Morphological and Anatomical studies on *Justicia adhatoda* L. and *Justicia ventricosa* Wall.

Win Win Khaing[1], Yin Min Yhu[2] and Nu Nu Yee[3]

Abstract

Morphological and anatomical characteristics of *Justicia adhatoda* L. and *J. ventricosa* Wall. which belong to the family of Acanthaceae were studied. In morphological studies, the specimens were collected, identified and classified. In anatomical studies, the small pieces of specimens were cut into thin sections by using a rotary microtome according to Johansen (1940). In morphological characteristics, plants were perennial erect shrubs, leave simple, opposite and decussate, exstipulate in both species. The sizes and shapes of leaves, inflorescences, and flowers were different from one species to another. The anthers were superposed in *Justicia adhatoda* L. and reniform-shaped in *J. ventricosa* Wall. In anatomical characteristics, numbers and sizes of cells and thickness of cell layers were slightly different from one another. The stomata were diacytic types. In secondary body of stems of *J. ventricosa* Wall., sclereids were observed as continuous circular ring on the outside of phloem. In primary body of roots, vascular bundles were hexarch in *Justicia adhatoda* L. and tetrarch in *J. ventricosa* Wall. In secondary body of roots, pith was absent in *Justicia adhatoda* L. and present in *J. ventricosa* Wall. Many lacunae present in root of *J. ventricosa* Wall. The morphological and anatomical characteristics are useful in identification of genus *Justicia.*

Key words: *Justicia adhatoda* L., *J. ventricosa* L., Morphological, Anatomical

Introduction

The morphological and anatomical characteristics of *Justicia adhatoda* L. and *Justicia ventricosa* Wall. belonging to the family, Acanthaceae were studied in this research. In the family, some species are cultivated for medicinal purposes. The roots and leaves of *J. adhatoda* L., are used as bronchitis, asthma and fever and in treatment of bronchial diseases (Awan *et al*. and Gangwar & Ghosh 2014).

Justicia adhatoda L. is uses like food, spices, dyes, religious and cultural importance, economic importance and horticultural or floricultural significance (Singh & Hidrom 2013). The leaves are rich in Vitamin C and carotene and yield an essential oil. The plant has pungent and astringent taste. It is the presence of alkaloids, phytosterols, polyphenolics and glycosides as a major class of compounds (Hossain & Hoq 2016). *Justicia ventricosa* Wall. is used by grinding the leaf with steamed water for curing infantile convulsion. This plant is used to cure as traditional medicine (Somprasong *et al*. 2014).

In family Acanthaceae, stomata were diacytic type present in abaxial surface of genus *Justicia* (Metcalfe & Chalk 1950, 1983 & Cutler *et al*. 2007). Some anatomical characters are common to a very wide range of genera. One of the most outstanding anatomical features is the widespread occurrence of variously shaped cystoliths which are to be found in both stem and leaf. The occurrence of cystoliths, acicular fibres and crystals can also be seen under the leaf. The economic products obtained a yellow dye from the leaves of *Justicia adhatoda* L. It is used medicinally in India (Metcalfe & Chalk 1950).

The aim and objectives of this studies are to investigate the morphological and anatomical characteristics of *Justicia adhatoda* L. and *Justicia ventricosa* Wall., and to reveal their importance of anatomy in relation to taxonomy for the species confirmation.

[1]Dr, Lecturer, Department of Botany, University of Mandalay

[2]M.Sc Student, Department of Botany, University of Mandalay

[3]Dr, Professor and Head, Department of Botany, University of Mandalay

Materials and Methods

The specimens of *Justicia adhatoda* L. and *J. ventricosa* Wall. belonging to family Acanthaceae were collected from Yae Ta Gon Taung Traditional Medicinal Garden of Patheingyi Township, Mandalay Region in the year of 2019. For microtome sections, dehydration, infiltration, embedding, staining and mounting were made according to Johansen's (1940) method. The parts of specimens were macerated by using Franklyn's method modified by Berlyn & Miksche (1976).

Results

1. Morphological studies (Table 1 & Figure 1)

1.1 *Justicia adhatoda* L. Sp. Pl. 1: 15. 1753.

