5. Discussion & Conclusion

The family Sterculiaceae exhibit huge diversification in intermodal, nodal and petiloar anatomical features. The leaf venation similarly shows immense variability among the species. Thus these diversified characters have tremendous systematic value. These diversified features are illustrated below in details.

TRIBE I STERCULIEAE

The tribe Sterculieae consists of six Indian genera, viz. *Cola* Schott & Endl., *Firmiana* Marsili, *Heritiera* Aiton, *Pterocymbium* R. Br., *Pterygota* Schott & Endl. and *Sterculia* L. Among these six Indian genera, five genera namely, *Firmiana* Marsili, *Heritiera* Aiton, *Pterocymbium* R. Br., *Pterygota* Schott & Endl. and *Sterculia* L. have been studied. The genus *Firmiana* Marsili is represented in India by two species, viz. *Firmiana colorata* and *F. fulgens* and both the species have been investigated. The genus *Heritiera* Aiton in India is represented by six species in India, out of which five species, namely *Heritiera dubia*, *H. fomes*, *H. littoralis*, *H. macrophylla* and *H. papilio* have been studied; *Heritiera kanikensis* is known only from its type collection. The genus *Pterocymbium* R. Br. is represented by only one species in India, viz. *P. tinctorium* and that has been studied. Similarly in case of *Pterygota* Schott & Endl. also only one species, *P. alata* has been studied. Among the members of the tribe Sterculieae the genus *Sterculia* L. has maximum numbers of species in India (15 species) and 11 species have been investigated in the present programme.

Genus *Firmiana* Marsili

Both the species of the genus, *F. colorata* and *F. fulgens* have simple, 3–5–lobed, entire leaves with actinodromous venation pattern (Fig.11A.a&12A.a). Leaves are with free lateral, linear stipules. Node is trilacunar 3–traced (Fig.11A.c_2). The vasculature of proximal part of petiole is quiet diverse in regard to number and configuration of vascular traces. The number of vascular traces varies from single as in *F. fulgens* (Fig.12A.b_1) to eleven as in *F. colorata* (Fig.11A.d_1). The arrangement of vascular traces is almost circular in both the cases. Both the studied species exhibit accessory vascular bundles in the proximal part of the petiole. Accessory

vascular bundles one in case of *F. fulgens* (Fig.12A.b_1), whereas, two in *F. colorata* (Fig.11A.d_1). In both cases the main vascular bundle (s) are encircled by patches of sclerenchymatous bundle sheath. Pith is more or less well defined. Mucilaginous cavities are present both in cortex and pith in *F. fulgens* (Fig.12A.b_1), however, in *F. colorata* (Fig.11A.d_1) mucilaginous cavities are present only within periphery of the pith.

The middle portions of the petiole also show diversified vasculature in terms of number and arrangement of vascular traces. Vascular bundles are numerous in case of *F. colorata* (Fig.11A.d_2) and single in case of *F. fulgens* (Fig.12A.b_2). Both the species have accessory vascular bundles at their middle portions of petioles. Number of accessory vascular bundles varies from single in *F. colorata* (Fig.11A.d_2) to three in *F. fulgens* (Fig.12A.b_2). In both the species vascular bundles are ensheathed by patches of sclerenchymatous bundle sheath. Pith is more or less well defined. Mucilaginous cavities present in both cortex and pith in *F. fulgens* (Fig.12A.b_2), whereas in *F. colorata* (Fig.11A.d_2) mucilaginous cavities are present only within pith.

The distal part of the petiole also shows variations in number of main and accessory vascular bundles. The number of main vascular bundles varies from three in *F. fulgens* (Fig.12A.b_3) to numerous in *F. colorata* (Fig.11A.d_4). Accessory vascular bundles are present in both the species. Number of accessory vascular bundles ranges from three in *F. fulgens* (Fig.12A.b_3) to twelve in *F. colorata* (Fig.11A.d_4) and thus appeared more complex than the former. The main vascular bundles remain encircled by dissected sclerenchymatous bundle sheath though it may be absent in some cases (Fig.11A.d_4). Pith is almost occupied by either accessory vascular bundles as in *F. colorata* (Fig.11A.d_4) or with large mucilaginous cavities as in *F. fulgens* (Fig.12A.b_3). Mucilaginous cavities in both the cases present in both cortex and pith. The number is less in case of *F. colorata* (Fig.11A.d_4) than in *F. fulgens* (Fig.12A.b_3).

Both *F. colorata* and *F. fulgens* have actinodromous type of venation pattern (Fig. 11A.a & 12A.a). The primary veins may be straight as in *F. fulgens* (Fig.12A.a) or slightly curved (Fig.11A.a). Secondary veins in both the cases are alternately arranged with very few opposite as in *F. fulgens* (Fig.12A.a) or even

sub–opposite as in *F. colorata* (Fig.11A.a). In case of *F. colorata* (Fig.11A.a) three arches are present at transmarginal region, whereas in *F. fulgens* (Fig.12A.a) two arches are formed at transmarginal region. Intersecondary and intramarginal veins are absent in both the species. Number of outersecondaries to basal pairs is four–five in *F. fulgens* (Fig.12A.a) and six–eight in *F. colorata* (Fig.11A.a). Tertiary veins are represented by both interangular and joining veins. Number of interangular veins varies from one as in *Firmiana colorata* (Fig.11A.a) to three–four in *F. fulgens* (Fig.12A.a).

Minor venation type is lax in *F. colorata* (Fig.11B.a) and massive in *F. fulgens* (Fig.12B.a). Areoles are formed by joining of 4° of veins in *F. colorata* (Fig.11B.a) and 6° or 7° of veins in *F. fulgens* (Fig.12B.a). Areoles are variously shaped and either with inclusion of free vein endings or vein endings may be absent.

In both the species of *Firmiana* free vein endings are of two types, unbranched and branched (Fig.11B.c_1&c_2; 12B.c_1&c_2). They remain associated with parenchymatous sheath cells. Vein end frequency varies from 3.2/mm^2 as in *F. colorata* to 5.8/mm^2 as in *F. fulgens* and areole frequency varies from 11.4/mm^2 in *F. colorata* to 24.8/mm^2 in *F. fulgens.*

Marginal venation is looped in *F. colorata* (Fig.11B.b) and incomplete in *F. fulgens* (Fig.12B.b).

Trichomes in both the species are represented by nonglandular stellate type (Fig.11B.d & 12B.d) having 2 to 8 arms.

Stomata in both the species are anomocytic (Fig.11B.e & Fig.12B.e).

Crystals are absent in both the species.

Genus *Heritiera* Aiton

All the studied five species of *Heritiera* Aiton have simple, entire leaves with brochidodromous type of venation. Leaves are with free lateral, linear stipules. Node is trilacunar 3–traced (Fig.18A.c_2). The vasculature of proximal part is quite diverse in regard to number and arrangement of vascular traces. The number of vascular traces varies from one in *H. fomes* (Fig.18A.d_1), *H. dubia* (Fig.17A.b_1), specimen of *H. littoralis* from Andaman Islands (Fig.19A.d_5) and *H. papilio* (Fig.21A.b_1), few to several in *H. macrophylla* (Fig.20A.b_1) to numerous in *H. littoralis* (Fig.19A.d_1). The single vascular bundle is circular and in case of several to numerous bundles

they are arranged in an oval ring. All the studied species exhibits accessory vascular bundles in the proximal part of the petiole. Accessory vascular bundles one in *H. dubia* (Fig.17A.b_1) and *H. fomes* (Fig.18A.d_1), few to several in *H. littoralis* (Fig.19A.d_1, d_5) and *H. macrophylla* (Fig.20A.b_1) and many in case of *H. papilio* (Fig.21A.b_1) and often they are fused to each other. In all the cases the vascular bundles are encircled by well defined patches of sclerenchymatous bundle sheath except in *H. dubia* (Fig.17A.b_1). In *H. dubia* (Fig.17A.b_1) very less deposition of sclerenchymatous fibre cells were observed within the phloem layer of main bundle. Pith is more or less well defined except in *H. papilio* (Fig.21A.b_1) where accessory vascular bundles occupied almost whole of pith. Mucilaginous cavities are present both in cortex and pith in case of *H. littoralis* (Fig.19A.d_1), *H. dubia* (Fig.17A.b_1), *H. macrophylla* (Fig.20A.b_1), however, in *H. papilio* (Fig.21A.b_1) mucilaginous cavities are present only in cortical region. In *H. fomes* (Fig.18A.d_1) no mucilaginous cavity has been seen.

The middle portions of the petioles of the studied species also show diversified vasculature pattern. The number of vascular traces varies from single as in *Heritiera dubia* (Fig.17A.b_2), *H. fomes* (Fig.18A.d_2), *H. macrophylla* (Fig.20A.b_2) and *H. papilio* (Fig.21A.b_2) to few to several in *H. littoralis* (Fig.19A.d_2). However, specimens of *H. littoralis* (Fig.18A.d_1) collected from Andaman Islands shows single circular vascular strand (Fig.19A.d_6). All the species exhibits accessory vascular bundles in the middle portion of the petioles. Number and nature of accessory vascular bundles remain the same as in proximal part of the petioles, their number ranging from single as in *H. dubia* (Fig.17A.b_2), *H. fomes* (Fig.18A.d_2) to few to several in *H. littoralis* (Fig.19A.d_2), *H. macrophylla* (Fig.20A.b_2) and *H. papilio* (Fig.21A.b_2). All the vascular traces are ensheathed by sclerenchymatous bundle sheath. Pith is more or less well defined except in *H. papilio* (Fig.21A.b_2) where the accessory vascular bundles occupied the whole of pith. Mucilaginous cavities are present both in cortex and pith in case of *H. dubia* (Fig.17A.b_2), *H. fomes* (Fig.18A.d_2), *H. littoralis* (Fig.19A.d_2), *H. papilio* (Fig.21A.b_2), but in *H. macrophylla* (Fig.20A.b_2) mucilaginous cavities are present only in pith region.

The distal regions of the petioles are with variations regarding the vasculature but almost similar to that of proximal and middle parts of the petiole. The number of vascular traces ranges from single as in *H. dubia* (Fig.17A.b_3), *H. fomes* (Fig.18A.d_3), *H. macrophylla* (Fig.20A.b_3) and *H. papilio* (Fig.21A.b_3) to few to several in *H. littoralis* (Fig.19A.d_3) but specimens of *H. littoralis* collected from Andaman Islands show single circular vascular strand (Fig.19A.d_7). All the species exhibit accessory vascular bundles in their distal portion and the number range from one as in *H. dubia* (Fig.17A.b_3), two in *H. fomes* (Fig.18A.d_3) to few to several in *H. littoralis* (Fig.19A.d_3&d_7), *H. macrophylla* (Fig.20A.b_3), *H. papilio* (Fig.21A.b_3). All these vascular traces are provided with patches of sclerenchymatous bundle sheath. Pith is more or less well developed except in *H. papilio* (Fig.21A.b_3) where the accessory bundles completely occupied the pith. Mucilaginous cavities are present both in cortex and pith as in *H. dubia* (Fig.17A.b_3), *H. fomes* (Fig.18A.d_3), *H. littoralis* (Fig.19A.d_3), *H. macrophylla* (Fig.20A.b_3) but in *H. papilio* (Fig.21A.b_3) the cavities are present only in cortical region. *H. littoralis* of Asndaman Islands (Fig.19A.d_7) do not show any mucilaginous cavities.

All species of *Heritiera* have brochidodromous type of venation. The primary vein is either straight as in *Heritiera fomes* (Fig.18A.a) or slightly curved as in *H. littoralis* (Fig.19A.a) and *H. macrophylla* (Fig.20A.a) or prominently curved as in *H. dubia* (Fig.17A.a). Secondary veins mostly alternate, but some are sub–opposite to opposite (Fig.18A.a, 19A.a, 20A.a, 21A.a). The secondaries at the transmarginal region from 3–4 arches, however, 4 arches are rare in *H. macrophylla* (Fig.20A.a) and 4 arches mostly seen in *H. papilio* (Fig.21A.a). Interseconndary and intramarginal veins are absent in all the species. Number of outer secondaries to basal pairs varies from 2 as in *H. fomes* (Fig.18A.a) – 14 as in *H. dubia* (Fig.17A.a). Tertiary veins are represented by both interangular and joining veins. Number of interangular veins varies from 2 in *H. fomes* (Fig.18A.a) to 9 in *H. littoralis* (Fig.19A.a).

Minor venation in all the studied species is massive. Areoles are formed by joining of either 4^o or 5^o of veins as in *H. dubia* (Fig.17B.a) or 6^o or 7^o of veins as in

H. fomes (Fig.18B.a). They are variously shaped and with either inclusion of free vein endings or free vein endings may be absent.

