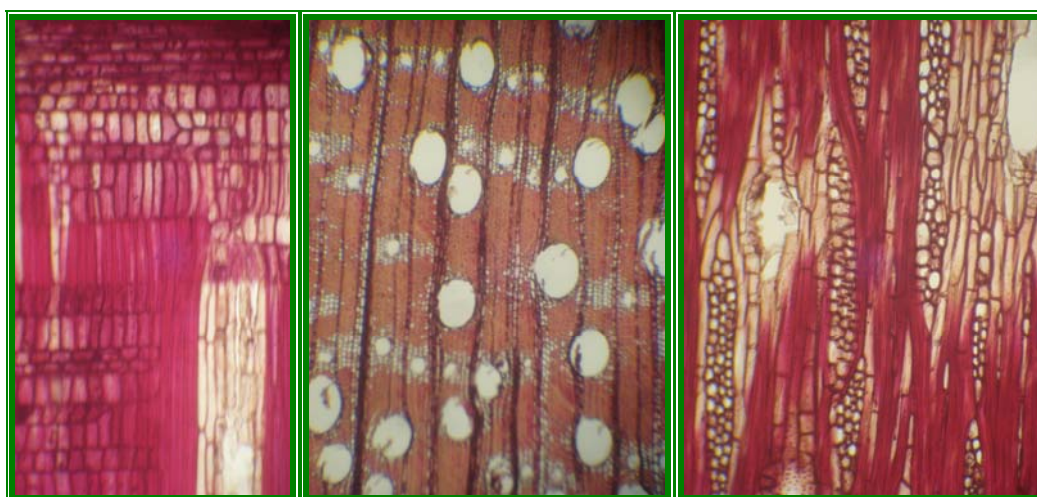




Ministry of Forestry
Forest Department
Forest Research Institute



**A Study on Morphology and Anatomy of Two Myanmar
Timber Species of the Genus *Dipterocarpus*, *D. tuberculatus*
Roxb. and *D. turbinatus* Gaertn. f.**



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မြန်မာ့အင် (*Dipterocarpus tuberculatus* Roxb.) နှင့် ကညင် (*D. turbinatus* Gaertn. f.) တို့၏ ပြင်ပရုပ်သွင်နှင့် ခန္ဓာဗေဒကို လေ့လာခြင်း

ရီရီဟန်၊ သုတေသနအရာရှိ
ကျော်ဝင်းမောင်၊ လက်ထောက်သုတေသနအရာရှိ
ကြည်ကြည်ခိုင်၊ သုတေသနလက်ထောက် -၃
စိုးမြင့်၊ ပါမောက္ခချုပ် (ငြိမ်း)

စာတမ်းအကျဉ်း

မြန်မာနိုင်ငံအလယ်ပိုင်းတွင်သဘာဝအလျောက် ပေါက်ရောက်သော အင် (*Dipterocarpus tuberculatus* Roxb.) နှင့် ကညင်ပင် (*D. turbinatus* Gaertn. f.) တို့ကို ၂၀၀၈ နှင့် ၂၀၀၉ ခုနှစ်တို့တွင် အပင်နမူနာစုံစု (sample) များစုဆောင်းခဲ့ပါသည်။ ၎င်းတို့၏မျိုးပွားအင်္ဂါပိုင်းနှင့် ပင်ပိုင်းတို့၏ပြင်ပရုပ်သွင် လက္ခဏာများကိုလည်းကောင်း၊ ပင်စည်နှင့်အရွက်တို့၏ ခန္ဓာဗေဒလက္ခဏာများကိုလည်းကောင်း၊ လေ့လာပြီး ဆွေးနွေးတင်ပြထားပါသည်။ ဤလက္ခဏာရပ်များသည် သစ်ပင်များကို မျိုးမည်ဖော်ခြင်းတွင် အသုံးဝင်ပါသည်။

A study on morphology and anatomy of two Myanmar Timber species of the genus *Dipterocarpus*, *D. tuberculatus* Roxb. and *D. turbinatus* Gaertn. f.

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Abstract

Dipterocarpus tuberculatus Roxb.(In) and *D. turbinatus* Gaertn. f. (Ka-nyin) members of the family Dipterocarpaceae, grown wild in Central Myanmar were collected in 2008 and 2009. Their morphological characteristics of reproductive and vegetative organs and anatomical characteristics of wood of stem and leaves were studied, described and discussed. These characteristics were useful in identification of the tree species.

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1. Introduction

Numerous tree species of the forests including the genus *Dipterocarpus* are much also important in forest management covering impacts on conservation of biodiversity, maintaining content of atmospheric carbon dioxide, climatic change and socio-economic development.

Most of *Dipterocarpus* species are magnificent and having crowns of distinct stratification in the dipterocarp forest and in fact they serve as indicators of the principal strata. The production of timbers from *Dipterocarpus* trees plays an important role in domestic consumption as well as in export.

An oleoresin, source of “Kanyin oil”, traditionally used for torches and as lampoil in Myanmar and formerly exported, is yielded from *Dipterocarpus* species, including *D. tuberculatus* and *D. turbinatus*. The principal source of oleoresin known as “In oil” in Myanmar and gurjan oil in India is *D. tuberculatus*.

Resin extracted from *Dipterocarpus* species is known as “Indwe”, and it is a kind of dammar and also important for income generation of local people. Although *D. tuberculatus* are deciduous, their leaves are large and broad so that they are extensively harvested to use as wrapping materials. “In-o”, a kind of puffball growing wild under *D. tuberculatus* trees is edible, delicious and famous for local people and it seems to be associated with *D. tuberculatus*. The oleoresin containing essential oil is also used in the treatment of genitor-urinary diseases.

In Myanmar, twelve species of the genus *Dipterocarpus* are growing wild together with the 42 species of other six genera viz. *Anisoptera*, *Hopea*, *Oleoxylum*, *Parashorea*, *Shorea* and *Vatica* belonging to the family of Dipterocarpaceae according to Kress *et al.* (2003).

In this paper, *D. tuberculatus* and *D. turbinatus* growing wild in Forest Research Institute Campus and Kin-tha, Tat-Kon Township respectively were collected, and morphological characteristics of vegetative and reproductive parts and anatomical characteristics of their leaves and wood of the stems are studied, described and discussed by the help of photomicrographs.

2. Literature Review

The genus *Dipterocarp* had also a wide distribution all over the country. Most of the species were in the evergreen forests, a few staying in the moist and dry deciduous forests (Thant shin & Thein Kyi 2005).

The number of the species of the genus *Dipterocarpus* had been variously reported. This genus was known to comprise 30 species (Symington 1943); 18 species (Anonymous 1985); and 12 species found to be growing wild in Myanmar (Kress *et al.* 2003).

These species of the genus *Dipterocarpus* was found in the evergreen dipterocarp forest, the eastern tropical evergreen forest and South tropical semi-evergreen forest in Myanmar, (Champin 1936; Hundley and Chit Ko Ko 1961).

According to Kerala Forest Research Institute (1985), the leaves of *D. tuberculatus* were shedded in February and March and those of *D. turbinatus* shedded in December (Andamans, India). The flowering periods of *D. tuberculatus* was March to April, and January to March in Andamans and India, and that of *D. turbinatus* was March to April (Eastern India and Bangladesh) respectively, and the fruiting period of *D. tuberculatus* was May and that of *D. turbinatus* May to July respectively (Anonymous, 1985)

Scott (1931) described the trade differences between “In” and “Kanyin” converted timber as shown in the following table (Parkinson 1932).

Table 2.1 Trade differences between *In* and *Kanyin* converted timber

No.	In	Kanyin
1	Reddish grey after exposure to sunlight.	A paler variety (White <i>Kanyin</i>), remaining pale even after exposure. A darker variety (red <i>kanyin</i>), resembling <i>In</i> .
2	Rougher look; woolly fibres present.	Neater look; woolly fibres absent.
3	Fine grain and texture.	Coarse grain and texture.
4	Less straight in the grain.	Straighter grain.
5	More apt to crack. Cracks irregular in pattern.	Less apt to crack.
6	Less apt to warp.	More apt to warp, bend and twist.
7	More resinous.	Less resinous

8	Air cannot be blown through 4" to 6" length of 3" x 3".	Air can be blown through such a piece.
9	More durable. Resists white-ants better than Kanyin.	Less durable. White-ants are liable to destroy untreated wood within a few months.

The timbers were extensively used as commercial plywood, for railway sleepers after treatment, dugouts and boat building and suitable for jetty piles, poles and bridge constructive (Anonymous 1985, Pearson & Brown 1932, and Rodger 1936.)

Metcalf and Chalk (1957) described that mucilage cells were sometimes found in rows, situated in the ground tissue of the petiole and/or midrib and lateral veins in certain species of *Dipterocarpus*. Resin canals were often found associated with the outer part of the xylem of the larger veins and in the petiole. Cluster and, more rarely, solitary crystals were commonly present and frequently abundant in the parenchymatous tissues of the mesophyll and petiole.

Metcalf and Chalk (1957) stated that the vessels of wood were found almost exclusively solitary in *Dipterocarpus*. Tyloses were usually abundant in members of the family Dipterocarpaceae except in *Dipterocarpus*. Mean member length was usually 0.4 – 0.7 mm; longest (up to 1.1 mm) in *Dipterocarpus*. Parenchyma were typically with both scattered (apotracheal) and aliform (paratracheal) types and usually abundant. Mean length of fibers were 1.2 – 2.0 μm ; longer in *Dipterocarpus*.

Pearson and Brown (1932) stated that the heartwood of *D. tuberculatus* was reddish-brown, turning darker on exposure, with short, whitish, tangential lines (resin canals) at irregular but relatively close intervals, without characteristic odour or taste, fairly straight or somewhat interlocked-grained, even- and course-textured. Growth ring was wanting. The vessels of the wood were large to very large, open or occasionally plugged with reddish-brown tyloses, frequently with contiguous rays, the majority solitary, occasionally paired; vessel segment 470 – 760 μm long, truncate or abruptly tailed, thin-walled, the largest 90 – 265 μm in diameter; perforations simple, horizontal or nearly so.