Myanmar Name : Maya gyi, May gyi, Ye ma gyi
English Name : Malabar nut tree

Perennial erect shrub; stems and branches subquandrangular, pubescent. Leaves simple, opposite and decussate, exstipulate; petiolate. Inflorescences terminal or axillary raceme. Flowers bisexual, zygomorphic, hypogynous, white, sessile; bracts ovate, embracing the 1- or 2- flowered, bracteolate, pubescent. Calyx 5- lobed; corolla 2-lipped, with 5-lobed, white with purple striated at the central lobe of lower lips. Stamens 2, inserted, attached at the middle portion of the corolla tube; filaments slendar, pubescent at the lower half of the filament; anther dithecous, basifixed, superposed, lower one with minutely spurred, dehiscencing longitudinally. Carpels 2, fused, ovary superior, bilocular, with one ovule in each locule on the axile placentae; style slendar, glabrous; stigma bilobed. Capsule loculicidal.

1.2 *Justicia ventricosa* Wall. Bot. Mag. 54, pl 2766, 1827.

Myanmar Name : Unknown
English Name : Unknown

Perennial erect shrub; stems and branches subquandrangular, glabrous. Leaves simple, opposite and decussate, exstipulate; petiolate. Inflorescences terminal or axillary spike. Flowers bisexual, zygomorphic, hypogynous, creamy white, bracts ovate, embracing the 3-5 flowers, bracteoles minute, pubescent. Calyx 5-lobed; corolla 2-lipped, with 5-lobed, upper lip 2-lobed and lower lip 3-lobed. Stamen 2, exerted, attached at the base of the corolla tube; filaments slender, white, glabrous; anther dithecous, dorsifixed, reniform-shaped, lower one with prominent spurred, dehiscencing longitudinally. Carpels 2, fused, ovary superior, bilocular, with one ovules in each locule on the axile placentae; style slender, glabrous; stigma bilobed. Capsule loculicidal.

2. Anatomical Studies

2.1 Internal structure of the leaf of *Justicia adhatoda* L. (Table 2 & Figure 2)

Petiole

In transverse section, petiole of *Justicia adhatoda* L. studied was shallow heart-shaped in outline, 1500.0-1650.0 µm in length and 2000.0-2300.0 µm in width, distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: Composed of epidermal cells. In transverse section, both upper and lower epidermis 1-layered, parenchymatous cells. **Ground Tissue System:** Differentiated into collenchymatous and parenchymatous tissues; collenchymatous cells below the epidermis; parenchymatous cells lying inside the collenchyma. **Vascular Tissue System:** A large vascular bundle with 2 small accessory bundles, each bundle collateral type; a large bundle crescent-shaped; phloem lying abaxial side and xylem lying adaxial side. Phloem composed of 4- to 5-layered; xylem composed of 2- to 5-layered, the layers 130.0-220.0 µm thick.

Lamina

In transverse section, lamina of *Justicia adhatoda* L. studied was dorsiventral, 350.0-600.0 µm thick, distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: In surface view, epidermal cells of both surfaces were parenchymatous, cell walls wavy, thin-walled; stomata present on the abaxial surface, diacytic type. Cystolith present on both surfaces and more abundance on abaxial surface, multicellular uniseriate trichome present. In transverse section, both adaxial and abaxial epidermis composed of parenchymatous cells, 1-layered, the cells oval or barrel-shaped. **Ground Tissue System:** Mesophyll differentiated into palisade parenchyma cells at upper side and spongy parenchyma cells at the lower side. **Vascular Tissue System:** Vascular bundles of lateral veins were embedded in the mesophyll tissues. They were collateral type and different in size according to their position.

Midrib

In transverse section, the midrib of *Justicia adhatoda* L. studied was semicircular-shaped in outline, wavy wall on abaxial surface, 750.0-1250.0 µm in length and 625.0-1375.0 µm in width. They were distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: Both upper and lower epidermis 1-layered, parenchymatous, the cell barrel-shaped, outer and inner walls convex, anticlinal wall straight. **Ground Tissue System**: Composed of collenchymatous and parenchymatous tissues. Collenchymatous cells below the epidermis; parenchymatous cells lying inside the collenchyma. **Vascular Tissue System**: A large vascular bundle with 2 small accessory bundles embedded in the ground tissues, collateral type, a large bundle crescent-shaped, xylem on the adaxial side and phloem on the abaxial side; phloem 2- to 6-layered, the layers xylem 2- to 4-layered.

