plant specimens and wood samples were done partly at the Department of Botany, University of Mandalay and partly at the Wood Anatomy Research Section, Forest Research Institute, Yezin.

4. Observation

4.1 Morphology

Among the nine species of the genus *Quercus* included in this research. *Q. dealbata*, *Q. helzeriana*, *Q. mespilifolia* and *Q. truncata* are large evergreen trees whereas *Q. brandisiana*, *Q. fenestrata* and *Q. lindleyana* are medium-to large - sized evergreen trees, but *Q. griffithii* and *Q. serrata* are large and deciduous.

The leaves are simple, alternate in all of the nine species but closely spiral at the tips of the branchlets in *Q. griffithii*. The leaves of these species very widely in shape as described in the Table 4.1.

The venation of the leaves are unicostate and penninerved. The number of the lateral veins, shape of the tips, bases and margins of the leaves are observed as shown in the Table 4.2.

Table 4.1 The shape of the leaves of the genus *Quercus*

NO.	Species	Shape of Leaves
1.	<i>Q. brandisiana</i> (Palat)	oblanceolate (or) elliptic (or) obovate
2.	<i>Q. dealbata</i> (Kywetsa-ni)	broadly lanceolate (or) narrowly elliptic with tapering ends
3.	<i>Q. fenestrata</i> (Kamyin)	lanceolate (or) elliptic
4.	<i>Q. griffithii</i> (Nyan-bo)	obovate to elliptic-ovate
5.	<i>Q. helzeriana</i> (Yingu-akyi)	ovate-lanceolate (or) elliptic
6.	<i>Q. lindleyana</i> (Phet-Kyan)	obovate
7.	<i>Q. mespilifolia</i> (Yingu-athe)	ovate-lanceolate (or) elliptic
8.	<i>Q. serrata</i> (Nyan)	broadly lanceolate (or) oblong (or) narrowly elliptic-lanceolate
9.	<i>Q. truncata</i> (Kywetsa-net)	oblong-lanceolate (or) elliptic (or) narrowly elliptic with tapering ends

Table 4.2 No. of lateral veins, shapes of the tips, bases and margins of the leaves of the genus Quercus

No.	Species	No. of lateral veins (in pairs)	tip	base	margin
1.	<i>Q. brandisiana</i> (Palat)	11-13	acute	acute	serrate
2.	<i>Q. dealbata</i> (Kywetsa-ni)	9-17	acuminate	acute	entire
3.	<i>Q. fenestrata</i> (Kamyin)	14-17	acuminate	acute	entire
4.	<i>Q. griffithii</i> (Nyan-bo)	10-17	acute to acuminate	acute	serrate with triangular teeth
5.	<i>Q. helferiana</i> (Yingu-akyi)	10-16	acute to acuminate	acute	serrate
6.	<i>Q. lindleyana</i> (Phet-Kyan)	9-14	acute to obtuse	acute	entire (or) rarely sinuate toothed in the upper part
7.	<i>Q. mespilifolia</i> (Yinguathe)	7-15	acute	acute	serrate at the upper part
8.	<i>Q. serrata</i>	9-17	acute to acuminate	rounded (or) acute (or) obtuse	serrate with long brittle-like appendage
9.	<i>Q. truncata</i>	7-14	acuminate	acute	entire

Table 4.3 Hairy characteristics of the lower surfaces of the leaves of the genus *Quercus*.

No.	Species	Hairy characters
1.	<i>Q. brandisiana</i> (Palat)	stellate tomentose
2.	<i>Q. dealbata</i> (Kywetsa-ni)	glabrous
3.	<i>Q. fenestrata</i> (Kamyin)	velutinous
4.	<i>Q. griffithii</i> (Nyan-bo)	stellate pubescent
5.	<i>Q. helferiana</i> (Yingu-akyi)	stellate tomentose
6.	<i>Q. lindleyana</i> (Phet-kyan)	stellate tomentose
7.	<i>Q. mespilifolia</i> (Yinguathe)	stellate tomentose
8.	<i>Q. serrata</i> (Nyan)	pubescent
9.	<i>Q. truncata</i> (Kywetsanet)	glabrous

Table 4.4 The length of the petioles of the genus *Quercus*.

No.	Species	Length of the petioles (cm)
1.	<i>Q. brandisiana</i> (Palat)	1.2-3.0
2.	<i>Q. dealbata</i> (Kywetsa-ni)	1.0-2.0
3.	<i>Q. fenestrata</i> (Kamyin)	1.0-1.7
4.	<i>Q. griffithii</i> (Nyan-bo)	0.7-1.5
5.	<i>Q. helferiana</i> (Yingu-akyi)	0.9-2.5
6.	<i>Q. lindleyana</i> (Phet-kyan)	0.4-0.8
7.	<i>Q. mespilifolia</i> (Yinguathe)	1.5-2.5
8.	<i>Q. serrata</i> (Nyan)	1.7-6.0
9.	<i>Q. truncata</i> (Kywetsanet)	0.4-1.5

The upper surfaces of the leaves of *Q. lindleyana* are stellate pubescent but these of the other species are glabrous. In *Q. helferiana*, *Q. lindleyana* and *Q. mespilifolia*, both of the surfaces of the leaves are stellate tomentose when young. The hairy characters of the lower surfaces of the leaves are observed as shown in the Table 4.3.

The leaves are variable in size. The largest are found in *Q. fenestrata* (i.e., 9.5-32.5 cm long and 3.0-10.5 cm wide) and the smallest in *Q. truncata* and *Q. dealbata* (i.e., 2.5-18.0 cm long and 1-8 cm wide, and 6.5-15.0 cm long 2.0-6.3 cm wide respectively).

The petioles are usually cylindrical and vary considerably in length. The longest petioles are found in *Q. serrata* and the shortest in *Q. lindleyana* (Table 4.4).

The inflorescence are found to be axillary and terminal spikes and the types of flowers borne on the spikes are shown in the Table 4.5.

Tables 4.5 Types of flowers on the spikes of the genus *Quercus*

No.	Species	Pendulous spike	erect spike
1.	<i>Q. brandisiana</i> (Palat)	male	female
2.	<i>Q. dealbata</i> (Kywetsa-ni)	-	male and female (or) male
3.	<i>Q. fenestrata</i> (kamyin)	-	male and female (or) male
4.	<i>Q. griffithii</i> (Nyan-bo)	male	female
5.	<i>Q. helferiana</i> (Yingu-akyi)	male	female
6.	<i>Q. lindleyana</i> (Phet-kyan)	-	male (or) female
7.	<i>Q. mespilifolia</i> (Yingu-athe	male	female
8.)	male	female
9.	<i>Q. serrata</i> (Nyan)	-	male and female
	<i>Q. truncata</i> (Kywetsa-net)		(or) male

Table 4.6 The number of the perianth and stamens of the genus *Quercus*

No.	Species	No. of perianth lobes	erect spike
1.	<i>Q. brandisiana</i> (Palat)	9-10	13-17
2.	<i>Q. dealbata</i> (Kywetsa-ni)	4-5	8-10
3.	<i>Q. fenestrata</i> (kamyin)	4-6	8-12
4.	<i>Q. griffithii</i> (Nyan-bo)	4-7	6-11
5.	<i>Q. helferiana</i> (Yingu-akyi)	4-5	12-15
6.	<i>Q. lindleyana</i> (Phet-kyan)	3	9-13
7.	<i>Q. mespilifolia</i> (Yingu-athe	7-10	10-15
8.)	2-5	3-5
9.	<i>Q. serrata</i> (Nyan)	5	8-10
	<i>Q. truncata</i> (Kywetsa-net)		

The flowers are small, unisexual, monoecious, bracteate and regular. The perianth lobes of male flowers are valvate in aestivation. The number of the perianth lobes and stamens are shown in Table 4.6. The pstillodes are found only in the male flowers of *Q. fenestrata*, *Q. lindleyana*, and *Q. truncata*.

The filament are filiform and free. The anthers are ditheous, basifixed and dehiscence by longitudinal slits.

The female flowers are solitary or fasciculated at each point of the attachment on the spikes in all of the nine species. Each of the female flowers is enclosed by involucre of minute numerous bracts. The pistils are tetra-or penta-carpellary in *Q. helferiana* and *Q. mespilifolia*, but tricarpellary in the other seven species. All of the nine species have syncarpous ovary with 2 ovules in each locule. Ovaries are globose in *Q. dealbata* but ovoid in the rest of the species.

The placentation are axile-pendulous in *Q. dealbata*, *Q. fenestrata*, and *Q. lindleyana*; but axile in the rest of the other species.

Table 4.7 Hairy characters of the ovaries and the number of the styles of the genus *Quercus*

No.	Species	Hairy characters of the ovaries	No. of the styles
1.	<i>Q. brandisiana</i> (Palat)	Stellate tomentose	3
2.	<i>Q. dealbata</i> (Kywetsa-ni)	tomentose	1
3.	<i>Q. fenestrata</i> (kamyin)	velutinous	2-4
4.	<i>Q. griffithii</i> (Nyan-bo)	softly stellate tomentose	1
5.	<i>Q. helferiana</i> (Yingu-akyi)	glabrous	4 (or) 5
6.	<i>Q. lindleyana</i> (Phet-kyan)	tomentose	3 (or) 4
7.	<i>Q. mespilifolia</i> (Yingu-athe)	softly stellate tomentose	5-8
8.	<i>Q. serrata</i> (Nyan)	tomentose	1
9.	<i>Q. truncata</i> (Kywetsa-net)	stellate tomentose	1-4

Table 4.8 The shape and size of the nuts of the genus *Quercus*

No.	Species	shape	Size	
			length (mm)	wide (mm)
1.	<i>Q. brandisiana</i> (Palat)	globose (or) sub-globose	9 (or) 10	6 (or) 7
2.	<i>Q. dealbata</i> (Kywetsa-ni)	globose (or) sub-globose	4-17	5-15
3.	<i>Q. fenestrata</i> (Kamyin)	globose (or) sub-globose	13-19	18-23
4.	<i>Q. griffithii</i> (Nyan-bo)	elongate ovoid	12-27	7-16
5.	<i>Q. helferiana</i> (Yingu-akyi)	flattened & apiculate	4-7	11-17
6.	<i>Q. lindleyana</i> (Phet-kyan)	cylindricconical (or) slightly triangular	12-23	8-17
7.	<i>Q. mespilifolia</i> (Yingu-athe)	globose (or) sub-globose	6.5-17.0	6-15
8.	<i>Q. serrata</i> (Nyan)	globose (or) sub-globose	13-21	12-18
9.	<i>Q. truncata</i> (kywetsa-net)	obovoid	10-15	7-14