In all the studied species free vein endings are of two types, unbranched and branched. Though branched vein endings are very rare as well. The vein endings remain associated with parenchymatous sheath cells (Fig.17B.c_1&c_2; 18B.c_1&c_2). In case of *H. fomes* (Fig.18B.c_1&c_2) vein endings are associated with vesiculosclereids. Vein end frequency varies from 1.4/mm^2 (in *H. fomes*) to 10/mm^2 (in *H. dubia*). Areole frequency varies from 18.7/mm^2 (in *H. macrophylla*) to 45.8/mm^2 (in *H. papilio*).

All the studied five species of *Heritiera* have looped marginal venation (Fig.17B.b, 18B.b, 19B.b, 20B.b, 21B.b).

The genus *Heritiera* is characterized by the presence of scales on the under surface of the lamina. All studied species possess circular scales with fringed margins adpressed to abaxial surfaces of the lamina (Fig.17b.d, 18B.d, 19B.d, 20B.d, 21B.d). Notably, trichomes are absent in general. However, few glandular trichomes are observed in *H. littoralis* (Fig. 19B.e). Stomata in all the cases are anomocytic type (Fig.17B.e, 18B.e, 19B.f, 20B.e, 21B.d).

Crystals are absent in all the species.

Genus *Pterocymbium* R. Br.

The genus *Pterocymbium* R. Br. is represented by one species, *P. tinctorium* and it has been thoroughly studied. Leaves are simple with free lateral, linear stipules. Petiolar anatomy shows variations in vasculature related to number and arrangement of vascular bundles.

Proximal part of petiole has single, circular vascular bundle [Fig.33A.b_1]. Sclerenchymatous bundle sheath is present in patches. Pith is well developed. Accessory vascular bundle is absent. Sclerenchymatous bundle sheath is present in patches. Pith is more or less well developed. Mucilaginous cavities are many and arranged in circular pattern within cortex and randomly distributed within pith.

Middle part of petiole shows single, circular vascular bundle [Fig.33A.b_3]. Sclerenchymatous bundle sheath is in patches. Pith is well developed. Accessory vascular bundle is absent. Mucilaginous cavities are many and arranged in circular fashion within cortex and only one cavity is present within pith.

Distal end of petiole has single, circular vascular bundle (Fig.33A.b_5). Vascular bundle is a lobed structure. Sclerenchymatous bundle cap is in patches. Mucilaginous cavities are many and arranged in a circular fashion within cortex and only two cavities are present within pith.

Leaves are simple and have brochidodromous type of major venation [Fig.33A.a]. Primary vein is straight. Secondaries are alternately arranged. Outer secondaries to basal pairs are 6–7. Intersecondary and intramarginal veins are absent. Tertiaries are of both interangular and joining veins.

Minor venation is massive, up to 6º of veins [Fig.33B.a]. Areoles are well developed, formed by5º of veins and are variously shaped.

Free vein endings are of two types, unbranched and branched [Fig.33B.c_1&c_2]. Both types of vein ends are associated with parenchymatou sheath cells. Vein end frequency is found to be 3.8/mm^2 and areole frequency is 28.9/mm^2.

Marginal venation is looped [Fig.33B.b].

Trichomes are very rare in this species. Only nonglandular trichomes are present. Trichomes are acicular and 2–4 armed stellate types [Fig.33B.d_1&d_2].

Stomata are anomocytic type [Fig.33B.e].

Crystals are of druses of various size and restricted only in petiole and not found on lamina [Fig.33B.f].

Genus *Pterygota* Schott & Endl.

The genus *Pterygota* Schott & Endl. is represented by one species, *P. alata* and it has been thoroughly studied. Leaves are simple with free lateral, linear stipules. Node is trilacunar three–traced [Fig.44A.c_1&c_2]. Petiolar anatomy shows variations in vasculature related to number and arrangement of vascular bundles.

The proximal end of petiole is represented by numerous vascular bundles, arranged in an almost circular fashion [Fig.44A.d_1]. Bundles are slender, triangular shaped and varies in size. Sclerenchymatous bundle cap in patches encircles all vascular bundles.. Accessory vascular bundles are 8 to 10, most of which are associated with main bundles. Mucilaginous cavities are few, variable in diameter and arranged in a random fashion within periphery of pith.

The middle part of petiole has single, circular vascular bundle with a cut at adaxial face [Fig.44A.d_2]. Sclerenchymatous bundle cap in patches encircles the

vascular bundle. Accessory vascular bundles are 7, more or less rounded or spherical and some elongated. Mucilaginous cavities are very few and randomly arranged only within pith.

The distal end of petiole has numerous vascular bundles arranged in a circular pattern [Fig.44A.d_4]. Nature, configurations and features of xylem, phloem and bundle cap of main vascular bundles are similar to the proximal and middle parts. Accessory vascular bundles are numerous, occupying almost whole of pith. Mucilaginous cavities are two, present within cortex.

Leaves are simple with brochidodromous type of major venation [Fig.44A.a]. Secondaries are alternately or oppositely arranged. Outer secondaries to basal pair are 6–8. Intersecondary and intramarginal veins are absent. Tertiaries are of both interangular and joining veins.

Minor venation is massive, up to 6º of veins [Fig.44B.a]. Areoles are formed with the joining of 5º of veins, well developed and are variously shaped.

Free vein endings are of two types as unbranched and branched [Fig.44B.c_1&c_2]. Both types of vein ends are associated with parenchymatous sheath cells.

Marginal venation is looped [Fig.44B.b].

Trichomes are of only glandular type [Fig.44B.d]. Glandular trichomes are either stalked or sessile globular, multicellular structures. Stalk or basal cell when present unicellular or rarely multicellular. Globular body comprises of 5 to 12 cells arranged in tiers and provided with both longitudinal and perpendicular septa. Trichomes remain scattered on laminar surface and also arranged along veins.

Stomata mostly anomocytic [Fig.44B.e]. However, many other types and subtypes also recorded. Brachyparacytic, diacytic, paracytic, cyclocytic, and many more are observed. Thirteen types of stomata along with 18 subtypes and 3 intermediate subtypes between brachyparahexacytic monopolar and dipolar are reported to be present in the leaves of *Pterygota alata* (Roxb.) R. Br. var. *alata* and *Pterygota alata* (Roxb.) R. Br. var. *irregularis* (W. W. Sm.) Deb & S. K. Basu. The observed stomata are amphibrachyparacytic, amphicyclocytic, anisocytic, anomocytic, anomotetracytic, brachyparacytic, brachyparahexacytic, brachyparatetracytic, cyclocytic, paracytic, parahexacytic (dipolar), paratetracytic

and stephanocytic. Besides these, the presence of giant stomata is a significant finding. Cuticular striations are present on the subsidiary cells, epidermal cells and sometimes even on guard cells.

Crystals are of druses and of diamond–shaped with variable size [Fig.44B.f]. Crystals are distributed on laminar surfaces and sometimes along veins, and also seen in stem and petiole.

Genus *Sterculia* L.

In India the genus *Sterculia* L. is represented by 15 species, out of which 11 species were investigated.

Among the studied species, only two members have compound leaves, viz. *S. foetida* (Fig.47A.a&b) and *S. versicolor* (Fig.55A.a). Rest nine species have simple leaves. All the species except *S. urens* (Fig.54A.a) and *S. villosa* (Fig.56A.a) have brochidodromous type of leaf venation. *S. urens* (Fig.54A.a) and *S. villosa* (Fig.56A.a) have actinodromous type of major venation. Leaves are with free lateral, linear, oblong, ovoid or lanceolate stipules. Node is uniformly trilacunar 3–traced (Fig.47A.d_2; 48A.b_2; 52A.c_1). The vascular supply of stipules arises from lateral traces as also seen in other cases. The vasculature of proximal part of petiole is quite diverse in regard to number and configuration of vascular traces. Number of vascular traces ranges from single as seen in *S. balanghas* (Fig.46A.b_1), *S. guttata* (Fig.48A.d_1), *S. macrophylla* (Fig.53A.b_1), to few to many as in *Sterculia foetida* (Fig.47A.e_1,e_2&e_3), *S. hamiltonii* (Fig.49A.b_1), *S. kayae* (Fig.50A.b_1), *S.kingii* (Fig.51A.b_1), *S. lanceifolia* (Fig.52A.d_1), *S. urens* (Fig.54A.b_1), *S. versicolor* (Fig.55A.b_1) and *S. villosa* (Fig.56A.b_1). The arrangement of all the vascular traces in the studied species is more or less circular to oval. The bundle (s) remains encircled by sclerenchymatous bundle sheath, either in an almost continuous fashion as in *S. balanghas* (Fig.46A.b_1) or in dissected fashion as seen in other species. In case of *S. versicolor* (Fig.55A.b_1) sclerenchymatous bundle sheath is ill developed. All the studied species exhibits accessory vascular bundles in this region of the petiole. Notably, only in *S. lanceifolia* the accessory vascular bundles occupied the entire pith (Fig.52A.d_1). The number of accessory vascular bundles varies from 2 [*S. balanghas* (Fig.46A.b_1), *S. foetida* (Fig.47A.e_1&e_3), *S. macrophylla* (Fig.53Ab$_1$), *S. versicolor* (Fig.55A.b_1) to few in *S. guttata* (Fig.48A.d_1), *S. hamiltonii*

(Fig.49A.b_1), *S. kayae* (Fig.50A.b_1), *S. kingii* (Fig.51A.b_1)], to several–many as in *S. urens* (Fig.54A.b_1), *S. villosa* (Fig.56A.b_1). Pith is more or less well defined in *S. foetida* (Fig.47A.e_1– e_3), *S. guttata* (Fig.48A.d_1), *S. hamiltonii* (Fig.49A.b_1), *S. kayae* (Fig.50A.b_1). In *S. balanghas* (Fig.46 A.b1), *S. kingii* (Fig.51A.b_1), *S. macrophylla* (Fig.53A.b_1), *S. urens* (Fig.54A.b_1), *S. versicolor* (Fig.55A.b_1) and *S. villosa* (Fig.56A.b_1) pith is inconspicuous and more or less occupied by accessory vascular bundles. Specifically in *S. lanceifolia* (Fig.52A.d_1) the pith is completely diminished as the main vascular bundles occupied the area. Mucilaginous cavities are present both in cortex and pith as seen in *S. balanghas (*Fig 46A.b_1), *S. foetida* (Fig.47A.e_1– &e_3), *S. guttata* (Fig.48A.d_1), *S. kayae* (Fig.50A.b_1), *S. kingii* (Fig.51A.b_1), *S. macrophylla* (Fig.53A.b_1), *S. urens* (Fig.54A.b_1), *S. versicolor* (Fig.55A.b_1) and *S. villosa* (Fig.56A.b_1). In *S. hamiltonii* (Fig.49A.b_1) and *S. lanceifolia* (Fig.52A.d_1) mucilaginous cavities are present only within pith.

The middle portion of the petioles of studied species shows much variation in vasculature pattern. The number of vascular bundle ranges from single as in *S. balanghas* (Fig.46A.b_4), *S. guttata* (Fig.48A.d_2), *S. hamiltonii* (Fig.49A.b_2), *S. kayae* (Fig.50A.b_2), *S. lanceifolia* (Fig.52A.d_7), *S. macrophylla* (Fig.53A.b_2), *S. foetida* (Fig.47A.e_9) to few as seen in *S. foetida* (Fig.47A.e_7), *S. kingii* (Fig.51A.b_2), *S. urens* (Fig.54A.b_2), *S. versicolor* (Fig.55A.b_2) to several in *S. villosa* (Fig.56A.b_3). Arrangement of vascular bundles is more or less similar to that of the proximal regions of the petioles of the respective species. Accessory vascular bundles are present at the middle portions of all studied species. Number of accessory vascular bundles varies from one as in *S. balanghas* (Fig.46A.b_4), *S. foetida* (Fig.47A.e_7), *S. hamiltonii* (Fig.49A.b_2), *S. kingii* (Fig.51A.b_2), *S. lanceifolia* (Fig.52A.d_7), *S. macrophylla* (Fig.53A.b_2) to few as seen in *S. foetida* (Fig.47.A.e_8& e_9), *S. guttata* (Fig.48.A.d_2), *S. kayae* (Fig.50A.b_2), *S. urens* (Fig.54A.b_2), *S. versicolor* (Fig.55A.b_2), *S. villosa* (Fig.56A.b_3). All the main vascular bundles are encircled by sclerenchymatous bundle sheath in patches except in *S. lanceifolia* (Fig.52A.d_7), where the bundle sheath is in continuous layer. In case of *S. versicolor* (Fig.55A.b_2) sclerenchymatous bundle cap is very ill developed. Mucilaginous cavities are present both in cortex and pith as seen in *S. balanghas* (Fig.46A.b_4), *S. foetida* (Fig.47A.e_8&e_9), *S. guttata* (Fig.48A.d_2), *S. kayae*

(Fig.50A.b_2), *S. kingii* (Fig.51A.b_2), *S. lanceifolia* (Fig.52A.d_7), *S. macrophylla* (Fig.53A.b_2), *S. villosa* (Fig.56A.b_3). In *S. hamiltonii* (Fig.49A.b_2) and *S. urens* (Fig.54A.b_2) mucilaginous cavities are present only within pith and not within cortex. In *S. versicolor* (Fig.55A.b_2) mucilaginous cavities are present only within cortex and not in pith. In *S. balanghas* (Fig.46A.b_4), *S. villosa* (Fig.56A.b_3) hypodermis is represented by thick collenchymatous layer.