In the wood of *D. tuberculatus*, tracheids were relatively sparse, paratracheal, generally peripherally flattened about the vessels, 700 – 950 μm long, with maximum diameter of 30 – 40 μm , with numerous, horizontally aligned, narrowly bordered, elliptical pits (Pearson and Brown (1932).

In the wood of *D. tuberculatus*, parenchyma was of paratracheal and metatracheal type, and encircling all resin canals. Paratracheal parenchyma was relatively sparse, intermingled with tracheids and difficult to distinguish in the transverse section. Metatracheal parenchyma was fairly abundant, scattered or in short, tangential, usually uniseriate lines. Parenchyma about the resin canals was in broad rather tracts, frequently extending tangentially and uniting with tracts encircling neighbouring canals forming broad, 3 – 10 seriate bands. Reddish-brown gummy infiltration was frequent in all types of parenchyma; crystals wanting; starch deposits not observed (Pearson and Brown (1932)).

In the wood of *D. tuberculatus*, fibers were filiform, rather coarse, angled in the transverse section and aligned in radial rows, non-septate, 810 – 2450 μm long, 20 – 28 μm wide, walls 8 – 12 μm thick, infiltration occasional, reddish-brown. Rays were scarcely visible with the naked eye, rather fine, 5 – 7 per mm, separated by 3 – 15 rows of fibers, 1 – 6 seriate, heterogeneous, the largest 70 – 90 μm wide, crystals wanting; starch deposits not observed. Resin canals were present, longitudinal, embedded in parenchyma, diffused or 2 – several at intervals or rarely contiguous in broad, 3 – 7 (mostly 5 – 7) seriate bands extending across a number of rays, epithelium forming a single layer, thin-walled, canal orifices with maximum diameter of 80 – 100 μm , contents white (solidified) (Pearson and Brown (1932)).

Pearson and Brown (1932) also stated that the sapwood of *D. turbinatus* was pale reddish-white, ageing to grayish- or brownish-white, heartwood light red to reddish-brown with lighter interrupted tangential lines (resin canals) at irregular and relatively close intervals, fairly straight or somewhat interlocked-grained, even and coarse-textured. In the wood of *D. turbinatus*, growth ring was absent or scarcely distinct and approximately 5 – 8 per inch. Vessels were very large to extremely large, open or occluded with brown tyloses, frequently with contiguous rays, forming broad, conspicuous, close vessel lines along the grain containing frequent deposits of tyloses, the majority solitary, occasionally paired, close and quite evenly distributed, 2 – 7 per mm^2 ; vessel segments 350 – 750 μm long, thin-walled, truncate or abruptly short-tailed, the largest 280 – 315 μm in diameter; perforations simple, horizontal or nearly so. Tracheids were sparse, paratracheal, intermingled with parenchyma and usually peripherally flattened about the vessels, 660 – 875 μm long, with maximum diameter of 30 – 40 μm .

Pearson and Brown (1932) described that parenchyma in the wood of *D. turbinatus* were paratracheal, metatracheal, and encircling all resin canals; paratracheal

parenchyma relatively abundant, intermingled with tracheids and difficult to distinguish in the transverse section; metatracheal parenchyma abundant, scattered or in short, tangential, usually uniseriate line which end blindly or unite neighbouring rays; parenchyma about the resin canals in rather broad tracts, frequently extending tangentially and uniting with tracts encircling neighbouring canals forming broad, 3 – 12 (mostly 4 – 10) seriate bands; reddish-brown gummy infiltration frequent in all types of parenchyma; crystals wanting; starch grains not observed.

Pearson and Brown (1932) mentioned fibres in the wood of *D. turbinatus* were libriform, rather fine, angled in the transverse section and aligned in radial rows, forming tracts between the vessels and the rays, non-septate, 800 – 2440 μm long, 23 – 33 μm in diameter; wall 7 – 10 μm thick; gummy infiltration frequently present, reddish-brown. Rays were scarcely visible with the naked eye, rather coarse, 6 – 8 per mm, separated by 3 – 15 rows of fibers; gummy infiltration copious, occluding many cells, reddish-brown; crystals wanting; starch deposits not observed. Resin canals were present, longitudinal, embedded in parenchyma, solitary or 2 – several at intervals or rarely contiguous in broad 3 – 12 (mostly 7 – 10) seriate bands extending across a number of rays, 0 – 5 per mm^2 ; epithelium thin-walled, forming a single layer; contents white (solidified).

3. Materials and Methods

The specimens of two *Dipterocarps* species taken in this research were collected from Forest Research Institute campus, Yezin, Nay Pyi Taw district and Kintha Reserved Forest, Tatkon Township, during the flowering and fruiting periods of 2008 and 2009, which occurred from February to April.

For morphological studies, both fresh and preserved specimens of the vegetative and reproductive parts were used. Small pieces of the petioles and midribs with leaf blade attached preserved in 50% ethyl alcohol were washed by running water and dehydrated through a series of tertiary butyl alcohol solution. Then the specimens were infiltrated in a series of paraffin of which melting points were 49°C, 54.5°C and 60°C respectively and then they were embedded in paraffin wax of 60°C and 17 – 30 μm thick sections were cut by using a rotary microtome. Then the sections obtained were double-stained with safranin and fast green solution according to Johansen (1940) with slight modification.

To study the anatomical characteristics of the wood, the samples measured 8" x 6" x 1" were taken from the main trunk particularly at the breast level of stem. Each wood sample includes the bark, the sapwood and portion of heartwood. Then the

specimens with heartwood were selected and cut into small cubes of 1 cm x 1 cm x 2 cm, and transverse, tangential and radial sections were made by using sliding microtome. The sections were stained with haematoxylin and safranin solution and mounted in Canada balsam.

All of the sections stained were studied under research microscope and recorded from the microscope by a digital camera.

Maceration of leaves and wood were prepared by heating them in equal volume of 30% hydrogen peroxide and glacial acetic acid solution according to Franklin's (1946) method.

4. Observation

4.1 Morphology

Both of *Dipterocarpus tuberculatus* and *D. turbinatus* are timber producing trees with straight boles, but *D. tuberculatus* are medium-sized and deciduous, whereas *D. turbinatus* are large and semi-evergreen or ever green. The stems are terete, stout, straight and glabrous and the branchlets are pubescent in *D. tuberculatus* and glabrous in *D. turbinatus*.

Outer surface of the barks of *D. tuberculatus* is grey with deep vertical and horizontal cracks and that of *D. turbinatus* is grayish brown with large lenticels and large vertical cracks in younger stems, with many large vertical cracks and some of the bark flakes peeled off in older stems. Inner surface of the barks of *D. tuberculatus* and *D. turbinatus* are found to be brown and reddish brown respectively.

The leaves are alternate, simple, petiolate and stipulate in both species of *Dipterocarpus* studied but the leafblades of *D. tuberculatus* are larger than those of *D. turbinatus*. The leafblades of *D. turbinatus* are ovate or elliptic-ovate, glabrous, bright and deep green, however, those of *D. tuberculatus* are ovate, pubescent to slightly tomentose, green with reddish area of anthocyanin on the upper surface while young.

In both species of the genus *Dipterocarpus* studied, stipules are sheathing, found at the top of the branchlets, caducous and tomentose, but long hairs are found at the tips in *D. turbinatus*. The scars of stipules are found at the lower nodes of the branchlets in both species.

In both species, inflorescences appear at the top of branchlets, but emerged at the base or axil of the sheathing stipules so that sheathing stipules are always found at the top of the branchlets, and inflorescences are monochasial scorpioid cymes. But the inflorescences of *D. turbinatus* are slightly longer and bear a few more flowers than those of *D. tuberculatus*.

The flowers are pedicellate, ebracteolate, complete, bisexual, pentamerous and slightly irregular and zygomorphic due to the presence of two larger calyx-lobes which are modified into wings in the fruits. The flowers are cyclic and hypogynous in both species and the pedicels are very short. The flowers of *D. tuberculatus* are bracteate, but those of *D. turbinatus* are ebracteate. Sometimes small vestigial structures are observed at the base of some flowers in *D. turbinatus*.

Calyxes of both species are 5 in number, gamosepalous, quincuncial, persistent, accrescent and two of the lobes are larger than the rest three, calyx tubes are bell-shaped.

In the calyx tubes of *D. tuberculatus*, five ridges are present on the outer surface of upper portion and pale green in colour, velvety tomentose with short hairs. In *D. turbinatus* the calyx tubes are smooth and have no ridges, whitish green in the upper portion and pale green in the lower and glabrous.

In both species, corolla lobes are 5 in number and united at the base, twisted, but the lobes can easily be separated along the adnate line on the tubes. In *D. tuberculatus* the corolla lobes are pinkish red, deeper inner, whitish or pinkish in the floral bud, but in *D. turbinatus*, those are pinkish white with pinkish column in the central portion, greenish white in the floral bud.

In both species, stamens are numerous in number, apostemonous in 2 or 3 series, anthers ditheous, basifixed, dehiscence longitudinal, connective prolong and pointed, filaments very short dilated at the base. In *D. tuberculatus*, stamens are brownish yellow to yellow and those of *D. turbinatus* are yellow in colour.

In both species, the gynaecia are tricarpallary, syncarpous, trilocular, axile placentation with two pendulous ovules in each loculus, styles slender, stigma simple; ovary yellowish white, tomentose and superior.

In both species, the fruits are samaroids with 5 persistent and accrescent calyx lobes forming wings for wind dispersal, 2 wings are larger and 3 wings are smaller. The fruits of *D. tuberculatus* have 5 ridges on their walls at the upper portion, but there are no ridges on the fruits of *D. turbinatus*.

