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Morpho-Anatomical Investigation of selected Verbenaceae taxa from Ri-Bhoi District, Meghalaya

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Abstract

The Verbenaceae family, known for its diverse plant species, displays remarkable morphological and anatomical variations. This study explores the morphological and anatomical traits of five selected taxa belongs to Verbenaceae family i.e. *Lippia alba* (Mill.) N.E.Br. ex Britton & P. Wilson, *Lantana camara* L, *Clerodendrum infortunatum* L. *Stachytarpheta indica* (L.) Vahl and *Vitex negundo* L., found across various locations on the University of Science and Technology Meghalaya (USTM) campus, shedding light on their taxonomy and systematics. Through detailed analysis of leaf, petiole, and stem morphology, this research enhances our understanding of the family's diversity and provides valuable data for plant identification and classification. The findings have significant implications for the taxonomy and phenology of the Verbenaceae family, underscoring the critical role of morphological and anatomical characteristics in plant systematics.

Key word: *Anatomy, Morphology, Taxonomy, Verbenaceae, Meghalaya.*

Introduction

The Verbenaceae family, also commonly known as Verbena family, consists of plants mainly from tropical regions like herbs, shrubs, trees, etc. The family Verbenaceae of about 99 genera and 3151 species distributed chiefly in tropics and subtropics. About 22 genera and over 30 species have been

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reported from India (Roy et al., 2016). The habit of members of Verbenaceae family is widely varied from small trees to lianas to herbs and shrubs. The stems are generally 4-sided with simple leaves**.** The inflorescence is a raceme, panicle, cyme or head. The flowers are 4-5-merous, mostly zygomorphic with a 2-carpellate gynoecium having a *terminal style*, the fruit a *schizocarp of 1-seeded mericarps or a drupe of pyrenes (*Simpson*,* 2010). Most of the plants belong to this family are widely used for traditional medicinal systems in several countries. Relatively a number of the plants have been reported to comprise of bio-active phytochemicals with significant pharmacological effects. Several species belong to this family are of much economic importances *viz*. *Vitex*, *Tectona*, *Premna, Gmelina*, *Callicarpa, Clerodendrum, Holmskioldia, Stachytarpheta jamaicensis* (ornamental) etc. as some of these species are the source of important medicines (Srivastava & Choudhary, 2008; Sultana & Rahaman, 2020).

Ecological factors frequently cause members of the same taxon occurring in different regions to exhibit significant morphological variation. Subsequently, morpho-anatomical investigation plays a vital role in the identification and systematic revision of taxa (Metcalfe & Chalk, 1979). To accurately determine stem characteristics—such as shape, size, and the structure of primary and secondary veins—it is essential to examine anatomical features, as these traits are often difficult to assess through external morphological observation alone. Therefore, the present study aims to describe the anatomical features of petioles and stems *Lippia alba* (Mill.) N.E.Br. ex-Britton & P. Wilson, *Lantana camara* L, *Lippia alba* (Mill.) N.E.Br. ex Britton & P. Wilson, *Clerodendrum infortunatum* L. *Stachytarpheta indica* (L.) Vahl and *Vitex negundo* L., as a contribution to future taxonomical studies of Verbenaceae family.

Materials and methods

The flowering twig of 5 selected species of Verbenaceae family were collected from different locations of Ri-Bhoi District, Meghalaya. The collected specimens were preserved as herbarium specimen following standard methods (Jain & Rao, 1977) and are deposited at the herbarium of USTM. The plant specimens were identified by consulting different local relevant floras and literature (Kanjilal et al., 1938; Hooker, 1982). For micromorphological analysis, thin sections of stem and petiole were prepared and stained with safranin and fast green following Johansen's (1940) method. Anatomical descriptions were studied by Metcalfe and Chalk's (1979) review.