Table 4.9 The shape and size of the cups of the genus *Quercus*

No.	Species	shape	Size	
			length (mm)	wide (mm)
1.	<i>Q. brandisiana</i> (Palat)	hemispheric with 3-5 concentric rings	5-7	7-9
2.	<i>Q. dealbata</i> (Kywetsa-ni)	hemispheric with woody scales	4-7	5-12
3.	<i>Q. fenestrata</i> (Kamyin)	hemispheric with thin scales	5-20	20-25
4.	<i>Q. griffithii</i> (Nyan-bo)	hemispheric with woody scales	7-10	8-14
5.	<i>Q. helferiana</i> (Yingu-akyi)	hemispheric(or) flattened with 9-11 concentric rings	7-10	17-22
6.	<i>Q. lindleyana</i> (Phet-kyan)	hemispheric with woody scales	4-6	12-15
7.	<i>Q. mespilifolia</i> (Yingu-athe)	hemispheric with 4-7 concentric rings	7-14	6-22
8.	<i>Q. serrata</i> (Nyan)	hemispheric with tentacle-like bracts	13-16	16-20
9.	<i>Q. truncata</i> (kywetsa-net)	sub-hemispheric and flat truncate at the top	11-20	13-21

Table 4.10 Shape of the seeds of the genus *Quercus*

No	Species	Shape
1.	<i>Q. brandisiana</i> (Palat)	globose
2.	<i>Q. dealbata</i> (Kywetsa-ni)	globose
3.	<i>Q. fenestrata</i> (Ka-myin)	5-lobed ovoid
4.	<i>Q. griffithii</i> (Nyanbo)	elongated-ovoid
5.	<i>Q. helferiana</i> (Yingu-akyi)	horizontally
6.	<i>Q. lindleyana</i> (Phet-kyan)	compressed
7.	<i>Q. mespilifolia</i> (Yingu-athe)	cylindric-conical
8.	<i>Q. serrata</i> (Nyan)	ovoid
9.	<i>Q. truncata</i> (Kywetsa-net)	globose
		globose

Hairy characters of the ovaries and the number of the styles of the nine species are shown in Table 4.7.

The stigma are simple in *Q. dealbata*, *Q. fenestrata*, *Q. lindleyana* and *Q. truncata*, discoid in *Q. brandisiana*, *Q. helferiana* and *Q. mespilifolia*, 2- to 4- fid in *Q. griffithii* and 3-to 5- fid in *Q. serrata*.

The fruits are indehiscent one-seeded nuts. The nuts vary in shape and size as shown in Table 4.8.

The cups are formed by the persistent and growing involucre of bracts. The cups vary in shape and size as shown in Table 4.9.

The nuts are one-seeded and the seeds vary in shape as in Tables 4.10.

ANATOMY Key to the species

1. Ring porous; large rays: apotrachela parenchyma sparse 2.
2. Diffuse porous; aggregate rays; apotrachel parenchyma abundant..... 3.
 2. Mean pore per sq. mm less than 7; pore with tyloses abundant; wood coarse-textured; odour in heartwood distinct *Q. griffithii* (1)
 2. Mean pore per sq. mm more than 9; pore with tyloses spare; wood medium-textured; odour in heartwood not distinct..... *Q. serrata* (2)
3. Vessel with perforation exclusively simple..... 4.
3. Vessel with perforation scalariform-simple, reticulate-simple or foraminate-simple..... 7.
 4. Pores solitary or occasionally in radial multiples; tyloses absent; ray per mm more than 17..... *Q. dealbata* (3)
 4. Pores exclusively solitary, tyloses present; ray per. mm less than 16..... 5.
5. Pore tangential diameter very small to medium-sized; crystals rare or absent in the ray cells..... *Q. brandisiana*(4)
5. Pore tangential diameter moderately small to moderately large; crystals present in the ray cells..... 6
 6. The maximum height of multiseriate rays less than 3000 um: prismatic crystals frequently present in 1- to 11 chambered axial parenchyma cells..... *Q. helferiana* (5)
 6. The maximum height of multiseriate rays more than 4000 um; prismatic crystals frequently present in 1 to 4 chambered axial parenchyma cells..... *Q. lindleyana* (6)
7. Pore pre sq. mm. few to moderately few; ray wide less than 10 cells wide; the minimum ray per mm more than 10..... *Q. truncata* (7)

7. Pore pre sq. mm.. few to moderately few; ray wide more than 10 cells wide; the minimum ray per mm less than 10..... 8.
8. Prismatic crystals occasionally present in 3 to 4 chambered axial parenchyma cells; crystal spare in way cells; vessel with reticulate-simple perforation; wood fine-textured..... *Q. fenestrata* (8)
8. Prismatic crystal frequently present in 1 to 27 chambered axial parenchyma cells; crystal abundant in ray cells; vessel with foraminate-simple perforation; wood medium-textured..... *Q. mespilifolia*(9)

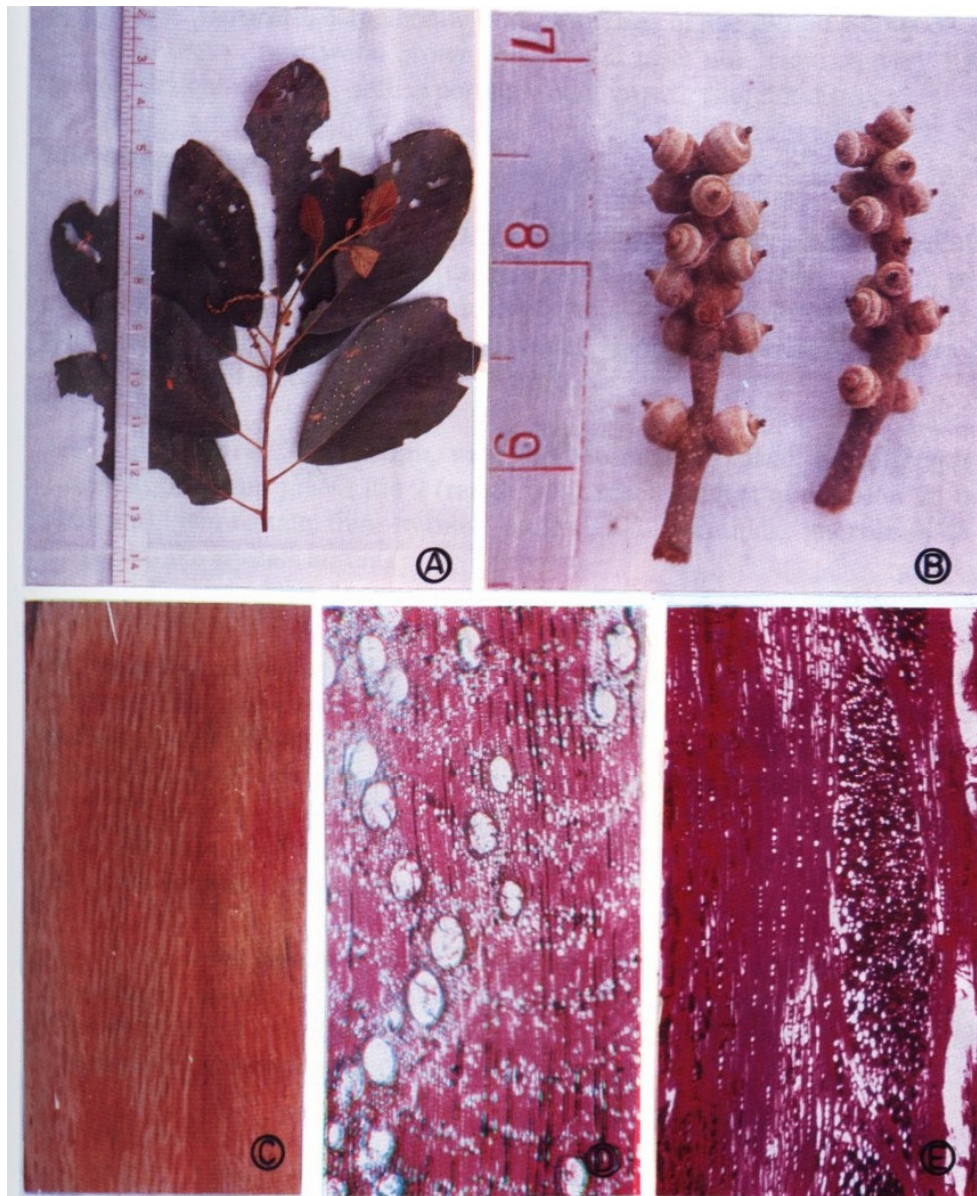


Fig.1. *Quercus brandisiana*.

- A. Inflorescences on a branchlet.
- B. Young fruits (acorns) with persistent style.
- C. Portion of wood in natural colour as seen.
- D. T.S. of wood showing distribution of vessels in solitary (x 37).
- E. T.L.S of wood showing aggregate rays (x 37).

1. *Quercus Brandisiana* Kurz

General Characteristic and properties of the Wood Sapwood light pale yellowish- brown, heartwood brown; odour and taste not distinct; very hard; fine-texture; straight-grained; diffuse porous wood; growth ring not distinct.

Microscopic Characteristic

Vessel element : Diffused porous; pore very small to medium-sized; mean tangential diameter 127 μm (range 41-185 μm); number per sq .mm. moderately numerous (range 5-12); pores exclusively; thick-walled; tyloses present; perforation plate simple, tailed one or both ends; vessel element moderately short to medium sized, mean length 462 (range 227-779 μm).

Fibres : Libriform, very short to medium sized, mean length 974 μm (range 687-1353 μm) F/V ratio 2 (range 1-5); mean tangential diameter 21 μm (range 13-30 μm) : non-septate, thin-to thick –walled, 3-11 μm thick; interfibre pits minute, simple, slit-like crystals absent.

Rays : Homocellular, 1-25 cells wide, mostly uniseriate and aggregate rays, rarely bi-to tetra –seriate; 6-19 per mm tangentially, moderately numerous to very numerous; uniseriate rays extremely fine to moderately fine, mean width 15 μm (range 10-26 μm), mean height 238 μm (range 82-605 μm), 3-16 cells high; multiseriate rays moderately fine to extremely board, mean wide 338 μm (range 41-605 μm), mean high 1571 μm (range 174-5556 μm), 6-168 cells high; ray vessel pitting alternate, round or oval or elliptic in shape, bordered, 3-15 μm diameter; gum deposits in ray cells; crystals occasionally present.

Axial parenchyma : Abundant, pareteracheal unilateral or vasicentric or confluent connecting 2-4 pores; apotrascheal parenchyma relatively abundant, diffuse or diffuse in aggregate; prismatic crystal moderately abundant, frequently in 2 to 12 chambered parenchyma; gum deposits present.