2.2 Internal Structures of the Stems of *Justicia adhatoda* L. (Table 3 & Figure 3)

In transverse section, the stem of *Justicia adhatoda* L. was oval-shaped in outline, 1587.5-1850.0 µm in length, 2250.0-2500.0 µm in width, distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: In transverse section, epidermis 1-layered, cells barrel in shape, outer and inner walls convex, anticlinal walls straight. **Ground Tissue System**: Composed of cortex, endodermis, pericycle and pith. The cortex differentiated into outer collenchymatous tissue and inner parenchymatous tissue. The outer collenchymatous tissues were composed of 5- to 10-layered. The inner parenchymatous tissues were composed of 6- to 12-layered. Endodermis and pericycle inconspicuous. Pith were composed of parenchymatous cell, intercellular space was present.

Vascular Tissue System: Vascular bundles embedded in the ground tissue, the bundle arranged in a circular ring, collateral type, open, vascular cambium occured between the vascular bundles, tangentially flattened and dividing to give secondary phloem outward and secondary xylem inward.

2.3 Internal Structures of the Roots of *Justicia adhatoda* L. (Table 4 & Figure 4)

In transverse section, the root of *Justicia adhatoda* L. was circular-shaped in outline, 1350.0-1750.0 µm in length and 1650.0-1800.0 µm in width, distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue system: The root epiblema cells 1-layered, parenchymatous, the cells rectangular or irregular in shape. **Ground Tissue System**: Composed of cortex,

endodermis, pericycle and pith. Cortex composed of homogenous parenchymatous cells, 8- to 13-layered. Endodermis 1-layered, pericycle 1-layered. Pith present. **Vascular Tissue system**: Vascular bundles embedded in the ground tissues, radial type, hexarch in young root and polyarch in mature root, xylem strands alternating with the phloem group. Xylem elements were in exarch condition, with protoxylem towards periphery and metaxylem towards the centre. Xylem composed of vessel elements, tracheids, xylem fibers and xylem parenchyma. Phloem composed of sieve tube elements, companion cells, phloem fibers and phloem parenchyma.

2.4 Internal Structures of the Leaves of *Justicia ventricosa* Wall. (Table 2 & Figure 2)

Petiole

In transverse section, petiole of *Justicia ventricosa* Wall. studied was shallow heart-shaped in outline, 1250.0-2187.5 µm in length and 1375.0-2500.0 µm in width, distinguishable into dermal, ground and vascular tissue systems.

It was composed of epidermal cells. In transverse section, both upper and lower epidermis 1-layers were parenchymatous cells. **Ground Tissue System:** Differentiated into collenchymatous and parenchymatous tissues; collenchymatous cells below the epidermis; parenchymatous cells were lying inside the collenchyma. **Vascular Tissue System:** A large vascular bundle with 2 small accessory bundles, each bundle collateral type; a large bundle crescent-shaped; phloem lying abaxial side and xylem lying adaxial side. Phloem was composed of 3- to 5-layered; xylem composed of 2- to 5-layered, the layers 190.0-300.0 µm thick.

Lamina

In transverse section, lamina of *Justicia ventricosa* Wall. studied was dorsiventral, 350.0-480.0 µm thick, distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: In surface view, epidermal cells of both surfaces were parenchymatous, cell walls wavy, thin-walled; stomata present on the abaxial surface, diacytic type. Cystolith was present on both surfaces and more abundance on abaxial surface, multicellular uniseriate trichome present. In transverse section, both adaxial and abaxial epidermis were composed of parenchymatous cells, 1-layered, the cells oval or barrel-shaped. **Ground Tissue System:** Mesophyll was differentiated into palisade parenchyma cells at upper side and spongy parenchyma cells at the lower side. **Vascular Tissue System:** Vascular bundles of lateral veins were embedded in the mesophyll tissues. They were collateral type and different in size according to their position.

Midrib

In transverse section, the midrib of *Justicia ventricosa* Wall. studied was semicircular-shaped in outline, 1125.0-1437.5 µm in length and 1250.0-1500.0 µm in width. It was distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: Both upper and lower epidermis 1-layered, parenchymatous, the cell barrel-shaped, outer and inner walls convex, anticlinal wall straight. **Ground Tissue System**: It was composed of collenchymatous and parenchymatous tissues. Collenchymatous cells were below the epidermis; parenchymatous cells lying inside the collenchyma. **Vascular Tissue System**: A large vascular bundle with 2 small accessory bundles was embedded in the ground tissues, collateral type, a large bundle crescent-shaped, xylem on the adaxial side and phloem on the abaxial side; phloem 4- to 7-layered, the layers xylem 2- to 5-layered.

