

A STUDY ON MORPHOLOGICAL AND ANATOMICAL CHARACTERISTICS OF SOME SPECIES OF THE FAMILY CAPPARIDACEAE

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ABSTRACT

Morphology and anatomy of some species found in family Capparidaceae especially growing in the tropical region of central Myanmar, collected from Patheingyi, Sagaing and its surrounding area, had been done. The morphology of vegetative and reproductive parts, anatomy of the wood of the stems have been described. The species studied in this research are as described. The species studied in this research are as follows:

1. *Boscia variabilis* Coll.& Hems. (Tha-mon)
2. *Capparis flavicans* wall. (Saung-kyan)
3. *Capparis grandis* Linn. (Kaung -wa)
4. *Crataeva religiosa* Forst. (kadet)

The outstanding characteristics of the species and important anatomical characteristics in reference to their wood have been compared and discussed.

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1. INTRODUCTION

Capparaceae (or) Capparidaceae of some authorities, the Caper family, derives its name and importance from Kapparis, the Greek name used by Dioscorides for *Capparis spinosa* (Anon., 1768). The name of the family Capparidaceae is conserved previously, it was also called Capparidaceae (Chayamarit, 1991).

The family Capparidaceae is derived from the core of the order Capparales. They have many common vegetative and floral features and cells. Other shared features suggest that the family Capparidaceae is ancestral to the Brassicaceae. Others, however consider the Capparales to have originated from the most primitive members of the order Violales (Anon., 1768).

The Caper family consists of 42 genera and 725 tropical and warm temperate flowering plant species (Anon., 1950) with strong drought resistant tendencies. It include herbs, shrubs or trees with simple or palmately compound alternate leaves and mostly bisexual, somewhat irregular flowers with usually four separate sepals and petals, six to many stamens, a superior one called ovary and fruit that may be sessile but is more characteristically stalked. The woody Capparidaceae have indehiscent, rather fleshy berries and usually many stamens (Anon., 1768).

Economically, the Capparidaceae is not of much importance to us (Datta, 1969). Some of the species are important silviculturally from their grown in the driest regions where the numbers of woody plants is small; otherwise they are of but little forest importance (Gamble, 1922). Several species are noted for their medicinal properties (Kennard, 1995).

In the family Capparidaceae, the genus *Boscia* and *Crataeva* are well known for their medicinal values. The barks of the genus *Crataeva* is used as antibiotics, disorders of urinary organs and used in snake bite. The barks contain saponin and tennin (Chopra, 1956). The juice of the bark is used to treat convulsions (Oliver - Bever, 1963).

A strong cement is made by mixing the fruit with mortar; the rind serves as a mordant in dyeing (Dastur, 1962). In Trichinopoly it is also used very liable to the attacks of boring beetles (Gamble, 1922).

A large genus of *Capparis* is also used as medicine. Infusion of barks and leaves of Kaung - wa was used internally for swellings and eruptions (Chopra, 1956), and yields an oil which is used by the native for ploughshares and rafters-beam. A review of literature has been mentioned that very little work on wood anatomy of these species done in Myanmar but morphology of some species are stated but the taxonomic study is totally lacking.

In the present research the habit, distribution, morphological and taxonomic characteristics, flowering and fruiting periods, general and microscopic characteristics of the wood and uses have been given for each species. In the present study, included the four species belonged to Capparidaceae are as follows:

1. *Boscia variabilis* Coll. & Hems.
2. *Capparis flavicans* Wall.
3. *Capparis grandis* Linn.
4. *Crataeva religiosa* Forst.

2. LITERATURE REVIEW

According to Hutchinson (1964), the Capparidaceae is included under the Capparidales. But Benth-Hooker placed it under the cohort Parietales and Rendle under the Rhoadales (Datta, 1969). According to Hutchinson (1964) and Anon. (1768) Capparidaceae is divided into two subfamilies namely Capparidoideae and Cleomoideae based on habit and characters of fruits.

Datta (1969) mentioned that this family is widely distributed in the tropical parts of both hemispheres. This family is abundant throughout the warm regions of the earth (Anon., 1950) and also found in the tropics and warmer countries (Anon., 1950 and Kennard, 1995).

In the family Capparidaceae, there are about 45 genera and 700 species by Datta, (1969), Chayamarit (1991) and Kennard (1995). According to Brandis (1907), this family has 40 genera and 450 species.

2.1. *Boscia variabilis* Coll. & Hems.

The genus *Boscia* was distributed in adjoining Siamese province of Radbooree (Kurz, 1877) and hills on the east side of the Western Peninsula (Brandis, 1907). In Myanmar, according to Kurz (1877), *Boscia variabilis* was found in Ava. According to Kurz (1877), it is shrub, but Brandis (1907) and Gamble (1922) described that it is a small tree. Leaves were simple (Brandis, 1907), very variable in size, shape and even nervature by (Kurz, 1877). The shape of leaves was narrowly oblong (Brandis, 1907), linear or oblong or cuneate lanceolate (Kurz, 1877). According to Brandis (1907), calyx tube was very short and lined by fleshy annular disk. Petals were absent. The ovaries contained two placenta bearing a small number of ovules.

Metcalf and Chalk (1950) noted that the pattern of vessel pores are radial, perforation plates were simple, rays were homogeneous and consists of mostly procumbent cells. And than rays are 2-3 seriate. Axial parenchyma was paratracheal. Anomalous stems structure was also present. According to Hutchinson (1964), fruits and seeds of various species of *Boscia* are eaten in tropical Africa. In Myanmar, medicinal values are mentioned by Ashin Nagathein (1978). He stated that the leaves and roots were used in aching, sedema, cold extremities and also used as stomachic, expectorant, and counter irritant.

2.2. *Capparis flavicans* Wall.

Sawyer (1926) mentioned that they are occasional plant in dry, open situations. It was distributed from central Burma to Southern Indochina (Chayamarit, 1991). According to Kurz (1877), this species was armed shrub with very short, straight and spreading thorns. It was a shrub or small tree stated by Sawyer (1926) and Chayamarit (1991). The leaves are glabrous, oblong or obovate- oblong or retuse and mucronate described by Hooker (1872). Sawyer (1926) mentioned that the leaves were coriaceous and obovate, elliptic or rhomboid in shape (Chayamarit, 1991). According to Kurz (1877), inflorescences were sparious raceme or corymbs. Flowers were small, solitary or bipairs, (Kurz, 1877), unisexual (Brandis, 1907) and (Sawyer, 1926). Sepals have densely tawny tomentose (Kurz, 1877) and densely fulvous tomentose outside (Chayamarit, 1991). Sawyer (1926) and Chayamarit (1991) stated that densely tomentose is seen on the outside of petals.