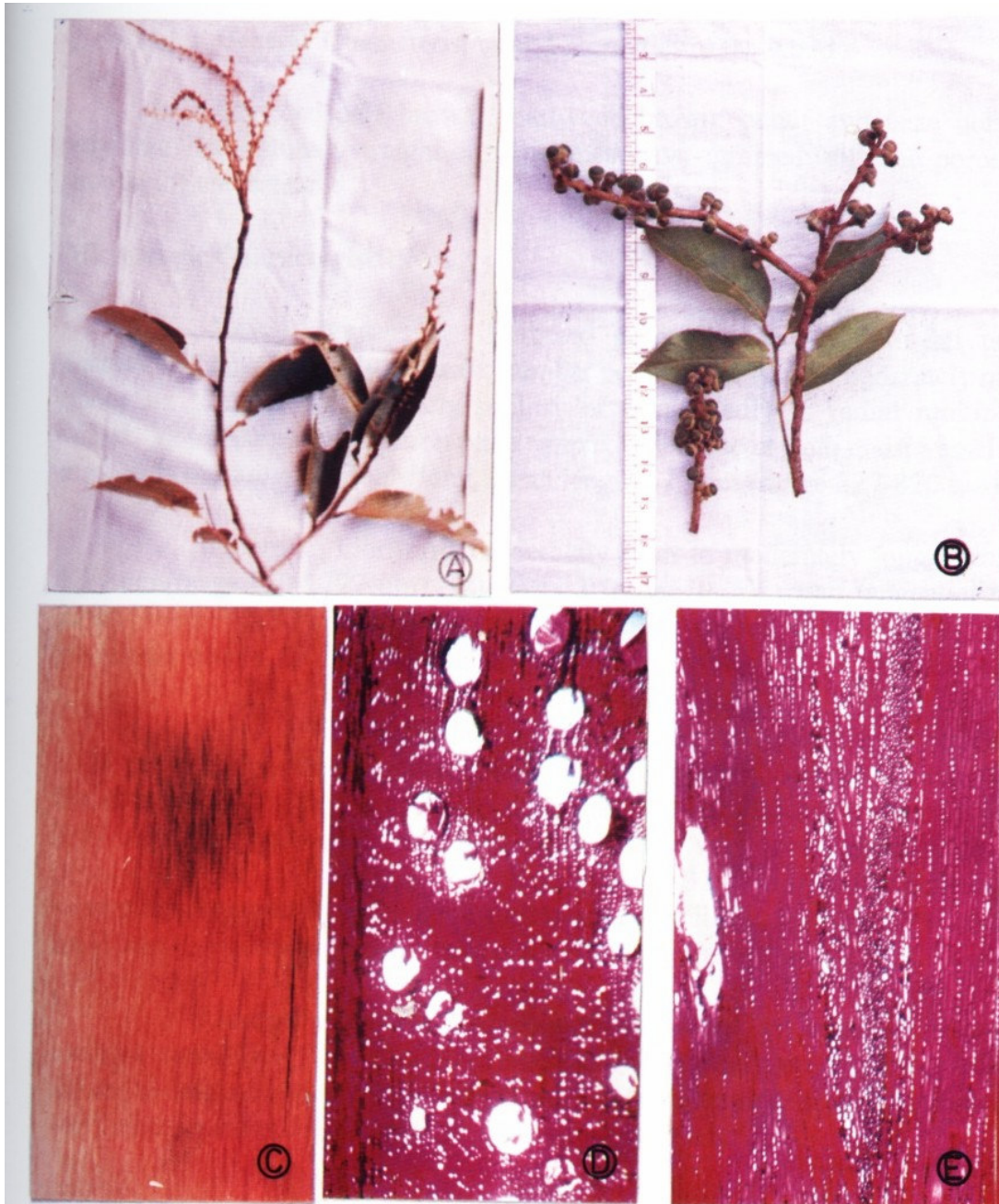


Fig.2. *Quercus dealbata*.

- A. Inflorescences on the branchlets.
- B. Fruits (acorns) with persistent styles.
- C. Portion of wood in natural colour as seen.
- D. T.S of wood showing distribution of vessel in solitary and abundant apotracheal parenchyma (x 37).
- E. T.L.S of wood showing types of aggregate rays and uniseriate rays (x 37).

2. *Quercus Dealbata* Hook. F & Thoms.

General Characteristics and properties of the wood.

Sapwood pale brown, heartwood brown; odour and taste not distinct; very hard; fine-textured; straight or sometimes wavy-grained; diffused porous wood; growth ring not distinct.

Microscopic Characteristics

Vessel element : Diffused porous; pores large; mean tangential diameter 135 um (range 41-236 um); number per sq. mm. few to moderately numerous (range 3-n 12), pores exclusively solitary or occasionally in radial multiples; thin walled; tyloses absent, perforation plate simple, tailed one or both ends; vessel elements moderately short to moderately long, mean length 527 um (range 227-820 um).

Fibres : Libriform, moderately short to moderately long, mean length 1220 um (range 810-1722 um), F/V ratio 2 (range 1-5), mean tangential diameter 22 um (range 13-30 um); non-septate, thin to thick-walled, 4-13 um thick; interfibre pits minute, simple, sit-like; crystals absent.

Rays : Homocellular, 1-19 cells wide, uniseriate and aggregated rays; 10-26 per mm tangentially, numerous to very numerous; universal rays extremely fine, mean width 15 um (range 10-26 um) mean height 224 um (range 51-461 um), 2-37 cells high; multiseriate rays moderately fine to very broad, mean wide 136 um (range 41-236 um), mean height 840 um (range 164-3178 um), 9-100 cells high; rays vessel pitting opposite to alternate, round or oval or elliptic in shape, bordered, 4-20 um in diameter; gum deposits in rays cells; crystals present.

Axial parenchyma : Abundant, paratracheal unilateral or vasicentric or confluent connecting 2 or 3 pores; apotracheal parenchyma relatively abundant, diffused or diffused in aggregate; prismatic crystals moderately abundant, frequently in 1 to 7 chambered axial parenchyma; gum deposits present.



Fig.3. *Quercus fenestrata*.

- A. Inflorescences on a branchlet.
- B. Mature fruits (acorns) almost enclosed by the cup
- C. Portion of wood in natural colour as seen.
- D. T.S of wood showing distribution of vessels in solitary and confluent parenchyma (x 37).
- E. T.L.S of wood showing aggregate rays (x 37).

3. *Quercus Fenestrata* Roxb.

General Characteristic and properties of the wood.

Sapwood pale brownish-white, heartwood radish-brown; odour and taste not distinct; hard; fine-textured; straight-grained d; diffused porous wood; growth ring not distinct.

Microscopic Characteristics

Vessel element : Diffused porous; pores very small to medium sized; mean tangential diameter 120 µm (range 41-174 µm); number per sq. mm . few to moderately numerous (range 3-n 12), pores exclusively solitary or occasionally in radial multiples; thin walled; tyloses spare; perforation plate simple or occasionally reticulate; tailed one or both ends; vessel elements moderately short to medium sized, mean length 456 µm (range 256-707 µm).

Fibres : Libriform, very short to medium-sized, mean length 880 µm (range 636-1199 µm), F/V ratio 2 (range 1-4), mean tangential diameter 18 µm (range 10-25 µm); non-septate, thin to thick-walled, 3-8 µm thick; interfibre pits minute, simple, slit-like; crystals absent.

Rays : Homocellular, 1-30 cells wide, uniseriate and aggregate rays to large rays; 6-25 per mm tangentially, numerous to very numerous; uniseriate rays extremely fine to very fine, mean width 14 µm (range 10-21 µm), mean height 210 µm (range 51-451 µm), 2-25 cells high; multiseriate rays medium-sized extremely broad, mean wide 267 µm (range 51-707 µm), mean height 2112 µm (range 185-6786 µm), 9-315 cells high; rays vessel pitting opposite to alternate, rounded or oval or elliptic in shape, bordered, 4- 20 µm in diameter; gum deposits in rays cells; crystals present.

Axial parenchyma : Abundant, paratracheal unilateral or vasicentric or confluent connecting 2 or 3 pores; apotracheal parenchyma relatively abundant, diffused or diffused in aggregate; prismatic crystals rare, occasionally in 3 to 4 chambered axial parenchyma; gum deposits in abundant.

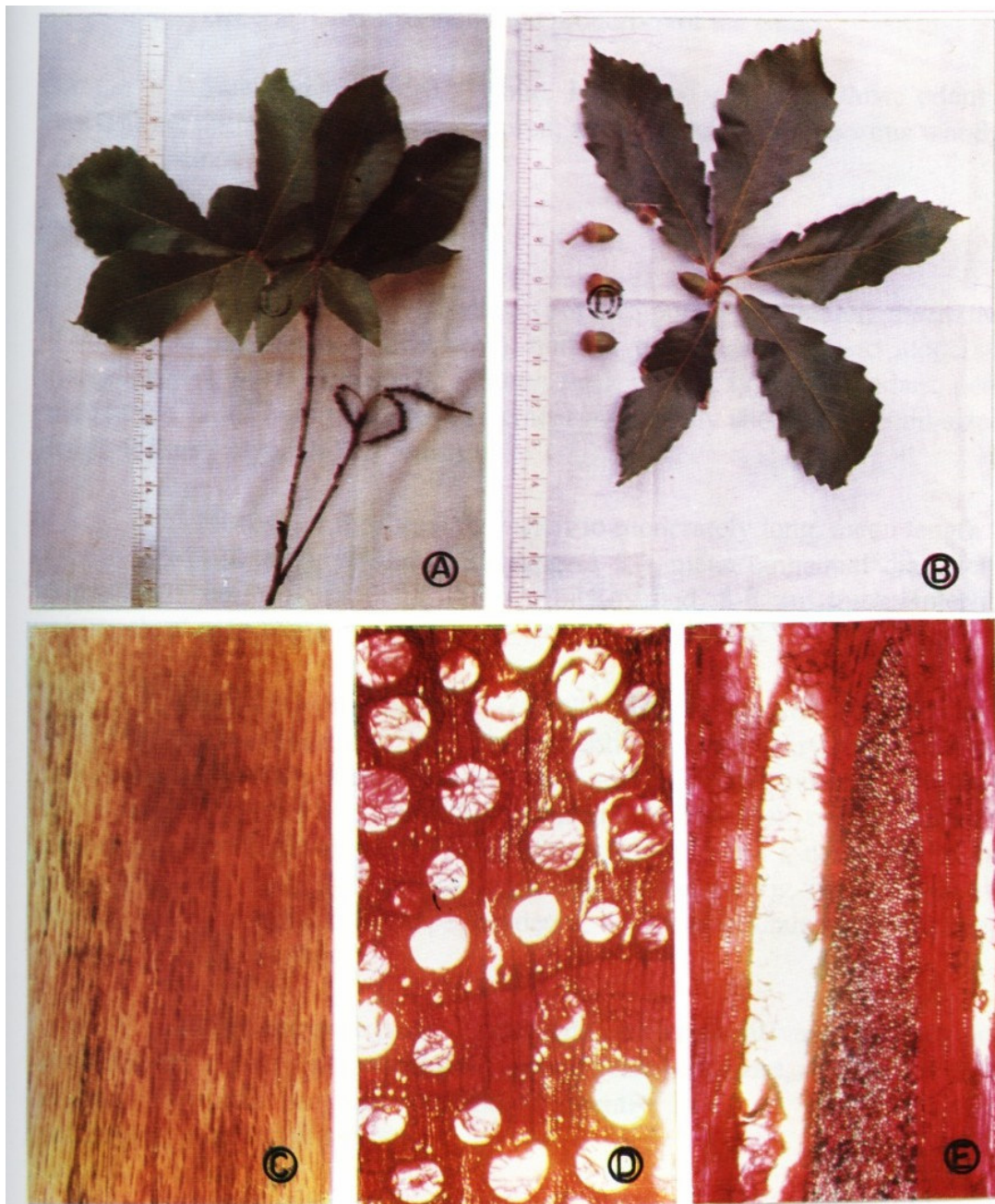


Fig.4. *Quercus griffithii*.