Distal part of the petioles of studied species shows enough variation regarding the number and arrangement of vascular bundles. Number ranges from in *S. balanghas* (Fig.46A.b_5), *S. guttata* (Fig.48A.d_3), *S. hamiltonii* (Fig.49A.b_3), *S. lanceifolia* (Fig.52A.d_{10}), *S. macrophylla* (Fig.53A.b_3) to few as in *S. kayae* (Fig.50A.b_3), *S. kingii* (Fig.51A.b_3), *S. urens* (Fig.54A.b_3), *S. versicolor* (Fig.55A.b_4) and *S. villosa* (Fig.56A.b_7). Arrangement of the vascular bundles is more or less circular to oval. All the species of *Sterculia* exhibit accessory vascular bundles within pith, however, number and the arrangements varies. Number of accessory vascular bundles ranges from single as in *S. balanghas* (Fig.46A.b_5), *S. hamiltonii* (Fig.49A.b_3), *S. kingii* (Fig.51A.b_3), *S. lanceifolia* (Fig.52A.d_{10}), *S. macrophylla* (Fig.53A.b_3) to few to (several–) many as in *S. foetida* (Fig.47A.e_{10}), *S. guttata* (Fig.48 A.d_3), *S. kayae* (Fig.50A.b_3), *S. urens* (Fig.54A.b_3), *S. versicolor* (Fig.55A.b_4) and *S. villosa* (Fig.56A.b_7). Except *S. versicolor* (Fig.55A.b_4) all other species have dissected to continuous sclerenchymatous bundle sheath. Mucilaginous cavities are present both in cortex and pith as in *S. balanghas* (Fig.46 A.b_5), *S. foetida* (Fig.47A.e_{10}), *S. guttata* (Fig. 48A.d_3), *S. kingii* (Fig.51A.b_3), *S. macrophylla* (Fig.53A.b_3), *S. versicolor* (Fig.55A.b_4) and *S. villosa* (Fig.56A.b_7).

All species under present investigation have brochidodromous type of major venation whereas only two, viz., *S. urens* (Fig.54A.a) and *S. villosa* (Fig.56A.a) have actinodromous type of venation.

Minor venation includes both lax and massive types. Massive minor venation is found in *S. balanghas* (Fig.46B.a), *S. foetida* (Fig.47B.a), *S. guttata* (Fig.48B.a), *S. hamiltonii* (Fig.49B.a), *S. kayae* (Fig.50B.a), *S. kingii* (Fig.51B.a), *S. macrophylla* (Fig.53B.a), *S. urens* (Fig.54B.a), *S. versicolor* (Fig.55B.a) and *S. villosa* (Fig.56B.a). Free vein ending are formed by 6 °, 7° or 8° of veins. *S. lanceifolia*

(Fig.52.B.a) has lax type of minor venation and free vein endings are formed by 4° or 5° of veins.

Free vein endings are of two types, unbranched and branched. The veins endings remains associated with parenchymatous sheath cells and sometimes with vesiculosclereids as in *S. balanghas* (Fig.46B.c_1&c_2), *S. hamiltonii* (Fig.49B.c_1&c_2), *S. kayae* (Fig.50B.c_1&c_2). The size and shape of the free vein endings varies from species to species. Vein end frequency varies from 2.5 mm^2 (in *S. foetida*) to 19.2 mm^2 (in *S. balanghas*), areoles are well developed, formed by 3°, 4°, 5°, 6° or 7° of veins and are variously shaped including triangular, quadrangular, even irregular Areole frequency varies from 15.8/mm^2 (in *S. lanceifolia*) to 39.6/mm^2 (in *S. versicolor*).

Marginal venation is either looped or incomplete looped type. Looped marginal venation is seen in *S. foetida* (Fig.47B.b), *S. guttata* (Fig.48B.b), *S. kayae* (Fig.50B.b), *S. lanceifolia* (Fig.52B.b), *S. macrophylla* (Fig.53B.b), *S. urens* (Fig.54B.b), *S. versicolor* (Fig.55B.b) and *S. villosa* (Fig.56B.b). Rest of the species has incomplete marginal loops that remain associated with either unbranched or branched or both types of free vein endings. Free vein endings may also be absent.

Trichomes included both non glandular and glandular types. In case of nonglandular types both acicular and stellate trichomes are present. Trichomes sometime associated with basal cells. Species comprising both nonglandular and glandular trichomes are *S. balanghas* (Fig.46B.d_1–d_3), *S. foetida* (Fig.47B.d_1–d_3), *S. guttata* (Fig.48B.d_1&d_2), *S. urens* (Fig.54B.d_1–d_3) and *S. villosa* (Fig.56B.d_1–d_3), whereas rest members has only nonglandular trichomes.

Stomata are predominantly of anomocytic type in all the studied species, however, paracytic and anisocytic types are observed in *S. guttata* (Fig.48B.e).

Crystals are present in all the studied species of *Sterculia*. Predominant type of crystals is druses of various shape and size. In *S. balanghas* diamond– and rhomboid–shaped crystals are also present (Fig.46B.f). In *S. foetida* diamond– and rectangular–shaped crystals are observed (Fig.47B.f), whereas in *S. versicolor* diamond–shaped crystals are noticed (Fig.55B.f) along with druses.

TRIBE II HELICTEREAE

The tribe Helictereae consists of five Indian genera, viz. *Helicteres* L., *Kleinhovia* L., *Leptonychia* Turcz., *Pterospermum* R. Br. and *Reevesia* Lindl.

Genus *Helicteres* L.

In India, the genus *Helicteres* L. is represented by five species, out of which three species, viz. *H. elongata*, *H. hirsuta* and *H. isora*. have been studied. All the three studied species have simple leaves with serrate margin and free lateral, linear stipules. The genus is characterized by trilacunar three–traced node (Fig.16A.c_1). Petiole anatomy shows variations regarding vasculature and arrangement of vascular bundles. Number of vascular bundles varies from single as in *H. elongata* (Fig.14A.b_1) and *H. isora* (Fig.16A.d_1) to three vascular bundles in *H. hirsuta* (Fig.15A.b_7). All bundles are provided with dissected patches of sclerenchymatous bundle sheath. Accessory vascular bundle is present only in *H. elongata* (Fig.14A.b_1) and they occupy major portion of the pith. However, in other two cases, *H. hirsuta* (Fig.15A.b_7) and *H. isora* (Fig.16A.d_1) pith is well developed and prominent and with out any accessory vascular bundle. Mucilaginous cavities are present only in the cortex in random fashion in case of *H. elongata* (Fig.14A.b_1), but in case of *H. hirsuta* (Fig.15A.b_7) and *H. isora* (Fig.16A.d_1) mucilaginous cavities are present both in cortex and pith.

The middle portion of the petiole is almost uniform and is represented by single, circular vascular bundle in all the three cases (Fig.14A.b_2, Fig.15A.b_8 and Fig.16A.b_5&b_6). Nature and configuration of main vascular bundles remain alike to the proximal part. Accessory vascular bundles are two in *H. elongata* (Fig.14A.b_2) and one in *H. hirsuta* (Fig.15A.b_8). In both the cases major portions of piths are occupied by accessory vascular bundles. Middle portion of petiole of *H. isora* (Fig.16A.b_5&b_6) is devoid of accessory vascular bundle. Mucilaginous cavities are present only in the cortex in random to more or less circular pattern in *H. elongata* (Fig.14A.b_2) and *H. hirsuta* (Fig.15A.b_8), whereas in *H. isora* (Fig.16A.b_5&b_6) cavities are present both in cortex and pith.

The distal portion of the petiole exhibits single circular vascular bundle in case of *H. elongata* (Fig.14A.b_3) and *H. isora* (Fig.16A.b_7), whereas, single horse–

shoe–shaped bundle in *H. hirsuta* (Fig.15A.b_{13}. All the three species have accessory vascular bundles in central pith region and their number varies from two to four. Though major portion of pith is occupied by accessory bundles, yet pith is visible. Mucilaginous cavities are present only in cortex in random to somewhat circular pattern in *H. elongata* (Fig.14A.b_3) and *H. hirsuta* (Fig.15A.b_{13}), whereas in *H. isora* (Fig.16A.b_7) cavities are present both in the cortex and pith.

Leaves are simple with semicraspedodromous type of major venation pattern in *H. elongata* (Fig.14A.a). Actinodromous type of major venation pattern is observed in *H. hirsuta* (Fig.15A.a) and *H. isora* (Fig.16A.a). In all cases intersecondaries and intramarginal veins are absent. Secondaries are alternate or opposite. Tertiaries are of both interangular and joining veins.

Minor venation is lax in case of *H. elongata* (Fig.14B.a), *H. hirsuta* (Fig.15B.a) and massive in case of *H. isora* (Fig.16B.a). Areoles are well developed and variously shaped.

Free vein ends are of two types, unbranched and branched (Fig.14B.c_1&c_2, Fig.15B.c_1&c_2 and Fig.16B.d_1&d_2). Both types of vein ends are associated with parenchymatous sheath cells, however in case of *H. elongata* (Fig.14B.c_1&c_2) vein ends are associated with additional sclereids. Vein end frequency varies from 1.6/mm^2 (in *H. elongata*), to 2.6/mm^2 (in *H. isora*). Areole frequency varies from 19.8/mm^2 (in *H. elongata*) to 31/mm^2 (in *H. isora*).

Marginal venation is incomplete in all the three cases i.e., *H. elongata* (Fig.14B.b) and *H. hirsuta* (Fig.15B.b) and *H. isora* (Fig.16B.b).

Trichomes are of only nonglandular types in *H. elongata* (Fig.14B.d_1&d_2) and comprises of both acicular and stellate. In *H. hirsuta* trichomes are of both nonglandular and glandular types (Fig.15B.d_1&d_2), where nonglandular includes only stellate. Both nonglandular and glandular trichomes are also present in *H. isora* (Fig.16B.e_1–e_2), however, nonglandular trichomes include both acicular and stellate types.

Stomata are of anomocytic type in all the three species (Fig.14B.e, Fig.15B.e and Fig.16B.f).

Crystals are present in all the three studied species. Crystals are druses and diamond–shaped of variable sizes in *H. elongata* (Fig.14B.f) and present in petiole only. In *H. hirsuta* (Fig.15B.f) crystals are of only druses and present in petiole only. *H. isora* (Fig.16B.g) has druses type of crystals, present in stem, petiole as well as in lamina.

Genus *Kleinhovia* L.

Genus *Kleinhovia* L. in India is represented by only species *K. hospita* and it has been thoroughly studied.

The leaves of *K. hospita* are simple, broadly ovate with entire margin and free lateral, linear stipules. Node is trilacunar 3–traced (Fig. 22A.c_2). Petiolar anatomy shows variations regarding the vasculature related to number and arrangement of vascular bundles.

The proximal part of the petiole shows 6, 7 or 8 vascular bundles, arranged in a more or less circular fashion. All vascular bundles are provided with sclerenchymatous bundle sheath in patches. Pith is well developed and prominent (Fig.22A.d_1). Accessory vascular bundle is absent. Mucilaginous cavities are few and are present within cortex only.

The middle part of the petiole shows 7 or 10 vascular bundles, arranged in a circular pattern. Nature and configuration remains alike to proximal part (Fig.22A.d_2). Pith is well developed and prominent. Accessory vascular bundle is absent. Mucilaginous cavities are few and present only within cortex.

The distal end has single, circular vascular bundle (Fig.22A.d_4). However, in some specimens 7 or 10 vascular bundles are also observed. Configuration and nature of vascular bundles remain same as in proximal and middle parts of the petiole. Pith is well developed and prominent. Accessory vascular bundle is absent. Mucilaginous cavities are few and present only within cortex.

Leaves are with brochidodromous type of major venation (Fig.22A.a). Primary vein is almost straight. Secondaries are arranged in alternate manner. Outer secondaries to basal pair are 6–7. Intersecondary and intramarginal veins are absent. Tertiary veins are both interangular and joining veins.