Results

Taxonomic enumeration

1. ***Clerodendrum infortunatum*** L. in Sp. Pl.: 637 (1753)

Terrestrial shrub, 2-4 feet in height; slightly woody; quadrangular, blackish stem and simple, opposite-decussate, petiolate, exstipulate, coriaceous, hairy leaves with a displeasing odour. Flowers are bluish-purple often white in pyramid shaped terminal panicles. Leaves opposite oblong or elliptic, serrate, flowers are blue, many in long cylindrical thyrsus and the fruits are 4-lobed, purple drupe.

Flowering & Fruiting: August-September

Local name: Dhopat-tita (Ass.), Bhant (Beng.)

2. ***Lantana camara*** L. in Sp. Pl.: 627 (1753)

Shrubs, branch weak, recurved prickles, pubescent. Petiole 1.1-2 cm; leaf blade ovate to oblong, 3.2-7.5 x 1.5-5 cm, rough, aromatic, base rounded to subcordate, margin crenate; lateral veins 5 pairs, prominent. Capitula terminal, 1.5-3cm. Flowers yellow or orange, deep red. Ovary glabrous. Drupes globose

Flowering & Fruiting: throughout the year

Local name: Goubon Gu-phul (Ass.), Raimuniya (Hin).

3. ***Lippia alba*** (Mill.) N.E.Br. ex Britton & P. Wilson in Bot. Porto Rico 6: 141 (1925)

shrub, about 1-2 m height with thin-arched quadrangular, light brown to whitish branches. Petiole is 0.5-1.4 cm long. Leaves simple, 1.2-3.1 cm long with opposite phyllotaxy with an oblong, elliptic to ovoid leaf blade. Inflorescence is axillary with short axis. Flowers are bisexual, small, rosy-violet corolla with yellow nectar. Ovary superior, fruit globose, pear shaped with rosy-pink seeds.

Flowering & Fruiting: Throughout the year

Local name: Pohukota bon (Ass.) Shada Motmotiya (Beng.)

4. ***Stachytarpheta indica*** (L.) Vahl in Enum. Pl. Obs. 1: 206 (1804)

An erect branched woody, with slightly angled stem. stem is hairy, leaves elliptic to oblong-ovate, serrate and 2-9 cm long, decurrent base. Inflorescence, terminal spikes. Flowers deep-blue, sessile, glabrous, slender, rachis dark-green, bracteates, bracts lanceolate. The terminal spikes are rather slender, 10–30 cm long and 0.3-0.4 cm thick. The calyx is small, oblique with four teeth on margin. Corolla blue or blue-purple. Fruit enclosed with calyx and oppressed to and somewhat sunk in the smooth and oblong rachis.

Flowering & Fruiting: June to September

Local name: Nilchori/ Jarbo/ Jarbas (Assamese)

5. ***Vitex negundo*** L. in Sp. Pl.: 638 (1753)

Deciduous shrub, woody aromatic, 2-4 m in height, branches quadrangular, bark grey. Leaves palmately compound, petiole 2.5-3.6 cm long, leaflet lanceolate or narrowly lanceolate, middle leaflet 5-10 cm long with 1-1.3 cm long petioles, remaining two sub-sessile; surface glabrous above and tomentose beneath, texture leathery. Flowers bluish-purple, small, inflorescences terminal, often compound pyramidal panicles. Fruit is rounded drupe and light brown to black in colour.

Flowering & Fruiting: July- January
Local name: Posotia (Ass.) Samalu (Beng.)

Morpho-Anatomy

1. *Clerodendrum infortunatum* L.

Leaf shape: Ovate. *Petiole outline:* D-shaped. *Epidermis:* Irregular, Circular. *Cortex:* 1-5 layers of hypodermal collenchymatous cells and 1-9 layers of parenchymatous cells. *Trichome:* Present, simple, uniseriate and multicellular (Fig.1). *Vascular bundle:* 14-15, *collateral. Pith:* Consist of thick-walled parenchymatous cells. *Stem outline:* Rectangular. *Hypodermal cells:* 1-5. *Cortex parenchymatous cells*: 7-9. *Epidermis:* Irregular, round. *Cortex cells:* Angular, Round (fig.2).