- A. Inflorescences on the branchlets.
- B. Mature fruits (acorns).
- C. Portion of wood in natural colour as seen.
- D. T.S of wood showing distribution of vessels in solitary and abundant tyloses (x 37).
- E. T.L.S of wood showing large ray (x 37).

4. *Quercus Griffuthii* Hook. f Thoms.

General Characteristics and properties of the wood.

Sapwood yellowish-white, heartwood greyish-yellow; odour distinct and taste not distinct; hard; coarse-textured; straight grained ring porous wood; growth ring very distinct.

Microscopic Characteristics

Vessel element : Ring porous; pores very small; mean tangential diameter 205 um (range 41-349 um); number per sq. mm. few to moderately few (range 2-n 10), pores exclusively solitary; thick walled; tyloses abundant, perforation plate simple, tailed both ends; vessel element moderately short to medium-sized, mean length 488 um (range 267-707 um).

Fibres : Libriform, very short to moderately long, mean length 808 um (range 595-1128 um), F/V ratio 2 (range 1-5), mean tangential diameter 20 um (range 13-28 um); non-septate, thin to thick-walled, 3-8 um thick; interfibre pits minute, simple, slit-like; crystals absent.

Rays : Homocellular, 1-28 cells wide, mostly uniseriate and large rays, rarely bi-to tertra-seriate; 4-15 per mm tangentially, few to very numerous; universal rays extremely fine to moderately fine, mean width 19 um (range 10-31 um), mean height 202 um (range 51-451 um), 2-20 cells high; multiseriate rays moderately broad to extremely broad, mean wide 331 um (range 154-513 um), mean height 1927 um (range 133-5679 um), 7-278 cells high; rays vessel pitting opposite to alternate, rounded or oval or elliptic in shape, bordered, 4-13 um in diameter; gum deposits in rays cells; crystals abundant.

Axial Parenchyma : Abundant : Abundant, paratracheal vasicentric or confluent connecting 2-7 pores; apotracheal parenchyma relatively spare, diffused in aggregate; prismatic crystals present, frequently in 3 to 35 chambered axial parenchyma; gum deposit present.



Fig.5. *Quercus helferiana*.
 A. Inflorescences on the branchlets.
 B. Mature fruits (acorns).
 C. Portion of wood in natural colour as seen.
 D. T.S of wood showing distribution of vessels in solitary and abundant apotracheal parenchyma (x 37).
 E. T.L.S of wood showing aggregate rays (x 37).

5. *Quercus Helferiana* A. DC.

General Characteristics and properties of the wood.

Sapwood pale brown, heartwood reddish-brown; odour and taste not distinct; very hard; fine-textures; straight grained diffused porous wood; growth ring not distinct.

Microscopic Characteristics

Vessel element : Diffused porous; pores moderately small to moderately large; mean tangential diameter 139 μm (range 51-277 μm); number per sq. mm. few to moderately few (range 2-8), pores exclusively solitary; thin walled; tyloses present, perforation plate simple, tailed one or both ends; vessel elements moderately short to moderately long, mean length 549 μm (range 267-707 μm).

Fibres : Libriform, moderately short to moderately long, mean length 1187 μm (range 789-1619 μm), F/V ratio 2 (range 1-4), mean tangential diameter 21 μm (range 13-28 μm); non-septate, thin to thick-walled, 3-10 μm thick; interfibre pits minute, simple, slit-like; crystals absent.

Rays : Homocellular, 1-31 cells wide, uniseriate and aggregate rays, 10-20 per mm tangentially, few to very numerous; universal rays extremely fine to moderately fine, mean width 17 μm (range 10-27 μm), mean height 315 μm (range 62-789 μm), 4-44 cells high; multiseriate rays moderately fine to extremely broad, mean wide 254 μm (range 31-656 μm), mean height 847 μm (range 123-2614 μm), 5-95 cells high; rays vessel pitting opposite to alternate, rounded or oval, bordered, 4-9 μm in diameter; gum deposits in rays cells; crystals present.

Axial parenchyma : Moderately abundant, paratracheal unilateral or vasicentric or confluent connecting 2-3 pores; apotracheal parenchyma relatively abundant, diffused or diffused in aggregate; prismatic crystals present, frequently in 1 to 11 chambered axial parenchyma; gum deposits present.

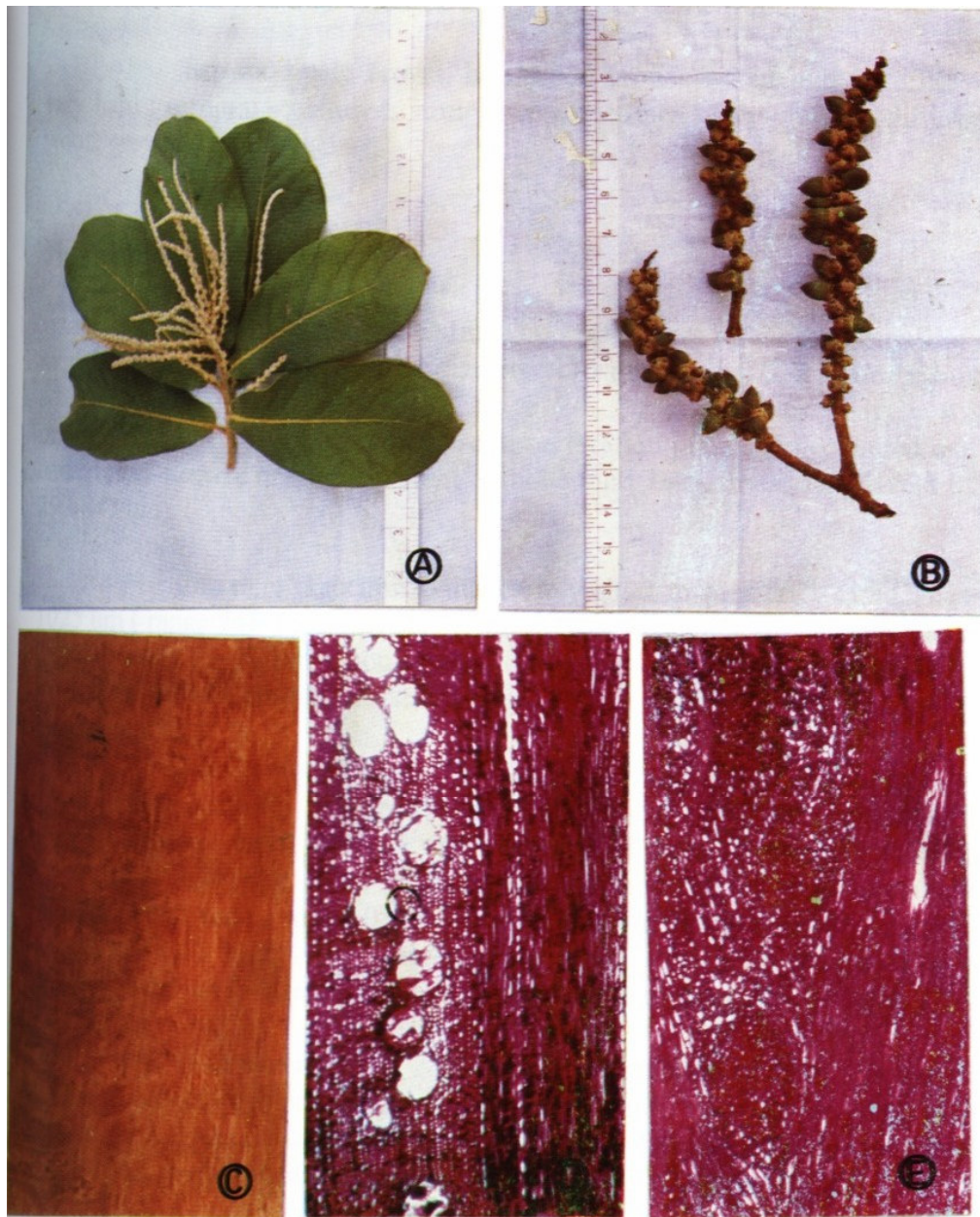


Fig.6. *Quercus lindleyana*.

- A. Inflorescences on a branchlet showing male and female spikes.
- B. Fruits (acorns).
- C. Portion of wood in natural colour as seen.
- D. T.S of wood showing distribution of vessels in solitary (x 37).
- E. T.L.S of wood showing aggregate rays.

6. *Quercus Lindleyana* Wall.

General Characteristic and properties of the wood.

Sapwood pale brown, heartwood brown; odour and taste not distinct; very hard; medium-textured; straight or sometimes wavy-grained; diffused porous wood; growth ring not distinct.

Microscopic Characteristics

Vessel element : Diffused porous; pores moderately small to medium moderately large; mean tangential diameter 173 μm (range 72-256 μm); number per sq. mm. few to moderately few (range 2-n 10), pores exclusively solitary or occasionally; thin walled; tyloses present; perforation plate simple; tailed one or both ends; vessel elements moderately short to moderately long, mean length 538 μm (range 297-841 μm).

Fibres : Libriform, moderately short to medium-sized, mean length 1025 μm (range 748-1302 μm), F/V ratio 2 (range 1-4), mean tangential diameter 21 μm (range 13-30 μm); non-septate, thin to thick-walled, 3-10 μm thick; interfibre pits minute, simple, slit-like; crystals absent.

Rays : Homocellular, 1-41 cells wide, uniseriate and aggregate rays; 4-21 per mm tangentially, numerous; uniseriate rays extremely fine to moderately fine, mean width 16 μm (range 10-31 μm) mean height 235 μm (range 82-502 μm), 2-26 cells high; multiseriate rays moderately broad extremely broad, mean wide 558 μm (range 103-953 μm), mean height 2437 μm (range 185-7144 μm), 6-259 cells high; rays vessel pitting opposite to alternate, rounded or oval, bordered, 4-10 μm in diameter; gum deposits in rays cells; crystals present.

Axial parenchyma : Abundant, paratracheal unilateral or vasicentric or confluent connecting 2 pores; apotracheal parenchyma relatively abundant, diffused or diffused in aggregate; prismatic crystals rare, sometimes 1 or 4 chambered axial parenchyma; gum deposits abundant.

