



Comparative anatomical study of two *Cordia* species (Boraginaceae) from the Northern Western Ghats, India

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Abstract

The genus *Cordia* L. (Boraginaceae) is a medicinally important taxon. *Cordia dichotoma* G. Forst. has been used for the treatment against fever, ulcers, dyspepsia, ringworm, etc. It has also been reported for its activities such as analgesic, antidiabetic and anti-inflammatory actions. Another species, *C. sinensis* Lam., which is endemic to the northern Western Ghats, is a potential medicinal plant and presumed to have similar biochemical activities. Since, the species is consumed mainly in the crude form, it is difficult to establish the identity based on only leaf or stem characters. A comparative study has been carried out to authenticate the identity of these two species based on anatomical characters. The anatomical sections of stem (TS, TLS and RLS), leaf (TS), and petiole (TS) of both the species were observed under the bright-field microscope and characters were documented. Though the diagrammatic outline of the stem and leaf sections is similar, detail anatomical characters are significantly different. The characters such as arrangement of cortical tissues, pericyclic fibres, phloem fibres and phloem rays are useful in differentiating the stem and petiole of both the species. The structure and number of the trichomes are also found to be useful characters for identification. In case of leaf, number and arrangement of vascular bundles, arrangement of collenchyma at lower epidermis, palisade cells and distribution of storage cells are the major characters to differentiate both the species. During the study we also observed the detail characters of cuticular layer, trichomes and stomatal characters. Ranunculious type stomata, the presence of cystoliths in the basal cell of the trichome are the common characters observed in both the species. On the basis of preliminary study the species can be differentiated based only on anatomical characters.

Keywords: *Cordia*, authentication, anatomy, vegetative parts

Introduction

The word “anatomy” comes from the Greek words “*ana*,” meaning “up,” and “*tome*,” meaning “a cutting.” The study of anatomy goes back to over 2,000 years, to the ancient Greeks period. It can be categorized into three broad areas: Human anatomy, zootomy and plant anatomy. Anatomy is the scientific study of the internal structure of organisms including organs and different kinds of tissues (Bozman, 1967; Gray, 2003) [2, 6]. Understanding and evaluation of *Cordia* species anatomy is important to the study of emergence branches are plant taxonomy, plant systematic, plant physiology, ecology, paleobotany and evolutionary biology. During the study we cover many of comparative aspects of physical and anatomical structure of stem, leaf and petiole. Describe a internal structure of *Cordia* spp. using a hand lens, light compound microscope and Stereo Zoom Microscope (MSZ Bi). Carolus Linnaeus described the *Cordia* genus in the format of *Cordia* L., Sp. Pl. 1: 190 (1753). A detailed anatomy study stem, leaf, and petiole of *Cordia sinensis* Lam., Tabl. Encycl. n. (1914) [2] and *Cordia dichotoma* G. Forst., Fl. Ins. Austr. 18, n. 110 (1786) species from northern western ghats of Maharashtra. The plant family Boraginaceae worldwide distributed and its contained 145 genera. In the *Cordia* genera *C. dichotoma*, *C. domestica*, *C. macleodii*, *C. sinensis*, *C. wallichii*, this five specie distributed in the Northern Western Ghats Maharashtra state (Singh & al., 2000) [19]. *Cordia* species are perennial tree species.

The *C. sinensis* medicinal uses are diarrhea & dysentery, anthelmintic, antidiabetic activity, throat pain treatment, this plant bark making a decoction and these decoction use as a gargle for throat treatment and economic use- *Cordia* use as most timber yielding plant (Kirtikar & Basu, 1918; Metcalfe & Chalk, 1965; Modhvadia, 2009; Lohidas & al., 2015; Patil, 2018) [10, 13, 14, 11, 16]. Fresh leaves use as treat to jaundice and fruit jounce use as fevers treatment. Human consume a plant parts as food considering a primary requirements but sometime human use a plant part as fodder and medicines. In Ayurvedic medicinal system both plant considered as source of Laghushleshmataka (Maundu, 1999; Khare, 2007) [12, 9].

During the literature study of *cordia* species we observed many of anatomical variation TS of stem (Cork layer, Cortex cell layer, Pericyclic fiber cell number, Phloem cell layer, Phloem medullary layer, Xylem medullary layer, Xylem vessels), TS leaf (Epidermis, Palisade layer, Collenchyma, Number vascular bundles, and Parenchyma cell) and TS of petiole (Epidermis, Palisade layer, Collenchyma, Number vascular bundles, and Parenchyma cell) of both the species were observed under the bright-field light compound microscope and their characters were documented (Metcalfe & Chalk,