4.2 Taxonomy

4.2.1 Synoptic key to the species

1. Ever green or semi-evergreen large trees, outer surface of the bark grayish brown with large lenticels forming tubercles and large vertical cracks in stems, leaf blades glabrous, corolla lobes pinkish white with pinkish column in the central portion, glabrous, fruits without ridges*Dipterocarpus turbinatus*

1. Deciduous medium-sized trees, outer surface of the bark gray with deep vertical and horizontal cracks in stems, leaf blades pubescent to slightly tomentose above and velvety tomentose beneath, corolla lobes pinkish red, deeper inside, tomentose, fruits with 5 ridges *Dipterocarpus tuberculatus*

4.2.2 *Dipterocarpus tuberculatus* Roxb.

Dipterocarpus tuberculatus Roxb. Hort. Beng. [93]; Fl. Ind. ii: 614. 1832.

Synonym: *Dipterocarpus grandifolius* Teijsm. ex Miq., Ann. Mus.
Lugd. Bat. 214. 1864

D. cordatus Wall. ex A. DC., Prodr. 16(2): 618. 1868.

Common name: Dipterocarp, In.

Local name: In. Eng

Locality: Campus of Forest Research Institute, Yezin, Nay Pyi Taw District.

Family: Dipterocarpaceae.

Specimen examined: Yi Yi Han & Kyaw Win Maung, 1.8.2009; Herbarium
Registered No. 2440/09, Forest Research Institute,
Yezin.

Habit: Medium-sized deciduous trees with sub-cylindrical crown, 5 – 7 m to the first
branch from the ground level.

Stem: Terete, stout, grey, 0.5 – 1.0 m in girth, straight, glabrous, with terete branches,
branchlets terete, pubescent, gray with distinct leaf scars and nodes.

Bark: Outer surface of the bark gray with deep vertical and horizontal cracks in older or
younger stems, inner surface brown.

Leaves: Alternate, simple, petiolate, stipulate; petioles terete, 7.7 – 20.0 cm long and 0.6
– 1.2 cm in diameter, tomentose; pulvinus base of the petiole 0.7 – 1.4 cm long
and 0.9 – 1.5 cm wide, pulvinus top of the petiole 2.1 – 5.0 cm long and 0.8 – 1.5
cm wide; leaf blades ovate, 32.5 – 65.9 cm long and 20.9 – 48.5 cm wide, green,
with reddish area of anthocyanin on the upper surface while young paler beneath,
pubescent to slightly tomentose above and velvety tomentose beneath, more
numerous hairs on veins and veinlets, uncostate, mid-veins and lateral veins
prominent, lateral veins alternate; tips acute or obtuse, margin entire and ciliated,
bases slightly cordate; sheathing stipules 1.1 – 2.5 cm long and 0.6 – 1.0 cm wide,
pale yellowish green, tomentose, caducous; leaf scars and nodes distinct on
branchlets.

Inflorescences: Appeared at the top of branchlets, emerged at the base or axil of stipule,
monochasial scopioid cymes with 3 – 5 flowers, 11.2 – 13.2 cm long, primary
peduncles terete, 3.5 – 3.7 cm long and 0.4 cm in diameter, secondary peduncles
1.7 – 2.5 cm long and 0.3 cm in diameter, pale green, tomentose with short hairs.

Flowers: Bracteate, pedicellate, ebracteolate, 3.5 – 4.2 cm long and 3.8 – 4.5 cm across;
pedicel very short, terete, velvety tomentose, green; bract 10 mm long and 3 mm
wide, elliptic in shape with tapering end; slightly irregular and zygomorphic due
to the presence of two larger calyx-lobes which are modified into wings in the
fruits, complete, bisporangiate, pentamerous, cyclic, hypogynous, ovary superior.

Calyx: Calyx lobes (1+2+2), gamosepalous, unequal, green in floral bud, sepaloid,
quincuncial; anterior one and posterior two lobes small and short, triangular,

persistent, pale green, 0.5 – 0.6 cm long and 0.4 – 0.5 cm wide at the base, tomentose; two lateral lobes larger and longer, slightly wavy, pinkish with distinct veins and veinlets, 1.3 – 1.6 cm long and 0.5 – 0.6 cm wide with tapering end, accrescent, tomentose; calyx tube bell-shaped, with five ridges at the upper portion, 1.0 – 1.3 cm long and 0.9 – 1.0 cm in diameter, velvety tomentose with short hairs; inferior.

Corolla: Corolla lobes (5), gamopetalous, united at the base, lobes can easily be separated along the adnate line, twisted, petaloid, pinkish red, deeper inner, whitish or pinkish in the floral bud; corolla lobes 2.6 – 4.2 cm long and 0.8 – 1.4 cm wide, corolla tubes 0.6 – 0.8 cm long and 0.4 – 0.8 cm wide; tomentose, inferior.

Androecium: Stamens numerous, apostemonous, polyandrous, in two or three series, brownish yellow to yellow; anthers ditheous, basifixed, dehiscence longitudinal, pollen granular, connective prolong and pointed, filaments very short, dilated at the base, curved towards inside, glabrous, yellowish in colour, inferior.

Gynaecium: Tricarpellary, syncarpus, trilocular, very rarely tetra locular with one extra small locule, the placentation axile, with two pendulous ovules in each loculus; style yellowish white, terminal, slender, stigma simple; ovary yellowish white, tomentose, superior.

Fruits: Samaroids globose, with 5 persistent and accrescent calyx lobes forming wings, two larger and longer and three smaller and shorter, fruits after removing wings 2.3 – 3.0 cm long and 2.0 – 3.1 cm wide, 2 larger wings 11.0 – 17.5 cm long and 2.3 – 3.6 cm wide, 3 smaller wings 1.3 – 2.0 cm long and 1.2 – 1.6 cm wide, green while young, wings gradually turned brown when mature, sometimes 1 small calyx lobe developed into wing but shorter and smaller than the larger wings, gums usually exuded from fruit walls; dispersal by wind. True fruits developed from ovary after removing the outer wall 2.9 – 3.1 cm high and 1.4 – 2.1 cm in diameter.

Flowering Period: February to March, fruits appeared in March.

Distribution: *Dipterocarpus tuberculatus* is found in upper and lower Myanmar chiefly along the valleys of the Chindwin, Ayeyarwady and Sittang rivers; from

Myitkyina southwards, through Katha, Myittha, Shan States, Minbu, Magway, Pyay, Hinthada, Yezin, Tatkon, Taungoo, Yangon, Moattama and Kyaukpyu.

Uses: The timber is used for boats, rough furniture, carts, boxes, railway carriage and wagon floor, plywood, sleeper wood, poles and posts, firewood. Leaves are used as wrapping materials. The oleoresin is used in torches and as lamp oils. It is used for varnishes and for water proofing umbrellas and bamboo well-baskets. It is used with assafoetida and coconut oil for large ulcers.

Distinguishing character:

- (1) Deciduous medium-sized trees with deep vertical and horizontal cracks on the barks, leaf scars and nodes distinct on the branchlets.
- (2) Simple, petiolate, alternate and ovate leaves with sheathing stipules, pubescent to slightly tomentose on the upper surface and velvety tomentose on the lower one, hairs more numerous on veins and veinlets.
- (3) Monochasial scorpioid cymes with 3 to 5 flowers appeared at the top of branchlet at the base or axil of stipules.
- (4) Bracteate, pedicellate, ebracteolate, pentamerous and hypogynous flowers.
- (5) Calyx united and accrescent, modified into wings in the fruits, two wings larger than the rest three for wind dispersal.
- (6) Corolla lobes 5 in number and lobes can easily be separated along the adnate line, pinkish red, deeper inner and tomentose, twisted.
- (7) Stamens numerous and dithecous anthers with prolong connectives.
- (8) Gynecium tricarpeily, trilocular, axile placentation with two pendulous ovules in each loculus and ovary tomentose.
- (9) Fruits samaroid with two larger wings, 5 ridges on the upper part of the fruits, one seeded.

Floral Formula: $\overset{\uparrow}{\underset{\downarrow}{\text{Q}}} K_{(1+2+2)} C_{(5)} A_{\infty} \underline{G}_{(3)}$

4.2.3 *Dipterocarpus turbinatus* Gaertn.f.

Dipterocarpus turbinatus Gaertn. f. **Fruct. iii: 51. t. 188. – Ind. or.**

Synonym: *Dipterocarpus laevis* Ham. Mem. Wern. Soc. 6: 299. 1832.

D. jourdainii Pierre, Fl. For. Cochinch. Pl. 220. 1889.

D. scgmiddtii Heim, Bot. Tidsskr. 25: 42. 1902.

Common name: Dipterocarp, wood oil tree

Local name: Kanyin, Kanyin-ni.

Locality: Kintha Reserve Forest, Tatkon Township, Nay Pyi Taw District

Family: Dipterocarpaceae

Specimen examined: Yi Yi Han & Kyaw Win Maung, 1.8.2009; Herbarium Registered No. 2441/09, Forest Research Institute, Yezin.

Habit: Large evergreen or semi-evergreen trees with laxly sub-globose crown, 15 – 18 m to the first branch from the ground level.

Stem: Terete, stout, gray, 1.0 – 1.5 m in girth, straight, glabrous, with terete branches, branches deep brown while young; branchlets terete, glabrous, green at the upper parts, deep brown at the lower, scars of sheathing stipules and leaves distinct on the branchlet.

Bark: Outer surface of the bark grayish brown with large lenticels forming tubercles and large vertical cracks in younger stems, with many large vertical cracks and some of the bark flakes peeled off in older stems, inner surface reddish brown.

Leaves: Alternate, simple, petiolate, stipulate; petioles 2.0 – 4.0 cm long and 0.2 – 0.3 cm in diameter, glabrous; leaf blades 19.0 – 38.5 cm long and 10.7 – 17.5 cm wide; ovate or elliptic-ovate, glabrous, bright and deep green above and paler beneath,

bases rounded or obtuse, margins entire and slightly wavy, tips acute or acuminate; midrib pronounced, with many lateral veins; lateral veins alternate; stipules sheathing, 1.5 – 2.4 cm long and 0.4 – 0.7 cm wide at the base, tomentose with long hairs at the tip, caducous.

Inflorescences: Appeared at the top of branchlets, emerged at the base or axil of the stipule, monochasial scorpioid cymes with 3 – 8 flowers; 11.4 – 16.5 cm long, peduncles glabrous, primary peduncles terete, 4.5 – 5.5 cm long and 0.4 – 0.5 cm in diameter.