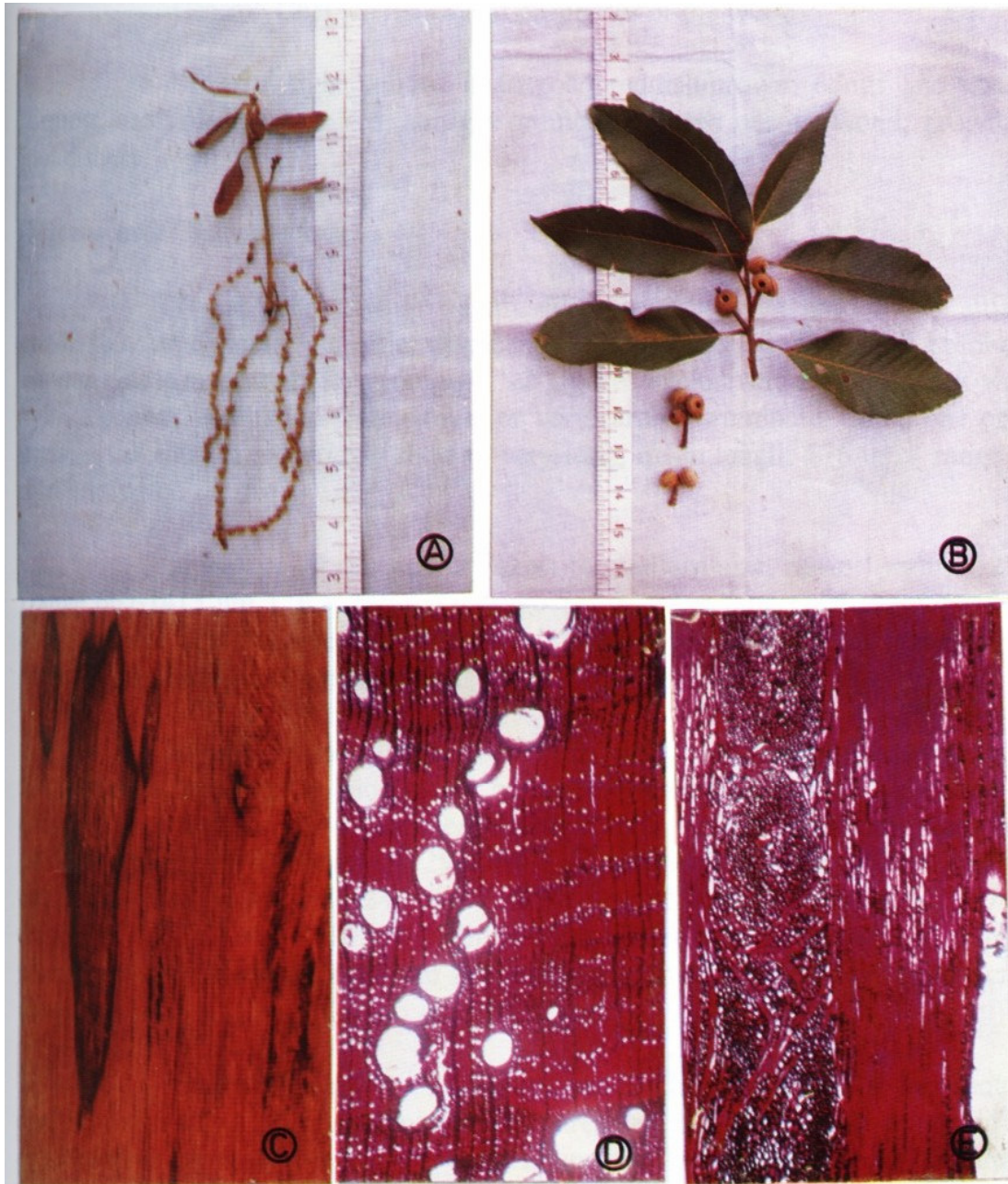


Fig.7. *Quercus mespilifolia*.

A. Inflorescences on a branchlet.

B. Young fruits (acorns).

C. Portion of wood in natural colour as seen.

D. T.S of wood showing distribution of vessels in solitary and abundant confluent parenchyma (x 37).

E. T.L.S of wood showing types of aggregate rays and uniseriate rays (x 37).

7. *Quercus Mespilifolia* Wall

General Characteristics and properties of the wood.

Sapwood light yellow, heartwood reddish-brown; odour and taste not distinct; hard; medium-textured; straight grained; diffused porous wood; growth ring not distinct.

Microscopic Characteristics

Vessel element : Diffused porous; moderately small to moderately large; mean tangential diameter 175 µm (range 51-287 µm); number per sq. mm. few to moderately few (range 4-12), pores exclusively solitary; thick walled; tyloses present, perforation plate simple or very rarely foraminate, tailed one or both ends; vessel elements moderately short to very long, mean length 576 µm (range 287-1148 µm).

Fibres : Libriform, very short to medium size, mean length 1029 µm (range 667-1415 µm), F/V ratio 2 (range 1-4), mean tangential diameter 21 µm (range 13-30 µm); non-septate, thin to thick-walled, 3-11 µm thick; interfibre pits minute, simple, slit-like; crystals absent.

Rays : Homocellular, 1-28 cells wide, uniseriate and aggregate rays, 5-18 per mm tangentially, moderately numerous to very numerous; universal rays extremely fine to moderately fine, mean width 15 µm (range 10-26 µm), mean height 269 µm (range 103-615 µm), 2-29 cells high; multiseriate rays moderately fine to extremely broad, mean wide 249 µm (range 31-533 µm), mean height 1376 µm (range 277-3680 µm), 7-168 cells high; rays vessel pitting opposite to alternate, rounded or oval, bordered, 4-18 µm in diameter; gum deposits in rays cells; crystal abundant.

Axial parenchyma : Abundant, paratracheal unilateral or vasicentric or confluent connecting 2-7 pores; apotracheal parenchyma relatively abundant, diffused or diffused in aggregate: prismatic crystals abundant, frequently in 1 to 27 chambered axial parenchyma; gum deposits present.

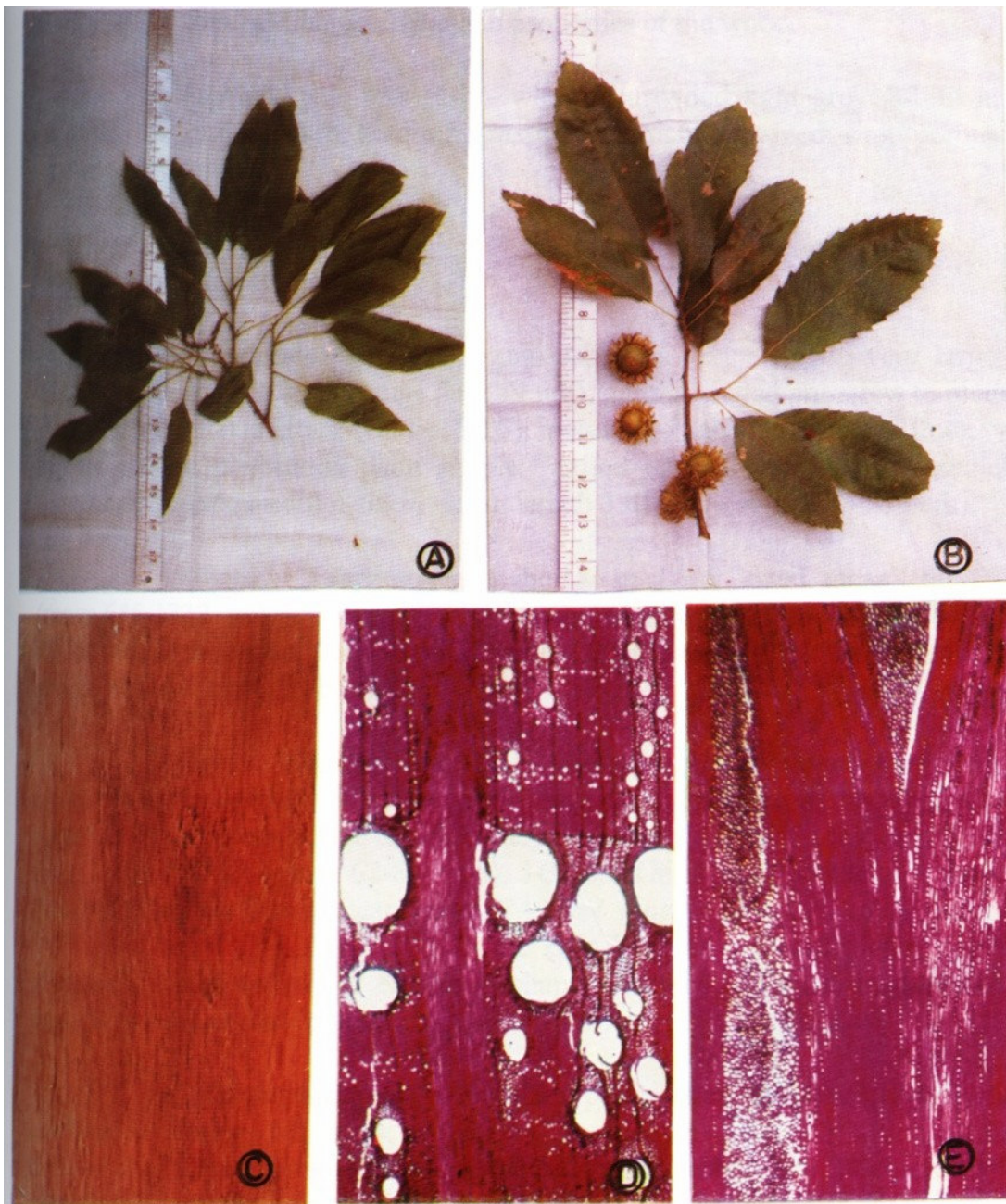


Fig.8. *Quercus serrata*.

- A. Inflorescences on the branchlets.
- B. Mature fruits (acorns).
- C. Portion of wood in natural colour as seen.
- D. T.S of ring porous wood showing distribution of vessels in solitary (x 37).
- E. T.L.S of wood showing large rays (x 37).

8. *QUERCUS SERRATA* THUNB.

General Characteristic and properties of the wood.

Sapwood pale brownish-white, heartwood light greyish-brown, odour and taste not distinct; hard; medium-textured; straight-grained; ring porous wood; growth ring distinct.

Microscopic Characteristics

Vessel element : Ring porous; pores very small to very large; mean tangential diameter 180 µm (range 31-349 µm); number per sq. mm. few to moderately few moderately numerous (range 5-16), pores exclusively solitary; thick walled; tyloses present; perforation plate simple; tailed one or both ends; vessel element moderately short to medium-sized, mean length 390 µm (range 267-564 µm).

Fibres : Libriform, very short to medium-sized, mean length 930 µm (range 646 –1312 µm), F/V ratio 3 (range 1-4), mean tangential diameter 18 µm (range 10-28 µm); non-septate, thin to thick-walled, 3-10 µm thick; interfibre pits minute; simple, slit-like; crystals absent.