1965; Khandelwal & Sethi, 2019) [13, 8]. Both the species produces a annual ring and observed a secondary growth. These plant shows annual rings because of well developed secondary growth. In stem woody anatomy observed a broad range arrangement of vessels and fibers produces a porous wood (Metcalf & Chalk, 1965) [13]. Xylem is a complex tissue system composed of different cell types. The term tracheary element is derived from "trachea," a name originally resembling insect tracheae (Katherine, 1960) [7]. Two basic types of tracheary element: tracheids and vessel elements. The vessel elements adjoining to each other, at their end possess a perforations, whereas tracheids elements lack these perforations. Tracheids elements are elongated, lignified, thick walled and pointed at both end. The perforations several openings which are scalariform perforation plate (Fig.2). Xylem vessels showing a simple pitted in their lateral walls. To observe xylem structure, mature stem are sectioned transversely (transverse section: TS) and longitudinal planes: along the rays (radial longitudinal section: RLS and tangential longitudinal section: TLS). Rays are termed one cell wide tangentially called uniseriate and more than one cell wide called multiseriate observed in both species, viewed in TS and TLS. (fig) The vascular cambium produces from secondary xylem and phloem of stem. Prismatic calcium oxalate crystals observed in *C. sinensis* in the pith region of stem (Evert, 2006; Rudall, 2007; Khandelwal & Sethi, 2019) [5, 18]. Starch grains is one of the non-nitrogenous stored form observed in studied plant species. Tapioca starch grain type observed in both plant species (Stevens, 1907; Wallis, 1939) [20, 23]. The tannins red or brown stained in the cells (fig. 2a). Tannins are a polyphenolic important secondary metabolite compound. It is observed in mature stem part of phloem and pith region of *C. sinensis*. The primary important function of tannins is protective mechanism repellent to predators (Rao & Das, 1979; Zobel, 1985; Evert, 2006) [17, 24, 5]. Plants that produce and show a allelopathy phenomenon. Some plants leaf synthesized released in response to environmental stress (Bussotti *et al.*, 1998) [3]. The sclerenchyma found in the pericyclic region of stem. The stone cells are observed in both species. Stone cells important function is thickening and lignification of the walls of thin-walled parenchyma cells. Stone cell providing a strengthening and toughness of parenchyma cells. The presence of stone cells are frequent and important landmarks in the study of powdered drugs. In powdered drug stone cells are use apparently. Sclerenchyma cells are classified into two categories fibers and sclereids (Rao, 1957; Evert, 2006) [5].

In leaf observed outermost protodermal single cell layer i.e epidermis tissue that covers the entire The epidermis is a arise from radial patterning of L1 layer of tunica. The cortex and endodermis arises from L2 layer and combinely L1 and L2 is a part of tunica. The pericycle and vasculature arises radial patterning from L3 layer of carpous. Meristemoid tissues get superficial change of cells that gives rise epidermal outgrowths trichome and stomata. In both species observed a ranunculaceous type stomata and simple uniseriate trichome (Taiz & Zeiger, 2002) [21]. The present study revealed the cystoliths unique character in *Cordia* species that are important for identify the taxa at their vegetative stage (Evert, 2006) [5]. Ranunculious type stomata are observed on the abaxial and adaxial surface of the leaf (Van Cotthem, 1970) [22]. Trichome is specialized epidermal cell are used as a trait in taxonomy. Collenchyma and sclerenchyma cell are supporting tissues in plants. In both species, vascular bundles are observed in parts of leaf and petiole but in both species of petiole arc type vascular bundles observed. Abundance of tapioca starch grains type found in stem of both *Cordia* species (Stevens, 1907; Wallis, 1939) [20, 23].

Table 1: Classification of *Cordia sinensis* and *Cordia dichotoma*

Kingdom	Plantae	Plantae
Division		
Class	Dicotyledons	Dicotyledons
Sub-class	Gamopetalae	Gamopetalae
Series	Bicarpellatae	Bicarpellatae
Order	Polemoniales	Polemoniales
Family	Boraginaceae	Boraginaceae
Genus	<i>Cordia</i>	<i>Cordia</i>
Species	<i>C. sinensis</i> Lam.	<i>C. dichotoma</i> G. Forst.
Common names	Gondani, Gondi, Gundi, Naruvili	Lasura, Bhokar, Lasoore and Gunda

(Bentham & Hooker, 1862)

Table 2: Morphology of *Cordia sinensis* and *Cordia dichotoma*

Characteristics	<i>Cordia sinensis</i>	<i>Cordia dichotoma</i>
Hight	5.8 m high	5 to 10 m high
Bark	Brown in colour	White in colour
Leaves	simple	simple
Flower	white in colour	white in colour
Inflorance	axillary cymes	cymose
fruit	reddish.brown, pulpy, edible, single seeded.	fruit yellow or pink, edible, single seeded.
Occurance		

(Singh *et al.*, 2000) [19]

Materials and Methods

Study area and collection: Leaf and stem bark of *Cordia sinensis* were collected from Pune, Nashik and Aurangabad district during 2019-2020 of Maharashtra, India. The plant was identified and authenticated by. The valid voucher herbarium specimen was deposited in Department of Life Science, Sandip University, Nashik.