Flowers: Ebracteate, pedicellate, sometimes small vestigial structures present at the base of some flowers, ebracteolate; pedicels very short, terete, green, glabrous; flowers 5.0 – 6.6 cm long and 4.5 – 6.3 cm across, complete, bisporangiate, slightly irregular and zygomorphic due to the presence of two larger calyx-lobes which are modified into wings in the fruits, pentamerous, cyclic, hypogynous, ovary superior.

Calyx: Calyx lobes (5), gamosepalous, calyx lobes unequal, green in floral bud; anterior one smaller and shorter; two lateral lobes larger and longer, pinkish with distinct veins and veinlets, 3.4 – 5.2 cm long and 0.9 – 1.3 cm wide; two posterior smaller and shorter; the anterior one and posterior two 0.4 – 0.7 cm long and 0.5 – 0.6 cm wide, triangular; all lobes persistent and accrescent, calyx tubes bell-shape, 1.2 – 1.6 cm long and 0.1 – 1.1 cm wide, whitish green at the upper portion and pale green at the lower; glabrous.

Corolla: Corolla lobes (5), gamopetalous, lobes can easily be separated along the adnate line, twisted, petaloid, corolla lobes 4.4 – 4.9 cm long and 0.9 – 1.1 cm wide, pinkish white with pinkish column in the central portion, greenish white in the floral bud, corolla tubes 0.7 – 0.9 cm long and 0.7 – 0.9 cm wide; glabrous. inferior.

Androecium: Stamens numerous, polyandrous, apostemonous, in two or three series, yellowish; anther ditheous, basifixed, dehiscence longitudinal, pollen granular, connective prolong and pointed; filaments very short, dilated at the base, glabrous, whitish or brownish yellow in colour.

Gynaecium: Tricarpellary, syncarpus, trilocular, the placentation axile, with two pendulous ovules in each loculus, style yellowish white, terminal, slender, stigma simple, ovary yellowish white, tomentose, superior.

Fruits: Samaroids, sub-cylindric, with five persistent and accrescent calyx lobes forming wings, two larger and longer and three smaller and shorter, fruits after removing wings 2.0 – 3.5 cm long and 1.4 – 1.8 cm wide, 2 larger wings 9.5 – 15.0 cm long and 1.9 – 3.1 cm wide, 3 smaller wings 0.4 – 0.6 cm long and 0.5 – 0.8 cm wide, green while young, wings gradually turned brown when mature; gums usually exuded from fruit walls, dispersed by wind; fruits wall smooth without ridges; veins of wings prominent.

Flowering Period: March to April, fruits appeared in March.

Distribution: The trees are frequently found in the mixed deciduous and evergreen forests on slopes and ridges from the altitude of 350 m up to 1,000 m from the sea level; from Myitkyina, Myitha, Katha, Mu to Southern Shan States, Minbu, North and South Taungoo, Nyaunglaybin, and as far as the Thauung yin.

Uses: The timber is used in Myanmar as rafters, scantlings and planking in other than high grade construction work. It was also used for the beams and joists of the room. It is used in plywood. The oleoresin is used in torches and lamp oil, and in medicine for treatment of genitor-urinary diseases. The oil is used as a varnish and drying paints.

Distinguishing character:

- (1) Ever green or semi-evergreen large-sized trees, the bark grayish brown with large lenticels forming tubercles and large vertical cracks. Scars of leaves and sheathing stipules distinct on the branchlet.
- (2) Simple, petiolate, alternate and ovate or elliptic-ovate leaves with sheathing stipules, stipules tomentose with long hairs at the tip, leaf blades glabrous, bright and deep green above.

- (3) Monochasial scorpioid cymes with 3 – 8 flowers appeared at the top of branchlet at the base or axil of stipules.
- (4) Ebracteate, pedicellate, ebracteolate, pentamerous and hypogynous flowers.
- (5) Calyx united and accrescent, modified into wings in the fruits, two wings larger than the rest three for wind dispersal.
- (6) Corolla lobes 5, twisted, can easily be separated along the adnate line, pinkish white with pinkish column in the central portion, twisted.
- (7) Stamens numerous and ditheous anthers with prolong connectives.
- (8) Gynaecia tricarpelly, trilocular, axile placentation with two pendulous ovules in each loculus and ovary tomentose.
- (9) Fruits samaroid with two larger wings, smooth on the fruit wall without ridges, one seeded.

Floral Formula: $\overset{\uparrow}{\underset{+}{\text{O}}} K_{(5)} C_5 A_{\infty} \underline{G_{(3)}}$

4.3 Anatomy

4.3.1 *Dipterocarpus tuberculatus* Roxb.

4.3.1.1 Petioles

The petioles of *Dipterocarpus tuberculatus* studied are more or less broadly elliptic in outline in transverse section, the section 9 mm long and 7 mm wide; dermal tissues, ground tissues and vascular tissue system distinguishable.

Dermal tissue system: Epidermal tissues one-layered, made of parenchymatous cells; epidermal cells 7.5 – 12.5 μm in tangential diameter, 5 – 10 μm in radial diameter, rectangular, polygonal, rounded or irregular in shape, outer wall convex, cuticle thin, peltate trichome present, nucleus present in some cells, crystal absent.

Ground tissue system: Outer cortex made of 15 to 42 layered between epidermis and outermost vascular bundles, 369.0 – 1127.5 μm thick, some of ground tissue interrupted the inner vascular bundles and found between the bundles so that outer and inner bundles situated in the ground tissue; cells of a few peripheral layers smaller than those of the rest layers, parenchymatous, cells rounded, oval, rectangular, polygonal or irregular in shape, 7.5 – 52.5 μm long and 5.0 – 52.5 μm wide, large druses present in some cells, intercellular space present; mucilaginous cells present throughout the cortex; resin canals throughout the inner ground tissue, 30.75 – 82.00 μm in diameter, surrounded by one layer of epithelial cells, endodermis not distinct.

Vascular tissue system: The whole mass of vascular bundles more or less broadly elliptic in outline, 7540 μm long and 5460 μm wide, outermost vascular bundle forming a discontinuous ring with wavy outline; the second inner ring internal to outermost ones also discontinuous ring with wavy outline; the rest central bundles irregularly and discontinuously arranged and folded inside the two outer rings; closed and collateral, xylem towards inside and phloem outside in each vascular bundle; amphicribal in two outer rings, bundles interrupted by parenchymatous cells of 1 – 3 rows; xylem 82.0 – 174.3 μm thick and 2 – 5 layered, endarch, protoxylem towards inside, metaxylem outside, cells polygonal or rectangular in shape, large metaxylem contained 1 – 3 cells in each row, metaxylem lying side by side in some rows, xylem composed of vessel elements, tracheids, fibres and xylem parenchyma, druses present in xylem parenchyma and in some parenchyma cells which interrupted between the vascular bundles; phloem 15 – 60 μm thick and 3 – 11 layered, phloem composed of sieve tubes, companion cells, phloem parenchyma and phloem fibres; phloem fibres of outermost ring of vascular bundles forming a pericyclic ring, 3 – 10 layered, 41.0 – 153.75 μm thick, cells polygonal in shape, thick-walled, phloem fibres usually forming phloem caps in the inner vascular bundles, druses present in some parenchyma cells adjacent to the phloem fibres; sieve tubes polygonal or irregular in shape, companion cells small in size and contained nucleus; some of the inner bundles smaller in size and contained a few numbers of xylem cells.

4.3.1.2 Midrib

The midrib of *D. tuberculatus* studied more or less circular in outline in transverse section, 1209.5 – 1291.5 μm in diameter; dermal tissue, ground tissues and vascular tissue system distinguishable.

Dermal tissue system: Epidermal cell one layered in both of surfaces, parenchymatous, cells rectangular, quadrangular, slightly elongated, elliptical or pear shaped and nucleus present in some cells, outer wall mostly convex or transverse or pointed, cuticle thin.

Ground tissue system: 10 – 16 layered between upper epidermis and vascular bundle, 20 – 24 layered between lower epidermis and vascular bundle, parenchymatous, cells oval, rounded, rectangular, polygonal or irregular in shape, deeply stained materials present in a few cell; mucilaginous cells present; druses present in some cells in the cortex or between the vascular bundle; intercellular space present, intercellular space of parenchymatous cells between the bundles filled with colouring material; resin canals present in the ground tissue between the vascular bundle, 41 – 102.5 μm in diameter, surrounded by one layer of epithelial cells.

Vascular tissue system: The whole mass of vascular bundles more or less rounded in outline and slightly flattened at the adaxial side in transverse section. Vascular bundles irregularly arranged and folded inward, interrupted by parenchymatous cells, each group of vascular bundles 102.5 – 307.5 μm thick; outer ring of vascular bundles surrounded by pericyclic phloem fibres interrupted by parenchymatous cells; phloem outer, xylem inner; protoxylem towards inside, cells polygonal or rounded in shape; metaxylem towards outside, cells polygonal in shape, 15 – 55 μm in tangential diameter and 12.5 – 37.5 μm in radial diameter, large metaxylem 1 to 4 cells in each row; xylem composed of vessel elements, tracheids, fibres, and xylem parenchyma; vessel elements 150 – 1100 μm long and 20 – 70 μm wide, perforation plates simple or scalariform, end wall transverse or oblique, tailed at one or both ends; tracheids 420 – 1650 μm long and 10 – 60 μm wide, end walls tapering, thickenings spiral or pitted; fibers 340 – 2500 μm long and 10 – 30 μm wide; phloem 41 – 143.5 μm in thickness, composed of sieve tubes, companion cells, phloem parenchyma and phloem fibres; sieve tubes polygonal or irregular in shape, companion cells small and contained nucleus; pericyclic phloem fibres 3 – 13 layered, thick-walled; phloem fibres in small groups and 1 to 5 layered in the inner vascular bundles; druses present in some parenchymatous cells associated with phloem fibres.