2. *Lantana camara* L.

Leaf shape: Ovate. *Petiole outline:* D-shaped or Oval shaped. *Epidermis:* Irregular, Circular. Cortex: 2-3 layers of hypodermal collenchymatous cells and 7-8 layers of parenchymatous cells. *Trichome:* Present, simple, uniseriate and unicellular. *Vascular bundle:* 30-31. Collateral.
Pith: Consist of thin-walled parenchymatous cells. *Stem outline:* Rectangular, Hypodermal cells: 3-4. Cortex parenchymatous cells: 7-9. *Epidermis:* Irregular, Round. *Cortex cells:* Round. The secretory idioblasts were observed in the petiole and the leaf blades (fig.1).

3. *Lippia alba* (Mill.) N.E.Br. ex Britton & P. Wilson

Leaf shape: Oblong. *Petiole outline:* Oval shaped. *Epidermis:* Irregular, Circular. Cortex:2-3 layers of hypodermal collenchymatous cells and 6-7 layers of parenchymatous cells. *Trichome:* Present, simple, uniseriate and multicellular. *Vascular bundle:* 6-7, collateral. Pith: Consist of thick-walled parenchymatous cells. Stem outline: Round. *Hypodermal cells:* 2-3. Cortex parenchymatous cells: 6-7. *Epidermis:* Irregular, round. *Cortex cells:* Angular (Fig.1).

4. *Stachytarpheta indica* (L.) Vahl

Leaf shape: Elliptical to oblanceolate. *Petiole outline:* Shallowly grooved. *Epidermis:* Irregular, Circular. Cortex: 3-4 layers of hypodermal collenchymatous cells and 8-9 layers of parenchymatous cells. *Trichome:* Present, simple, uniseriate and multicellular (fig.1). *Vascular bundle:* 28-29. collateral, *Pith:* Consist of thin-walled parenchymatous cells. *Stem outline:* Round, *Hypodermal cells:* 3-4. *Cortex parenchymatous cells:* 8-9. Epidermis: Irregular, round. *Cortex cells*: Round.

5. ***Vitex negundo*** L.

Leaf shape: Digitate. Petiole outline: U-shaped. *Epidermis:* Irregular, Circular. *Cortex:* 4-5 layers of hypodermal collenchymatous cells and 7-8 layers of parenchymatous cells. Trichome: Present, simple, uniseriate and multicellular. *Vascular bundle:* 40-45. collateral, *Pith:* Consist of thick-walled parenchymatous cells. *Stem outline:* Rectangular. Hypodermal cells: 3-4. Cortex parenchymatous cells: 7-8. *Epidermis:* Irregular. *Cortex cells:* Angular, Round (Fig.2).

Table 1: The qualitative anatomical characteristics of petiole of studied species

Sl.no.	Species	Leaf Shape	O.S.P.C.S.	Trichomes	E.C.L.	Cortex cell shape	Pith Cells
1.	*Clerodendrum infortunatum* L.	Ovate	D- shaped	+	Irregular, Circular	Angular, Round	Thick walled, Parenchymatous cells
2.	*Lantana camara* L.	Ovate	D- shaped or Oval shaped	+	Irregular, Circular	Round	Thin walled Parenchymatous cells
3.	*Lippia alba* (Mill.) N.E.Br. ex Britton & P. Wilson	Oblong	Oval shaped	+	Irregular, Circular	Angular	Thick walled, Parenchymatous cells
4.	*Stachytarpheta indica* (L.) Vahl	*Elliptic-oblanceolate*	Shallowly grooved	+	Irregular, Circular	Round	Thin walled Parenchymatous cells
5.	*Vitex negundo* L.	Digitate	U-shaped	+	Irregular	Angular, Round	Thick walled Parenchymatous cells

+= Presence of trichomes, **O.S.P.C.S.** - Outline shape of petiole cross section, **E.C.L.**-Epidermal cell layer

Table 2: The quantitative anatomical characteristics of petiole of studied species.