Anatomical study of stem, leaf and petiole: Make a thin sliced from fresh mature stem samples for anatomical study (8mm to 10mm), leaf (main vein and lamina) and petiole (centre of the petiole) from both plants species. Prepare hand sections stained were stain using 0.1% Safranin and mount in glycerin and examined under bright-field compound microscope (Chamberlain, 1920; Khandelwal & Sethi, 2019) [4, 8]. Measure a morphometric observations of length, diameter, breadth and number of layers (μm). Calculate stomatal index for the abaxial leaf surface using. Calculate trichome density and identify a type of trichomes. (Salisbury's, 1927; Evert, 2006) [5]

Results

1. Anatomical study of stem: Transverse Section (T.S.) of stem of two species of *Cordia* (Figs. 2) (Table 2, 3 and 4)

Corck: Supperfacial and strongly thickened corck layer observed in both species. It was 10-12 and 6-8 cork layer in *C. sinensis* and *C. dichotoma* respectively.

Cortex: The cortex layer are divided into outer and inner cortex. Outer cortex was made up of collenchyma and thick walled cell cells. Inner cortex was parenchyma and thin walled cell (fig.2 a, b), which varied among the species. It was total cortex 10-13and 12-14 layered in *C. sinensis* and *C. dichotoma* respectively.

Pericyclic fiber: Perivascular fibers are commonly known as pericyclic fibers. Pericycle is a part of ground tissue. Ground tissue are primary function is mechanical support. Pericyclic fiber are sclerenchyma in nature. Sclerenchyma cells are classified into two categories fibers and sclereids. Pericyclic fiber were observed in both species. There are thick-walled sclerenchymatous cell arranged in clump manner. It was observed in each clump number of cells are 18 – 25 and 10 – 28 *C. sinensis* and *C. dichotoma* respectively.

Vascular tissues

Phloem: The phloem stratified in to soft and hard portions. In which hard portions is nothing but primary phloem fibers, or protophloem fibers and secondary phloem fibers. Phloem observed in both species there are 50 – 53 and 33 – 35 layered *C. sinensis* and *C. dichotoma* respectively. Phloem medullary rays observed in both species there are 2 – 3 and 3 - 4 layered *C. sinensis* and *C. dichotoma* respectively. A starch grains observed in phloem medullary rays of both species. Various cluster of crystalline structures and secondary depositions, such as starch, calcium carbonate in both species. Deposition were present in pith cells of *C. sinensis*.

Xylem: Diffuse porous wood observed because of tracharory elements presents (trachides and vessels). Medullary rays broader and expanded at the distal end. Vessels are arranged in vertical rows. Vessels varying in size 187.16 μm and 58.33 μm *C. sinensis* and *C. dichotoma* respectively. Medullary rays mostly are 2-4 and 3-4 layered *C. sinensis* and *C. dichotoma* respectively. Well-developed xylem fibers were arranged in vertical rows and in group. Fiber both end are pointed. Diffuse, aliform and confluent of parenchymatous cell observed in both species. In the region of phloem medullary rays of both species observed a calcium carbonate.

Pith

Pith are unligified, large pitted parenchymatous cell with thin walled. Various cluster of crystalline structures and secondary depositions, such as starch, calcium oxalate and tannins deposition were present in pith cells of *C. sinensis*.

2. Anatomical characteristics of leaf

Leaf anatomical studies using Bright-field light microscope, the transverse section (t.s.) of the leaf at the midrib region, Ovate shape (*C. sinensis*.), elongated lanceolate (*C. dichotoma*) (Figs.- 3, Table- 5)

Epidermis: Single cuticular layer observed on adaxial and abaxial surface of the leaf. Structures such as cystoliths are present on adaxial and abaxial surface of the leaf. Epidermal cell structure are straight, isobilateral, unicellular and papillose lower surface of leaf. There were significance variation between taxa i.e papillose projection lower surface epidermis observed in *C. dichotoma* and absent in *C. sinensis*. Cystoliths were present in both species of adaxial and abaxial surface of leaf. The *Cordia* species studied showed “Rananculous” type of stomata, The stomatal index was calculated abaxial surface of leaf. Trichomes were present in both species of adaxial and abaxial surface of the leaf. Calculate trichome density. Simple uniseriate trichomes observed in both species.

Collenchyma cell: The terms collenchyma derived from the Greek word *colla* i.e glue. Thick glistening cell wall is a unique characteristic of Collenchyma cell. Collenchyma is a living tissue with cell wall is thickened (Fig.). In studied species 3 - 4 layered and 3 - 5 layered of collenchymas cell in *C. sinensis* and *C. dichotoma*

respectively. Generally observed a chloroplast in collenchyma cell, but in studied species chloroplast are not observed. collenchyma cell layer is observed beneath the epidermis. The wall thickening in collenchyma cell observed several patterns, on the basis of that patterns collenchyma cells are classified (1) lamellar, or plate, collenchyma (2) angular collenchymas (3) the lacunar, or lacunate, collenchymas (4) annular collenchym. During the study lamellar, or plate, collenchyma type of collenchymas are observed (fig.) (Katherine, 1960; Evert, 2006; Rudall, 2007) ^[7, 18].