4.3.1.3 Leaf blades

The leaf blades of *D. tuberculatus* studied are 200 – 300 mm thick, and of dorsiventral type; dermal tissue, ground tissue and vascular tissue system distinguishable.

Dermal tissue system: Epidermal cells one layered, upper epidermal cells slightly larger than the lower ones; upper epidermal cells rectangular or polygonal in shape, cells 27.5 – 32.5 μm in horizontal diameter and 25.0 – 37.5 μm in vertical diameter, nucleus present in some cells, deeply stained materials present in most of the cells; lower epidermal cells elliptical, barrel, rectangular, quadrangular, polygonal or irregular in shape, some of the cells showed periclinal division, stoma present, trichomes present, nucleus present in some cells.

Ground tissue system: Mesophyll cells distinguished into palisade and spongy parenchyma, palisade cells at adaxial side, spongy cell at abaxial side; palisade parenchyma two layered, 30.0 – 52.5 μm thick, cells 20.0 – 47.5 μm long and 5 – 10 μm wide, contained chloroplast, some cells large and mucilaginous, some cells contained deeply stained materials, druses present in some cells; spongy cells 7 – 8 layered, 77.5 – 90 μm thick, loosely arranged, cells 12.5 – 27.5 μm long and 5.0 – 17.5 μm wide, rounded, oval, polygonal or irregular in shape, druses present in some cells, chloroplast present.

Vascular tissue system: Many small vascular bundles arranged in a linear row in mesophyll cells, bundles 50 – 77.5 μm in vertical diameter, 27.5 – 50 μm in horizontal diameter; vascular bundles supported by a group of cells in linear rows between the two layers of epidermal cells, supporting cells parenchymatous or sclerenchymatous; xylem composed of vessel elements, tracheids, xylem parenchyma and xylem fibres; vessel elements 140 – 290 μm long and 20 μm wide, perforation plates simple or scalariform, end wall transverse or oblique, tailed at one or both ends; tracheids 180 – 420 μm long and 10 – 15 μm wide, end walls tapering, thickenings spiral or pitted, fibers 220 – 900 μm long and 10 μm wide, phloem 41.0 – 143.5 μm in thickness, phloem composed of sieve tubes, companion cells and phloem parenchyma.

4.3.1.4 Wood of stem

General characteristics of the wood

Sapwood of *D. tuberculatus* studied is about 1 cm thick, not defined and not differentiated by colour from heartwood which is pale reddish-brown, growth-rings present, inconspicuous; wavy or inter-locked grained, texture even or moderately fine; odour present; pores medium-sized to large, distinct to the naked eye and visible with hand lens.

Microscopic characters

Vessels: Diffuse, 3 – 8/mm², few to moderately few, absolutely solitary, solitary pores rounded or oval, mean tangential diameter 164.61 µm (range 71.75 – 246.00 µm), medium-sized; mean length 528.56 µm, (range 307.50 – 994.25 µm), medium-sized; perforation plates simple, end walls transverse or oblique, one end or both ends tailed, inter-vessel pits alternate, 9 µm, small, rounded or oval; intercellular resin canals present, proportion of vessel and resin canal contents in transverse section 78% and 22% respectively, resin canals 55 µm in diameter, moderately small, rounded in shape, epithelial cells one layered; pale reddish-brown gum deposits present; tyloses present or rare.

Fibers: Mostly non-septate, rarely septate, mean length 1611.10 µm (range 922.50 – 2460.00 µm), moderately long; mean width 22.50 µm (range 15 – 30 µm); mean fibers wall thickness 8.3 µm (range 5 – 10 µm), thick-walled; slightly dentate and forked; silica body present; border pits minute and readily observed on radial walls; libriform; slit-like; vasicentric tracheids present, mean length 593.82 µm and mean width 30 µm, usually observed in macerated material.

Rays: Heterogeneous, 2 – 6 cells wide; (mostly 4 – 5); 6 – 12 /mm tangentially, normally space to fairly close; mean height of multiseriate rays 615.21 µm, (range 174.25 – 1435 µm), very low; mean width 65.09 µm (range 20.50 – 102.50 µm), medium-sized and 6 – 54 cells high; mean height of uniseriate rays 234.31 µm (range 92.85 – 512.50 µm), extremely low; 3 – 17 cell high; rays vessel pitting 7.13 µm in diameter, small, oval or rounded in shape; multiseriate rays and uniseriate rays 58% and 42% respectively; pale reddish-brown gum deposits present.

Axial parenchyma: Diffuse, diffuse in aggregate, vasicentric, rarely confluent and associated with the axial intercellular canals.

4.3.2 *Dipterocarpus turbinatus* Gaertn.f.

4.3.2.1 Petioles

The petioles of *Dipterocarpus turbinatus* studied are oval in shape in outline in transverse section, the section 2990 – 3068 µm long and 1976 – 2673 µm wide; dermal tissues, ground tissues and vascular tissue system distinguishable.

Dermal tissue system: Epidermal tissues one-layered, made of parenchymatous cells; cells 7.5 – 15 μm in tangential diameter, 5 – 7.5 μm in radial diameter, rectangular, oval or irregular in shape, outer wall straight, cuticle thin, trichome absent, crystal absent.

Ground tissue system: Made of 16 – 19 layered between epidermis and outermost vascular bundles, 450 – 610 μm thick, cells of peripheral layer smaller than those of the other layers; parenchymatous, cells rectangular, polygonal or irregular in shape, 7.5 – 52.5 μm long and 5.0 – 52.5 μm wide; druses present in some cells; intercellular space minute and rare; mucilaginous cells present throughout the ground tissue, 30.75 – 82.00 μm in diameter, endodermis not distinct.

Vascular tissue system: The whole mass of vascular tissues more or less broadly elliptic in wavy outline, vascular bundles irregularly arranged, 275.0 – 515.0 μm in diameter, xylem towards inside and phloem outside, closed and collateral, amphicribal, xylem 41 – 133.25 μm thick and 2 – 5 layered, phloem 41 – 256.25 μm thick and 3 – 17 layered; xylem endarch, protoxylem towards inside, metaxylem outside, cells polygonal in shape; xylem composed of vessel elements, tracheids, fibres and xylem parenchyma; vessel elements 150 – 680 μm long and 15 – 70 μm wide, perforation plates simple or scalariform, end walls transverse or oblique, tailed at one or both ends; tracheids 110 – 1250 μm long and 10 – 40 μm wide, end walls tapering, thickenings spiral or pitted; fibers 420 – 2350 μm long and 10 – 20 μm wide, thick-walled, lumen narrow or wide; phloem composed of sieve tubes, companion cells, phloem parenchyma and phloem fibres; sieve tubes polygonal in shape; companion cells small, polygonal in shape, phloem fibres present in small groups, 1 – 5 layered, cells polygonal in shape, thick-walled; resin canals present in the ground tissue between the vascular bundles.

4.3.2.2 Midrib

The midribs of *D. turbinatus* studied are more or less circular in outline, slightly flattened at the adaxial side, 2002 – 2236 μm in diameter; dermal tissue, ground tissues and vascular tissue system distinguishable.

Dermal tissue system: Epidermal cells one layered on both sides; parenchymatous, rectangular, quadrangular, elliptical, horizontally elongated, a few cell tangentially elongated or polygonal in shape, outer walls transverse or slightly convex, cuticle thin, deeply stained material present in the cells.

Ground tissue system: 13 or 14 layered between upper epidermis and vascular bundle, 9 – 17 layered between lower epidermis and vascular bundle, 123.0 – 256.3 μm thick; cells parenchymatous, oval, rectangular, polygonal or irregular in shape, deeply stained materials present in most of the cells; mucilaginous cells large in the ground tissue, 30.75 – 82.0 μm in diameter; intercellular space present; druses present in some cells.

Vascular tissue system: The whole mass of vascular tissues more or less semi-circular in outline with flattened surface at the adaxial side in transverse section; vascular bundles irregularly arranged; outermost vascular bundles discontinuously forming a ring; one large vascular bundle and small five bundles inside the outer ring; vascular bundles of the outer ring 102.5 – 225.5 μm thick; central larger one slightly crescent-shaped, 943.0 – 1189.0 μm long, 184.5 – 287.0 μm wide; inner small bundles 133.25 – 225.5 μm long and 92.25 – 205 μm wide; closed and collateral, phloem outer and xylem inner, pericyclic phloem fibres discontinuously surrounded the outer vascular bundles; xylem 61.5 – 174.3 μm thick, protoxylem towards inside, metaxylem towards outside; large metaxylem 2 – 4 cells in each row, 20.5 – 61.5 μm in radial diameter, polygonal in shape, xylem rows interrupted by uniseriate parenchymatous cells; some of the inner vascular bundles capped with phloem fibres; xylem composed of vessel elements, tracheids, fibres and xylem parenchyma; vessel elements 220 – 600 μm long and 20 – 50 μm wide, perforation plates simple or scalariform, end walls transverse or oblique, tailed at one or both ends; tracheids 380 – 1000 μm long and 15 – 30 μm wide, end walls tapering, thickenings spiral or pitted; fibers 400 – 2800 μm long and 10 – 20 μm wide; phloem 41 – 92.25 μm thick; phloem composed of sieve tubes, companion cells and phloem parenchyma; sieve tubes polygonal or irregular in shape, companion cells rectangular or polygonal in shape; pericyclic phloem fibres 3 – 11 layered, 82.0 – 215.25 μm thick, cells thick-walled, associated with parenchymatous cells; resin canals found in the ground tissue between the vascular bundles surrounded by one layers of epithelial cell.

4.3.2.3 Leaf blades

The leaf blades of *D. turbinatus* studied are 235.75 – 276.75 μm thick, of dorsiventral type; and dermal tissue, ground tissues and vascular tissue system distinguishable.

Dermal tissue system: Upper epidermal cells slightly larger than lower one; upper epidermal cells vertically elongated, rectangular, rarely triangular or polygonal in shape,

lower epidermal cells horizontally flattened, rectangular or polygonal in shape, stomata present, deeply stained materials present in both layers; mucilaginous cells present in upper epidermis and large.