Minor venation is massive with free vein ending endings at 6^0 of veins (Fig.22B.a). Areoles are well developed and variously shaped.

Free vein endings are of two types, unbranched and branched. Both types of vein end are associated with parenchymatous sheath cells (Fig.22B.c_1&c_2). Vein end frequency is 3.8/mm^2 and areole frequency is 18.8/mm^2.

Marginal venation is looped, formed by 5^0 of veins (Fig.22B.b).

Trichomes are of both nonglandular and glandular types (Fig.22B.d_1–d_3). Nonglandular trichomes include only acicular type (Fig.22B.d_1). Glandular trichomes are with a single–celled stalk and 1–5–celled ovoid to elongated body (Fig.22B.d_2). Cells are always uniseriate.

Stomata are of anomocytic type (Fig.22B.e).

Crystals are of druses and diamond–shaped of variable sizes (Fig.22B.f). Druses remain scattered on lamina and diamond–shaped are predominantly arranged along veins and vein ends.

Genus *Leptonychia* Turcz.

Genus *Leptonychia* Turcz**.** in India is represented by only species *L. caudata* and it has been thoroughly studied. It has simple leaves with brochidodromous type of venation. Leaves are with free lateral, linear stipules. Variations in the vasculature of petiole have been observed. Proximal part (Fig.23A.b_1) comprises of three vascular bundles arranged in a circular fashion. Sclerenchymatous bundle sheath encircles the entire vascular strand. Mucilaginous cavities very few, variable in diameter and randomly arranged within cortex as well as pith.

Middle part of the petiole (Fig.23A.b_2) has single, more or less circular vascular bundle. Bundle sheath encircles the vascular strand in patches. Mucilaginous cavities few, differing in diameter and randomly arranged within cortex and pith.

Distal end of the petiole (Fig.23A.b_3) has single, more or less oval vascular bundle. Sclerenchymatous bundle sheath in dissected fashion encircles the vascular strand. Accessory vascular bundles are two. Mucilaginous cavities are absent.

Leaves have brochidodromous type of major venation (Fig.23B.a).

Minor venation is massive with 6° of veins (Fig.23B.a). Areoles are of various shapes and mostly formed by 5^0 of veins.

Free vein endings are of two types as unbranched and branched (Fig.23B.c_1&c_2). Free vein endings remain associated with parenchymatous sheath cells. Vein end frequency is 6.2/mm^2 and areole frequency is 15.6/mm^2

Marginal venation is incomplete (Fig.23B.b). Marginal ultimate venation is formed by 4º or 5º of veins and is associated with branched and unbranched vein endings.

Trichomes included both glandular and glandular types (Fig.23B.d_1&d_2). Nonglandular trichomes are stellate only (Fig.23B.d_1). Glandular trichomes have single–celled stalk with uniseriate, multicellular (mostly 6–8) body. Moreover, the apical cell is always larger than the others (Fig.23B.d_2).

Stomata predominantly anomocytic, however, brachyparacytic and anisocytic are also observed (Fig.23B.e).

Crystals are mostly of rhomboid– and diamond–shaped (Fig.23B.f).

Genus *Pterospermum* Schreb.

The genus *Pterospermum* Schreb**.** in India is represented by eleven species, out of which ten species have been studied. The studied species are *P. acerifolium*, *P. aceroides*, *P. diversifolium*, *P. lanceifolium*, *P. obtusifolium*, *P. reticulatum*, *P. rubiginosum*, *P. semisagittatum*, *P. suberifolium* and *P. xylocarpum*.

All the studied species have simple leaves with entire margins. Stipules are large, ovate with fringed margin in case of *P. acerifolium* and *P. semisagittatum*. Node is trilacunar three–traced in all cases (Fig.36A.c_2). Petiolar anatomical variations are related to vasculature in respect to number and arrangement of vascular bundle.

The proximal part of the petiole of *P. acerifolium* shows either sixteen or numerous vascular bundles (Fig.34A.d_1–d_3). Bundles are provided with dissected sclerenchymatous bundle sheath. Accessory vascular bundles are 6 or 9 and often arranged in a line towards adaxial face of the pith (Fig.34A.d_2&d_3). However, in some specimens major part of pith is occupied by accessory vascular bundles (Fig.34A.d_1). Mucilaginous cavities are many and arranged in random fashion within cortex and pith. In case of *P. aceroides* proximal end is represented by single, circular vascular bundle and remain encircled by sclerenchymatous bundle sheath (Fig.35A.b_1) in patches. Accessory vascular bundles are many, often united to

each other and occupy major part of the pith. Mucilaginous cavities are very few and randomly arranged within cortex. A single large mucilaginous cavitiy is observed in pith. There are seven vascular bundles in *P. diversifolium* and are arranged in circular fashion (Fig.36A.d_1). Sclerenchymatous bundle sheath is ill–developed and present in patches. Accessory vascular bundles are two and often associated with main cylinder. Mucilaginous cavities are many and arranged randomly within both cortex and pith. *P. lanceifolium* shows single, horse–shoe–shaped vascular bundle with strong incurved margins (Fig.37A.d_1). Sclerenchymatous bundle sheath is present in patches. Pith almost replaced by accessory vascular bundles. Mucilaginous cavities are many and arranged within cortex only. Proximal part of *P. obtusifolium* has three vascular bundles, arranged in more or less circular fashion (Fig.38A.b_1). Sclerenchymatous bundle sheath is ill–developed. Mucilaginous cavities are few and arranged randomly within cortex and pith. *P. reticulatum* has single, circular vascular bundle (Fig.39A.b_1). Sclerenchymatous bundle sheath encircles the vascular strand in patches. Accessory vascular bundle is single, large, and irregular in shape and occupies major portion of pith. Mucilaginous cavities are many and present only within cortex. There are three vascular bundles present in *P. rubiginosum* (Fig.40A.b_1). Notably, bundle sheath is absent. Accessory vascular bundle is also absent. Mucilaginous cavity is single and present within pith. *P. semisagittatum* is with single, circular to oval vascular bundle with a small cut at lateral face (Fig.41A.d_1). Bundle sheath is present in patches. Accessory vascular bundles are formed by the branched portions of main vascular strand and occupy major part of the pith. Mucilaginous cavities are few and arranged within cortex and pith. In case of *P. suberifolium* there is single, horse–shoe–shaped vascular strand with the small cut at adaxial face (Fig.42A.d_1). Sclerenchymatous bundle sheath present in patches. Accessory vascular bundles are three. Mucilaginous cavities are absent. *P. xylocarpum* shows single, almost circular to bluntly triangular vascular bundle which is dissected into two segments (Fig.43A.d_1). Bundle sheath is absent. Accessory vascular bundles are few and occupy major portion of the pith. Mucilaginous cavities are absent.

The middle portions of the petiole of studied species are highly variable. *P. acerifolium* shows nineteen or numerous vascular bundles and remain alike to

proximal part (Fig.34A.d_6&d_7). Accessory vascular bundles are seven or eight, either arranged in a line towards adaxial face of the pith (Fig.34A.d_7) or several, scattered within pith (Fig.34A.d_6). Mucilaginous cavities are present both within cortex and pith. Single circular vascular bundle is present in *P. aceroides* (Fig.35A.b_4). Sclerenchymatous bundle sheath is ill–developed. Accessory vascular bundle is single, circular, occupying major portion of pith. Mucilaginous cavities are arranged randomly within cortex only. *P. diversifolium* has four vascular bundles arranged in circular fashion (Fig.36A.d_2). Sclerenchymatous bundle sheath is ill–developed. Accessory vascular bundles are three. Mucilaginous cavities many and are arranged both within cortex and pith. Single, circular vascular bundle is present in *P. lanceifolium* (Fig.37A.d_4). Accessory vascular bundle is single and is present within pith. Mucilaginous cavities are many and present within cortex only. *P. obtusifolium* exhibits single, horse–shoe–shaped vascular bundle with strongly incuved margins (Fig.38A.b_{10}). Bundle sheath is in patches. Accessory vascular bundle fuses with main strand forming complex structure within pith. Mucilaginous cavities are few and arranged within cortex only. In case of *P. reticulatum* configuration remains alike to proximal part (Fig.39A.b_2), however, accessory vascular bundle is not associated with main vascular strand. Mucilaginous cavities are few and arranged within cortex only. In *P. rubiginosum* single, circular vascular bundle is present (Fig.40A.b_2). Sclerenchymatous bundle sheath is present in dissected fashion. Mucilaginous cavities are absent. *P. semisagittatum* has single, circular vascular bundle. Importantly, bundle sheath is absent (Fig.41A.d_2). Accessory vascular bundle is single, irregular in shape and remains associated with main strand. Mucilaginous cavities are very less and present within cortex and pith. In case of *P. suberifolium* single, circular vascular bundle is present with dissected bundle sheath (Fig.42A.d_3). Accessory vascular bundle is single and occupies major portion of pith. Mucilaginous cavities are few and arranged within cortex only. *P. xylocarpum* also shows single, circular vascular bundle with ill–developed bundle sheath. Accessory vascular bundle is single and occupies almost whole pith (Fig.43A.d_3). Single mucilaginous cavity is observed within cortex.

The distal portions of petioles of studied species are also variable. In *P. acerifolium* single, bi–lobed vascular bundle is present (Fig.34A.d_9).

Sclerenchymatous bundle sheath is in patches. Accessory vascular bundles are four and present within pith. Mucilaginous cavities are many and present with cortex and pith. *P. aceroides* has single, horse–shoe–shaped vascular bundle with strongly incuved margins (Fig.35A.b_9). Single accessory vascular bundle is observed. Mucilaginous cavities are randomly arranged within cortex only. In *P. diversifolium* three vascular bundles are arranged in more or less circular fashion, However, the adaxial one is much larger than the other two (Fig.36A.d_3). Bundle sheath is ill–developed. Accessory vascular bundles are two. Mucilaginous cavities are many and are present only within cortex. In *P. lanceifolium* vascular bundle as well as accessory vascular bundle is almost similar to *P. aceroides* (Fig.37A.d_6). Mucilaginous cavities are present only within cortex. *P. obtusifolium* has single, circular vascular bundle (Fig.38A.b_{19}). Bundle sheath is in patches. Accessory vascular bundle is one and present within pith. Mucilaginous cavities are few and arranged randomly within cortex only. In *P. reticulatum* the vasculature is complex than the others. The main bundle completely fuses with the accessory bundle and the pith is almost replaced by the same (Fig.39A.b_9). Bundle cap seems ill–developed. Mucilaginous cavities are many and remain arranged in a more or less circular fashion within cortex only. *P. rubiginosum* is with single, oval vascular bundle (Fig.40A.b_3). Bundle sheath is present in patches. Single accessory vascular bundle is present within pith. Mucilaginous cavities are less and present within cortex only. In case of *P. semisagittatum* single, circular vascular bundle is present (Fig.41A.d_5). Accessory vascular bundle is single, triangular and present towards adaxial face of the pith and often associated with the main cylinder. Mucilaginous cavities are very few and arranged randomly within cortex and pith. In *P. suberifolium* configuration is similar to middle part (Fig.42A.d_4). *P. xylocarpum* is with single, horse–shoe–shaped vascular bundle with adaxial cut (Fig.43A.d_4). Single, large accessory vascular bundle almost occupied the entire pith and remains associated with the main cylinder at the adaxial face. Bundle sheath is ill–developed. Mucilaginous cavities are absent.

The major venation pattern in the studied species is represented by actinodromous in *P. acerifolium* (Fig.34A.a) and brochidodromous in rest of the species, viz. *P. aceroides* (Fig.35A.a), *P. diversifolium* (Fig.36A.a), *P. lanceifolium*

(Fig.37A.a), *P. obtusifolium* (Fig.38A.a), *P. reticulatum* (Fig.39A.a), *P. rubiginosum* (Fig.40A.a), *P. semisagittatum* (Fig.41A.a), *P. suberifolium* (Fig.42A.a) and *P. xylocarpum* (Fig.43A.a).

The minor venation in all the studied species is massive [*P. acerifolium* (Fig.34B.a), *P. aceroides* (Fig.35B.a), *P. diversifolium* (Fig.36B.a), *P. lanceifolium* (Fig.37B.a), *P. obtusifolium* (Fig.38B.a), *P. reticulatum* (Fig.39B.a), *P. rubiginosum* (Fig.40B.a), *P. semisagittatum* (Fig.41B.a), *P. suberifolium* (Fig.42B.a) and *P. xylocarpum* (Fig.43B.a)].