Parenchyma cell: The word parenchyma is derived from the Greek *para*, beside, and *en-chein*, to pour. intercellular spaces are observed in both species. Parenchyma is a living tissue with cell wall is thin. In studied species 3 - 4 layered and 2 - 3 layered of parenchyma cell in *C. sinensis* and *C. dichotoma* respectively.

Palisade layer: A transverse section of *Cordia* leaf the palisade layer composed a single layered parenchyma cells that were closely packed. Palisade parenchyma cells are arranged vertically elongated. bundle sheath extension observed in between palisade layer of leaf lamina *Cordia* leaf.

Vascular Tissue: Vascular bundle composed a xylem and phloem, in which smaller vein vertically transcurrent by sclerenchyma. The water conducting tissue, xylem on the adaxial side and the food conducting tissue, phloem on the abaxial side of leaf. Xylem tissue are thick walled and phloem tissue are thin walled. *Cordia* species can be categorised into two types i.e. broad U-shaped and narrow U-shaped. The species *C. sinensis* and *C. dichotoma* show broad U-shaped, show narrow U-shaped.

3. Characteristics of petiole

transverse section (T.S.) of the petiole, petiole shape are ovate (Figs. 4, Table- 6) The petiole shape of *C. sinensis* and *C. dichotoma* abaxial surface concave and adaxial surface convex. The epidermis is a single layer of cells. Trichomes were found in *C. dichotoma* and absent in *C. sinensis*. A well-developed collenchyma cells are beneath to the epidermal cells. In collenchyma cells observed a tanniniferous secondary compounds. Collenchyma 3 – 4 and 5 – 7 layered *C. sinensis* and *C. dichotoma* respectively. The pitted parenchymatous cells are irregular in outline in *C. dichotoma*. The parenchymatous cells are hexagonal or irregular. Parenchyma 3 – 4 and 4 – 5 layered *C. sinensis* and *C. dichotoma* respectively. t.s of petiole generally shows an 10 – 13 and 22- 24 vascular bundle with arc type of separate vascular bundle *C. sinensis* and *C. dichotoma* respectively. vascular bundle were broad U-shaped in both species. Both cell types contain chloroplasts

Discussion

The inclusive current study was to find out documentation of anatomical characterisation and its intimation for the identification of *Cordia* species in vegetative stage.

Stem anatomy: The vascular bundles pattern in both species is dictyostele (Pacheco *et al.*, 2013) ^[15] In the region of phloem medullary rays of both species observed a calcium carbonate. Tannins are a polyphenolic important secondary metabolite compound. It is observed in mature stem part of phloem and pith region of *C. sinensis*. During the study we observed secondary depositions, such cluster of calcium oxalate and tannins were present in pith cells of *C. sinensis*. This is a unique anatomical features characteristics for the identification of *C. sinensis* species in vegetative stage. Types and deviations in the formation of macrotracheoids observed in *C. sinensis* species (Rao & Das, 1979) ^[17]. Very small vessel size of *C. dichotoma* and large size of *C. sinensis*.

Leaf anatomy: At the base of epidermal hairs cystoliths are observed. Cystoliths are a Greek word (*kustis*, bag; *lithos*, stone). In cystoliths calcium carbonate crystals are accumulated.) (Katherine, 1960; Evert, 2006; Rudall, 2007) ^[7, 5, 18]. Cystoliths are confined to a *Cordia* species (Boraginaceae). Large amount of silica accumulated in cystoliths and reported in species of Boraginaceae (Metcalf & Chalk, 1965; Evert, 2006) ^[13, 5].

The vascular bundles organization in both species is collateral open. The region of vascular cambium and pith region of *C. sinensis* calcium carbonate observed. Variations in the arrangement of the shape of vascular bundles were observed in the present study. During the study, two types of vascular bundles are arranged i.e. broad U-shaped and narrow U-shaped. During the studies showed that the trichomes were of single types in the present study: Non-glandular trichomes. Ranunculious type stomata are observed on the abaxial and adaxial surface of the leaf. The stomatal index of leaves differs in studied *Cordia* species. Stomatal Index (SI) was highest observed in *C. dichotoma* and the lowest in *C. sinensis*. Highest trichomes density in *C. dichotoma* and the lowest in *C. sinensis* of abaxial and adaxial leaf surface.

Petiole anatomy: During the study, two types of vascular bundles are identified i.e. broad U-shaped and narrow U-shaped. The vascular bundles organization in both species is collateral open. In both species of petiole arc type vascular bundles observed. The region of vascular cambium and pith region of *C. sinensis* calcium carbonate observed. Epidermal outgrowths i.e trichomes are observed in *C. dichotoma*. During the study we observed broad pith parenchymatous cells in *C. dichotoma* and narrow pith parenchymatous cells in *C. sinensis*. During

the present study, the parenchymatous cells, collenchymas cell of ground tissue showed structures such as cystoliths, calcium carbonate crystals and tannin cells seen in various region. The region pith of petiole pited parenchyma cell are observed in *C. dichotoma* and not observed in *C. sinensis*, there are a unique characteristics important to taxonomical identification of *Cordia* species. The significance of collateral open types of vascular bundles was observed of species of *Cordia* species. New anatomical documentation of petiole anatomy are taxonomically informative characters (Metcalf & Chalk, 1965; Evert, 2006) [13, 5].