Ground tissue system: Differentiated in to palisade and spongy parenchyma; palisade at adaxial side, spongy parenchyma at abaxial side; palisade parenchyma two layered, cells of upper layer longer than those of the lower ones, cells elongate, contained abundant chloroplast, druses present in some cells; spongy parenchyma loosely arranged, spongy cells 6 – 10 layered, 77.5 – 90 μm thick, cells 12.5 – 25 μm long and 5 – 10 μm wide, elongated, elliptical, polygonal, rounded or irregular in shape, cells, 10.0 – 25 μm long, and 5.0 – 10 μm wide, contains abundant chloroplast, resin canals present, 35 – 52.5 μm in diameter, druses present in some cells.

Vascular tissue system: Small vascular bundles arranged in a linear row between the mesophyll cells, some bundles slightly larger, 65 – 87.5 μm long and 27.5 – 47.5 μm wide, supported by a group of cells between the epidermal cells, supporting cells parenchymatous, rounded, oval or polygonal in shape, contained deeply stained materials, bundle sheath not distinct, xylem upper and phloem lower, xylem composed of tracheids, vessel elements, fibres and xylem parenchyma; vessel elements 170 – 450 μm long and 20 – 40 μm wide, perforation plates simple or scalariform, end walls transverse or oblique, tailed at one or both ends; tracheids 130 – 520 μm long and 10 – 20 μm wide, end walls tapering, thickenings spiral or pitted; fibers 200 – 670 μm long and 10 – 20 μm wide; phloem 41.0 – 143.5 μm in thickness, phloem composed of sieve tubes, companion cells and phloem parenchyma.

4.3.2.4 Wood of stem

General characteristics of the wood

Sapwood of *D. turbinatus* is about 2 cm thick, not defined and not differentiated by colour from heartwood which is pale yellowish-brown, wavy or interlocked grained, texture even or moderately fine; odour absent; diffuse porous wood; growth rings indistinct, pores medium-sized to large, visible with hand lens.

Microscopic characters

Vessels: Diffuse, 3 – 7/mm², few to moderately few, absolutely solitary, solitary pores rounded or oval, mean tangential diameter 116.7 µm (range 71.75 – 148.63 µm), medium-sized; mean length 440.07µm (range 225.0 – 676.50 µm), medium-sized; perforation plate simple, end walls transverse or oblique, one end or both ends tailed, intervessel pits alternate, 5.54 µm wide, small, rounded or oval; intercellular resin canals present, 48 µm in diameter, very small, rounded in shape, proportion of vessel and resin canal contents in transverse section 27% and 63% respectively; epithelium cell one layered; reddish-brown gum deposits present; tyloses absent.

Fibers: Mostly non-septate, rarely septate, mean length 1363.87 µm (range 768.75 – 2050.00 µm), medium-sized; mean fiber width 21.73 µm (range 15 - 30 µm); mean fibers wall thickness 8µm (range 5 - 10 µm), thick-walled; slightly dentate and forked; silica body present; border pits minute and readily observed on radial walls; libriform, slit-like; vasicentric tracheids present, mean length 693.15 µm and mean width 32 µm, usually observed in macerated material.

Rays: Heterogeneous, 2 - 6 cells wide; (mostly 4 - 5); 6 – 12/mm tangentially, normally spaced to fairly close; mean height of multiseriate rays are 383.56 µm (range 153.75 - 707.25 µm), extremely low; mean width 67.96 µm (range 30.75 - 97.38 µm), medium-sized and 6 - 27 cells high; mean height of uniseriate rays 217.10 µm (range 71.75 – 410.00 µm), extremely low; 3 - 12 cell high; rays vessel pitting 6.07 µm in diameter, oval or rounded in shape; multiseriate rays and uniseriate rays contents 67 % and 33 % respectively; reddish-brown gum deposits present; silica body present.

Axial parenchyma: Diffuse, diffuse in aggregate, vasicentric, rarely confluent and associated with the axial intercellular canals; silica body present.

5. Discussion

5.1 Morphology

The flowering period of *D. tuberculatus* was March to April, and January to March in Andamans and India, and that of *D. turbinatus* was March to April (Eastern India and Bangladesh) respectively (Anonymous, 1985). In this research, the flowering

period of *D. tuberculatus* was February to March, and that of *D. turbinatus* March to April.

In this paper, the outer surface of the bark of *D. tuberculatus* is dark gray, with vertical and horizontal cracks in older or younger stems, which agree to Anonymous (1985). The outer surface of the bark of in *D. turbinatus* is grayish brown, with large lenticels forming tubercles and large vertical cracks in younger stems, inner surface reddish brown. Anonymous (1985) stated that the bark surface light gray, yellowish-brown inside; exfoliating in irregular rounded flakes.

The flowers are bracteate in *D. tuberculatus* and ebracteate in *D. turbinatus*; calyx lobes two larger, which are modified into wings in the fruits, pentamerous, cyclic, hypogynous, ovary superior in both species, and these characters are agreed with those described by Parkinson (1932).

In this paper, the fruits are samaroids with 5 persistent and accrescent calyx lobes forming wings, 2 wings larger and 3 wings smaller in both species. The fruits of *D. tuberculatus* have 5 ridges on their walls at the upper portion, but there are no ridges on the fruits of *D. turbinatus*. According to Anonymous (1985), Hooker (1874), Kurz (1877) and Parkinson (1923), fruits belly are ovoid or almost globular, glabrous or slightly stellate and pilose, furnished with tubercles at the upper end in *D. tuberculatus*; ovoid, smooth in *D. turbinatus*.

In this paper, some morphological characteristics and wood of the two species of the genus *Dipterocarpus* are compared as shown in the following Tables 1, and 2.

Table 1. Comparison of habits, size, bark and wood of the two species of the genus *Dipterocarpus*

No.	Characters	<i>Dipterocarpus tuberculatus</i>	<i>Dipterocarpus turbinatus</i>
1	Habits	medium-sized, with sub-cylindrical crown	large evergreen trees, with laxly sub-globose crown
2	Size	5 – 7 m, 0.5 – 1.0 m in girth	15 – 18 m, 1.0 – 1.5 m in girth
3	Bark	outer surface of the bark grey, with vertical and horizontal cracks	outer surface of bark grayish brown, with large lenticels forming tubercles and large vertical
4	Sapwood	Pale reddish brown	Pale yellowish brown
5	Heartwood	Pale reddish brown	Pale yellowish brown

Table 2. Comparison of leaves of the two species of the genus *Dipterocarpus*

No.	Characters	<i>Dipterocarpus tuberculatus</i>	<i>Dipterocarpus turbinatus</i>
1	Colour	green, with reddish anthocyanin area on the upper surface,	bright and deep green above
2	Shape	ovate, 32.5 – 65.9 cm long and 20.9 – 48.5 cm in wide	ovate or elliptic-ovate, 19.0 – 38.5 cm long and 10.7 – 17.5 cm wide
3	Tip	acute or obtuse	acute or acuminate
4	Base	slightly cordate	rounded or obtuse
5	Margins	entire and ciliated	entire and slightly wavy

5.2. Anatomy

In this paper, mucilagenous cells, resin canals and druses are found in tissues of *D. tuberculatus* and *D. turbinatus* as shown in the following table 3.

Table 3. The presence of mucilagenous cells, resin canals and druses in *D. tuberculatus* and *D. turbinatus*

Species	mucilagenous cells	resin canals	druses
<i>D. tuberculatus</i>	petiole ground tissue	petiole ground tissue	petiole ground tissue
	midrib ground tissue	midrib ground tissue	
	leaf blade ground tissue	wood of stem	leaf blade ground tissue
<i>D. turbinatus</i>	petiole ground tissue		petiole ground tissue
		petiole vascular bundle	
	midrib ground tissue	midrib vascular bundle	midrib ground tissue
	leaf blade dermal tissue	leaf blade ground tissue	leaf blade ground tissue
		wood of stem	

Metcalf and Chalk (1957) also described that mucilage cells were sometimes found in the ground tissue of the petiole and/or midrib and lateral veins in certain species of *Dipterocarpus*. Resin canals were often found in the petiole. Cluster and, more rarely, solitary crystals were commonly present and frequently abundant in the parenchymatous tissues of the mesophyll and petiole.

Pearson and Brown (1932) stated that parenchyma of paratracheal and metatracheal type encircling all resin canals in the wood of *D. tuberculatus* and *D. turbinatus*.

In this paper, vessels of both species of the genus *Dipterocarpus* were found to be exclusively solitary, with reddish-brown gum deposits. But Pearson and Brown (1932) stated that the vessels of the wood are majority solitary, occasionally paired, open or occasionally plugged with reddish-brown tyloses in *D. tuberculatus*.

However, Metcalfe and Chalk (1957) stated that the vessels of wood were found almost exclusively solitary in *Dipterocarpus*. Tyloses were usually abundant in members of the family Dipterocarpaceae except in *Dipterocarpus*.

In this paper, fibers are mostly non-septate, rarely septate and libriform in both species of the genus *Dipterocarpus*, but Pearson and Brown (1932) mentioned that fibres in the wood of *D. turbinatus* and *D. tuberculatus* were libriform and non-septate.

In this paper, the multiseriate rays of *D. tuberculatus* are heterogeneous, 2 – 6 cells wide; (mostly 4 – 5); mean height 615.21 μm , (range 174.25 – 1435 μm), 6 – 54 cells high; multiseriate rays and uniseriate rays 58% and 42% respectively; pale reddish-brown gum deposits present; and the multiseriate rays of *D. turbinatus* are heterogeneous, 2 - 6 cells wide; (mostly 4 - 5); mean height 383.56 μm (range 153.75 - 707.25 μm), 6 - 27 cells high; multiseriate rays and uniseriate rays contents 67 % and 33 % respectively; reddish-brown gum deposits present; silica body present.

However, Pearson and Brown (1932) stated that in *D. tuberculatus*, rays were 1 – 6 seriate, heterogeneous, crystals wanting; starch deposits not observed.

Qualitative and quantitative characteristics of the wood structure of *D. tuberculatus* and *D. turbinatus* studied are compared in the following table 4 and 5.