Rays : Homocellular, 1-31 cells wide, mostly uniseriate to large rays, rarely bi-to tetra-seriate; 9-22 per mm tangentially, numerous to very numerous; uniseriate rays extremely fine to moderately fine, mean width 16 µm (range 10-26 µm), mean height 296 µm (range 62-820 µm), 3-33 cells high; multiseriate rays moderately broad to extremely broad, mean wide 274 µm (range 144-441 µm), mean height 1443 µm (range 133-5709 µm), 5-302 cells high; rays vessel pitting opposite to alternate, rounded or oval or elliptic in shape, bordered, 4-14 µm in diameter; gum deposits present; crystals present.

Axial parenchyma : Abundant, paratracheal unilateral or vasicentric or confluent connecting 2-5 pores; apotracheal parenchyma relatively spare, diffused or diffused in aggregate; prismatic crystals abundant, frequently 1 to 20 chambered axial parenchyma; gum deposits abundant spare.

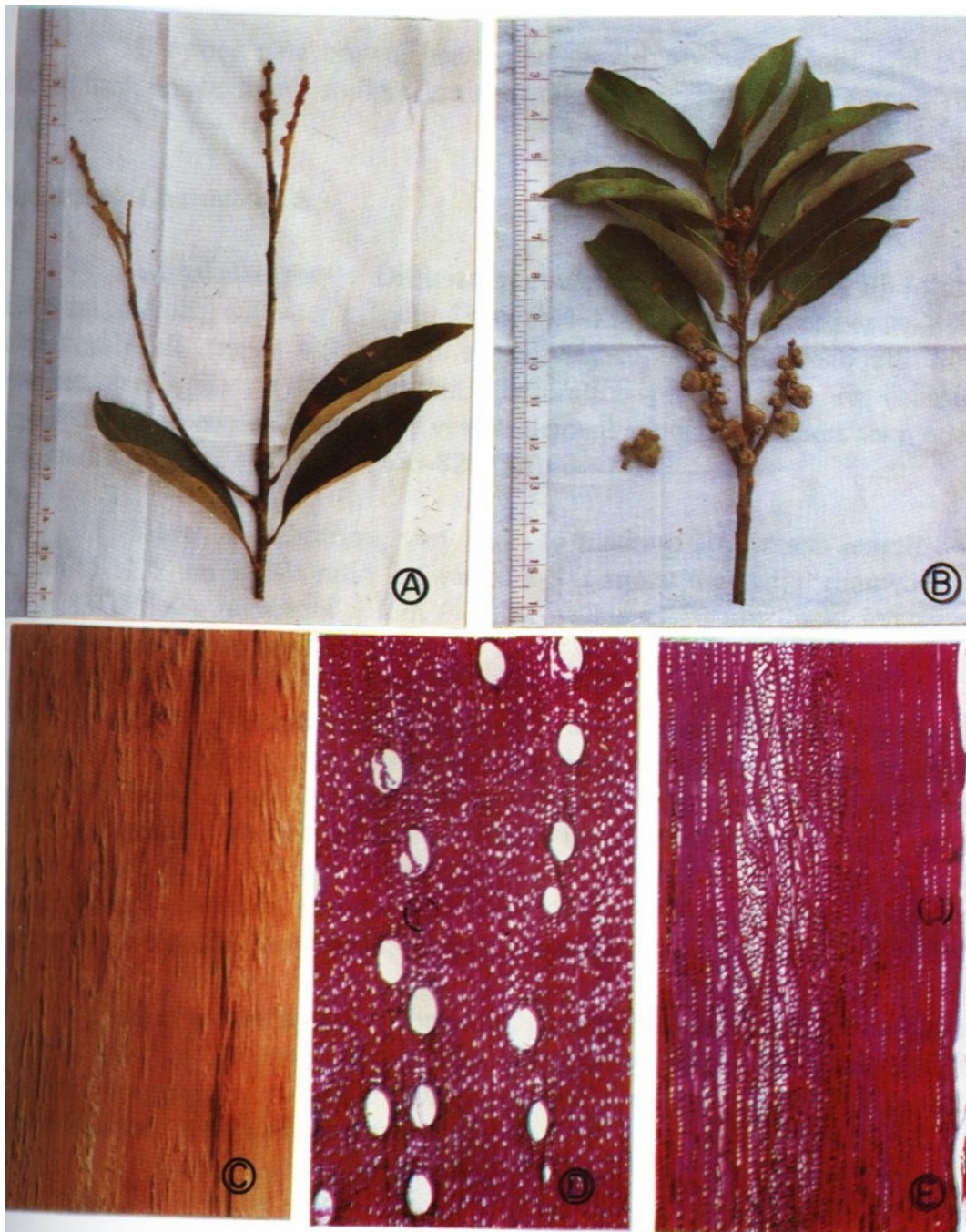


Fig.9. *Quercus truncata*.

- A. Inflorescences on the branchlets.
- B. Young fruits (acorns).
- C. Portion of wood in natural colour as seen.
- D. T.S of wood showing distribution of vessels in solitary and in radial multiples (x 37).
- E. T.L.S of wood showing small aggregate rays (x 37).

9. *QUERCUS TRUNCATA* KING

General Characteristics and properties of the wood.

Sapwood pale brown, heartwood greyish-brown; odour and taste not distinct; hard; fine-textured; straight grained; diffused porous wood; growth ring not distinct.

Microscopic Characteristics

Vessel element : Diffused porous; pores moderately small to medium size; mean tangential diameter 110 µm (range 41-174 µm); number per sq. mm. few to moderately few (range 4-9), pores exclusively solitary or occasionally in radial multiples; thin walled; tyloses present, perforation plate simple or occasionally scalariform, tailed one or both ends; vessel element moderately short to moderately long, mean length 582 µm (range 256-820 µm).

Fibres : Libriform, very short to medium size, mean length 840 µm (range 615-1179 µm), F/V ratio 2 (range 1-3), mean tangential diameter 19 µm (range 13-28 µm); non-septate, thin to thick-walled, 3-10 µm thick; interfibre pits minute, simple, slit-like; crystals absent.

Rays : Homocellular, 1-8 cells wide, uniseriate and aggregate rays, 14-25 per mm tangentially, very numerous; universal rays extremely fine to very fine, mean width 15 µm (range 10-21 µm), mean height 374 µm (range 51-1056 µm), 3-35 cells high; multiseriate rays moderately fine to broad, mean wide 98 µm (range 31-205 µm), mean height 669 µm (range 164-1456 µm), 6-115 cells high; rays vessel pitting opposite to alternate, rounded or oval or elliptic in shape, bordered, 4-20 µm in diameter; gum deposits in rays cells; crystals present.

Axial parenchyma : Abundant, paratracheal unilateral or vasicentric or confluent connecting 2-4 pores; apotracheal parenchyma relatively abundant, diffused or diffused in aggregate; prismatic crystals present, frequently in 1 to 8 chambered axial parenchyma; gum deposits sparsely.

5. Discussion

5.1 Morphology

All the species studied in this work are found to be growing wild in Pyinoolwin township.

Bor (1953) mentioned that *Quercus brandisiana* was small tree. According to Brandis (1906), (1955) and Hooker (1890), *Q. dealbata* was shrub or small tree. Kanjilal (1940) and Bor (1955) also stated that *Q. lindleyana* was small tree. In general, all the species of the genus *Quercus* included in this research are medium to large evergreen or deciduous trees.

In this study, the leaves *Q. brandisiana* are found to be oblanceolate or elliptic or obovate, but kurz (1877) stated their shape was oblong to obovate-oblong.

In this work, the leaves of *Q. dealbata* are found to be broadly lance lanceolate or narrowly elliptic with tapering ends, however, it had been described as elliptic-ovate or elliptic-ovate by Hooker (1890), and ovate-lanceolate tapering to the point and downwards to the stalk by Scott & Parkinson (1930).

The shape of the leaves of *Q. fenestrata* is found to be lanceolate or elliptic but, kurz (1877) described that it was elliptically to oblong-lanceolate.

The *Q. griffithii*, the shape of the leaves is found to be obovate or elliptic-ovate, however, Hooker (1890) stated that it was obovate-oblong or oblanceolate.

The leaves of *Q. helferiana* are ovate-lanceolate or elliptic, but Scott & Parkinson (1930) mentioned that they are elliptic to oblong.

The shape of the leaves of *Q. lindleyana* is obovate, but, according to kurz (1877), it is obovate-oblong.

In *Q. mespilifolia*, the leaf is ovate-lanceolate or elliptic, although Kurz (1877) described that it was oblong to elongate-oblong.

The leaves of *Q. serrata* are broadly lanceolate or oblong-lanceolate or elliptic-lanceolate, however, Roxburgh (1971) stated that they were oblong.

In *Q. truncata*, the leaves are oblong-lanceolate or elliptic or narrowly elliptic with tapering ends. But, according to Brandis (1906), the leaves were lanceolate or elliptic-lanceolate, and Scott & Parkinson (1930) stated that they were ovate-lanceolate tapering to a fine long point narrowing downwards to the petioles.

In the present work, the margin of the leaf of *Q. brandisiana* is coarsely repand serrate in the upper part, but, according to Brandis (1906) and Scott & Parkinson (1930), it was undulate-serrate.

In *Q. lindleyana*, it is entire or rarely sinuate-toothed in the upper part, but, Brandis (1906) stated that it was undulate.

In the present work, the stipules of the genus *Quercus* are caducous.

In the present work, the pistillodes are found in the male flower of *Q. dealbata*, *Q. fenestrata*, *Q. lindleyana*, and *Q. truncata*. But Hooker (1890), Hutchinson (1926), and Kirtikar & Basu (1935) stated that the pistillodes and staminodes were absent in these species.

In *Q. brandisiana*, many solitary acorns are borne along the common main stalk.

In *Q. dealbata*, acorns are found to be 2-5 in number per fascicle and borne along the spike, but Bor (1935) stated that acorn was solitary or 2 or 3 in number together on a stout rachis. It was also described as densely clustered in spikes by Scott & Parkinson (1930).

In *Q. fenestrata*, 2-4 immature fruits are usually found at the base of each of single mature ones.

In *Q. griffithii*, acorn is solitary or some-times 2 or 3 in number and fasciculated on a short stalk although Kanjilal (1940) described that it was 2-5 in number, fasciculated, and borne at the end of the branchlet.

In *Q. helferiana*, the acorn is 1-3 in number and borne on the tips of the short stalk at the leaf axial.

In *Q. lindleyana*, 1-3 immature fruits are found at the base of each of the mature ones along the long common stalk, but according to Brandis (1906) and Bor (1935), acorns were fused together in group of 3-6.

In this work, acorns of *Q. mespilifolia* are found to be solitary and axillary on a short common stalk; those of *Q. serrata* are found to be solitary or fasciculated of 2-4.