The fruits of this species are subglobose or elliptical in shape and covered with densely grayish tomentose (Chayamarit, 1991). According to Sawyer (1926), the shape of fruits are ovoid oblong. Gamble (1922) mentioned that the color of wood was white or yellowish white, the vessel of wood were small to moderate sized, rarely large, and usually arranged in radial lines. According to Metcalfe and Chalk (1950), solitary and in short radial multiples pores were formed without any pattern, commonly in clusters. Perforations were simple, the fibres were thin to thick walled. Rays were homogeneous. The medullary rays were moderately broad (Gamble, 1922). Parenchyma was paratracheal, most commonly vesicentric and sparse (Metcalf and Chalk, 1950).

2.3. *Capparis grandis* Linn.

According to Kurz (1877), this species is frequently common in the dry forests, especially the mixed ones of the Prome District. Chayamarit (1991), stated that this species was in India, Ceylon, Burma and South Vietnam. The species was a small tree by Watt (1889), Anon. (1950), Talbot (1902), Brandis (1907) and Gamble (1922). Although this species are found to be tree with small thorns, according to Chayamarit (1991). Brandis (1907) mentioned that it is softly tomentose beneath rhomboid ovate or obovate. The leaves of this species are elliptic or ovate, papery to subcoriaceous (Chayamarit, 1991). Hooker (1872) and Brandis (1907) mentioned that flowers were white; inflorescences were terminal corymbs or racemes. Sepals were tawny puberulous (Kurz, 1877) but pubescent (Chayamarit, 1991). Hooker (1872) described that petals were narrow obovate obliquely ascending. Moreover they were ciliate at the base and rounded at the apex according to Chayamarit (1991).

Stamens were numerous (Kurz, 1877 and Chayamarit, 1991). Gynophores were slender described by Kurz (1877) and Chayamarit (1991). The fruits of this species were berries revealed by Kurz (1877) and found to be subglobose in shape by Hooker (1872). According to Kurz (1877), the wood colour was white, close grained,

heavy durable and good for turning, but Talbot (1902) and Gamble (1922) mentioned that they are moderately hard and durable. Pores were scanty small, moderate sized or large and arranged irregular at intervals between rays. Rays were homogenous by Gamble (1922). According to Metcalfe and Chalk (1950) the fibres were thin to thick walled. Paratracheal parenchyma, most commonly vesicentric and sparse. Gamble (1922) noted that maduallary rays were moderately broad and short. The medicinal values were mentioned by Nath Nair (1963), infusion of barks and leaves were used internally for swellings and eruptios. The wood of this species is much used by the natives for making agricultural implements and rafters by Talbot (1902) and Gamble (1922). An oil, which is used in medicine and as fuel were yield from this species, according to Watt (1889).

2.4. *Crataeva religiosa* Forst.

According to Watt (1889), Talbot (1902) and Dastur (1962), this species found in the central and southern India and Burma in the tropics of both hemisphere, Hooker (1872) and Hutchinson (1954) revealed that it widely spread towards the tropical Africa and Asia. Sawyer (1925) recorded that this species is occasionally found on the banks of canals.

According to Hooker (1872), Gamble (1922), Dastur (1962) and Chayamarit (1991), this species was an unarmed deciduous tree. It is small tree (Sawyer, 1926; Randhawa, 1957; and Thein kywe, 1987).

The leaves of this species contains 3-leaflets by Hutchinson (1954) and Brandis, (1972). There are elliptic or ovate leaflets (Chayamarit, 1991) and oblong to ovate (Kennard, 1995). The inflorescence of this species were pale yellow or cream-coloured Dastur, 1962), and coloured (Kurz, 1877). According to Ridley (1967) sepals were narrow lanceolate but elliptic or oval and ovate (Brandis, 1972 and Kennard, 1995). Petals were ovate or oblong with obtuse or acute tip and claw (Hooker, 1872 and Sawyer, 1926), rounded-ovate with long claw (Brandis, 1972), broadly elliptic (Chayamarit, 1991). The fruits were berries according to Hooker (1872), Kurz (1877), Anon (1950) and Sawyer (1926). The seeds were embedded in the yellow or cream-coloured pulp (Brandis, 1907; Dastur, 1962 and Kennard, 1995). The wood color was yellowish white, according to Watt (1889), Anon. (1950), Gamble (1922), Dalziel (1955), Dastur (1962) and Brandis (1972). According to Watt (1889), Talbot (1902) and Gamble (1922) it is when old turning light brown. The wood was even or close and smooth-grained (Brandis, 1972) and straight-grained (Thein Kywe, 1987), with a peculiar odour when fresh by Dalziel (1955).

According to Metcalfe & Chalk (1950) and Gamble (1922), pores were moderate sized. Metcalfe & Chalk (1950) stated that the perforation plates were simple, Vessels were solitary and radial multiples or in clusters; fibres were nonseptate and diffuse porous wood (Thein Kywe, 1987). According to Gamble (1922), rays were short, fine and moderately broad. Thein Kywe (1987) mentioned

that uniseriate to biseriate rays; heterocellular by Metcalfe and Chalk (1950), They mentioned that the paratracheal parenchyma most commonly vesicentric and sparse. According to Thein Kywe (1987) apotracheal parenchyma diffuse and paratracheal parenchyma sparse.

According to Watt (1889), Anon (1950), Gamble (1922), Dalziel (1955), Chopra (1956), Dastur (1962), Hutchinson (1964) and Oliver-Bever (1963), the barks and leaves are utilized as native medicine. The wood is durable and used for making drums, models, writing board, combs and small articles mentioned by Gamble (1922) and Brandis (1972). Hutchinson (1964) mentioned that the pickled flowers were consumed as a stomachic in Burma. Moreover Talbot (1902) recorded that the wood is utilized for toys and box-wood. Rodger (1935) also stated that the wood is used for furniture and might make a substitute for box-wood. Anon. (1950) reported that it is employed in match -sticks.