2.5 Internal Structures of the Stem of *Justicia ventricosa* Wall. (Table 3 & Figure 3)

In transverse section, the stem of *Justicia ventricosa* Wall. was oval-shaped in outline, 1187.5-1250.0 µm in length, 1750.0-2250.0 µm in width, distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: In transverse section, epidermis 1-layered, cells barrel in shape, outer and inner walls convex, anticlinal walls straight. **Ground Tissue System**: It was composed of cortex, endodermis, pericycle and pith. The cortex differentiated into outer collenchymatous tissue and inner parenchymatous tissue. The outer collenchymatous tissues were composed of 5- to 10-layered. The inner parenchymatous tissues composed of 6- to 12-layered. Endodermis and pericycle were inconspicuous. Pith was composed of parenchymatous cell, intercellular space present.

Vascular Tissue System: Vascular bundles were embedded in the ground tissue, the bundle arranged in a circular ring, collateral type, open, vascular cambium occurs between the vascular bundles, tangentially flattened and dividing to give secondary phloem outward and secondary xylem inward.

2.6 Internal Structures of the Roots of *Justicia ventricosa* Wall. (Table 4 & Figure 4)

In transverse section, the root of *Justicia ventricosa* Wall. was circular-shaped in outline, 650.0-900.0 µm in length and 700.0-850.0 µm in width, distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue system: The root of epiblema cells was 1-layered, parenchymatous, the cells rectangular or irregular in shape. **Ground Tissue System**: It was composed of cortex, endodermis, pericycle and pith. Cortex was composed of homogenous parenchymatous cells, 9- to 12-layered. Endodermis was 1-layered and pericycle was 1-layered. Pith was present. **Vascular Tissue system**: Vascular bundles were embedded in the ground tissues, radial type, hexarch in young root and polyarch in mature root, xylem strands alternating with the phloem group. Xylem elements were in exarch condition, with protoxylem towards periphery and metaxylem towards the centre.

Discussion and Conclusion

In this study, the morphological and anatomical characteristics of leaves, stems and roots of *Justicia adhatoda* L. and *Justicia ventricosa* Wall. belonging to family Acanthaceae were studied. In the morphological characteristics, the plants were erect shrubs. The leaves were simple, opposite and decussate, and exstipulate in *Justicia adhatoda* L. and *J. ventricosa* Wall. These characters were agreed with those mentioned by Hooker (1885).

The shapes and sizes of leaves and flowers, and the colour of flowers were different from one species to another. The size of leaves of *Justicia adhatoda* L. was larger than the size of *J. ventricosa* Wall. The leaves blades were pubescent on both surfaces in *J. adhatoda* L. and glabrous on both surfaces in *J. ventricosa* Wall. These characters were agreed with those stated by Hooker (1885), Backer & Brink (1965), Dassanayake (1998), Yun-fei *et al.* (2009), Jiaqi *et al.* (2011) and Singh & Huidrom (2013).

In the size of inflorescences, length of *Justicia ventricosa* Wall. was longer than *J. adhatoda* L. The flowers were bisexual, zygomorphic, hypogynous, bracteates and bracteolate in both species. The sizes of flowers were different from one species to another. The flower of *J. adhatoda* L. was larger than the *J. ventricosa* Wall. The calayx were 5-lobed in both species. In the corolla, purple stratiates were present at

the central lobe of lower lip in *J. adhatoda* L. and these characters were agreed with Hooker (1885), Backer & Brink (1965), Dassanayake (1998), Yun-fei *et al.* (2009) and Singh & Huidrom (2018). In the corolla, brown stratiates were present on both upper and lower lobes in *J. ventricosa* Wall. and these characters were agreed with those mentioned by Hooker (1885), Jiaqi *et al.* (2011), Somprasong *et al.* (2014) and Singh *et al.* (2017).

The anthers were dithecous, superposed with minutely spurred in *J. adhatoda* L. and reniform-shaped with prominently spurred in *J. ventricosa* Wall. The ovaries were superior, stigma bilobed and the loculicidial capsule in both species. These characters were agreed with those described by Hooker (1885), Backer & Brink (1965), Dassanayake (1998), Yun-fei *et al.* (2009), Jiaqi *et al.* (2011), Singh & Huidrom (2013) and Somprasong *et al.* (2014).