Table.4. Qualitative characteristics of wood structure of *Dipterocarpus tuberculatus* and *D. turbinatus*

Sr. No	Qualitative characteristics	<i>Dipterocarpus tuberculatus</i>	<i>Dipterocarpus turbinatus</i>
1.	Growth-rings	Present, inconspicuous	Inconspicuous
2.	Texture	Even or moderately fine	Even or moderately fine
3.	Grain	Wavy or interlock	Wavy or interlock
4.	Odour	Present	Absent
5.	Porosity	Diffuse	Diffuse
6.	Shape of pores	Rounded or oval	Rounded or oval
7.	Perforation plate	Simple	Simple
8.	Axial parenchyma	Diffuse, diffuse in aggregate, vasicentric	Diffuse, diffuse in aggregate, vasicentric
9.	Ray type	Heterogeneous	Heterogeneous
10.	Spacing of rays	Normally space to fairly close	Normally space to close
11.	Fiber septation	Septate	Septate
12.	Fiber type	Libriform	Libriform
13.	Tyloses	Present or rare	Absent
14.	Gum deposits	Present, pale reddish-brown colour	Present, reddish-brown colour
15.	Crystal	Absent	Absent
16.	Arrangement of intercellular canals	Diffuse, short tangential row	Diffuse, short tangential row
17.	Shape of intercellular canals	Rounded	Rounded
18.	Layer of epithelium cells	One layer	One layer

Table.5. Quantitative characteristics of wood structure of *Dipterocarpus tuberculatus* and *D. turbinatus*.

Sr. No	Quantitative characteristics	<i>Dipterocarpus tuberculatus</i>	<i>Dipterocarpus turbinatus</i>
1	Pore frequency (per sq mm)	3-8	3-7
2	Vessel diameter (μm)	164.61 71.75 – 246	116.75 71.75 – 148.63
3	Vessel length (μm)	528.56 397.50 – 994.25	440.07 225.50 – 676.50
4	Fiber length (μm)	1611.10 922.50 – 1260	1363.87 768.75 – 2050
5	Fiber width (μm)	22.50 15 – 30	21.73 15 – 30
6	Fiber wall thickness (μm)	8.3 5 – 10	8 5 – 10
7	Tracheid length (μm)	593.82 358.75 – 871.25	693.15 338.25 – 768.75
8	Tracheid width (μm)	29.67 22.50 – 37.50	32.19 22.50 – 45
9	Ray frequency (per mm)	6 – 12	7 – 15
10	Rays cells wide	2 – 6	2 – 6
11	Multiseriate rays height (μm)	615.21 174.25 – 1435	383.56 153.75 – 707.25
12	Multiseriate rays width (μm)	65.09 20.50 – 102.50	67.96 30.75 – 97.38
13	Multiseriate rays cells high	6 - 54	6 – 27
14	Uniseriate rays height	234.31 92.50 – 512.50	217.10 71.75 – 410
15	Uniseriate rays cells high	3 – 17	3 – 12
16	Intervessel pitting in diameter (μm)	9	5.54
17	Ray vessel pitting in diameter (μm)	7.13	6.07
18	Multiseriate rays percentage	59%	62%
19	Uniseriate rays percentage	42%	38%
20	Intercellular canals width (μm)	55	48
21	Intercellular canal percentage	22%	63%

6. Conclusions

The morphological and anatomical characteristics of the two Myanmar species of the genus *Dipterocarpus* studied in this paper are usefully informative in identification of the species, proper utilization and environmental and biodiversity conservation. Although the natural regeneration of the genus *Dipterocarpus* is still sustainable, more effective way of propagation is required for the long run, because of extremely and extensively extractions of the *Dipterocarpus* trees from the natural forests. Moreover, further research in the field of genetics, embryology, economic botany, environmental science, conservation of biodiversity and ecophysiology concerned with *Dipterocarpus* species should also be done.

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Figure 1. *Dipterocarpus tuberculatus* Roxb. and *D. turbinatus* Gaertn. f. n

A. *Dipterocarpus tuberculatus* tree grown in natural habit.

B. *D. turbinatus* tree grown in natural habit.

C. A portion of bark of *D. tuberculatus*.

D. A portion of bark of *D. turbinatus*.



Figure 2. *Dipterocarpus tuberculatus* Roxb. (In)

- A. Inflorescences.
- B. L.S of a flower and a group of stamens.
- C. Matured fruit



Figure 3. *Dipterocarpus turbinatus* Gaertn. f.n (Kanyin)

- A.** A flowering branchlet.
- B.** An inflorescence bearing mature flowers.
- C.** L.S of a portion of flower.
- D.** A dry matured fruit.

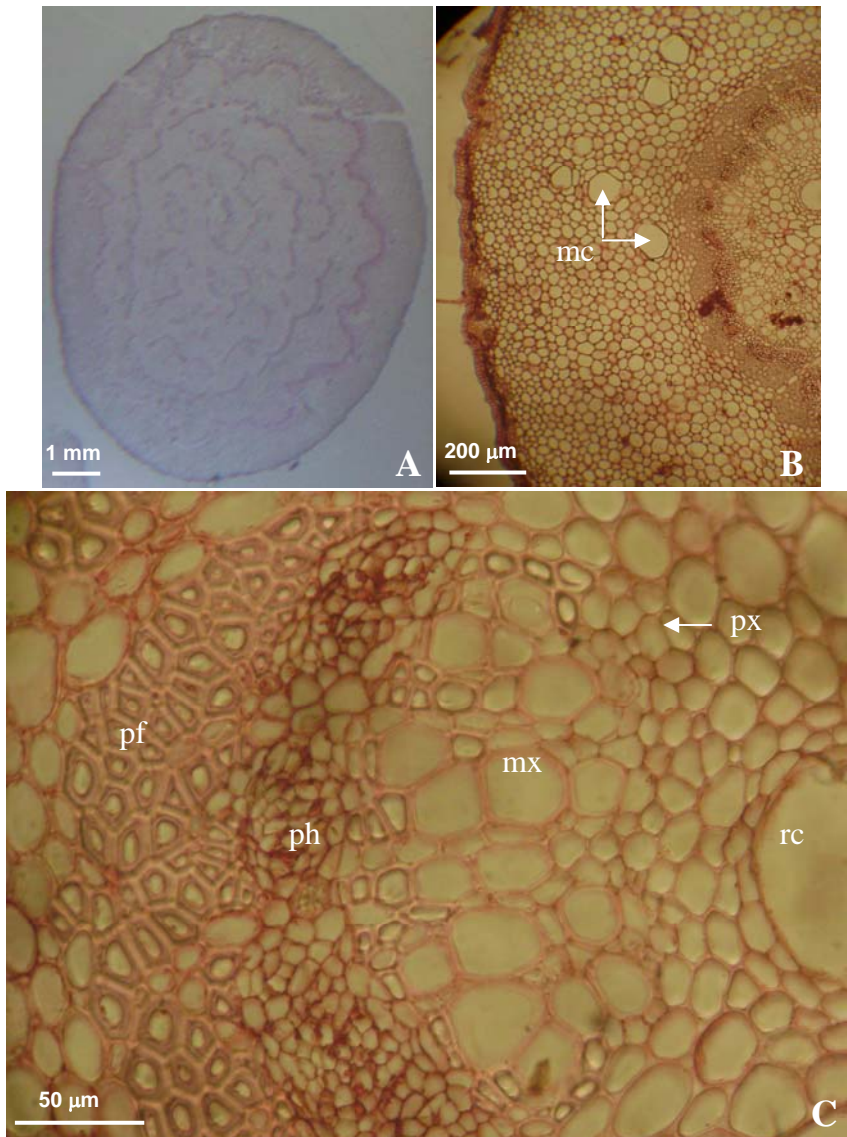


Figure 4. Petiole of *Dipterocarpus tuberculatus* Roxb.

- A.** T. S of a petiole showing two outer rings of vascular bundles and the rest central bundles irregularly arranged in ground tissue.
- B.** T. S of a portion of petiole showing ground tissue, resin canals and vascular bundles.
- C.** T. S of a portion of petiole showing a portion of outer vascular bundles.

(**Note:** pf – phloem fiber, ph – phloem, mx – metaxylem, px – protoxylem, mc – mucilaginous cell, rc – resin canal)

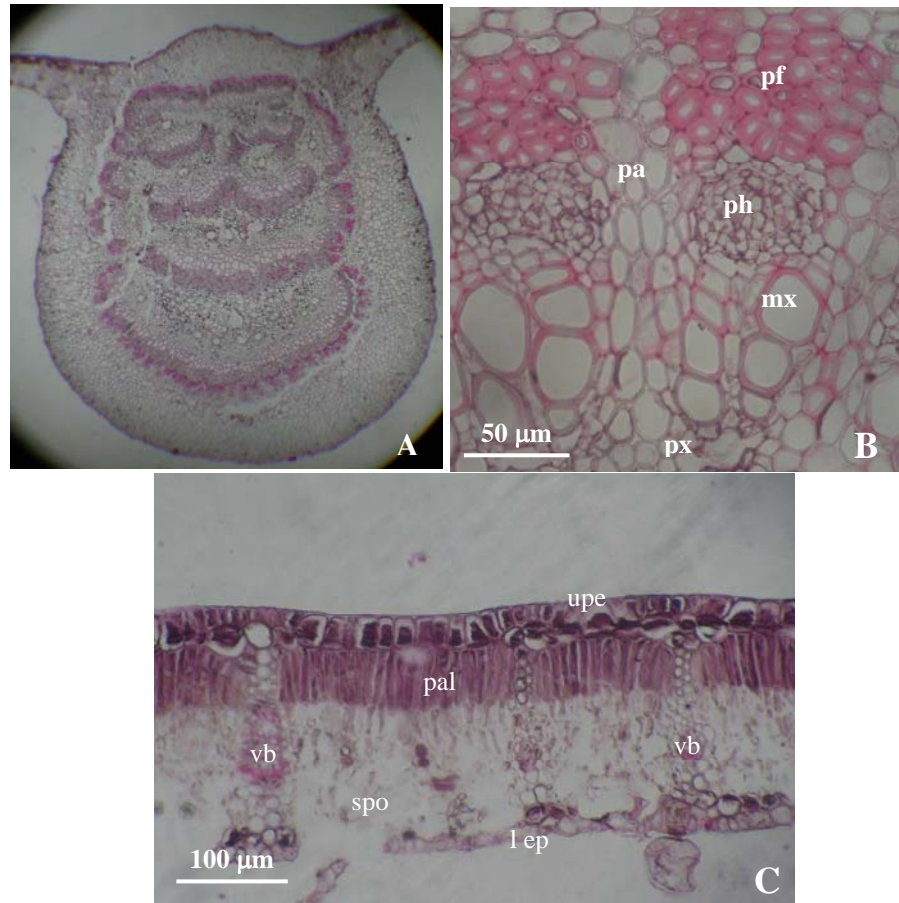


Figure 5. Midrib and leaf blade of *Dipterocarpus tuberculatus* Roxb.