3. MATERIALS AND METHODS

All the species used for morphological and taxonomic descriptions in the present study were taken from Sagaing and Patheingyi Townships. They were collected during the flowering periods from January to August during the year 1996 and 1997. For morphological and taxonomic studies the specimen were pressed, dried, and preserved for identification.

For anatomical observations, a portion of stem including the bark, with the diameter of (20 cm - 15 cm - 2.5 cm) was taken from the main trunk at the level of between 4 -5 feet high. The sectioning of the wood samples was prepared according to the method as given by (Jeffery, 1917) with slight modification.

For microscopic studies, sound hard wood specimens were selected and cut into different planes according to the required (1 cm - 1 cm - 2 cm) transverse, tangential and radial sections. Then these specimens were boiled in water depending on their hardness to become soft which renders easy sectioning respectively.

The specimens were stored in a mixture of 2 volume of 50% alcohol and 1 volume of glycerine solution before sectioning. For cutting transverse, tangential and radial sections, sliding microtome was used. The thickness of sections usually varied from 25 - 35 microns according to the nature of wood structures. After the sectioning they were stored in 50% alcohol - glycerine solution for mounting.

For staining and mounting, the sections were washed in tap water. When the sections were free of alcohol - glycerine. They were immersed in 3% solution of ferric ammonium sulphate for about 10 - 15 seconds and then they were washed again under tap water for 3 times. They were then stained in 0.5 % solution of haematoxyline about 10 -15 seconds, after which was followed by three repeated washing under water.

When the sections were properly stained, they were put into distilled water with 2 - 3 drops of safranin and left for over night. The sections were removed from

safranin solution and distilled and dehydrated by running them through a series of 50 %, 70 %, 90%, 95 % alcohol and lastly cleared with xylene. They were put into clove oil for further cleaning and mounted in Canada balsam dissolved xylene.

Finally, the transverse, tangential and radial section of each specimen were mounted on the same side. The slides were then dried in the air for one week. The plant materials for maceration were prepared by treating with a mixture of equal volume of 30 % hydrogen peroxide and glacial acetic acid according to Franklin's method (1946).

The color, texture, and grain direction were studied by using (20 cm - 15 cm - 2.5 cm) blocks of wood samples collected of the stems of above 1.5 m high.

The photomicrographs were taken by using Olympus Universal Research Microscope Vanox model and detailed drawing had also been made.

4. OBSERVATION

4.1. Morphology

Members of the family Cappariaceae of the genus *Boscia* and *Crataeva* are woody plants, one species of genus *Capparis* include trees, shrubs and climbers. In this paper the two species such as *Boscia variabilis* and *Crataeva religiosa* are unarmed trees. The other two species, *Capparis flavicans* and *C. grandis* are thorny.

The color of the bark are dark grey in *Boscia variabilis*, dark brown in *Capparis flavicans*, and *C. grandis*, whitish grey in *Crataeva religiosa*. Prominent longitudinal ridges are found in *Capparis flavicans*.

The arrangement of the leaves are alternate without stipules. Simple leaves are found in *Capparis flavicans* and *C. grandis*, palmately 2-5 foliolate in *Boscia variabilis* and *Crataeva religiosa*. Their shapes vary from ovate, elliptic to obovate. The tips obtuse to acuminate and even retuse, the margins entire and the bases obtuse, cuneate to oblique . The surfaces of the leaves are tomentose in *Capparis flavicans* and *C. grandis*.

The inflorescences are axillary and terminal racemes to corymbs. The flowers are bisexual and pedicellate; the colour of the flowers are yellowish green in *Boscia variabilis*, yellowish orange colour at the base in *Capparis flavicans*, white in *C. grandis*, and change of colours from white to yellow in *Crataeva religiosa* .

The number of sepals are four and free in *Capparis flavicans*, *C. grandis* and *Crataeva religiosa* but connate at the base into a short tube in *Boscia variabilis* . Tomenrose surfaces are found in *Capparis flavicans* and *C. grandis* .

The petals are also four, free in *Capparis flavicans*, *C. grandis* and *Crataeva religiosa* except *Boscia variabilis*, which is apetalous. The long and distinct clawed petals are found in *Crataeva religiosa*. In *Capparis flavicans* both the surfaces of the petals are pubescent.

The number of stamens are numerous, many seriate, free and exerted. They all attached to the bases of the gynophore. The anthers are dithecous, basifixed and

dehiscence by longitudinal slits. The ovaries are monocarpellary, unilocular and parietal placentation, the gynophores are long and distinct in all species.

Fruits are berries, ovoid oblong and tomentose in *Capparis flavicans*, ovoid or oval and glabrous in *Boscia variabilis* and *Capparis grandis*, ovoid oblong with dry flat papillae in *Crataeva religiosa*. Seeds are numerous in all species. They are immersed in the fleshy pulp.

Among the four species, the fermented leaves of *Crataeva religiosa* is eaten in the whole country. In upper Myanmar, the fermented fruit pulp of *Capparis flavicans* is edible. The barks of *Boscia variabilis* is used as medicine for eye disease, and the flowers are famous for making salad.

4.2. Taxonomy

4.2.1. Artificial key to the species

1. Leaves simple 2
1. Leaves palmately compound 3
 2. Barks irregularly ridge; inflorescence terminal or axillary corymbs; flowers white, glabrous; fruits globose *Capparis grandis*
 2. Barks deeply furrowed irregularly or vertically; inflorescences paniculate racemes; flowers yellow, densely pubescent; fruits oblong – ovoid..... *Capparis flavicans*
3. Leaves tri-foliolate; the base of the two lateral leaflets oblique; flowers white turn to yellowish white; petals distinctly clawed; fruits subglobose and large *Crataeva religiosa*
3. Leaves 2-5 foliolate; the bases not oblique; flowers pale green or yellowish green; petals absence, fruits globose and small *Boscia variabilis*

4.2.1.1. Botanical Name *Boscia variabilis* Coll. & Hems. (Tha-mon)

Habit and distribution Unarmed small tree, attaining 10-13 m in height. This species is commonly found in Upper Myanmar especially growing throughout Sagaing area and along the road side.