In the anatomical characteristics, the shapes of petioles were found in shallow heart- shaped in both species. The vascular bundles of petiole were observed a large cresent-shaped bundle with two small accessory bundles in the two species. These characters were agreed with those stated by Metcalfe & Chalk (1950) and Kanthale & Panchal (2015). The sizes and the numbers of cell layers were differ from one species to another.

The diacytic types of stomata were found in abaxial surface of lamina in both species. In transverse section, the thickness of lamina and the numbers of cell layers were slightly different from one species to another. The lamina of *J. adhatoda* L. was thicker than the *J. ventricosa* Wall. These characters were agreed with those described by Metcalfe & Chalk (1950, 1979 & 1983). In the transverse section of leaves, the palisade mesophyll cells were observed 1- to 2-layered in the two species and spongy mesophyll cells were observed 2- to 5-layered in *J. adhatoda* L. and 2- to 6-layered in *J. ventricosa* Wall. In the transverse sections of midribs, the numbers of cell layers were different from on species to another. The trichomes were present in *J. adhatoda* L. and absent in *J. ventricosa* Wall. These characters were agreed with those described by Metcalfe & Chalk (1950 &1979 and Kanthale & Panchal (2015).

In transverse section, the stems were oval-shaped in both species. The size of stems and the number of cell layers were differed from one species to another. The ground tissues were composed of the collenchymatous and parenchymatous tissues. Pith was present in the two species. The vascular budles were collateral type and vascular cambium tangentially flattened and dividing to give secondary phloem outward and secondary xylem inward in the both species. Pith was present in the two species. Sclereids were observed continuous cicruclar ring on the outside of phloem of *Justicia ventricosa* Wall.. These characters were agreed with those reported by Metcalfe & Chalk (1950), Dhale & Kalme (2012) and Kanthale & Panchal (2015).

The transverse sections of roots were circular-shaped in outline. Cortex was composed of homogenous parenchymatous cells and the numbers of cell layers were differ from one species to another. The vascular bundles of young roots were radial type and hexarch in *J. adhatoda* L. and tetrarch in *J. ventricosa* Wall. In the mature roots, vascular bundles were polyarch from both species. Pith absent in *J. adhatoda* L. and present in *J. ventricosa* Wall.. These character were agreed with those stated by Metcalfe & Chalk (1950), Dhale & Kalme (2012) and Kanthale & Panchal (2015). Many lacunae were observed in the cortex of root of *J. ventricosa* Wall.. These characters were agreed with those described by Metcalfe & Chalk (1950). The sizes of vessel elements, tracheids and fibers of leaves (petioles, laminae, midribs), stems and roots were also differed from one species to another.

According to the morphological characteristics, the plants were perennial, erect shrubs in the two species. The sizes of leaves, petioles, inflorescences and flowers were different from one species to another. The color of flowers and the shapes of anthers were also differed from one species to another. The anatomical characteristics of the leaves, stems and roots were basically similar in structure. However, the sizes of cell, the number and thickness of cell layers and the number of vascular bundles were differed from one species to another. In the secondary body, sclereieds were observed in stems and lacunae observed in roots of *Justicia ventricosa* Wall.

Therefore, it would be concluded that the morphological and anatomical characteristics will be useful in plant species confirmation, and importance of plant anatomy in relation to plant taxonomy for easy verification of identification within the genus *Justicia*.

Table 1. Morphological characteristics of *Justicia adhatoda* L. and J. *ventricosa* Wall.

Characters	*Justicia adhatoda* L.	*Justicia ventricosa* Wall.
Stem	Subquandrangular, pubescent	Subquandrangular, glabrous
Lamina	Oval-elliptic to elliptic lanceolate entire	Elliptic
Leaf margin	acuminate	entire
Leaf apex	cuneate	acute
Leaf base		cuneate
Size of leaves (cm)	6.0-24.0 by 2.0-7.0	6.0-11.5 by 2.0-5.0
Inflorescences	1-2 flowers on each node	3-5 flowers on each node
Size of flowers (cm)	3.0-4.0	About 1.5
Corolla	White, purple striate at the central lobe of lower lip	Creamy white, brown striate on the upper and lower lobes
Androecium	Stamen inserted; anther superposed, minutely spurred	Stamen exserted; anther reniform-shaped, prominent spurred
Gynoecium	Ovary superior, stigma bilobed	Ovary superior, stigma bilobed

Table 2 Anatomical characteristics of leaves of *Justicia adhatoda* L. and *J. ventricosa* Wall.