In *Q. truncata*, 1 or 2 immature fruits are at the base of each of mature ones along the common main stalk.

In this study, the cup of the fruits of *Q. brandisiana* are hemispheric, 5-8 mm in diameter with 3-5 concentric rings. However, those of *Q. brandisiana* were 12.5-16.7 mm in diameter as had been observed by Brandis (1906), 19 mm by Scott & Parkinson (1930), 12.5 mm by Kurz (1877). They are with 8 concentric rings as had been stated by Scott & Parkinson (1930) and with 5 or 6 concentric rings by Kurz (1877) and Hooker (1890).

The cup of *Q. lindleyana* is hemispherical, woody, hard and 12-15 mm in diameter although Kurz. (1877) mentioned that the cups were concave.

The cups of *Q. mespilifolia* are hemispherical and tapering at the base, 6-22 mm in diameter with 4-7 concentric ring, but it was deeper as had been observed by Scott & Parkinson (1930), 25-31.25 mm in diameter and with 6-8 concentric rings by Kurz (1877), 25.0-31.25 mm in diameter and with 8-15 concentric rings by Hooker (1890).

The nut of *Q. brandisiana* is globoses or sub-globose with flattened base, but Bor (1953) stated that, that of *Q. brandisiana* was ovoid or conic-hemispheric, broader than long. Kurz. (1877) also describe that it was ovoid, and Hooker (1890) mentioned that it was hemispheric with truncate base.

The nut of *Q. griffithii* is elongate-ovoid and 12-27 mm long. But, it was found to be narrowly ovoid to a point by Scott & Parkinson (1930), ovoid by Kanjilal (1940), and ovoid-oblong by Hooker (1890).

The nut of *Q. helferiana* is flattened and apiculate, 4-7 mm long and 11-17 mm wide, but Brandis (1906) stated that it was depressed and hemispheric. According to Kanjilal (1940), it was turbinate, hemispheric, apiculate with truncate base, 18.75 mm wide and 10 mm long and Bor (1953) mentioned that it was depressed, flattened and about 18.75 mm wide.

The nut of *Q. lindleyana* is cylindric-conical or slightly triangular, tapering at the tips and 12-23 mm long. But Hooker (1890) stated that it was elongate-ovoid.

The nut of *Q. mespilifolia* is sub-globose, tapering at the base, flattened at the top with a persistent style, 6-15 mm in diameter. However, that of *Q. mespilifolia* was depressed globose according to Brandis (1906), and 25 mm in diameter, globose or hemispheric or depressed-globose according to Kurz (1877) and Hooker (1890).

In the present work, the nut of *Q. serrata* is observed to be shining globose or sub-globosse, 13-21 mm long and 12-18 mm wide. But that of *Q. serrata* was 37.5 mm in diameter as had been described by Brandis (1874); 20-30 mm long and 15-25

mm in diameter by Troup (1921); barrel-shaped by Scott & Parkinson (1930), 18.75-25.0 mm in diameter by Kanjilal (1940).

Thenut of *Q. truncata* is obovoid and 10-15 mm long. But, that of *Q. truncata* was 18.75-25.0 mm long as had been described by Brandis (1906), and globose or turbinate by Hooker (1890).

In all of the nine species of the genus *Quercus*, only simple mature seeds are seen in the nut with thick and non-endospermic cotyledons.

5.2 Anatomy

In this study, all the general characteristics such as colour, grain and texture of the species are found to be similar to each other. Relatively few differences are seen as shown in Table 5.1.

The wood colour of *Q. dealbata* is pale brown to brown in the present study, but Gamble (1920) stated that the wood is light red. The sapwood of *Q. fenestrata* as observed in this work is found to be pale brownish-white and heartwood is reddish-brown. But Gamble (1902) described that the sapwood was pale and heartwood red.

In this study, the wood colour of *Q. griffithii* is yellowish-white to greyish-yellow. However Gamble (1902) mentioned that the wood colour is brown. At the present work the wood colour of the *Q. serrata* is pale brownish-white to light greyish-brown. It is agreed with Pearson & Brown (1932). But Gamble (1902), Troup (1921) and Brandis (Kanjilal, 1940) described that this wood colour is dark greyish-brown.

In all the species the odour and taste of the wood is not distinct, with the exception of *Q. griffithii*, which possess a distinct odour.

In the present work, it is observed that *Q. serrata* is straight-grained but Pearson & Brown (1932) mentioned that they are straight –to somewhat irregular – grained.

The wood of *Q. serrata* are medium – textured in this study. But Pearson & Brown (1932) stated that it is medium –but uneven textured.

The anatomical characteristics observed for all the species are shown in Table 5.2.

Growth ring of *Q. dealbata* is not distinct in the present work, but Gamble (1902) stated that these are distinct and in agreement with Gamble (1902). Growth ring of *Q. Serrata* is distinct in the present study, and it is agreed with Brandis (1906), Gamble (1902) and Pearson & Brown (1932).

All the species studies shown that the vessel are solitary but occasionally in radial multiples as in *Q. dealbata*, *Q. fenestrata* and *Q. truncata*. However, Pearson &

Table 5.1 Comparison of macroscopic characteristics of wood of the genus *Quercus*.

Species observed	Colour	Odour and taste	Grain	Texture
<i>Q. brandisiana</i>	light pale yellowish-brown to brown	not distinct	straight – grained	fine - texture
<i>Q. dealbata</i>	Pale brown to brown	not distinct	straight or sometimes wavy – grained	fine – texture
<i>Q. fenestrata</i>	Pale brownish-white to reddish – brown	not distinct	straight – grained	fine – texture
<i>Q. griffithii</i>	Yellowish – white to greyish - yellow	Odour distinct & taste not distinct	straight – grained	coarse-textured
<i>Q. helferiana</i>	Pale brown to reddish - brown	not distinct	straight – grained	fine – texture
<i>Q. lindleyana</i>	Pale brown to brown	not distinct	straight or sometimes wavy – grained	medium - textured
<i>Q. mespilifolia</i>	light yellow to reddish-brown	not distinct	straight – grained	medium - textured
<i>Q. serrata</i>	Pale brownish-white to light greyish-brown	not distinct	straight – grained	medium - textured
<i>Q. truncata</i>	Pale brown to greyish - brown	not distinct	straight – grained	medium - textured

Table 5.2 Quantitative characteristics of microscopic wood structures for nine species of the genus *Quercus*

Species observed	<i>Q. brandisiana</i>	<i>Q. dealbata</i>	<i>Q. fenestrata</i>	<i>Q. Griffithii</i>	<i>Q. Helferiana</i>	<i>Q. Lindleyana</i>	<i>Q. mespilifolia</i>	<i>Q. serrata</i>	<i>Q. truncata</i>
mean pores frequency (per sq.mm.)	9	8	7	6	5	6	7	9	6
mean vessel diameter (µm)	127	135	120	205	139	173	173	180	110
mean vessel length (µm)	462	527	456	448	594	538	576	390	582
mean fibre diameter (µm)	21	22	18	20	21	21	21	18	19
mean fibre length (µm)	974	1220	880	808	1187	1025	1029	930	840
mean fibre thickness (µm)	8	8	5	5	6	6	7	5	5
mean uniseriate ray height (cells)	10	11	11	10	16	10	10	15	15
mean uniseriate ray height (µm)	283	224	210	202	315	235	269	296	347
mean uniseriate ray width (µm)	15	15	14	19	17	16	15	16	15
mean ray frequency (per mm)	12	21	18	8	15	13	14	14	19
mean multiseriate ray height (cells)	45	31	59	86	36	94	52	68	32
mean multiseriate ray height (µm)	1571	840	2112	1927	847	2437	1376	1443	669
mean multiseriate ray width (µm)	338	136	267	331	254	558	249	274	98

Brown (1932), Metcalfe & Chalk (1950), Fahn (1974) and Van Stennis (1976) stated that the vessel are solitary.

In all the species studies, tyloses within the vessels are abundant, spares or wanting which agree with Pearson & Brown (1932). Metcalfe & Chalk (1950) also described that tyloses are present in *Quercus*.

Vessel distribution among these species ranges from porous to diffus porous in this study. It is generally agreed with Pearson & Brown (1932), Metcalfe & Chalk (1950). But Priestley (1955), Esau (1961), Cutter (1971) and Van Stennis (1976) described that all the species have ring porous wood.

The pores of *Q. dealbata* are found to be very small to very large. But, Gamble (1902) described that they are moderately small to moderately large. In this work, the pores of *Q. fenestrata* are very small to medium sized, however Gamble (1902) described that those are large. In the present study, the pores of *Q. griffithii* are observed to be very small to very large which is agreed with Gamble (1902).

In this study, the pores of *Q. serrata* are very small to very large. But those are found to be large by Brandis (Kanjilal, 1940); middle-sized by Brandis (1874); very large by Brandis (1906); large of very large by Pearson & Brown (1932).

Vessel element are found to be moderately short to very in all the species studies. Average length of these species range from 390-594 μm , with the largest occurring in *Q. helferiana* as shown in Table 5.2.

Tangential pores diameter exhibits the wide range among the species, however maximum diameter occur in *Q. griffithii* as shown in Diagram 5.1 and the maximum in *Q. truncata* as show in Diagram 5.2.

In the vessel element of all the species studies, perforation plate is simple; but it is sometimes reticulate in the case of *Q. fenestrata*; in *Q. mespilifolia* it is very rarely foraminate as had been described by Metcalfe & Chalk (1950). However, perforation plate of the genus *Quercus* is frequently scalariform according to Van Stennis (1976), and simple according to Pearson & Brown (1932).

The fibre of all the species are libriform in this study, Which is in agreement with Pearson & Brown (1932), and Esau (1961). In the present work, the fibre is non-septate, which agrees with the descriptions of Pearson & Brown (1932).

In cross sectional, axial parenchyma are similar to each other. Paratrachal parenchyma are unilateral, vasicentric and confluent forming tangential bands.

Axial parenchyma cells are often with transverse septation in multiple crystal chambers studied in all the species.