- A. T.S of a mid-rib.
- B. T.S of a portion of vascular tissue.
- C. T.S of a portion of leaf blade.

(Note: upe – upper epidermis, l ep – lower epidermis, vb – vascular bundle, pf – phloem fiber, ph – phloem, pa – parenchyma, mx – metaxylem, px – protoxylem, pal – palisade parenchyma, spo – spongy parenchyma)

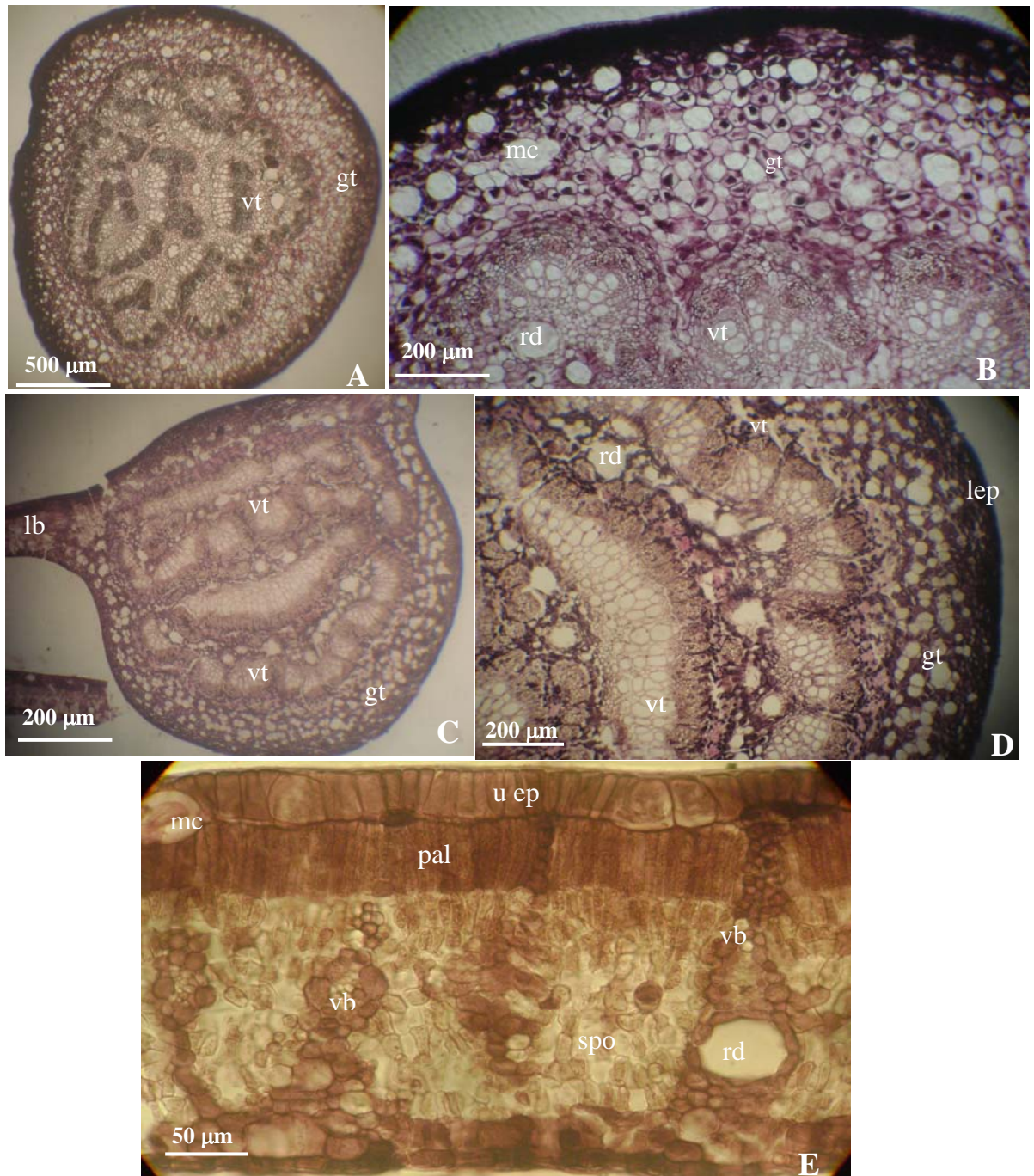


Figure 6. Petiole of *Dipterocarpus turbinatus* Gaert. f.

A. T.S of a petiole. **B.** T.S of a portion of petiole. **C.** T.S of a midrib.
D. T.S of a portion of a midrib. **E.** T.S of a portion of leafblade.

(**Note:** lb – leaf blade, uep – upper epidermis, gt – ground tissue, vt – vascular tissue, vb – vascular bundle, pal – palisade parenchyma, spo – spongy parenchyma, mc – mucilagenous cell,)

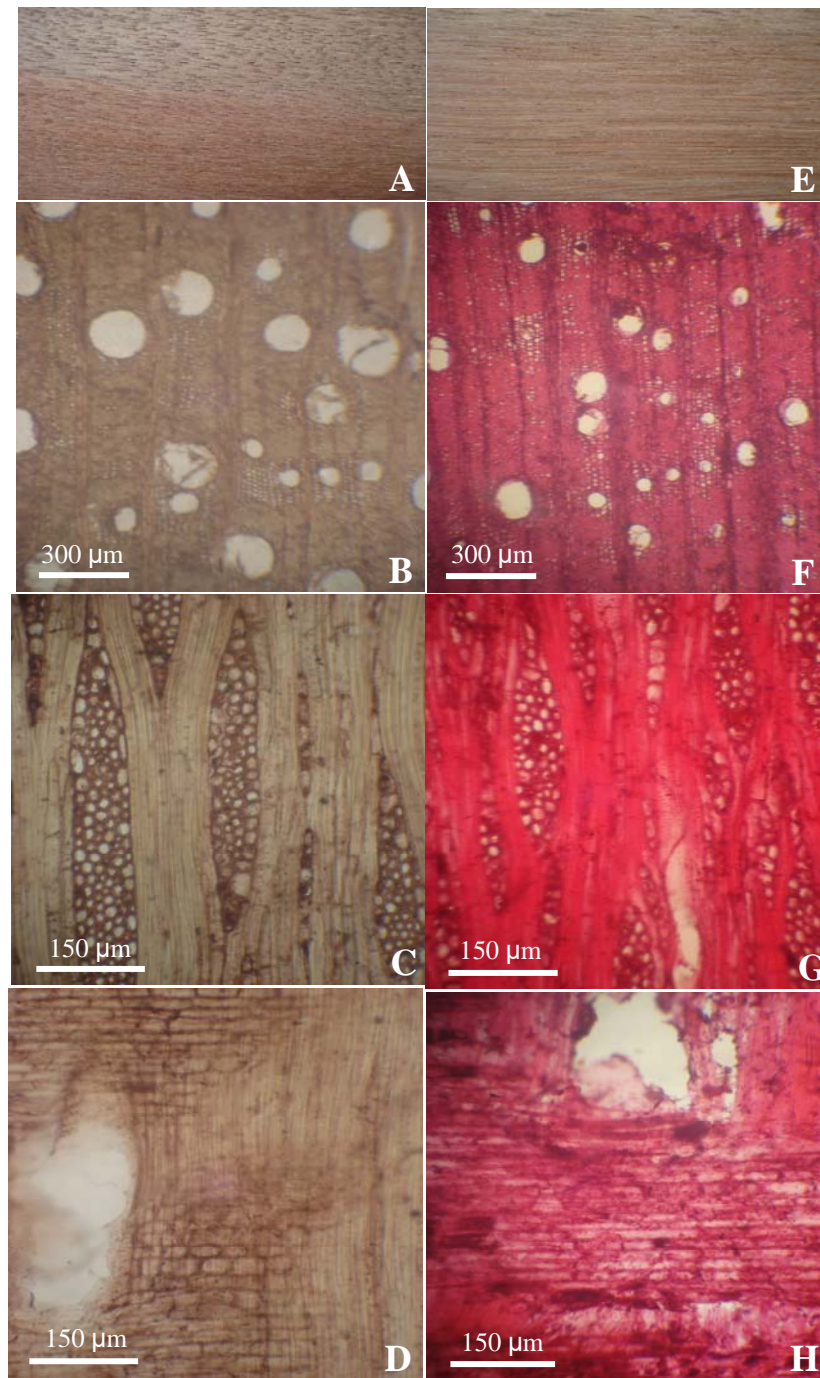


Figure 7. Wood of *Dipterocarpus tuberculatus* Roxb. and *D. turbinatus* Gaertn. f.

A. A portion of wood of *D. tuberculatus*
B. T.S of wood of *D. tuberculatus*
C. T.L.S of wood of *D. tuberculatus*.
D. R.L.S of wood of *D. tuberculatus*.

E. A portion of wood of *D. turbinatus*
F. T.S of wood of *D. turbinatus*
G. T.L.S of wood of *D. turbinatus*
H. R.L.S of wood of *D. turbinatus*



Figure 8. Location map of collection site.