The culmination, this study of the anatomical documentation of stem, leaf and petiole of the *Cordia* species of northern Western Ghats of Maharashtra. The revealed unique anatomical characters which could be of enormous taxonomic importance. Documentation of anatomical characterization is helpful to taxonomical identification of *Cordia* species. Using vegetative anatomical characters followed distinguishing vital role for plant taxonomy, plant systematic, plant physiology, ecology, paleobotany and evolutionary biology and histology, were useful for diagnostic purposes

Table Caption

Table 3: *Cordia* species studied from northern Western Ghats of Maharashtra.

Taxon	Place of Collection	Geographic coordinates	Elevation (m)
<i>Cordia sinensis</i> Lam.	N 19.265168, E 73.978847	Otur, Maharashtra	673
	N 19.701139, E 75.082472	Aurangabad, Maharashtra	431
<i>Cordia dichotoma</i> G.Forst	N 19.960905, E 73.668170	Nashik, Maharashtra	689
	N 19.263584, E 73.976226	Otur, Maharashtra	664

Table 4: Comparative stem anatomical characteristics of *Cordia* spp.

Characters	<i>C. sinensis</i>	<i>C. dichotoma</i>
Cork layer	10 - 12	6 - 8
Cortex layer	10 - 13	12 - 14
Pericyclic fiber cell number	18 - 25	10 - 28
Phloem cell layer	50 - 53	33 - 35
Phloem medullary layer	2 - 3	3 - 4
Xylem medullary layer	2 - 4	3 - 4
Xylem vessels	simple and perforation	simple and perforation
Pith cell	pitted Parenchyma cell- Calcium crystal, starch grain and something secondary metabolites stored (brown color) present	pitted Parenchyma cell

Table 5: Comparative T.S stem anatomical characteristics of *Cordia* spp.

Characters	<i>C. sinensis</i>	<i>C. dichotoma</i>
Cork layer length 10 X	16.22±2.71	18.46±5.90
Cortex 40 X	233.09±16.41	55.72±8.73
Pericyclic fiber cell diameter (cell number in each pach 18-25) 10 X	18.20±2.74	30.95±6.60
Vesicle diameter 40 X	99.77±16.46	49.47±20.33
Medullary rays length 40 X	73.33±30.32	31.04±10.52
Pith cell diameter 40 X	56.66±16.98	99.58±36.66

*Each value expressed as mean± S.D of 10 replicate

Table 6: Comparative T.L.S stem anatomical characteristics of *Cordia* spp.

Characters	<i>C. sinensis</i>	<i>C. dichotoma</i>
Vesicle Length 10 X	187.16±31.76	58.33±11.25
Bredth 10 X	63.90±32.12	14.10±4.62
Medullary rays length(Medullary rays cell layer number 2-4) 10 X	162.41±71.02	319.85±199.10
Bredth 10 X	13.82±4.16	26.80±10.42

*Each value expressed as mean± S.D of 10 replicates

Table 7: Comparative Leaf anatomical characteristics of *Cordia* spp.

Characters	<i>C. sinensis</i>	<i>C. dichotoma</i>
Upper Epidermis	1 layered	1 layered
Epidermal outgrowths	Present	Present
Palisade layer	1 layered	1 layered
Collenchyma	3 - 4 layered	3 - 5 layered
Parenchyma	3 - 4 layered	2 - 3 layered
Number of vascular bundle	13 - 15 layered	10 - 13 layered

Shape of vascular bundle	Broad U-shaped	narrow U-shaped
Lower epidermis	1 layered	1 layered
Pith- pited Parenchyma cell	Absent	Present

Table 8: Comparative Petiole anatomical characteristics of *Cordia* spp.

Characters	<i>C. sinensis</i>	<i>C. dichotoma</i>
Upper Epidermis	1 layered	1 layered
Epidermal outgrowths	Absent	Present
Collenchyma	3 - 4	5 - 7
Parenchyma	3 - 4	4 - 5
Number of vascular bundle	10 - 13	22- 24
Arc vascular bundle	2	2
Shape of vascular bundle	Narrow U-shaped	Broad U-shaped
Lower epidermis	1 layered	1 layered
Pith- pited Parenchyma cell	Absent	Present

Table 9: Stomatal characteristics of abaxial leaf surface of *Cordia* spp.

<i>Cordia</i> spp.	Leaf Surface	No. of stomata/ mm- 2	No. of cells/ mm-2	Stomatal Index
<i>C. sinensis</i>	Abaxial	24.2±3.03	103.2±35.66	0.20
<i>C. dichotoma</i>	Abaxial	20.8±0.83	55.4±6.06	0.27

*Each value expressed as mean± S.D of 05 replicates from 5 different leaves.