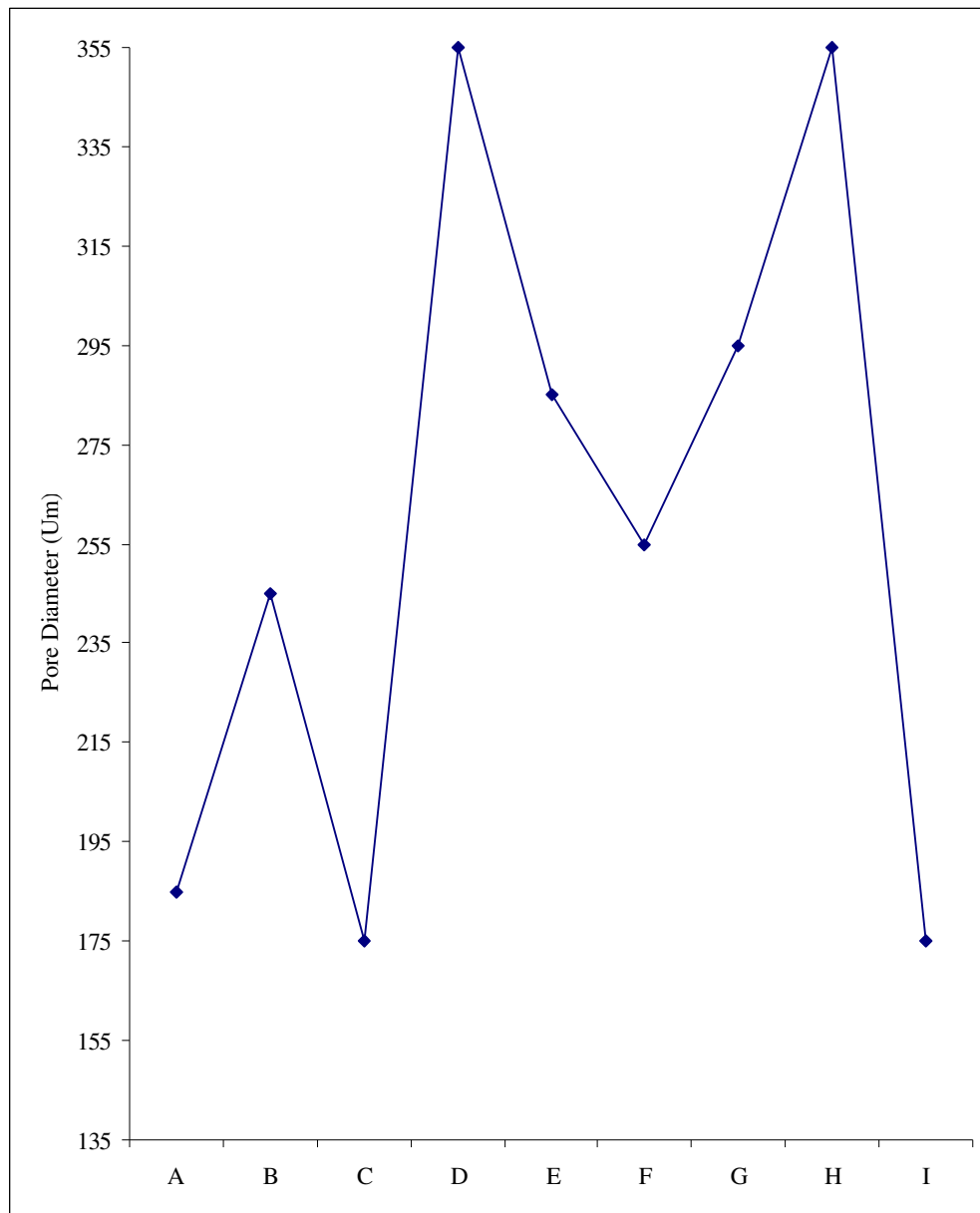
Ray very from low to high and uniseriate and aggregate to large rays, the minimum mean per millimeter tangentially is found in *Q. griffithii* and the tangentially is found in *Q. griffithii* and the maximum mean in *Q. dealbata* (Diagram 5.3)

The rays cells are found to be homogenous in this studied. It is agreed with Pearson & Brown (1932), Metcalfe & Chalk (1950). In this work, the crystals and gum deposits are present in the large ray which in agreed with Pearson & Brown (1932).

The rays of *Q. dealbata* are found to be uniseriate and aggregate in this study. It is in agreement with Gamble (1902). In the present work, the rays of *Q. fenestrata* are uniseriate and aggregate to large, but those are very fine, uniliform and equidistinct according to Gamble (1902), and very board according to Brandis (1784). In this study the rays of *Q. griffithii* are uniseriate and large which is agreed with Gamble (1902).

In the present study, the rays of *Q. serrata* are uniseriate and large which are with Gamble (1902) and Pearson & Brown (1932). But Brandis (1874) stated that the medullary rays are broad.

5.1 Diagram showing comparison of maximum pores diameter of *Quercus*



A. *Q. brandisiana*

B. *Q. dealbata*

C. *Q. fenestrata*

D. *Q. griffithii*

E. *Q. helferiana*

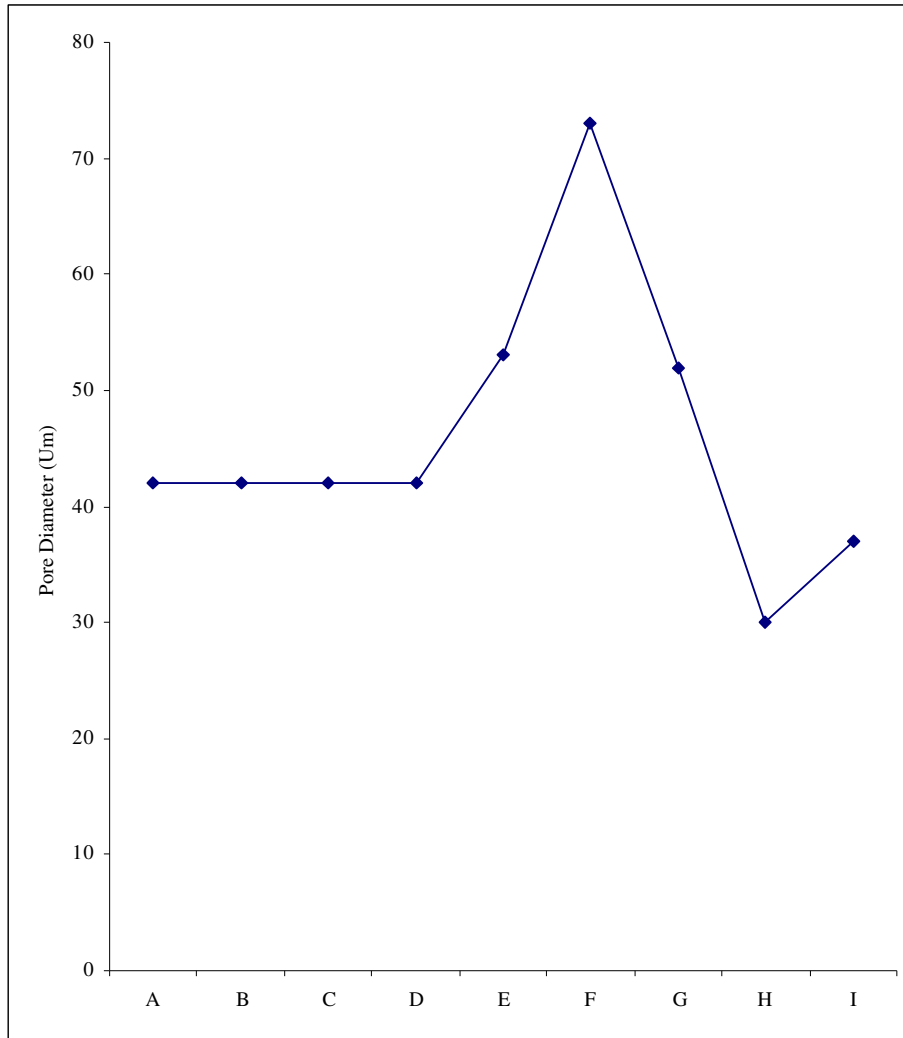
F. *Q. lindleyana*

G. *Q. mespilifolia*

H. *Q. serrata*

I. *Q. truncata*

5.2 Diagram showing comparison of minimum pores diameter of *Quercus*



A . *Q. brandisiana*

B. *Q. dealbata*

C. *Q. fenestrata*

D . *Q. griffithii*

E . *Q. helferiana*

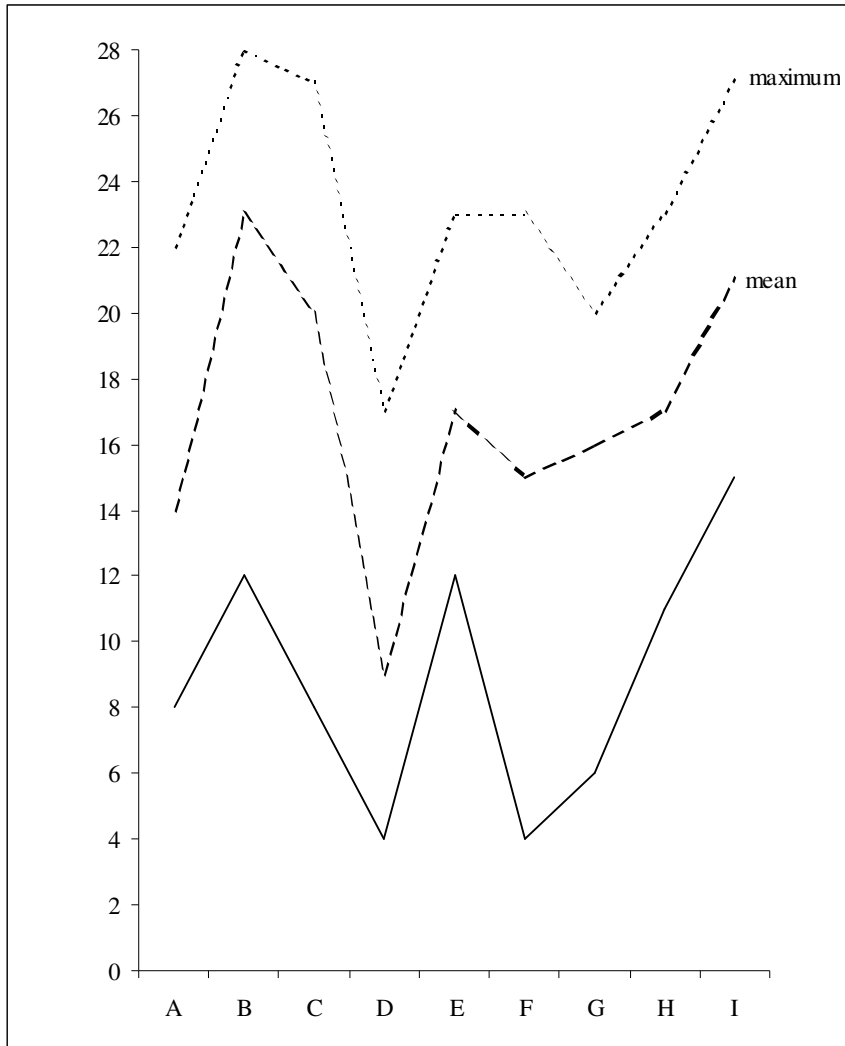
F. *Q. lindleyana*

G . *Q. mespilifolia*

H . *Q. serrata*

I. *Q. truncata*

5.3 Diagram showing comparison of rays numbers per millimeter of *Quercus*



A. *Q. brandisiana*

B. *Q. dealbata*

C. *Q. fenestrata*

D. *Q. griffithii*

E. *Q. helferiana*

F. *Q. lindleyana*

G. *Q. mespilifolia*

H. *Q. serrata*

I. *Q. truncata*

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