Morphological and taxonomical characteristics:

Unarmed small tree, stem cylindrical, glabrous, branches terete, branchlets slightly pubescent when young, present of swollen portion. Leaves palmately bi to penta foliolate compound, alternate, the laminae obovate oblong to linear oblong, 4.0-8.5 cm long, 2.5-3.5 cm wide, the bases cuneate or acute, the margins entire, the tips obtuse or rounded to emarginated, both surfaces glabrous, midrib prominent

beneath; petioles cylindrical, petiolules 0.2-0.5 cm long, leaflets unequal. Inflorescences paniculate racemes, 8-12 cm long. Flowers solitary, 1.5-2.5 cm in diameter, zygomorphic, apetalous; calyx 4, ovate oblong or acute at the apex, 1.0-1.5 cm long, 0.3-0.5 cm wide, connate at the base in to a short tube; petals absent; stamens numerous, adnate at the gynophore; ovary ellipsoid or oblongoid, about 0.2 cm long, 1.0 cm wide, unilocular with numerous ovules. Fruit berries, globoid, 1.5-2.4 cm across, glabrous; seeds reniform, embedded in pulp.

Flowering and fruiting period: It flowers from January to March and fruits from March to May.

Bark: Dark brown to grayish brown, about 0.4 cm thick, smooth or slightly rough.

4.2.1.2 Botanical Name *Capparis flavicans* Wall. (Saung-kyan)

Habit and distribution Armed small tree, about 10 m in height. It is scattered throughout the dry zone of Upper Myanmar.

Morphological and taxonomical characteristics:

Armed small tree, stem cylindrical, glabrous, branches terete, glabrous, branchlets terete, densely pubescent. Leaves simple, alternate, the laminae ovate or obovate, 2.5-5.0 cm long, 1.5-3.5 cm wide, the bases obtuse, the margins entire, the tips rounded or obtuse, but surfaces glabrous in old age, densely pubescent when young; petioles cylindrical, stipules spinous. Inflorescences axillary or terminal, fascicles, 10-25 cm long. Flowers solitary, about 2.0 cm long, 1.5 cm wide, zygomorphic, ebracteate; calyx 4, oval or elliptical in shape, about 0.5 cm long, 0.4 cm wide; petals 4, elliptical or oblong in shape, 1.0 cm long, 0.5 cm wide, yellow, orange color at the base; stamens numerous, free; ovary ovoid, about 0.2 cm wide, unilocular with numerous ovules, borne on long gynophore. Fruit berries, ovoid-oblong, 2.0-3.5 cm long, tomentose; seeds minute, reniform, embedded in pulp.

Flowering and fruiting period: It flowers from March to May and fruits from June to August.

Bark: Greyish brown to brown, 0.5-1.0 cm thick, deeply narrow irregularly or vertically.

4.2.1.3 Botanical Name *Capparis grandis* Linn. (Kaung-wa)

Habit and distribution Armed small tree, stem cylindrical, thorns not or curved, about 10 m in height. It is scattered throughout the dry zone of Upper Myanmar.

Morphological and taxonomical characteristics:

Armed small tree, stem cylindrical, thorns not or curved glabrous, branches terete, rough, branchlets terete, spinous. Leaves simple, alternate, the laminae obovate or ovate or oval in shape, 4.5-8.0 cm long, and about 3.5 cm wide, the bases acute, the margins entire, the tips obtuse, glabrous and green above, the lower surfaces paler and pubescent when young; petioles cylindrical. Inflorescences axillary or terminal, corymb, 6 cm long. Flowers solitary, 2.5-3.0 cm long, 2.0-2.5 cm wide, zygomorphic; calyx 4, oblong or linear oblong, 0.4-0.7 cm long, 0.3-0.5 cm wide; petals 4, oblong, 0.5-1.0 cm long, 0.3-0.6 cm wide, white; stamens numerous, free; ovary ovoid, about 0.2 cm long, unilocular with many ovules. Fruit berries, globoid or subgloboid, 1.5-3.5 cm long, 3-5 cm wide, glabrous, smooth. Seeds globoid.

Flowering and fruiting period: It flowers from May to June and fruits from July to September.

Bark: Brownish grey to dark brown, slightly thick, rough, longitudinally and irregularly ridges.

4.2.1.4. Botanical Name *Crataeva religiosa* Forst. (Ka-det)

Habit and distribution Unarmed deciduous small to medium sized tree, about 13 m. in height. This species is commonly found growing wild in Myanmar.

Morphological and taxonomical characteristics:

Unarmed, deciduous, small to medium sized tree, stem cylindrical, branches terete, glabrous, branchlets terete. Leaves palmately trifoliolate compound, alternate, the central leaflets slightly larger than the lateral ones, the laminae elliptic or obovate, 10-18 cm long, 4.5-7.5 cm wide, the bases cuneate, the margins entire, the tips acute or acuminate, both surfaces glabrous, the lateral leaflets elliptical, 7.5-17.0 cm long, 2.7-7.5 cm wide, the bases oblique acute, or cunete, the margins entire, the tips acuminate, both surfaces glabrous. Inflorescences terminal or axillary, simple corymbs, about 16 cm long, 18 cm wide. Flowers about 5-7 cm long, 4.0-5.5 cm

wide, zygomorphic, large white or creamy white; calyx 4, free ovate, acute at the apex, 2-4 cm long, 0.5-1.0 cm wide; petals 4, broadly ovate with long claw, 1.6-3.0 cm long, 1.0-2.5 cm wide, the claws 0.2-2.9 cm long, white when young and turning creamy white; stamens numerous free; ovary oblongoid, about 1.2 cm long, unilocular with numerous ovules, borne on long gynophore. Fruits berries, ovate or subglobose, 3-6 cm long, 3.0-4.5 cm wide, smooth, with dry flat papillae. Seeds reniform, embedded in pulp.

Flowering and fruiting period: It flowers from March to April and fruits from April to May.

Bark: Brownish grey to slightly grayish white, about 0.5-1.0cm thick, smooth. longitudinally and irregularly ridges.

4.3. Anatomy

4.3.1. Key to the species

1. Heart wood distinct; maximum pore frequency less than 20; average solitary pore percentage more than 40*Crataeva religiosa*
1. Heart wood not distinct, maximum pore frequency more than 20; average solitary pore percentage less than 402
 2. Maximum tangential diameter of pores less than 60 um; well marked radial pore pattern distinct; rays heterocellular; interlocked grained *Boscia variabilis*
 2. Maximum tangential diameter of pores more than 80 um; well marked radial pore pattern indistinct; rays homocellular; straight grained 3
3. Rays uni to triseriate, maximum uniseriate ray height more than 15 cell; gum deposit absent in pores*Capparis flavicans*
3. Rays uni to multiseriate, maximum uniseriate ray height less than 15 cell; gum deposit present in pores *Capparis grandis*

4.3.1.1. *Boscia variabilis* Coll. & Hems.