Sl. No.	Species	P.L. (cm)	B.O.P (cm)	No. of E.C.L	No. of H.C.C.L.	No. of C.P.C.L.	No. of V.B.	N.C.P.T
1.	*Clerodendrum infortunatum* L.	1-10	0.5	1	1-5	1-9	14-15	1-9
2.	*Lantana camara* L.	1.3	0.1-0.2	1	2-3	7-8	30-31	1

3.	*Lippia alba* (Mill.) N.E.Br. ex-Britton & P. Wilson	0.9-1	0.1	1	2-3	6-7	6-7	1-3
4.	*Stachytarpheta indica* (L.) Vahl	0.3-0.4	0.1	1	3-4	8-9	28-29	1-3
5.	*Vitex negundo* L.	3-6	0.1	1	4-5	7-8	40-45	1-3

P.L.- Petiole length, B.O.P.-Breadth of petiole, E.C.L.- Epidermis cell layer, H. C.C.L.- Hypodermal Collenchymatous Cell Layer, C.P.C.L.- Cortex Parenchyma Cell Layer, V.B.- Vascular Bundle, N.C.P.T.- Number of Cell Present in Trichomes

Table 3- The qualitative anatomical Characteristics of Stem of Studied species

Sl. no	Species	S.O.S.	Trichome	E.C.L.	C.C.L.	Pith Cells
1.	*Clerodendrum infortunatum* L.	Quadrangular	+	Irregular, Round	Angular, Round	Thick walled Parenchymatous cell
2.	*Lantana camara* L.	Quadrangular	+	Irregular, Round	Round	Thin walled Parenchymatous cell
3.	*Lippia alba* (Mill.) N.E.Br. ex Britton & P. Wilson	Round	+	Irregular, Round	Angular	Thick walled Parenchymatous cell
4.	*Stachytarpheta indica* (L.) Vahl	Round	+	Irregular, Round	Round	Thin walled Parenchymatous cell
5.	*Vitex negundo* L.	Quadrangular	+	Irregular	Angular Round	Thick walled Parenchymatous cell