Table 10: Trichome characteristics of abaxial and adaxial leaf surface of *Cordia* spp.

<i>Cordia</i> spp.	Leaf Surface	No. of Trichome/ mm- 2	Total area/ mm-2	Trichome Density
<i>C. sinensis</i>	Abaxial	67.1±26.51	4±0.00	16.77
	Adaxial	83.5±17.39	4±0.00	20.87
<i>C. dichotoma</i>	Abaxial	95.4±31.92	4±0.00	23.85
	Adaxial	117±34.57	4±0.00	29.25

*Each value expressed as mean± S.D of 05 replicates from 5 different leaves.

Figure Legends



Fig 1: Morphological appearance *Cordia* species from Northern Western Ghats of Maharashtra. (a) *Cordia sinensis* and (a) *Cordia dichotoma*



Fig 2: Stem anatomy of *Cordia* spp. (a) *C. sinensis* (b) *C. dichotoma* (a) *C. sinensis* and (b) *C. dichotoma*

Cl= Cork layer, C=Cortex layer, E = epidermis, P = pith, Ph = phloem, X = xylem, Xylem vessels (40x), Hexagonal pitted parenchyma cell in the centre of pith (40X), R = raphides, T= tannin diposition, Mr= Medullary rays length (40 X), Xm= Xylem medullary layer, Pm= Phloem medullary layer

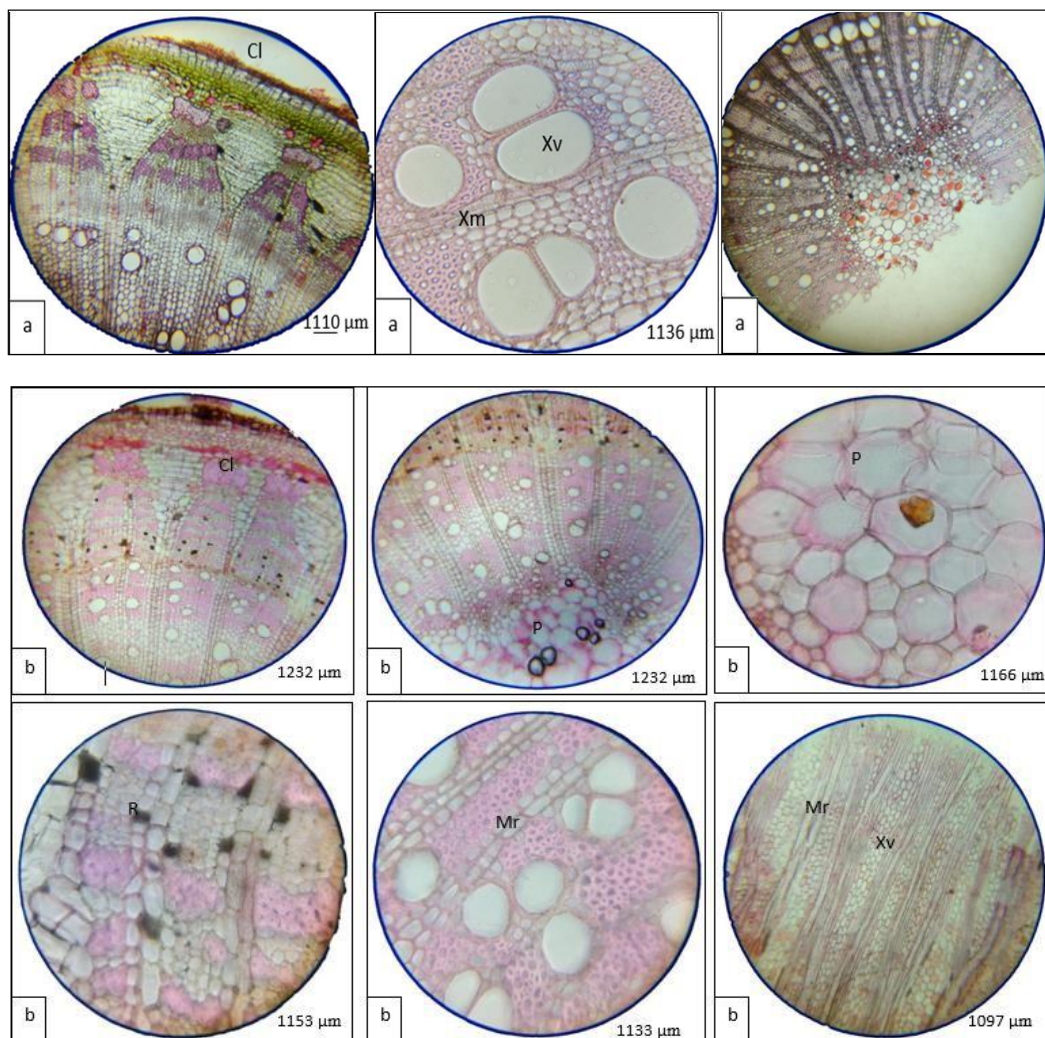


Fig 3: Leaf anatomy of *Cordia* spp. (a) *C. sinensis* (b) *C. dichotoma*

(a) *C. sinensis* (broad U-shaped), (b) *C. dichotoma* leaf (narrow U-shaped)