Free vein endings are of two types, unbranched and branched types in all the studied species. Both types of vein ends are associated with parenchymatous sheath cells [*P. acerifolium* (Fig.34B.c_1&c_2), *P. aceroides* (Fig.35B.c_1&c_2), *P. diversifolium* (Fig.36B.c_1&c_2), *P. lanceifolium* (Fig.37B.c_1&c_2), *P. obtusifolium* (Fig.38B.c_1&c_2), *P. reticulatum* (Fig.39B.c_1&c_2), *P. rubiginosum* (Fig.40B.c_1&c_2), *P. semisagittatum* (Fig.41B.c_1&c_2), *P. suberifolium* (Fig.42B.c_1&c_2) and *P. xylocarpum* (Fig.43B.c_1&c_2)].

Marginal venation is looped in all studied species [*P. acerifolium* (Fig.34B.b), *P. aceroides* (Fig.35B.b), *P. diversifolium* (Fig.36B.b), *P. lanceifolium* (Fig.37B.b), *P. obtusifolium* (Fig.38B.b), *P. reticulatum* (Fig.39B.b), *P. rubiginosum* (Fig.40B.b), *P. semisagittatum* (Fig.41B.b), *P. suberifolium* (Fig.42B.b) and *P. xylocarpum* (Fig.43B.b)].

Vein end frequency ranges from 1.6/mm^2 (in *P. lanceifolium*) to 4.6/mm^2 (in *P. acerifolium*). Areole frequency varies from 29.4/mm^2 (in *P. semisagittatum*) to 104.2/mm^2 (in *P. acerifolium*).

Trichomes are of only nonglandular type in all the species [*P. acerifolium* (Fig.34B.d_1–d_3), *P. diversifolium* (Fig.36B.d_1–d_3), *P. lanceifolium* (Fig.37B.d_1&d_2), *P. obtusifolium* (Fig.38B.d_1&d_2), *P. reticulatum* (Fig.39B.d_1&d_2), *P. semisagittatum* (Fig.41B.d_1–d_3), *P. suberifolium* (Fig.42B.d_1&d_2) and *P. xylocarpum* (Fig.43B.d_1&d_2)], whereas in *P. aceroides* (Fig.35B.d_1–d_3) and *P. rubiginosum* (Fig.40B.d_1–d_3) both glandular and nonglandular trichomes are observed.

Stomata are anomocytic type in all studied species [*Pterospermum acerifolium* (Fig.34B.e), *P. aceroides* (Fig.35B.e), *P. diversifolium* (Fig.36B.e), *P. lanceifolium* (Fig.37B.e), *P. obtusifolium* (Fig.38B.e), *P. reticulatum* (Fig.39B.e), *P.*

rubiginosum (Fig.40B.e), *P. semisagittatum* (Fig.41B.e), *P. suberifolium* (Fig.42B.e) and *P. xylocarpum* (Fig.43B.e)].

Crystals are absent in all the studied species except *P. xylocarpum* where druses, rhomboid– and diamond–shaped crystals are distributed along veins, vein ends and on laminar surface and also found in stem and petiole (Fig.42B.f).

Genus *Reevesia* Lindl.

In India genus *Reevesia* Lindl. is represented by only one species *Reevesia wallichii.* Two infraspecific taxa, viz. f. *pubescens* and f. *wallichii* are recorded from the country. Out of two forma, *R. pubescens* f. *pubescens* has been studied thoroughly.

R. pubescens f. *pubescens* has simple leaves with entire margin and brochidodromous type of major venation pattern. Stipules are free lateral and linear–lanceolate. Petiole shows variations in vasculature related to number and arrangement of vascular bundles. The proximal part is represented by single, irregurlarly shaped vascular strand at the central part of the petiole. Pith is thus inconspicuous. The vascular bundle remains encircled by ill–developed sclerenchymatous bundle sheath (Fig.45A.b_1). Accessory vascular bundle is absent. Mucilaginous cavities are numerous and present randomly within cortex, mostly around the vascular bundle.

The middle part of the petiole is represented by single, circular to trilobed vascular strand having much uneven xylem (Fig.45A.b_9). The vascular bundle remains encircled by well developed continuous sclerenchymatous bundle sheath. Accessory vascular bundle present and it remain associated with the main strand towards the adaxial face of the petiole. Pith is well–developed and prominent. Mucilaginous cavities are many and arranged in circular fashion within cortex only, often towards the periphery of vascular bundle.

The distal part of the petiole exhibits highly complex vascular cylinder due to fusion of accessory bundle and the main cylinder. Pith is almost absent. Bundle sheath is almost continuous. Mucilaginous cavities are many, often around the vascular strand (Fig.45A.b_{14}).

Leaves are simple with brochidodromous type of major venation (Fig.45A.a). Primary vein is almost straight. Secondaries are alternate to opposite.

Outer secondaries to basal pairs are 9–12. Intersecondaries and intramarginal veins are absent. Tertiaries are of both interangular and joining veins.

Minor venation is massive (Fig.45B.a). Areoles are well developed and variously shaped.

Free vein endings of two types, unbranched and branched (Fig.45A.e_1&e_2). Both types of vein end are associated with parenchymatous sheath cells. Vein end frequency is 5.2/mm^2 and areole frequency is 36/mm^2.

Marginal venation is looped, formed by 5^0 or 6^0 of veins (Fig.45B.c).

Trichomes are of only nonglandular type (Fig.45B.f_1&f_2). Nongladular trichomes comprise of both acicular (Fig.45B.f_1) and stellate (Fig.45B.f_2).

Stomata are exclusively of anomocytic type (Fig.45B.g).

A single rectangular crystal has been recorded within the vessel element of the petiole (Fig.45B.h).

TRIBE III ERIOLAENEAE

The tribe Eriolaeneae comprises the only genus *Eriolaena* DC. *Eriolaena* in India is represented by 7 species out of which 6 have been studied. The studied six species are *E. candollei, E. hookeriana, E. lushingtonii, E. quinquelocularis, E. spectabilis* and *E. wallichii.*

All the studied species have simple leaves. Leaves are provided with free lateral, linear to lanceolate stipules. The studied species shows trilacunar 3–traced condition of nodes [*E. hookeriana* (Fig.6A.c_2), *E. lushingtonii* (Fig.7A.c_4)]. There are tremendous variations noticed in the vasculature of petiole in regard to the number and arrangement of the vascular bundles.

In proximal part of petioles number of vascular bundles ranges from single as seen in *E. lushingtonii* (Fig.7A.d_1) to few to many in *E. candollei* (Fig.5A.b_1), *E. hookeriana* (Fig.6A.d_1), *E. quinquelocularis* (Fig.8A.b_1), *E. spectabilis* (Fig.9A.b_1) and *E. wallichii* (Fig.10A.b_1). The arrangements of all the bundles are more or less circular to oval. Pith is almost well defined except in *E. lushingtonii* (Fig.7A.d_1), *E. quinquelocularis* (Fig.8A.b_1) where mucilaginous cavities have occupied most of the part of central region. Accessory vascular bundle is absent at proximal part in all the studied species. The bundles are provided with

sclerenchymatous bundle sheaths in dissected fashion. Mucilaginous cavities are present both in cortex and pith in case of *E. candollei* (Fig.5A.b_1), *E. hookeriana* (Fig.6A.d_1), *E. lushingtonii* (Fig.7A.d_1), *E. spectabilis* (Fig.9A.b_1) and *E. wallichii* (Fig.10A.b_1). In both *E. spectabilis* (Fig.9A.b_1) and *E. wallichii* (Fig. 10A.b_1) the piths are occupied by large mucilaginous cavities. In *E. quinquelocularis* (Fig. 8A.b_1) mucilaginous cavities are absent in cortex.

The middle portion of the petioles of studied species show variation among them in regard to vasculature related to number and arrangement of vascular bundles. Number of vascular bundles ranges from single as in *E. candollei* (Fig.5A.b_6), *E. lushingtonii* (Fig.7A.d_4), to few to many in *E. hookeriana* (Fig.6A.d_2), *E. quinquelocularis* (Fig.8A.b_1), *E. spectabilis* (Fig.9A.b_2) and *E. wallichii* (Fig. 10A.b_2). The arrangement of the vascular bundles appears more or less oval to circular. The bundles are provided with sclerenchymatous bundles sheath except in *E. lushingtonii* (Fig.7A.d_4) where bundle sheath is absent. Pith is well developed in almost all the studied species except *E. lushingtonni* (Fig.7A.d_4), *E. quinquelocularis* (Fig.8A.b_2), *E. spectabilis* (Fig. 9A. b_2) and *E. wallichii* (Fig.10A.b_2), where two large mucilaginous cavities have occupied the central portion of the pith. Mucilaginous cavities are present both in cortex and within pith in case of *E. candollei* (Fig.5A.b_6), *E. hookeriana* (Fig. 6A.d_2), *E. lushingtonii* (Fig.7A.d_4) whereas in case of *E. quinquelocularis* mucilaginous cavities are absent within the cortex (Fig.8A.b_2). Accessory vascular bundles are absent in the studied species except *E. candollei* (Fig.5A.b_6). In *E. candollei* (Fig.5A.b_6), portions of phloem are present towards the periphery of the pith as accessory vascular bundles.

Distal part of the petioles of studied species show enough variations regarding vasculature related to number and configuration of bundles. Number of vascular bundles ranges from single as in *E. candollei* (Fig.5A.b_9), *E. wallichii* (Fig.10A.b_3) to few to many in *E. hookeriana* (Fig.6A.d_7), *E. lushingtonii* (Fig.7A.d_6), *E. quinquelocularis* (Fig.8A.b_3), *E. spectabilis* (Fig.9A.b_3). The arrangement of vascular bundles is more or less oval to circular to semi–lunar. The bundles remain encircled by sclerenchymatous bundle sheath in *E. candollei* (Fig.5A.b_9), *E. hookeriana* (Fig.6A.d_7), .*E. wallichii* (Fig.10A.b_3), whereas in rest of the species, viz., *E. lushingtonii* (Fig.7A.d_6), *E. quinquelocularis* (Fig.8A.b_3),

E. spectabilis (Fig. 9A.b_3) bundle sheath is absent. Pith is almost well developed in *E. hookeriana* (Fig.6A.d_7), *E. quinquelocularis* (Fig.8A.b_3), *E. wallichii* (Fig.10A.b_3), whereas in others, viz., *E. candollei* (Fig.5B.b_9), *E. lushingtonii* (Fig.7A.d_6), *E. spectabilis* (Fig.9A.b_3) it is not so prominent and occupied by mucilaginous cavities. Accessory vascular bundles are absent in the studied species except in *E. candollei* (Fig.5A.b_9) where accessory bundles and mucilaginous cavities occupied almost whole of pith (Fig.5A.b_9) and in *E. wallichii* (Fig.10A.b_3) where two accessory vascular bundles are present and occupies major portion of pith.

All the species have simple leaves (Fig.5A.a, Fig.6A.a, Fig.7A.a, Fig.8A.a, Fig.9A.a & Fig.10A.a) with actinodromous type of venation. Outer secondaries to basal pairs ranges from 4–8, however, in *E. spectabilis* (Fig.9A.a) there are no outer secondaries. Intersecondary and intramarginal veins are absent in all the studied species. Tertiary veins are of both interangular and joining veins.

Minor venation in all the studied species of *Eriolaena* has massive pattern (Fig.5B.a, Fig.6B.a, Fig.7B.a, Fig.8B.a, Fig.9B.a & Fig.10B.a). The terminal vein ending ends either in 6^o or 7^o or 8^o of veins Areoles are well developed, formed by 5^o or 6^o or 7^o and variously shaped with inclusion of free vein endings or free vein endings may be absent.

Free vein endings in all the cases are of two types, unbranched and branched (Fig.5B.c_1&c_2, Fig.6B.d_1&d_2, Fig.7B.c_1&c_2, Fig.8B.c_1&c_2, Fig.9B.c_1&c_2 and Fig.10B.c_1&c_2). All the free vein endings in all the studied species are associated with parenchymatous sheath cells. Free vein end frequency ranges from 1.4/mm^2 (in *E. hookeriana*) to 4.4/mm^2 (in *E. wallichii*) and areole frequency ranges from 10.6/mm^2 (in *E. quinquelocularis*) to 26.8/mm^2 (in *E. hookeriana*).

Marginal venation is both looped and incomplete types. Looped marginal venation type is seen in *E. candollei* (Fig.5B.b), *E. quinquelocularis* (Fig.8B.b) and *E. spectabilis* (Fig.9B.b), whereas in *E. hookeriana* (Fig.6B.b), *E. lushingtonii* (Fig.7B.b) and *E. wallichii* (Fig.10B.b) marginal venation is incomplete.