+=Trichome present, E.C.L.-Epidermal Cell Layer, C.C.S-Cortex Cell shape

Table 4- The quantitative anatomical characteristics of Stem of studied species

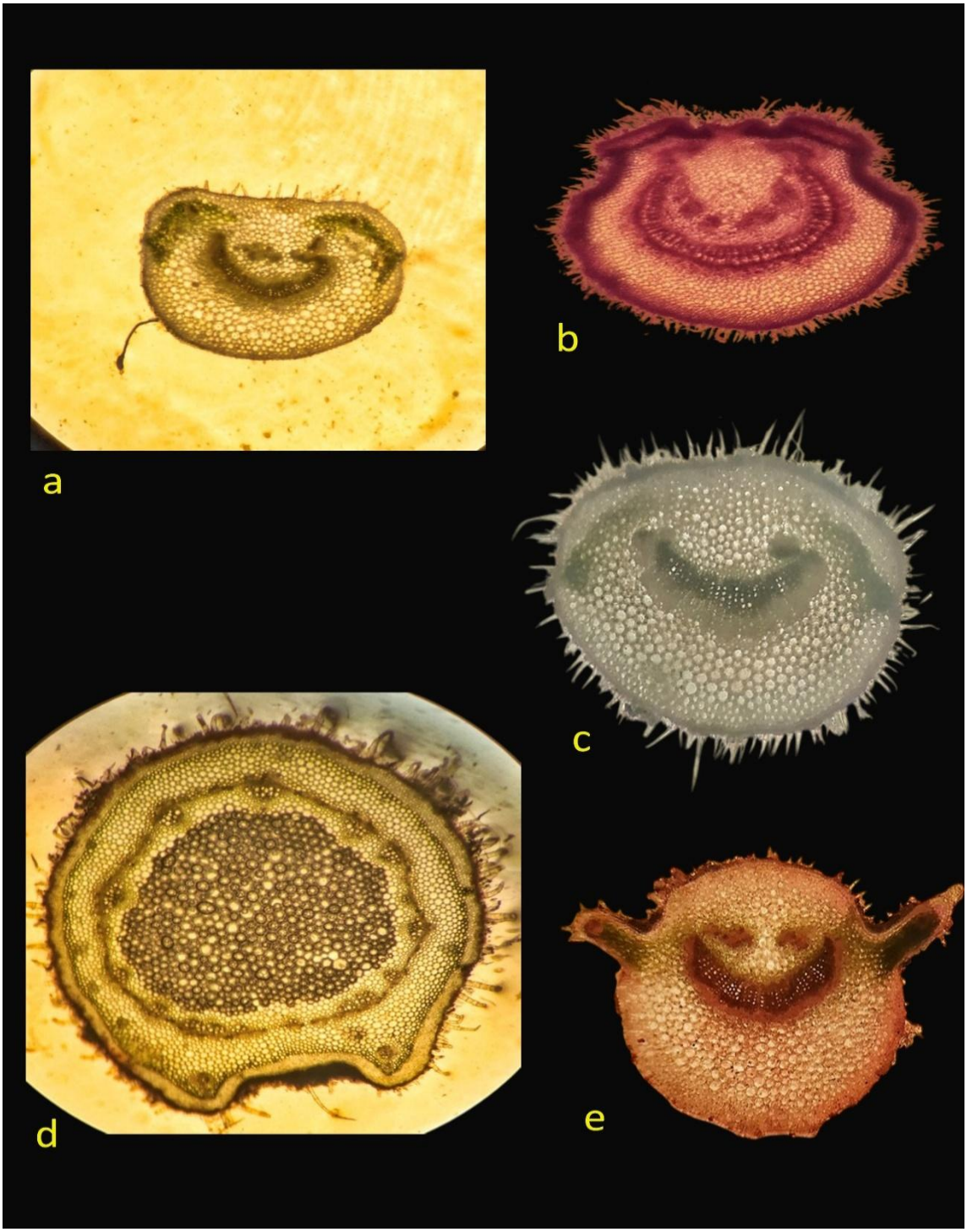
Sl. No.	Species	B.O.S. (cm)	N.O. E.C.L.	N.O. H.C.C.L.	N.O. C.P.C.L.	N.O. V.B.	N.O. C.P. T
1.	*Clerodendrum infortunatum* L.	1-2	1	1-5	7-9	14-15	1-9
2.	*Lantana camara* L.	0.6-0.7	1	3-4	7-9	30-31	1
3.	*Lippia alba* (Mill.) N.E.Br. ex Britton & P. Wilson	0.5-0.6	1	2-3	6-7	6-7	1-3
4.	*Stachytarpheta indica* (L.) Vahl	0.3-0.5	1	3-4	8-9	28-29	1-3

5.	*Vitex negundo* L.	0.3-0.4	1	3-4	7-8	40-46	1-3

P.L.- Petiole length**, B.O.S.-** Breadth of Stem, **N.O.E.C.L.-** Number of Epidermis cell layer**, N.O. H. C.C.L.-** Number of Hypodermal Collenchymatous Cell Layer**, N.O.C.P.C.L.-** Number of Cortex Parenchyma Cell Layer**, N.O.V.B.-** Number of Vascular Bundle**, N.C.P.T.**-Number of Cell Present in Trichomes.