General characteristics and properties of the wood

Sap wood grayish white or white, heart wood not distinct; odour and taste not distinct; moderately hard; interlocked grained; very fine textured; diffuse porous wood; growth ring not distinct.

Microscopic characteristics:**Vessel elements**

Diffuse porous; pores extremely small to moderately small, mean tangential diameter 34µm (range 10-60); number per sq. mm. moderately numerous to very numerous (range 17-86); average solitary pores 11% (range 0-27.5); pores solitary or pores clusters are rare, as radial pore multiples; oval or circular in cross section; thick walled; perforation plates simple, end walls of elements oblique or transverse, tailed one end or truncate or both end; intervascular pitting opposite to alternate, crowded, elliptical or oval, chambers with mean tangential diameter 4.38 µm (range 2.5-7.5); vessel elements extremely short to moderately short, mean length 184 µm (range 100-265 µm).

Fibres

Libriform, extremely short to medium sized, mean length 405.31 µm (range 215.25-1230 µm); F/V ratio 2.27 (range 1.11-7.06), mean tangential diameter 12.3 µm (range 7.5-22.5µm), non septate; thin wall; 2.5-5.0 µm thick, interfibre pits simple, slitlike, fork fibres present.

Rays

Heterocellular, uniseriate to multiseriate, mostly 4-6 seriate, 14-34 per mm. tangentially, very numerous; uniseriate rays extremely fine to very fine, mean width 11 µm (range 5-20 µm), mean height 110 µm (range 20-297 µm), 3-29 cells high; multiseriate rays very fine to medium sized, mean width 41 µm (range 20-80 µm), mean height 300 µm (range 70-645 µm), 7-63 cells high; ray vessel pitting opposite to alternate, elliptical or oval in shaped, (2.5-5.0 µm) in diameter, aggregate ray present; prismatic crystal absent.

Axial parenchyma

Paratracheal parenchyma scanty, confluent parenchyma does not form long wavy lines, due to tendency of nomalos formation. Prismatic crystals absent.

Uses

The medicinal value of Myanmar *Boscia* species were mentioned by Ashin Nagatiein (1978). The leaves and roots were used for aching and also used as stomachic, analgesic, expectorant and counter irritant.

4.3.1.2. *Capparis flavicans* Wall.

General characteristics and properties of the wood

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

Microscopic characteristics:

Vessel elements

Diffuse porous; pores very small to moderately small, mean tangential diameter 63 μm (range 30 - 92 μm); number per sq. mm. moderately few to numerous, (range 8 - 24); average solitary pore 28.56 % (range 0 - 62.5); pores solitary or mostly as radial pore multiples of 2 - 4 or pore clusters, oval or circular in cross sections; thick walled; perforation plate simple and walls of elements oblique or transverse, tailed one end or both ends or truncate; intervascular pitting opposite to alternate, crowded, elliptical or oval, chambers with mean tangential diameter 4.5 μm (range 2.5 - 10.0 μm); vessel elements extremely short to medium sized, mean length 245 μm (range 110 - 360 μm)

Fibres

Libriform, extremely short to very short, mean length 461.46 μm (range 305 - 598 μm); F/V ratio 2.02 (range 0.94- 4.18 μm), mean tangential diameter 15.2 μm (range 7.5 - 25.0 μm), non-septate; very thin to thick walled; 1.25 - 20.5 μm thick, interfibre pits simple, minute, slit-like.

Rays

Homocellular, uniseriate to triseriate, mostly uniseriate to triseriate, mostly uniseriate to biseriate, 15-27 per mm. tangentially, very numerous; uniseriate rays extremely height 231.86 μm (range 82-560 μm), 8-55 cells high; multiseriate rays extremely fine to moderately fine, mean width 16.91 μm (range 10-30 μm); mean height 320 μm (range 140-615 μm), 14-60 cells high; ray vessel pitting opposite to alternate, angular or oval in shaped, 2.5-5.0 μm in diameter, μm deposits absent.

Axial parenchyma

Paratracheal parenchyma scanty, terminal parenchyma inconspicuous band; apotracheal parenchyma diffused and gum deposits and prismatic crystals absent.

Uses

This species is used in native medicine. The fermented fruits are dible.

4.3.1.3. *Capparis grandis* Linn.

General characteristics and properties of the wood

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

Microscopic characteristics:

Vessel elements

Diffuse porous; pores very small to medium sized; mean tangential diameter 70 µm (range 30-102 µm); number per sq. mm. moderately few to numerous (range 9-34), average solitary pores 40% (range 9-70); pores solitary or as radial pores multiples of (2-5) and pore clusters; oval or rounded in cross section, thick walled; gum deposits present; perforation plates simple, end walls of elements oblique to transverse, tailed one end or both ends or truncate; intervascular pitting opposite to alternate, crowded, oval or rounded, chambers with mean tangential diameter 6.25 µm (range 2.5-70.0 µm); vessel elements extremely short to medium sized, mean length 200 µm (range 92-480 µm).

Fibres

Libriform, extremely short to very short, mean length 470 µm (range 360-615 µm); F/V ratio 2.5 (range 1.8-4.5), mean tangential diameter 16.6 µm (range 5-25 µm); non septate, thin walled, 1.25-6.25 µm thick, interfibre pit simple, minute, slit like.

Rays

Homocellular, uniseriate to multiseriate, mostly 4-6 seriate; 5-12 par mm. tangentially, moderately numerous to very numerous; uniseriate rays extremely fine to very fine, mean width 1.2-3 µm (range 5-20 µm), mean height 83.85 µm (range 10-164 µm), 1-10 cells high; multiseriate rays very fine to medium sized, mean width 45 µm (range 20-82 µm), mean height 340 µm (range 90-660 µm), 5-52 cells high; ray vessel pitting 3.4 µm in diameter (range 2.5-5.0 µm), alternate to opposite, crowded, elliptical or oval or rounded in shape; crystals absent.