E= Epidermis, Pp=Palisade parenchyma, Co= Collenchyma, Sp= Spongy parenchyma, Pa= Parenchyma P= Pith, Cyt = cystoliths

(a) *C. sinensis* (b) *C. dichotoma* (narrow U-shaped vascular bundle), (b) *C. dichotoma* Pith- pitted Parenchyma cell (10x)

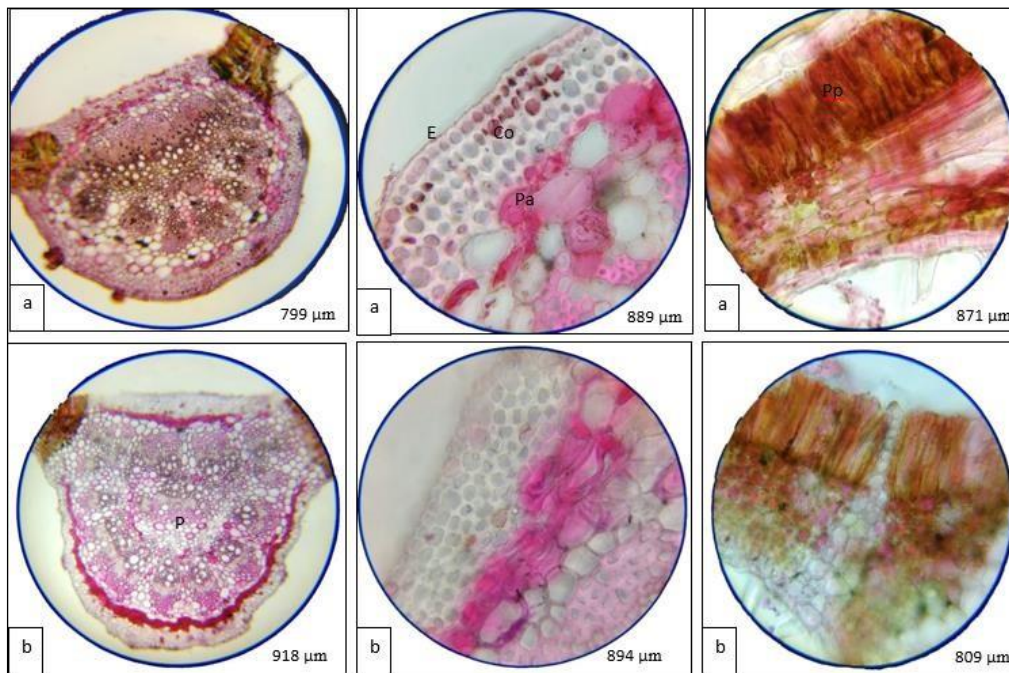


Fig 4: Petiole anatomy of *Cordia* spp. (a) *C. sinensis* (b) *C. dichotoma*

Showing structure of main vascular bundle (a) *C. sinensis* (b) *C. dichotoma* (U-shaped), Arc vascular bundle
 E= Epidermis (40x), Pp=Palisade parenchyma, Co= Collenchyma, Sp= Spongy parenchyma, Pa= Parenchyma,
 P= Pith (40x)

(a) *C. sinensis* (b) *C. dichotoma* (narrow U-shaped vascular bundle), (b) *C. dichotoma* Pith- pited Parenchyma cell (10x)