Table 5- Economic Importance of studied species

Sl. No.	Species	Parts used	Active compound	Uses
1.	*Clerodendrum infortunatum* L.	Leaf, slender stem, root	Glycerides, clerodone, luperol (Debnath et al., 2024)	The leaves are antiperiodic and tonic to treat Blenorrhoea, Leaf sap is used as an antiseptic skin wash also used to treat Poultice to burn, ulcer, boils and skin diseases, Roots are used as antidote for Antiaris poisoning and dysentery. Stem is used as toothbrush to treat toothache.
2.	*Lantana camara* L.	Stem, root, leaves, stalk	E-caryophyllene, germacrene, bicyclogermacrene (Bhoye & Hase, 2022)	Used to treat Cancers, Chicken pox, Measles, Asthma, Ulcers, Swellings, Eczema, Tumors, High blood pressure, Billous fever, Catarrhal infections, Tetanus, Rheumatism, Malaria, Antiseptic, Antispasmodic, Carminative, Diaphoretic and also used to make furniture from the stalk.
3.	*Lippia alba* (Mill.) N.E.Br. ex-Britton & P.Wilson	Root, leaves, flower	Citral, geraniol, limonene (Filho & Souza, 2009)	It cures ingestive troubles, Nausea or vomiting, Stomach pain, Diarrhea, Bronchitis, Sore throat, Cough syrup, Cold, Cardiovascular Hypertension, Headache, Skin diseases, also used as ornaments etc.
4.	*Vitex negundo* L.	Leaf, Seed, root	Viridiflorol, caryophyllene oxide, globulol (Haq et al., 2004).	Flavonoid glycoside and a long chain ester from the roots of *Vitex negundo*.
5.	*Stachytarpheta indica* (L.) Vahl	Stem, bark, leaves	Ipolamide, verbascoside & Verbascoside **(**Modi et al., 2025)	It is traditionally used to heal wounds, inhibit bacterial growth, promote tissue regeneration and reduce inflammation.



Fige-1: Comparison of outline shape of petiole cross section. a. *Lantana camara*, **b.** *Vitex negundo*, **c.** *Lippia alba*, **d.** *Clerodendrum infortunatum*, **e.** *Stachytarpheta indica.*