Axial parenchyma

Paratracheal parenchyma very sparse, scanty; apotracheal parenchyma diffuse terminal parenchyma in not distinct bands, gum deposits and prismatic crystals absent.

Uses

The medicinal value of *C. grandis* were mentioned by Nath Nair (1963), Infusion of bark and leaves were used internally for swellings and eruptions. The

wood is used by the natives Presidency for making agricultural implements and rafters and it is regarded as good for turning. An oil which is used in medicine and as fuel were yield from this species.

4.3.1.4. *Crataeva religiosa* Forst.

General characteristics and properties of the wood

Sapwood pale yellow or whitish yellow, heartwood yellowish brown; odour and taste not distinct; fairly straight grained; very fine textured, diffuse porous wood; growth ring not distinct.

Microscopic characteristics:

Vessel elements

Diffuse porous, pores very small to medium sized; tangential diameter 65.6 um (range 30-110 um); number per sq. mm. few to moderately numerous (range 5-18), average solitary pore 80% (range 50-100); pores mostly solitary or sometimes as radial pore multiples of 1-3; angular in cross section; thin walled; perforation plates simple, end walls of elements oblique or transverse, tailed one end or both ends or truncate; intervacular pitting opposite to alternate, crowded, elliptical or angular, chambers with mean tangential diameter 3.12 um (range 2.5-50 um), vessel elements extremely short to very short, mean length 173 um (range 110-245 um).

Fibres

Libriform, extremely short to medium sized, mean length 620 um (range 275-920 um): F/V ratio 3.7 (range 1.5-6.0), mean tangential diameter 21.15 um (range 2.5-32.5 um); non septate, thin walled, 2.25-5.0 um thick interfibre pit minute, simple, slit like.

Rays

Heterocellular, uniseriate to 8 seriate, mostly 4-6 seriate, 4-10 per mm. tangentially, few to numerous, uniseriate rays extremely fine to moderately fine, mean width 16 um (range 10-25 um), mean height 90 um (range 28-153 um), 1-8 cells high; multiseriate rays moderately fine to moderately broad, mean width 70 um (range 20-110 um), mean height 450 um (range 100-920 um), 5-40 cells high; ray vessel pitting alternate, crowded, elliptical or angular in shaped, (2.5-5.0 um) in diameter, gum deposits and crystals absent in ray cells.

Axial parenchyma

Paratracheal parenchyma scanty, vasicentric, aliform; apotracheal parenchyma diffuse in aggregate; terminal parenchyma inconspicuous band, gum deposits and prismatic crystals absent. Fusiform wood parenchyma present.

Uses

The fermented leaves are edible. It is bitter in taste. The bark is medicinal. The Juice from it raises the appetite and used as a laxative, it is considerably used in India. The wood is used for small particles and then elsewhere for firewood. It has been used for matches - sticks.

5. DISCUSSION

All the species studied in this research are well adapted to dry zone of central Myanmar. The species namely *Boscia variabilis* Coll. & Hems., *Capparis flavicans* Wall., *C. grandis* Linn. and, *Crataeva religiosa* Forst. were belonged to the family Capparidaceae. In this discussions, a comparison has been made between some of the morphological and anatomical characteristics of the four species found in the present research with those of the other workers.

5.1. Morphology

5.1.1. *Boscia variabilis* Coll. & Hems.

In the present work, *Boscia variabilis* are found to be unarmed, small trees. These features were agreed with those described by Gamble (1922), Than Than Aye (1974), Khin Maung Tin (1974), and Myint (1977). The leaves are found to be palmately bi-penta foliolate compound and alternate which agree with Khin Maung Tin (1974), but according to Than Than Aye (1974) and Hnin Hnin Mya (1977), palmately compound; and according to Brandis (1907), leaves are simple.

In this research, inflorescences are terminal pedunculate racemes, which agree with Than Than Aye (1974). But the inflorescences are terminal corymbs with few flowers had been described by Khin Maung Tin (1974). The calyx of this species are found to be connate at the base into a short tube, yellowish green, oblong in shape which agree with Than Than Aye (1974) and Khin Maung Tin (1974). Calyx tube very short lined by a fleshy annular disk as had been described by Brandis (1907).

The corolla is found to be absent which agree with the description of various authors. The stamens are numerous and adnate at the androgynophore in the present study which are in agreement with Hnin Hnin Mya (1977). The ovary of *Boscia variabilis* are found to be a small number of ovules on two placentas as had been mentioned by Brandis (1907). The anthers are dithecous, basifixed in the present study, which are in agreement with Than Than Aye (1974) and Hnin Hnin Mya (1977).

5.1.2. *Capparis flavicans* Wall.

In this research, *Capparis flavicans* are armed with small trees. These characters are agree with Khin Maung Tin (1974), Than Than Aye (1974) and Hnin Hnin Mya (1977), but Kurz (1877) described that it is shrub, (Sawyer, 1926; Myint,

1977 and Chayamarit, 1991) found that it is shrub or small trees. The leaves of this species are obovate, or ovate-oblong as has been described by Hooker (1872), Kurz (1877), Brandis (1902), Sawyer (1926), Khin Maung Tin (1974), Than Than Aye (1974), Myint (1977) and Hnin Hnin Mya (1977) but Chayamarit (1991) described it is elliptic or rhomboid.

Inflorescence are terminal or axillary, fascicles, in this work, it is terminal corymb form according to Khin Maung Tin (1974). The flowers are small, solitary or by pairs as has been described by Kurz (1877). According to Brandis (1907), the flowers are unisexual, small petals densely warty outside. The flowers are bisporangiate, zygomorphic, pedicels pubescent, which is in agreement with Than Than Aye (1974) and Myint (1977).

In this work, the sepals of this species are densely pubescent on both surfaces, which agree with Kurz (1877), Than Than Aye (1974), Khin Maung Tin (1974) and Myint (1977). The petals are pubescent in both surfaces in the present study is in agreement with Myint (1977). In this research, the stamens are found to be exerted which agree with Khin Maung Tin (1974) and Myint (1977). The fruits of this species are ovoid-oblong in the present study, which agree with Sawyer (1926) and Khin Maung Tin (1977).

5.1.3. *Capparis grandis* Linn.