Trichomes are both glandular and nonglandular types in *E. hookeriana* (Fig.6B.e_1&e_2), *E. lushingtonii* (Fig.7B.d_1&d_2), *E. quinquelocularis* (Fig.8B.d_1&d_2),

but in case of *E. candollei* (Fig.5B.d_1&d_2), *E. spectabilis* (Fig.9B.d) and *E. wallichii* (Fig. 10B.d) only nonglandular trichomes are observed. Nonglandular trichomes include either both acicular and stellate type or only stellate type as in *E. quinquelocularis* (Fig.8B.d_1), *E. lushingtonii* (Fig.7B.d_1), *E. spectabilis* (Fig.9B.d) and *E. wallichii* (Fig.10B.d).

Stomata in all studied species of *Eriolaena* is anomocytic type (Fig.5B.e, Fig.6B.f, Fig.7B.e, Fig.8B.e, Fig.9B.e and Fig.10B.e).

Crystals are of diamond–shaped, square, druses or rectangular–shaped and of various sizes. Crystals are seen in *E. hookeriana* (Fig.6B.g), *E. lushingtonii* (Fig.7B.f), *E. quinquelocularis* (Fig.8B.f). Notably, crystals are absent in stem, petiole and leaf lamina of *E. hookeriana*, *E. spectabilis* and *E. wallichii*.

TRIBE IV DOMBEYEAE

The Tribe Dombeyeae comprises of seven genera out of which three are Indian members. The Indian genera are *Dombeya* Cav., *Melhania* Forssk. and *Pentapetes* L..

In India, the genus *Dombeya* Cav. is represented by nine species out of which three species have been thoroughly studied. The three species are *Dombeya burgessiae*, *D. spectabilis* and *D. wallichii*. Under the genus *Melhania* seven species are present in India, out of which five species have been studied, namely, *Melhania denhamii*, *M. futteyporensis*, *M. hamiltoniana*, *M. incana* and *M. magnifolia*. Under *Pentapetes*, only one species is present in India, viz., *Pentapetes phoenicea* and it has been studied thoroughly.

Genus *Dombeya* Cav.

All the studied species of *Dombeya* have simple leaves. Leaves are provided with free lateral, linear to lanceolate stipules. Node is represented by trilacunar 3–traced condition as seen in *D. burgessiae* (Fig.58A.c_3), *D. spectabilis* (Fig.59A.c_1) and *D. wallichii* (Fig.60A.c_2). There is lot of variations in the petiolar anatomy of the three species of *Dombeya* related to the vasculature dealing with number and arrangement of vascular bundles.

In the proximal part of the petioles of studied species the number of vascular bundles ranges from five as in *D. spectabilis* (Fig.59A.d_2) to seven in *D. burgessiae*

(Fig.58A.d_1& d_2), *D. wallichii* (Fig.60A.d_1) to even ten in case of *D. spectabilis* (Fig.59A.d_1). All the bundles are arranged in more or less circular to oval fashion. The bundles are provided with sclerenchymatous bundle sheath in dissected fashion. Pith is well developed and prominent in all the three studied species. Accessory vascular bundles are not present in any of the studied species in their proximal parts of the petioles. Mucilaginous cavities are present both within cortex and pith in all three cases, viz. *D. burgessiae* (Fig.58A.d_2), *D. spectabilis* (Fig.59A.d_1) and *D. wallichii* (Fig.60A.d_1).

The middle portion of the petioles of the studied species shows variations regarding nature and configuration of vascular bundles with respect to their number and arrangement. Number of vascular bundles varies from four to five in *D. spectabilis* (Fig.59A.d_3&d_4), six in *D. wallichii* (Fig.60A.d_2) and single, circular in *Dombeya burgessiae* (Fig.58A.d_8&d_9). All bundles are arranged in a more or less circular fashion and are provided with dissected sclerenchymatous bundle sheath. Accessory vascular bundles are absent in all the middle portions of the studied species. Mucilaginous cavities are present both within cortex and pith in case of *D. burgessiae* (Fig.58A. d_8&d_9), *D. spectabilis* (Fig.59A.d_3&d_4) and *D. wallichii* (Fig.60A.d_2).

The distal part of the petioles of studied species has variations in the nature and configuration of vascular bundles. Number of vascular bundles varies from single as in *D. burgessiae* (Fig.58A.d_{13}&d_{14}), *D. spectabilis* (Fig.59A.d_5) and *D. wallichii* (Fig.60A.d_3) to five in specimens of *D. spectabilis* (Fig.59A.d_6) collected from Kolkata (W.B.). Bundles are arranged in more or less oval to circular fashion and provided with sclerenchymatous bundle sheath in dissected pattern. Pith is well developed in all the studied species. Accessory vascular bundles are absent in *D. burgessiae* (Fig.57A.d_{13}&d_{14}), *D. spectabilis* (Fig.59A.d_5&d_6). In *Dombeya wallichii* (Fig.60A.d_3) patches of xylem and phloem in the form of accessory vascular bundles are present in the periphery of pith and these bundles remain associated with main bundle. Mucilaginous cavities are present in both cortex and pith in *D. burgessiae* (Fig.58A.d_{13}&d_{14}), *D. spectabilis* (Fig.59A.d_5&d_6) and *D. wallichii* (Fig.60A.d_3). In rarest case mucilaginous cavities are absent in *D. burgessiae* (Fig.58A.d_9).

Among the studied species only *D. burgessiae* (Fig.58A.a) has actinodromous type of major venation, the rest two, i.e., *D. spectabilis* (Fig.59A.a) and *D. wallichii* (Fig.60A.a) have semicraspedodromous type of major venation.

Minor venation pattern in the three studied species is massive (Fig.58B.a, Fig.59B.a and Fig.60B.a). Areoles are well developed, formed by 5^{O} of veins and are variously shaped.

Free vein endings are of two types, viz., unbranched and branched in the three species of *Dombeya* (Fig.58B.c_1&c_2, Fig.59B.c_1&c_2 and Fig.60B.c_1&c_2). All the free vein endings are associated with parenchymatous sheath cells. Vein end frequency ranges from 3.5/mm^2 (in *D. burgessiae*) to 5.3/mm^2 (in *D. wallichii*). Areole frequency ranges from 25/mm^2 (in *D. burgessiae*) to 32.1/mm^2 (in *D. spectabilis*)

Marginal venation is incomplete in all the studied species of *Dombeya* (Fig.58B.b, Fig.59B.b and Fig.60B.b).

Trichomes are of both glandular and nonglandular types. Glandular trichomes are very less and are present only in *D.burgessiaae* (Fig.58B.d_2). Nonglandular trichomes are stellate type and arms of the trichomes are both unicellular and multicellular as in *D. burgessiae* (Fig.58B.d_1), *D. spectabilis* (Fig.59B.d) and *D. wallichii* (Fig.60B.d_2).

Stomata are anomocytic type in all three species (Fig.58B.e, Fig.59B.e and Fig.60B.e)

Crystals are of druses, rhomboid–, diamond–shaped of various sizes (Fig.58B.f, Fig.59B.f and Fig.60B.f).

GENUS *Melhania* Forssk.

The genus *Melhania* Forssk. in India is represented by seven species, out of which five species have been studied, namely, *Melhani denhamii, M. futteyporensis, M. hamiltoniana, M. incana* and *M. magnifolia*.

All the studied species have simple leaves with free lateral, linear to oblong stipules. There are several variations noticed in the petiolar vasculature of the studied species.

The proximal part of the petioles of the studied species show variations regarding vasculature related to number and arrangement of vascular bundles. Number of vascular bundles ranges from four as in *M. incana* (Fig.27A.b_1) to five as observed in rest of the species, i.e., *M. denhamii* (Fig.24A.b_1), *M. futteyporensis* (Fig.25A.b_1), *M. hamiltoniana* (Fig.26A.b_1) and *M. magnifolia* (Fig.28A.b_1). Arrangement of vascular bundles is either oval to circular or semi–lunar in fashion. In case of *M. denhamii* sclerenchymatous bundle sheath is ill–developed (Fig.24A.b_1), whereas in *M. futteyporensis* (Fig.25A.b_1) the bundle cap is well developed. Pith is well developed in all the studied species. Accessory vascular bundle is not present in any of the species of *Melhania*. Mucilaginous cavities are absent in *M. denhamii* (Fig.24A.b_1), *M. magnifolia* (Fig.28A.b_1). In *M. hamiltoniana* (Fig.26A.b_1) and *M. incana* (Fig.27A.b_1) mucilaginous cavities are few and present both in cortex and pith. In *M. futteyporensis* (Fig.25A.b_1) mucilaginous cavities are present only within pith.

The middle part of petioles of studied species has variations regarding vasculature related to number and configuration of vascular bundles. Number of vascular bundles ranges from three as in *M. hamiltoniana* (Fig.26A.b_2) to four in *M. denhamii* (Fig.24A.b_2) but five vascular bundles as in *M. futteyporensis* (Fig.25A.b_3), *M. incana* (Fig.27A.b_2) and *M. magnifolia* (Fig.28A.b_2). Arrangement of vascular bundles is almost alike to proximal parts of the petiole. In *M. denhamii* (Fig.24A.b_2) sclerenchymatous bundle sheath is well developed along with *M. futteyporensis* (Fig.25A.b_3), *M. hamiltoniana* (Fig.26A.b_2), *M. incana* (Fig.27A.b_2) and *M. magnifolia* (Fig.28A.b_2). Pith is well developed in all the studied species. Accessory vascular bundle is not present in the middle portion of the petioles of the studied species. In *M. denhamii* (Fig.24A.b_2), *M. futteyporensis* (Fig.25A.b_3) mucilaginous cavities are absent. In *Melhania incana* (Fig.27A.b_2), *M. hamiltoniana* (Fig.26A.b_2), *M magnifolia* (Fig.28A.b_2) mucilaginous cavities are few and arranged both within cortex and pith, whereas in *Melhania magnifolia* (Fig.28A.b_2) only one mucilaginous cavity is present within pith.

The distal part of the petiole of studied species exhibits variations among them with regard to number and configurations of vascular bundles. Number of

vascular bundle ranges from single as in *M. futteyporensis* (Fig.25A.b_3), *M. hamiltoniana* (Fig.26A.b_3) to two in *M. denhamii* (Fig.24A.b_3) to four in *M. incana* (Fig.27A.b_3) to five as seen in *M. magnifolia* (Fig.28A.b_3). Sclerenchymatous bundle cap is present in patches in all vascular bundles, either in well developed condition or ill–developed form. Pith is well developed in all the studied species and accessory vascular bundles are not present in any of the species. Mucilaginous cavities are absent in *Melhania denhamii* (Fig.24A.b_3), *M. fytteyporensis* (Fig.25A.b_3) and in the rest, i.e., *M. hamiltoniana* (Fig.26A.b_3) mucilaginous cavities are few and arranged both in cortex and within pith, in *M. incana* (Fig.27A.b_3) cavities are present both in cortex and pith but in *M. magnifolia* (Fig.28A.b_3) mucilaginous cavity is present only with pith.

The studied species of *Melhania* shows both actinodromous and craspedodromous types of major venation patterns. *M. denhamii* (Fig.24A.a), *M. hamiltoniana* (Fig.26A.a) and *M. magnifolia* (Fig.28A.a) have actinodromous type of major venation and *M. futteyporensis* (Fig.25A.a) and *M. incana* (Fig.27A.a) shows craspedodromous type of major venation.

Minor venation pattern in all the species is massive type with veins leading to final termination at 6^O or 7^O of veins (Fig.24B.a, Fig.25B.a, Fig.26B.a, Fig.27B.a and Fig.28B.a). Areoles are well developed, formed by 5^O or 6^O of veins and are variously shaped and with either inclusion of free vein endings or free vein endings may be absent.

Free vein endings are of two types, unbranched and branched in all the studied species (Fig.24B.c_1&c_2, Fig.25B.d_1&d_2, Fig.26B.c_1&c_2, Fig.27B.c_1&c_2 and Fig.28B.c_1&c_2). All free vein endings are associated with parenchymatous sheath cells. Vein end frequency ranges from 2.6/mm^2 (*M. incana*) to 8.4/mm^2 (*M. hamiltoniana*) and areole frequency varies from 15/mm^2 (in *M. denhamii*) to 29.6/mm^2 (in *M. magnifolia*).

Marginal venation of studied species is both looped and incomplete. Incomplete marginal venation is seen in *M. denhamii* (Fig.24B.b), *M. futteyporensis* (Fig.25B.b) and *M. magnifolia* (Fig.28B.b) and looped marginal venation is seen in two species, namely *M. hamiltoniana* (Fig.26B.b) and *M. incana* (Fig.27B.b).

In all the studied five species of *Melhania* trichomes are nonglandular types. In *M. denhamii* (Fig.24B.d), *M. futteyporensis* (Fig.25B.e), *M. hamiltoniana* (Fig.26B.d), *M. incana* (Fig.27B.d) and *M. magnifolia* (Fig.28B.d) nonglndular trichomes are of stellate form, the differences lies in the number of arms and presence or absence of basal cell.