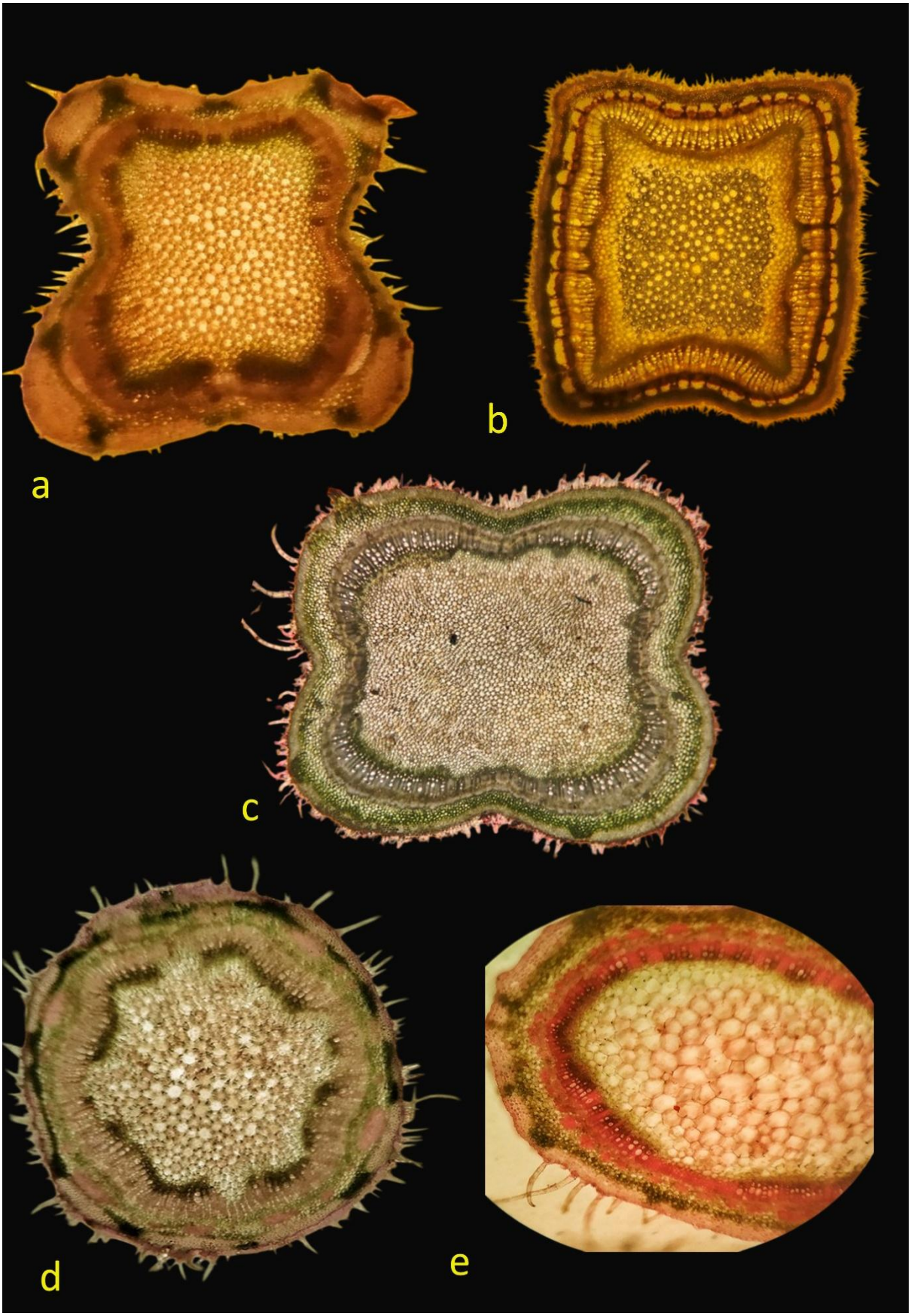


Fig-2: Comparision of outline shape of stem cross section a. *Lantana camara*, **b.** *Vitex negundo,* **c.** *Clerodendrum infortunatum,* **d.** *Lippia alba*, **e.** *Stachytarpheta indica*.

Discussion

The anatomical characters on the five species of the Verbenaceae family showed nearly similar anatomical characteristics, but some significant distinct features are observed. The resulted anatomical data offers reliable characters beneficial for the restriction of species. It is apparent that by a comparative analysis of the several petiolar characters, it will be possible to precisely characterize the taxa. Important taxonomic features for taxonomic evaluation include trichomes, petiole and stem outline shapes (in transverse section), air canals, number of main vascular bundles, thickness of chlorenchymatous and hypodermal layers and width of the middle portion and sheaths. Our observations suggest that combining morphological, qualitative and quantitative petiole and stem anatomical characters can aid in taxonomic treatment, even in the vegetative stage. More research should emphasis on integrating petiole anatomical examination with molecular data to improve taxonomic classification. Growing the study to include additional species across diverse environments could deliver deeper insights into the adaptive consequence of petiole structures (Mishra et al., 2021).

Conclusion

The comparative study of *Lantana camara*, *Vitex negundo*, *Clerodendrum infortunatum*, *Lippia alba* and *Stachytarpheta indica* reveals both shared patterns and distinctive adaptations within the Verbenaceae family. All five species exhibit a single, collateral vascular bundle surrounded by a well-defined bundle sheath, reflecting a conserved structural blueprint for the leaf-stem junction. However, notable differences emerge in collenchyma thickness, the development of sclerenchyma caps, and the presence of secretory cavities. Lantana *camara* shows a robust collenchymatous ring that likely provides mechanical support in its open, sunny habitats, while *Vitex negundo* possesses pronounced adaxial sclerenchyma, suggesting enhanced leaf rigidity. *Clerodendrum infortunatum* and *Stachytarpheta indica* display extensive secretory cavities, which may be linked to the production of secondary metabolites with ecological roles. *Lippia alba* exhibits a relatively thin collenchyma layer but a conspicuous perivascular parenchyma, possibly facilitating rapid water transport in its moist-shrub environments.

These anatomical variations correlate with the species' ecological preferences and highlight the petiole's role in mechanical support, vascular integration and chemical defence. The findings underscore the utility of petiolar characters for systematic and ecological inferences within Verbenaceae and suggest that further ontogenetic and phylogenetic investigations could clarify how these traits have evolved in response to environmental pressures.

Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

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