In this research, the habit of this species is armed, small trees, which are in agreement with Chayamarit (1991). The leaves are glabrous above when young and both surfaces in age which agree with Hooker (1872). However, while young they are softly tomentose all over according to Kurz (1877). The Inflorescences are axillary or terminal corymbs at the end of branches, which are in agreement with Brandis (1907). Hooker (1872) described that it is terminal corymbs or racemes.

In this research, the species were pubescent outside which agree with Chayamarit (1991). The petals were glabrous on both surfaces, but Kurz (1877) revealed that they are ciliate and slightly pubescent on the inner side. According to Hooker (1872), Myint (1977) and Chayamarit (1991), the petals were narrow-obovate, obliquely ascending.

In the present work, the stamens are numerous which agree with Kurz (1877), Myint (1977) and Chayamarit (1991). The ovaries of *C. grandis* are found to be superior, many ovulate on parietal placentae, with a long slender gynophore in the present study which is agree with Myint (1977). According to Hooker (1872), Brandis (1907) and Myint (1977), the fruits are size of a nutmeg, purple, subglobose. Chayamarit (1991) stated that the fruits are globose and pointed when young and Kurz (1877) recorded that they are berries.

5.1.4. *Crataeva religiosa* Forst.

Crataeva religiosa are found to be unarmed deciduous trees which agree with Hooker (1872), Gamble (1922), Dastur (1962), Hnin Hnin Mya (1977) and Chayamarit (1991), but Hutchinson (1954), Ridley (1967) and Kennard (1995) described that they were shrub or small trees. In the present study, the leaflets are found to be elliptic or obovate which agree with Chayamarit (1991), but Kurz (1877) and Sawyer (1926) mentioned that the leaflets were ovate to ovate lanceolate. In this research, the inflorescences are terminal corymbs. In this research, the sepals were ovate which agree with Brandis (1907), Hnin Hnin Mya (1977) and Kennard (1995), but there were narrow lanceolate as has been described by Ridley (1967).

The petals are ovate or broadly ovate with long claw, which agree with Hnin Hnin Mya (1977). According to Hooker (1872) and Sawyer (1926), petals were ovate or oblong with claw; but it is obovate or round with claw described by Ridley (1967). The color is pale yellow. But it is white, turning yellow as has been described by Hnin Hnin Mya (1977) and Chayamarit (1991).

According to Hooker (1872), Kurz (1877), Anon., (1950), Sawyer (1926) and Hnin Hnin Mya (1977), the fruits were berries, which are in agreement with this work.

5.2. Anatomy

The observed anatomical characteristics for the four woods studies were agreed with the descriptions for these species are given in the literature. The relative differences in general characteristics of the four species are stated as shown in the table 5.1. The sapwood of *Boscia variabilis* is found to be grayish white or white in color and without distinct heartwood. The wood color of *Capparis flavicans* is found to be yellowish brown or whitish brown in this study. However, Gamble (1922) stated that the wood color of *C. flavicans* was white or yellowish white. In *Capparis grandis*, wood is whitish brown or grayish white, which agree with Anon. (1950) and Gamble (1922). However, Kurz (1877), Watt (1889) and Talbot (1902) mentioned that it is white. The sapwood color of *Crataeva religiosa* is found to be pale yellow or whitish yellow and heartwood color is yellowish brown in this study, which is agree with Talbot (1902) and Thein Kywe (1987). According to Watt (1889), Anon., (1950), Gamble (1922), Dalziel (1955), Dastur (1962) and Brandis (1972) the wood color was yellowish white.

In the present study, the wood of these species is straight and has fairly straight-grained except *Boscia variabilis* in which it is inter-locked grain. According to Kurz (1877) the wood of *Capparis grandis* was close-grained, but it is straight-grained in this observation. Although the wood of *Crataeva religiosa* is fairly straight-grained in this study, it is even-grained as described by Watt (1889), Talbot (1902), Gamble (1922) and Rodger (1936). Moreover Brandis (1972) also noted that

the wood of this species was even or close and smooth grained. According to Their Kywe (1987), it is straight-grained.

The wood of all species studied is very fine textured according to Their Kywe (1987), Secondary xylem characteristics observed for all the species are shown in the table 5.2. Growth tings are not distinct in all species observed. All the species studied have diffuse porous wood. The vessels are solitary as well as radial multiples and occasionally in clusters. In *Boscia variabilis* the vessel pores arranged indefinite radial line, which agree with Metcalfe & Chalk (1950).

The pores of *Boscia variabilis* are extremely small to moderately small in this research. The pores of *Capparis flavicans* is very small to moderately small in this study but according to Metcalfe & Chalk (1950) it is small to medium sized. In *Capparis grandis*, pores are very small to medium sized. However Gamble (1922) stated that pores of this species were small or moderate sized or large. In the present study the pores of *Crataeva religiosa* is found to be very small to medium-sized. But it is medium-sized according to Gamble (1922) and Metcalfe & Chalk (1950).

Vessel elements are extremely short to moderately short in *Boscia variabilis*, extremely short to medium sized in *Capparis flavicans* and *C. grandis* are extremely short to very short in *Crataeva religiosa*. Average length of vessel elements of the four species of Capparidaceae are shown in table 5.2. Their tangential pores diameters revealed the narrow range and maximum mean diameter is observed in *Capparis grandis* and minimum mean diameter in *Boscia variabilis* as shown in table 5.3. The wall thickness of vessel elements four species studied was thick walled except in *Crataeva religiosa* in which it is thin walled. In cross sections the vessel pores are of all species observed are circular or oval in shape except *Crataeva religiosa* in which it is angular in shape. Perforation plates are simple in all of the species studied. Inter vascular pittings are alternate in *Boscia variabilis* and *Capparis flavicans*, and opposite to alternate in remaining species.

Table (5.1) Comparison of Macroscopic Characteristics of Wood of *Boscia variabilis*, *Capparis flavicans*, *Capparis grandis* and *Crataeva religiosa*.

Species observed	Colour	Odour and taste	Grain	Texture
<i>Boscia variabilis</i>	greyish white or white	not distinct	interlocked-grained	very fine textured
<i>Capparis flavicans</i>	yellowish brown or whitish brown	not distinct	straight-grained	very fine textured
<i>Capparis grandis</i>	whitish brown or greyish white	not distinct	straight-grained	very fine textured
<i>Crataeva religiosa</i>	pale yellow or whitish yellow to yellowish brown	not distinct	fairly straight-grained	very fine textured

Table (5.2) Quantitative Characteristics of Microscopic Wood structure of *Boscia variabilis*, *Capparis flavicans*, *Capparis grandes* and *Crataeva religiosa*.