Characters		*Justicia adhatoda* L.	*Justicia ventricosa* Wall.
Petiole			
Collenchyma	adaxial side	5- to 9-layered	11- to 13-layered
	abaxial side	9- to 12-layered	10- to 13-layered
Parenchyma	adaxial side	9- to 11-layered	9- to 13-layered
	abaxial side	10- to 16-layered	11- to 14-layered
Lamina	Thickness (μm)	350.0-600.0	350.0-480.0
	Trichome	present	absent
	Cystolith	present	absent
Midrib			
Collenchyma	adaxial side	2- to 5-layered	2- to 7-layered
	abaxial side	2- to 5-layered	4- to 9-layered
Parenchyma	adaxial side	4- to 6-layered	7- to 9-layered
	abaxial side	5- to 10-layered	5- to 11-layered

Table 3 Anatomical characteristics of stems of *Justicia adhatoda* L. and *J. ventricosa* Wall.

Characters	*Justicia adhatoda* L.	*Justicia ventric*
Collenchyma	5- to 10-layered	6- to 9-layered
Parenchyma	6- to 12-layered	7- to 10-layered
Pith	present	Present

Table 4 Anatomical characteristics of roots of *Justicia adhatoda* L. and *J. ventricosa* Wall.

	Characters	*Justicia adhatoda* L.	*Justicia ventricosa* Wall.
Young root	Cortex	8- to 13-layered	9- to 12-layered
	Vascular bundles	hexarch	tetrarch
	Pith	present	present
Mature root	Cortex	6- to 8-layered	12- to 15-layered
	Vascular bundles	polyarch	polyarch
	Pith	absent	present
	Lacunae	absent	present

Figure 1 Morphological characteristics of *Justicia adhatoda* L. and *J. ventricosa* Wall.
A & G. Habit. B & H. Inflorescences. C & I. L. S of Flower.
D & J. Androecium. E & K. Gynoecium. F & L. T. S of ovary
(A, B, C, D, E, F – *J. adhatoda* L.; G, H, I, J, K, L – *J. ventricosa* Wall.)

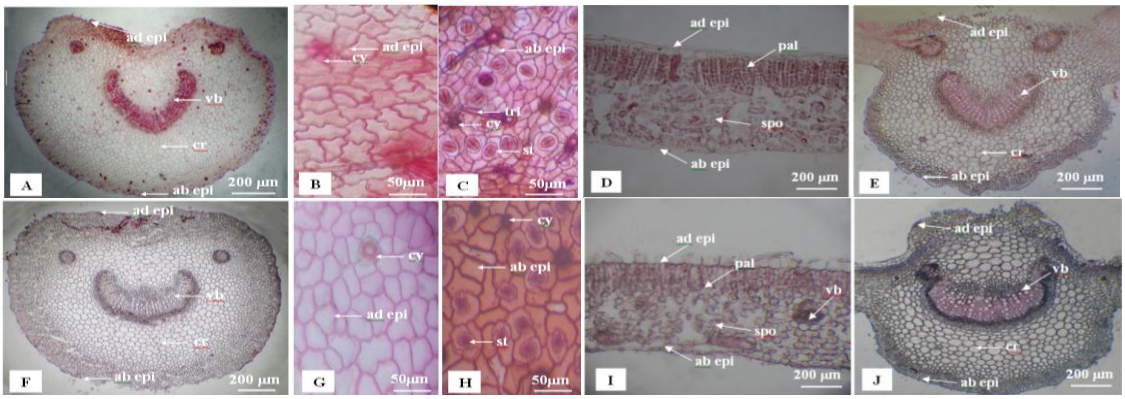

Figure 2 Internal structures of leaves of *Justicia adhatoda* L. and *J. ventricosa* Wall.
A & F. T.S of petiole. B & G. Adaxial surface view of lamina. C & H. Abaxial surface view of lamina. D & I. T.S of lamina. E & J. T.S of midrib
(ab epi = abaxial epidermal cell, ad epi = adaxial epidermal cell, cr = cortex, cy=cystolith, pal = palisade parenchyma cell, spo = spongy parenchyma cell, st = stoma, tri=trichome, vb = vascular bundle)