Stomata in all studies species is anomocytic type (Fig.24B.e, Fig.25B.f, Fig.26B.e, Fig.27B.e and Fig.28B.e).

Crystals are absent in four studied species, namely, *M. denhamii*, *M. futteyporensis*, *M. hamiltoniana* and *M. incana*. In *M. magnifolia* (Fig.28B.f) crystals are rhomboid–shaped of various sizes and seen to be distributed along the veins, vein endings and within parenchymatous sheath cells.

Genus *Pentapetes* L.

Genus *Pentapetes* L. has only one Indian species *Pentapetes phoenicea* and it has been thoroughly studied.

Pentapetes phoenicea has simple simple leaves with very small free lateral stipules. Leaves are with semi–craspedodromous type of major venation pattern (Fig.32A.a). The node is represented by trilacunar 3–traced condition (Fig.32A.c_2).

Throughout the length of petiole there have been variations in the vasculature related to number and configuration of vascular bundles. The proximal part of the petiole is represented by three or four or even six vascular bundles arranged in a circular fashion (Fig.32A.d_1&d_2). Bundles are provided with dissected sclerenchymatous bundle cap. Pith is well developed and no sign of any accessory vascular bundle. Mucilaginous cavities are few or many and present both within cortex and pith (Fig.32A.d_1&d_2).

The middle portion of the petiole is an exact copy of proximal part except for the number of mucilaginous cavities (Fig.32A.d_3&d_4).

The distal end of petiole is represented by single, circular vascular strand (Fig.32A.d_{11}–d_{13}). The vascular cylinder is provided with dissected sclerenchymatous bundle sheath. Pith is well developed. Accessory vascular bundle is absent. Mucilaginous cavities are present within cortex and pith.

The major venation pattern is semi–craspedodromous (Fig.32A.a). Intersecondary and intramarginal veins are absent. Tertiary veins are of both interangular and joining veins (Fig.32A.a).

Minor venation is massive (Fig.32B.a). Areoles are well developed, formed by 5^{O} of veins and are variously shaped, with inclusion of free vein endings or free vein endings may be absent.

Free vein endings are of two types, unbranched and branched (Fig.32B.d_1&d_2). Free vein endings are not provided with any parenchymatous sheath cells, Vein end frequency is 24.2/mm^2 and areole frequency is 27.6/mm^2.

Marginal venation is incomplete (Fig.32B.b).

Trichomes are both nonglandular (Fig.32B.e_1&e_2) and glandular (Fig.32B.e_3) types. Nonglandular trichomes are represented by both acicular and 2–4 armed stellate forms (Fig.32B.e_1&e_2).

Stomata are of anomocytic type (Fig.32B.f).

Crystals are of druses, with few diamond–shaped present in stem and petiole (Fig.32B.g).

TRIBE V HERMANNIEAE

The tribe Hermannieae has two Indian genera, namely *Melochia* L. and *Waltheria* L. In India *Melochia* L. is represented by three species, viz. *M. corchorifolia, M. nodiflora, M. umbellata.* and all the three species have been studied. *Waltheria* L. has only one member *Waltheria indica* and it has been thoroughly studied.

Genus *Melochia* L.

All the three species of *Melochia* have simple leaves with serrate to irregularly serrate margins. Node is trilacunar 3–traced as observed in *M. corchorifolia* (Fig. 29A.c_2) and *M. nodiflora* (Fig. 30A. c_4). The vasculature of proximal part of petiole shows diversified characters velated to number and configuration of vascular traces. Number of trces varies from three or five as in *M. corchoriolia* (Fig.29A.d_1–d_3) to five vascular bundles as seen in *M. nodiflora* (Fig.30A.d_1) and *M. umbellata* (Fig. 31A. d_1). All the vascular bundles are arranged in a more or less oval–circular region in *M. nodiflora* (Fig.30A.d_1) and *M. umbellata*

(Fig.31A.d_1), whereas, in *M. corchorifolia* (Fig.29A.d_1–d_3) vascular traces are arranged in a semi lunar fashion. Vascular bundles are provided with dissected patches of sclerenchymatous bundle sheath. Pith is well developed in all the studied species. Accessory vascular bundles are absent in the proximal part of the petioles of the studied species. Mucilaginous cavities are present in cortex and pith *M. corchorifolia* (Fig.29A.d_2&d_3), *M. nodiflora* (Fig.30A.d_1), *M. umbellata* (Fig.31A.d_1).

The middle prtion of the petioles also shows variations. Number of vascular bundles varies from single as in *M. corchorifolia* (Fig.29A.d_9) to few to many as in *M. corchorifolia* (Fig.29A.d_7&d_8), *M. nodiflora* (Fig.30A.d_2–d_6) and *M. umbellata* (Fig.31A.d_3). All the bundles are arranged in a more or less circular to round fashion in *M. nodiflora* (Fig.30A.d_2–d_6) and *M. umbellata* (Fig.31A.d_3), whereas in *M. cochorifolia* the bundles are arranged in a semi–lunar fashion (Fig.29A.d_7–d_9). Bundles are provided with sclerenchymatous bundles sheath. Piths are well developed in all the studied species. Accessory vascular bundles are absent in all three species. Mucilaginous cavities are present in both cortex and pith *M. corchorifolia* (Fig.29A.d_7–d_9), *M.nodiflora* (Fig.30A.d_2–d_6) and *M. umbellata* (Fig.31A.d_3) has no mucilaginous cavities in the middle portion.

The distal regions of the petioles show variations in terms of vasculature related to number and arrangement os vascular bundles. The number of vascular traces ranges from single as seen in *M. corchorifolia* (Fig.29A.d_{12}&d_{13}), *M. nodiflora* (Fig.30A.d_{11}) and *M. umbellata* (Fig.31A.d_5). In *M. corchorifolia* (Fig.29A.d_{12}) dorsal traces are present, and also sclerenchymatous patches engulfs the whole of pith (Fig.29A.d_{13}). In both *M. nodiflora* (Fig.30A.d_{11}) and *M. umbellata* (Fig.31A.d_5) piths are well developed. Mucilaginouss cavities are present only in cortex in case of *M. corchorifolia* (Fig.29A.d_{12}&d_{13}), *M. nodiflora* (Fig.30A.d_{11}). In case of *M. nodiflora* (Fig.30A.c_{12}) and *M. umbellata* (Fig.31A.d_5) mucilaginous cavities are absent.

All the studied species of *Melochia* have simple leaves with actinodromous venation. The mid vein is either straight as in *M. corchorifolia* (Fig.29A.a), *M.nodiflora* (Fig.30A.a), whereas in case of *M. umbellata* (Fig.31A.a) the primary veins are slightly curved. The secondary veinsue are alternate or opposite. Inter

secondary and intramarginal veins are absent in all the studied species. Interangular veins are present and varies from 2–10. Tertiaries are both interangular and joining veins.

Minor venation is massive in *M. corchorifolia* (Fig.29B.a&b) and *M. nodiflora* (Fig.30B.a) but in *M. umbellata* minor venation is lax (Fig.31B.a). Areoles are well developed, formed by 4^{O} or 5^{O} of veins and are variously shaped.

Free vein endings in all the studied species are of two types, unbranched and branched (Fig.29B.e_1&e_2, Fig.30B.c_1&c_2, Fig.31B.c_1&c_2). In case of *M. corchorifolia* (Fig.29B.e_1&e_2) and *M.nodiflora* (Fig.30B.d_1&d_2) free vein endings are associated with parenchymatous sheath cells. However, specimens of *M. corchorifolia* collected from Kolkata are devoid of these sheathb cells. In *M. umbellata* (Fig.31B.d_1&d_2) free vein endings are not associated with any parenchymatous sheath cells. Vein end frequency ranges from 3.2/mm^2 (in *M umbellata*) to 17.4/mm^2 (in *M. corchorifolia*) and areole frequency ranges from 14.4/mm^2 (in *M. umbellata*) to 24.8/mm^2 (in *M. corchorifolia*)

Marginal venation is looped in cases of *M. nodiflora* (Fig.30B.b_1&b_2) and *M. umbellata* (Fig.31B.b). In *M. corchorifolia* (Fig.29B.c) marginal venation is incomplete.

Trichomes are of both glandular and nonglandular types. Nonglandular trichomes include both acicular and stellate types. Acicular and 2–10 armed stellate trichomes are present in all the three species of *Melochia,* viz. *M. corchorifolia* (Fig.29B.f_1&f_2) and *M.nodiflora* (Fig.30B.e_1&e_2), *M. umbellata* (Fig.31B.e_1&e_2). Glandular trichomes are found in *M. corchorifolia* (Fig.29B.f_3), *M.nodiflora* (Fig.30B.e_3) and *M. umbellata* (Fig.31Be_3).

Stomata are predominantly anomocytic type as seen in all three studied species, namely, *M. corchorifolia* (Fig.29B.g), *M.nodiflora* (Fig.30B.f), and *M. umbellata* (Fig.31B.f). However, in *M. corchorifolia* (Fig.29B.g) other types like anisocytic, twin stomata, contiguous stomata and stomata with single guard cell are also seen.

Crystals are druses of various sizes and are present only in *M. nodiflora* (Fig.30B.g).

Genus *Waltheria* L.

Watheria L. has only one species in India, viz. *Waltheria indica* and that has been thoroughly studied. Leaves are simple and have linear, lanceolate stipules. Leaves are with serrate margin. Node is tri lacunar three–traced (Fig.57A.c_2). There are variations in the length of the petiole in regard to vasculature that relates to number and arrangement of vascular bundles.

Proximal part of the petiole has two vascular bundles arranged in a horse–shoe–shaped fashion (Fig.57A.d_1). Sclerenchymatous bundle cap encircles all the bundles in patches. Mucilaginous cavities are very less, only 2 present within cortex and pith is devoid of the same.

In the middle part of petiole single, crescent shaped vascular bundle is present (Fig.57A.d_2). Sclerenchymatous bundle cap encircles all the bundles in patches. Mucilaginous cavities are very less, only 2 present within cortex one placed adaxially and one abaxially.

Distal part of the petiole has single circular vascular bundle (Fig.57A.d_3). Sclerenchymatous bundle cap is absent. Mucilaginous cavities few, variable in diameter and randomly distributed within cortex only.

Leaves are with semi–craspedodromous type of major venation (Fig.57A.a). Primary vein is thin to moderate, straight. Outer secondaries to basal pairs are 3–5. Intersecondary and intramarginal veins are absent. Tertiaries (3º) are of only joining veins.

Minor venation is lax (Fig.57B.a). Areoles are well developed, formed by 4^O of veins and variously shaped. Areoles can remain associated with free vein endings or vein endings may remain absent.

Free vein endings are of two types as unbranched and branched (Fig.57B.d_1&d_2). Vein end frequency is 3.6/mm^2 and areole frequency is 8.2/mm^2

Marginal venation is incomplete (Fig.57B.b).

Trichomes are of both nonglandular and glandular types (Fig.57B.e_1&e_2). Nonglandular trichomes comprise of 6–10 armed stellate type (Fig.57B.e_1) whereas,

glandular trichomes are the multicellular, globular structures with 2–4 celled globular body (Fig.57B.e_2).

Stomata are anomocytic type (Fig.57B.f).

Crystals are of druses of various sizes and present in internodal, nodal and petiolar sections and not on lamina (Fig.57B.g).

TRIBE VI BUETTNERIEAE

The Tribe *Buettnerieae* comprises of nine genera out of which four are Indian. The genera growing in India are *Abroma*, *Byttneria*, *Guazuma* and *Theobroma*.

Genus *Abroma* Jacq.

The genus *Abroma* Jacq. in India is represented by only one species, *Abroma augusta* and its has been thoroughly studied. *A. augusta* has simple leaves, both of 3 veined and 5 veined, with free lateral, linear to lanceolate stipules. Node is represented by trilacunar 3–traced condition (Fig.1A.c&g).

The petiole throughout its lengths show variation both in case of 3 veined and 5 veined leaves. In case of 5–veined leaves proximal part is characterized by sixteen vascular bundles arranged in a more or less circular to oval fashion. All bundles are provided with dissected sclerenchymtous bundle sheath (Fig.1A.d_2). Accessory vascular bundle is absent. Pith is well developed. Mucilaginous cavities are many and arranged only within cortex and pith. In case of 3–veined leaves proximal part is represented by four vascular bundles and are arranged laterally. Bundle sheath is dissected. Pith is well developed. Accessory vascular bundle is absent. Mucilaginous cavities are very few and present within cortex only (Fig.1A.h_1).