Species observed mean value	<i>Boscia variabilis</i>	<i>Capparis flavicans</i>	<i>Capparis grandis</i>	<i>Crataeva religiosa</i>
mean pores frequency (per sq. mm.)	45	20	19	11
mean vessel diameter (mm)	34	63	70	65
mean vessel length (um)	184	245	200	173
mean fiber diameter(um)	12.3	15.2	16.6	21.15
mean fiber length (um)	406	461	470	620
mean fiber thickness (um)	3.38	2.65	3.35	3.17
mean uniseriate ray height (cells)	6	15	4	4
mean uniseriate ray height (um)	110	232	814	90
mean uniseriate ray width (um)	11	10	12	16
mean per frequency (per mm)	26	21	8	6
mean multiseriate ray height (cells)	12	26	22	21
mean multiseriate ray height (um)	300	320	340	450
mean multiseriate ray width (um)	41	17	45	70

Number of pores per square millimeter is varied among the species and their frequency and range are also mentioned in table 5.4. Maximum pores frequency is found in *Boscia variabilis* and minimum pores frequency in *Cratarva religiosa*. In the present study the fibre of all species observed are libriform and non-septate. Thein Kywe (1987) stated that in *Crataeva religiosa* fibres are non-septate which is in agreement with this study. In this research, the length of vessel to fibre ratio is calculated in present table 5.5. The maximum mean is found in *Crataeva religiosa*, minimum mean in *Capparis flavicans*.

Axial parenchyma of *Boscia variabilis* is found to be very sparse confluent parenchyma does not form long wavy line. In *Capparis flavicans* scanty paratracheal and diffuse apotracheal parenchyma are observed. As observed in this research axial parenchyma of *Capparis grandis* are found to be very sparse. Paratracheal parenchyma is scanty and apotracheal parenchyma is diffuse in this species. The axial parenchyma of *Crataeva religiosa* are observed to be scanty, vesicentric and aliform paratracheal parenchyma are diffuse in aggregate apotracheal parenchyma in the present study. However according to Thein Kywe (1987), axial parenchyma of these species are sparse, paratracheal parenchyma and diffuse apotracheal parenchyma.

Crystals and gum deposits are not observed in axial parenchyma of all species studied in this research. The rays vary from low to high and uniseriate to multiseriate, the maximum mean of ray frequency occur in *Boscia variabilis* and the minimum mean of ray frequency in *Crataeva religiosa* as shown in table 5.6. Rays were homocellular and heterocellular. Homocellular rays are found in two species studied except *Boscia variabilis*, in which it is heterocellular. Gamble (1922) revealed that the rays of *Capparis grandis* were homocellular, which is agreement with observation of the present study.

The rays of *Crataeva religiosa* are heterocellular, in this study. The rays are uniseriate to 4 seriate in *Boscia variabilis*. The rays of *Capparis flavicans* are uniseriate to triseriate and the rays of *Capparis grandis* are uniseriate to 6 seriate. In *Crataeva religiosa* the rays are uni to 8 seriate but it uni to biseriate and mostly biseriate according to Thein Kywe (1987). Crystals and gum deposits are not observed in the ray cells.

Table (5.3) Comparison of Vessel Pores Diameters among the Four Species of *Boscia variabilis*, *Capparis flavicans*, *Capparis grandis* and *Crataeva religiosa*

Species observed	Pores diameter (um)		
	mean	minimum	maximum
<i>Boscia variabilis</i>	34	10	60
<i>Capparis flavicans</i>	63	30	92
<i>Capparis grandis</i>	70	30	102
<i>Crataeva religiosa</i>	66	30	110

Table (5.4) Comparison of Pores per Square Millimeter of *Boscia variabilis*, *Capparis flavicans*, *Capparis grandis* and *Crataeva religiosa*

Species observed	Number of pores per sq.mm.		
	mean	minimum	maximum
<i>Boscia variabilis</i>	45.76	17	86
<i>Capparis flavicans</i>	20.24	8	24
<i>Capparis grandis</i>	19.26	9	34
<i>Crataeva religiosa</i>	11.68	5	18

Table (5.5) Comparison of Fiber Length and Vessel Length Ratio of *Boscia variabilis*, *Capparis flavicans*, *Capparis grandis* and *Crataeva religiosa*.

Species observed	The ratio of length of vessel to fiber		
	mean	minimum	maximum
<i>Boscia variabilis</i>	2.3	1.1	7.0
<i>Capparis flavicans</i>	2.0	0.9	4.2
<i>Capparis grandis</i>	2.5	1.8	4.5
<i>Crataeva religiosa</i>	3.7	1.5	6.45

Table (5.6) Comparison of Ray Number per Millimeter of *Boscia variabilis*, *Capparis flavicans*, *Capparis grandis* and *Crataeva religiosa*.

Species observed	ray per millimeter		
	mean	minimum	maximum
<i>Boscia variabilis</i>	26	14	34
<i>Capparis flavicans</i>	21	15	27
<i>Capparis grandis</i>	8	5	12
<i>Crataeva religiosa</i>	6	4	10

6. SUMMARY AND CONCLUSION

The morphology of the vegetative and reproductive parts and the anatomy of wood of the stems were collected from tropical region of Central Myanmar have been studied and described. In discussion, a comparison has also been made between the results of this research and those of other workers.

The outstanding morphological features of vegetative parts and the floral characteristics were found to be useful in the identification of the species.

The anatomical characteristics were also useful to distinguish the species. The number of vessel pores per unit area, the variation in the tangential diameter of vessel pores, the presence and absence of gum deposits, septate and nonseptate fibers, type of rays, height and width of multiseriate rays, the number of rays per millimeter, parenchyma patterns and fiber/vessel ratio were the diagnostic characteristics of the species.

The result of present study has contributed towards better understanding of four species of *Boscia variabilis*, *Capparis flavicans*, *C. grandis*, *Crataeva religiosa*, of family Capparidaceae. Moreover, it is hoped that the information given here are useful not only for the purpose of practical identification but also contribute towards the broader applied and academic interests.

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