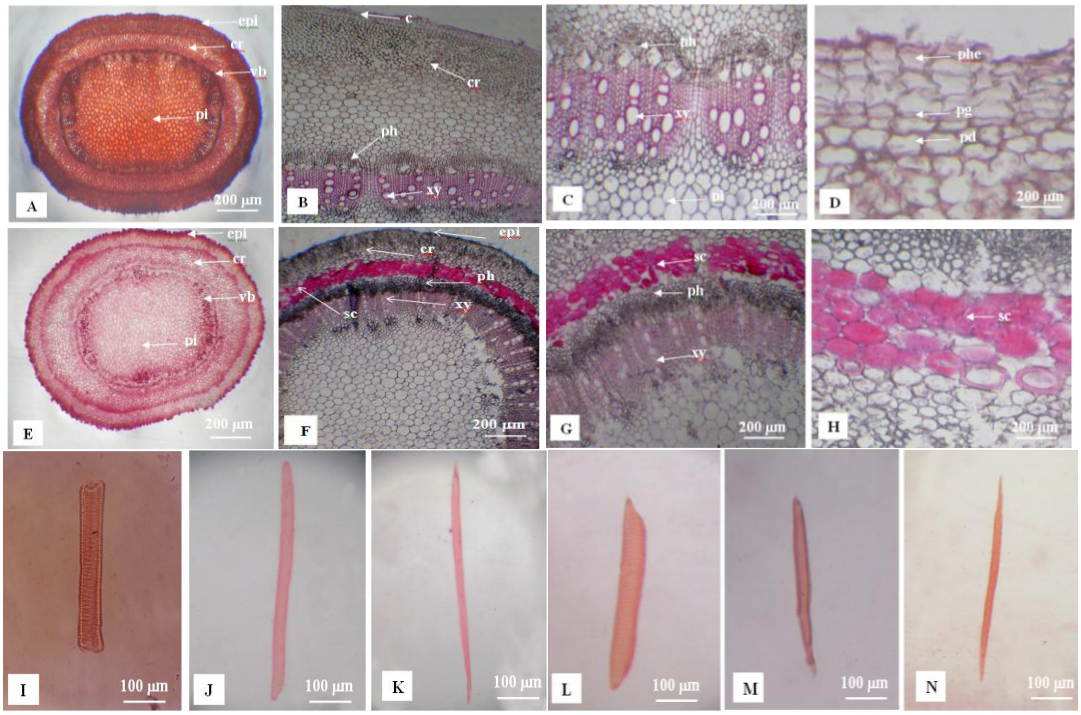

Figure 3 Internal structures of stems of *Justicia adhatoda* L. and *J. ventericosa* Wall.
A & E. T. S of young stem. B & F. T. S of mature stem. C & G. Close up view of vascular bundle. D. Close up view of periderm. H. Close up view of sclereids. I & L. Vessel elements. J & M. Tracheids. K & N. Fibers
(c = cork cell, cr = cortex, epi = epidermal cell, cr = cortex, pd = phelloderm, ph = phloem, phe = phellem, pg = phellogen, pi = pith, vb = vascular bundle, xy = xylem)
(A, B, C, D, I, J, K – *J. adhatoda* L.; E, F, G, H, L, M, N – *J. ventricosa* Wall.)