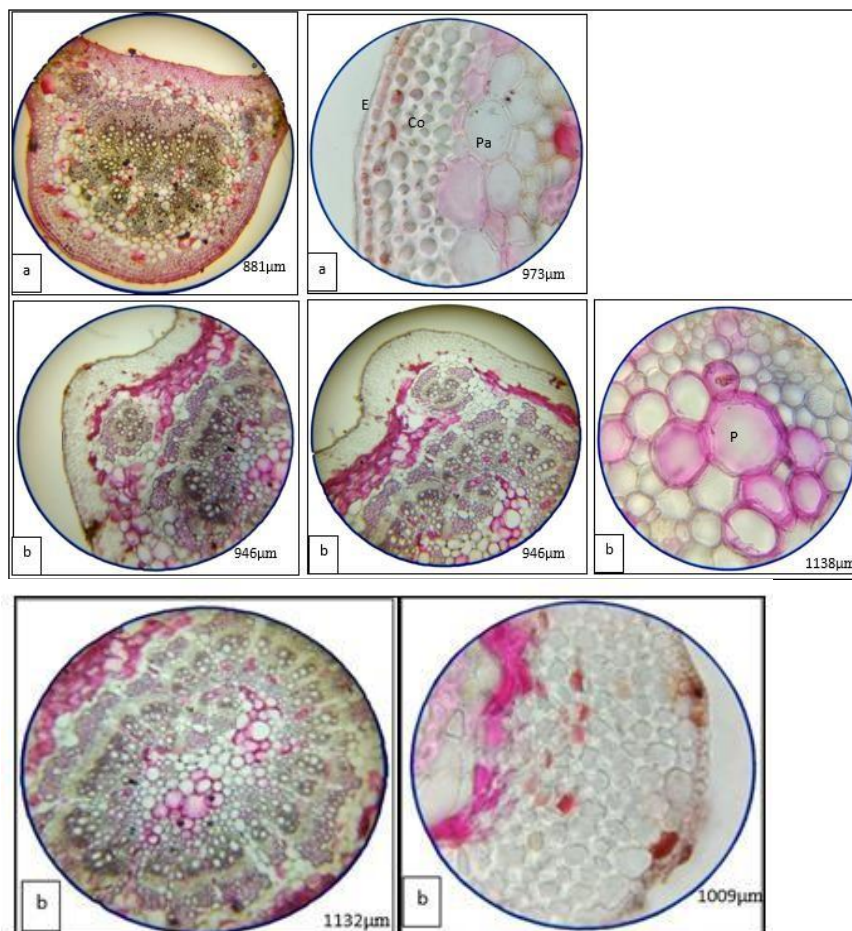


Fig 5: Stomata type of *Cordia* spp. (a) *C. sinensis* (b) *C. dichotom* (anomocytic type of stomata) (10x).

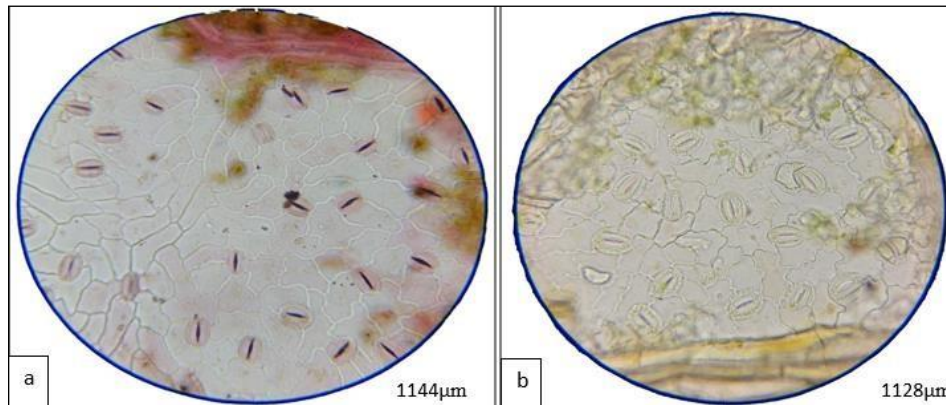


Fig 6: Trichome characteristics of abaxial and adaxial leaf surface of *Cordia* spp. (a) *C. sinensis* (b) *C. dichotoma* (anomocytic type of stomata) (10x). Non- glandular type trichome observed on the surface of both species leaf.

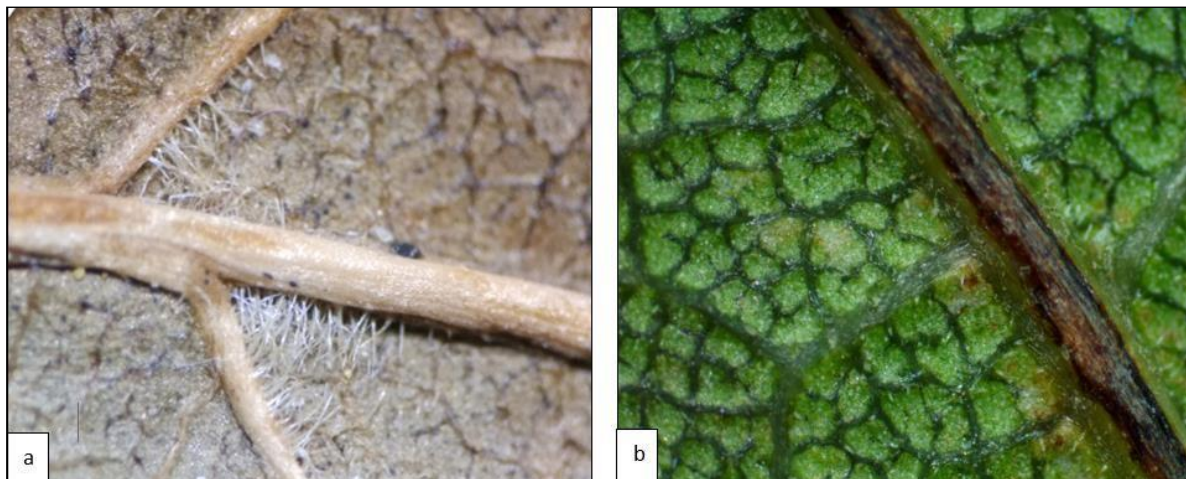


Fig 7

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