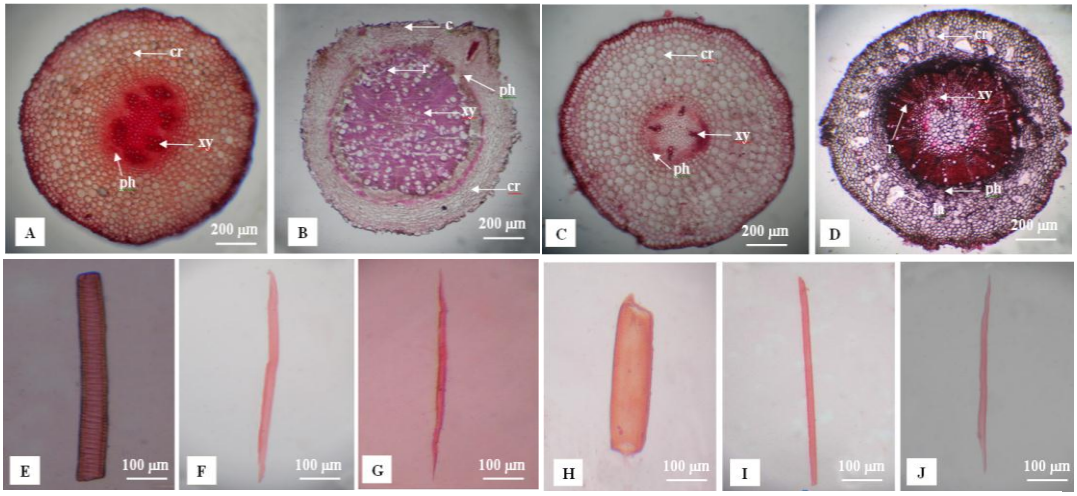

Figure 4 Internal structures of roots of *Justicia adhatoda* L. and *J. ventricosa* Wall.
A & C. T. S of young root. B & D. T. S of mature root.
E & H. Vessel elements. F & I. Tracheids. G & J. Fibers
(c = cork cell, cr = cortex, r = ray, ph = phloem, xy = xylem)
(A, B, E, F, G – *J. adhatoda* L.; C, D, H, I, J – *J. ventricosa* Wall.)

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References

Awan, A. J., C. B. Ahmed, M. Uzair, M.S. Aslam, U. Farooq. & K. Ishfaq. 2014. Family Acanthaceae and genus *Aphelondra*: ethnopharmacological and phytochemical review. International Journal of Pharmacy and Pharmaceutical Sciences. ISSN 0975 - 1491, Vol. 6, Issue 10.

Backer, C. A. & R. C. B. Van Den Brink. 1965. Flora of Java Vol. II. Rijksherbarium, Lelyden, N.V.P. Groningen, The Netherlands.

Cutler, D. F., T. Botha. & D. W. Stevenson. 2007. Plant anatomy: an applied approach. Blackwell publishing Ltd., Australia.

Dassanayake, M. D. 1998. A revised handbook to the flora of Ceylon. Vol. XII. University of Peradeniya, Department of Agriculture, Peradeniya, Sri Lanka.

Dhale, D. A. & R. K. Kalme. 2012. Pharmacognostic characterization of stem and root of *Adhatoda zeylanica* Medicus. International Journal of Pharmaceutical Sciences and Research, Vol.3 (11): 4264-4269. ISSN: 0975 - 8232.

Gangwar, A. K. & A. K. Ghosh. 2014. Medicinal uses and pharmacological activity of *Adhatoda vasica* Nees. International Journal of Herbal Medicine. ISSN 2321-2187. IJHM, 2 (1): 88-91.

Hooker, J. D. 1885. The flora of British India. Vol. IV. L. Reeve & Company, Henrietta Street-Convent Garten, London.

Hossain, M. T. & M. O. Hoq. 2016. Review: therapeutic use of *Adhatoda vasica* Nees. Asian Journal of Medical and Biological Research. ISSN 2411. 4472.

Jeffery, E. C. 1917. The anatomy wood plants. 1st edition Chicago, University of Chicago.

Jiaqi, H., D. Yun-fei., J. R. I. Wood. & T. F. Daniel. 2011. Flora of China. Vol. 19. Missouri Botanical Garden Press.

Johansen, D. A. 1940. Plant microtechnique. Megraw-Hil Book Company, Inc. New York and London.

Kanthale, R. P. & V. H. Panchan. 2015. Pharmacognostic study of *Adhatoda vasica* Nees. Bioscience Discovery, 6 (1): 49- 53.

Metcalfe, C. R. & L. Chalk. 1950. Anatomy of the dicotyledons. Vol II. Published in the United States by Oxford University Press, New York.

Metcalfe, C. R. & L. Chalk. 1979. Anatomy of the dicotyledons. 2nd ed, Vol I. Published in the United States by Oxford University Press, New York.

Metcalfe, C. R. & L. Chalk. 1983. Anatomy of the dicotyledons. 2nd ed, Vol II. Published in the United States by Oxford University Press, New York.

Singh, K. J. & D. Huidrom. 2013. Ethnobotanical uses of medicinal plant, *Justicia adhatoda* L. by *Meitei* community of Manipur, India. Journal of Coastal life Medicinal, 1(4): 322-325.

Somprasong, W., S. Vjarodaya & K. Chayamarit. 2014. Taxonomic study of the Family Acanthaceae used as traditional medicinal plants for ethnic groups in North, Central and Northeastern Thailand. Thi Agricultural Research Journal, Vol. 32. No.1.

Yun-fei, D., G. Chun-ming & X. Nian-he. 2009. Flora of Hong Kong. Vol. 3. Agriculture, Fisheries and Conservation Department of the Hong Kong Special Administration Region. Hong Kong.