The middle portion of the petiole of both 3– and 5–veined leaves shows variations related to vasculature associated with number and configuration of vascular bundles. In case of 5–veined leaves the middle part is represented by single, circular vascular strand (Fig.1A.d_4), encircled by dissected patches of sclerenchymatous bundle sheath. Accessory vascular bundle is absent. Pith is well developed and prominent. Mucilaginous cavities are arranged within pith only. In 3–veined leaves number of vascular bundle single and remain encircled by

dissected– to somewhat continuous sclerenchymatous bundle sheath. Accessory vascular bundle is absent as earlier (Fig.1A.h_3&h_4). Mucilaginous cavities are many as compared to 5–veined leaves and arranged both in cortex and pith. Mucilaginous cavities may also be absent within pith though it is of rare occurrence.

The distal part of the petiole is case of 3–veined and 5–veined leaves shows variations related to vasculature dealing with number and arrangement of vascular traces. In 5–veined leaves vascular bundles are nine, arranged in a circular fashion (Fig.1A.d_5). All bundles are provided with dissected sclerenchymatous bundle sheath. Pith is well developed. Accessory vascular bundle is absent. Mucilaginous cavities are present both in cortex and pith. In 3–veined leaves the distal part is represented by single, circular vascular bundle. Sclerenchymatous bundle sheath encircles the entire vascular strand in dissected fashion. Pith is well developed. Mucilaginous cavities are many and are arranged within both cortex and pith (Fig.1A.h_5&h_6).

Major venation in both 5–veined and 3–veined leaves is actinodromous (Fig.1A.a,e). 5–veined leaves are shallowly 3–5–lobed and have repand–denticulate margin, whereas 3–veined leaves are unlobed and have entire margin. In 5–veined leaves secondaries directly terminate into the margin and in 3–veined leaves secondaries form 3 arches at intra marginal region. Intersecondary and intramarginal veins are absent in both the cases. Tertiaries are of both interangular and joining veins (Fig.1A.a&e).

Minor venation in both 3–veined and 5–veined leaves is massive type (Fig.1B.a). Areoles are well developed and formed by the joining of 4° or 5° of veins and variously shaped.

Free vein endings in both 5–veined and 3–veined are of two types, unbranched and branched (Fig.1B.c_1&c_2). Free vein endings are naked and not associated with parenchymatous sheath cells. Vein end frequency was found to be 5.2/mm^2 and areole frequency to be 8.6/mm^2.

Marginal venation in both 5–veined and 3–veined leaves is incomplete (Fig.1B.b_1&b_2).

Trichomes are of both nonglandular and glandular types. Nonglandular trichomes comprise both acicular and stellate types (Fig.1B.d_1&d_2). Glandular

trichomes either stalked or sessile, multicellular, globular structures present on both the surfaces of lamina. The main globular form either of single cell or with mostly 3–celled structure (Fig.1B.d_3).

Stomata are mostly anomocytic (Fig.1B.e) but anisocytic, brachyparacytic and stoma with a single guard cell are also observed.

Crystals are of druses type with various size and arranged along the veins (Fig.1B.f).

Genus *Byttneria* Loefl.

In India, genus *Byttneria* Loefl. is represented by four species out of which three namely *B. andamanensis*, *B. aspera* and *B. herbacea* have been thoroughly studied. All the species have simple leaves with free lateral, linear–oblanceolate stipules. Node is trilacunar 3–traced (Fig.2A.b_2, Fig.3A.d_2). The petiolar anatomy shows variations among the species in respect to vasculature related to the number and arrangement of vascular bundles.

The proximal part of the petiole is represented by single, circular vascular bundle as in *B. anadamanensis* (Fig.2A.d_1), four vascular bundles in *B. herbacea* (Fig.4A.d_1) and by six vascular bundles in *B. aspera* (Fig.3A.b_1). The bundles in last two species are arranged in an oval to circular fashion. All the bundles are provided with sclerenchymatous bundle sheath either as continuous layer or in dissected patches. Pith is well developed and prominent in *B. andamanensis* (Fig.2A.d_1) and *B. herbacea* (Fig.4A.d_1), whereas in *B. aspera* (Fig.3A.b_1) mucilaginous cavities occupy major portion of the pith. Mucilaginous cavities are present both in cortex and pith in *B. andamanensis* (Fig.2A.d_1) and *B. aspera* (Fig.3A.b_1). Notably, mucilagimous cavities are absent in *B. herbacea* (Fig.4A.d_1). Accessory vascular bundles are not present in the proximal part of any of the studied species.

The configuration and number of vascular bundles remain same as proximal part in *B. andamanensis* (Fig.2A.d_2) and *B. herbacea* (Fig.4A.d_2). However, in *B. aspera* (Fig.3A.b_2) two vascular bundles are present in a horse–shoe–shaped fashion. All the bundles in all three species are provided with sclerenchymatous bundle sheath either in continuous or dissected fashion. Pith is well developed and prominent. Accessory vascular bundles are not present in the middle portion of any of the studied species. Mucilaginous cavities are present both in cortex and pith in

case of *B. andamanensis* (Fig.2A.d_2) and *B. aspera* (Fig.3A.b_2), however, cavities are absent in *B. herbacea* (Fig.4A.d_2).

The distal part the petiole of *B. andamanensis* (Fig.2A.d_3) and *B. herbacea* (Fig.4A.d_3) are similar in all respect to the middle part. In *B. aspera* (Fig.3A.b_3) two vascular bundles are present in horse–shoe–shaped manner. All bundles are provided with dissected to continuous sclerenchymatous bundle sheath. Pith is well developed, though in *B. aspera* (Fig.3A.b_3) mucilaginous cavity occupies the major part of the pith at centre. Mucilaginous cavities are present both in cortex and in pith in case of *B. andamanensis* (Fig.2A.d_3) and *B. aspera* (Fig.3A.b_3), however, mucilaginous cavity is absent in *B. herbacea* (Fig.4A.d_3). Accessory vascular bundle is absent in all three species.

The major venation is brochidodromous in *B. aspera* (Fig.3A.a) whereas, rest two species exhibit actinodromous type of venation (Fig.2A.a and Fig.4A.a).

Minor venation in the three cases is massive, the free vein ending is made up of 6° or 7° of veins (Fig.2B.a, Fig.3B.a and Fig.4B.a&b). Areoles are well developed by 5° or 6° of veins and are variously shaped.

Free vein endings are of two types in these species, i.e., unbranched and branched (Fig.2B.c_1&c_2; Fig.3B.c_1&c_2 and Fig.4B.e_1&e_2). Lowest free vein end frequency (2.5/mm^2) has been noted in *B. aspera* whereas highest (17.8/mm^2) frequency is exhibited by *B. herbacea*. Areole frequency is lowest (12.2/mm^2) in *B. aspera* and highest (23.8/mm^2) in *B. herbacea*.

Marginal venation in all the studied species of *Byttneria* is incomplete (Fig.2B.b, Fig.3B.b and Fig.4B.c_1&c_2).

Trichomes are both glandular and nonglandular types in *B.andamanensis* (Fig.2B.d_1–d_3), *B. aspera* (Fig.3B.d_1–d_3) and *B. herbacea* (Fig.4B.f_1–f_3). Nonglandular trichome comprises of both acicular (Fig.2B.d_1, Fig.3B.d_1 and Fig.4B.f_1) and 2 to 16 armed stellate type (Fig.2B.d_2, Fig.3B.b_2 and Fig.4B.f_2). Glandular trichomes are with multicellular globular body with unicellular stalk cells (Fig.2B.d_3, Fig.3B.d_3 and Fig.4B.f_3).

Stomata are anomocytic in *B. anadamanensis* (Fig.2B.e) and *B. aspera* (Fig.3B.e), whereas in *B. herbacea* (Fig.4B.g) along with anomocytic stomata, anisocytic and diacytic are also observed, though of rare occurrence.

Crystals are present in all the studied species of *Byttneria*. Crystals are square– or rhomboid–shaped in *B. andamanensis* (Fig.2B.f), diamond– and rectangular–shaped in *B. aspera* (Fig.3B.f), whereas only diamond–shaped observed in *B. herbacea* (Fig.4B.h). Crystals are distributed on the lamina in *B. anadamanensis* and *B. aspera*, but in case of *B. herbacea* crystals are observed only in petiole.

Genus *Guazuma* Mill.

In India, the genus *Guazuma* Mill. is represented by only species *Guazuma ulmifolia* and it has been thoroughly studied. *G. ulmifolia* has simple assymetric leaves with free lateral, linear stipules. Node is trilacunar 3–traced (Fig.13A.c_1). The petiolar anatomy shows variations in respect to number and arrangement of vascular bundles.

The proximal part of the petiole is represented by eight vascular bundles arranged in an oval fashion (Fig.13A.d_1) or single, circular vascular bundle (Fig.13A.d_2). Sclerenchymatous bundle sheath encircles all the bundles in patches. Pith is well developed. Accessory vascular bundle is absent. Mucilaginous cavities are few (Fig.13A.d_1) or many (Fig.13A.d_2) and present within cortex and pith.

The middle portion is represented by single, circular vascular bundle that remains encircled by continous to dissected sclerenchymatous bundle sheath. Pith is well developed (Fig.13A.d_6). Accessory vascular bundle is absent. Mucilaginous cavities are many and arranged both within cortex and pith (Fig.13A.d_6).

The distal portion has variations related to the number and arrangement of vascular bundle. The vascular bundle is single, dissected into three lobed structure forming dorsal bundles (Fig.13A.d_7&d_8) or the vascular bundle single, crescent shaped, with a cut at the adaxial face and the main strand branches and portions of xylem and phloem moves toward the pith forming accessory bundle (Fig.13A.d_9), or vascular bundles are two, with one larger, crescent shaped and placed abaxially, while other, small, rounded and bicollateral and present adaxially vascular bundles arranged in a circular manner (Fig.13A.d_{10}). In all three cases bundles are provided with discontinuous sclerenchymatous bundle sheath. Accessory vascular bundle is absent. Pith is more or less well developed (Fig.13A.d_7–d_{10}). Mucilaginous cavities are few to many and are arranged within cortex only (Fig.13A.d_7–d_{10}).

Leaves are simple, asymmetric with semicraspedodromous type of major venation. Primary vein is straight to curved with branches terminating into the marginal teeth. Outer secondaries to basal pairs are 8–10. Intersecondaries and intramarginal veins are absent. Tertiaries are of both interangular and joining veins (Fig.13A.a).

Minor venation is massive with vein endings at 7° or 8° of veins (Fig.13B.a). Areoles are well developed by 6° or 7° of veins and are variously shaped.

Free vein endings are of two types, unbranched and branched. Vein endings are not associated with parenchymatous sheath cells (Fig.13B.d_1&d_2). Vein end frequency is 6.6/mm^2 and areole frequency is 30.6/mm^2.

Marginal venation is incomplete (Fig.13B.b).

Trichomes are of two types, both nonglandular and glandular (Fig.13B.e_1–e_3). Nonglandular trichomes comprise both acicular (Fig.13B.e_1) and 3–8 armed stellate forms (Fig.13B.e_2). Glandular trichomes are multicellular with 3–18 celled globular body (Fig.13B.e_3).

Stomata are of anomocytic type (Fig.13B.f).

Crystals are diamond–, square– or rhomboid–shaped of variable sizes and arranged along the veins and also observed in stem and petiole (Fig.13B.g).

Genus *Theobroma* L.

In India, the genus *Theobroma* L. is represented by one species, *Theobroma cacao* and it has been thoroughly studied. *T. cacao* has simple leaves with free lateral, linear stipules. Node is trilacunar 3–traced (Fig.61A.c_2). The petiole anatomy shows variations in respect to vasculature related to number and arrangement of vascular bundles.

The proximal part of petiole is represented by six vascular bundles, arranged in a circular pattern (Fig.61A.d_1). The bundles are provided with sclerenchymatous bundle sheath in continuous to dissected fashion. Accessory vascular bundle is absent. Pith is well developed. Mucilaginous cavities are several and arranged both within cortex and pith (Fig.61A.d_1).

The middle part of the petiole is represented by single, circular, vascular strand. Sclerenchymatous bundle sheath in a continuous layer encircles the vascular

strand. Pith is well developed. Accessory vascular bundle is absent (Fig.61A.d_4). Mucilaginous cavities are many and present both within cortex and pith.

The distal end of the petiole has single, circular vascular bundle (Fig.61A.d_7). The vascular strand is encircled by continuous to dissected sclerenchymatous bundle sheath. Accessory vascular bundles are two, fused very lightly by their xylem and thesmall round bundle remains associated with main strand (Fig.61A.d_7). The accessory vascular bundles occupies major portion of pith. Mucilaginous cavities are many and present only within cortex (Fig.61A.d_7).

Leaves are simple with entire margin and brochidodromous type of major venation. Primary vein is straight with outer secondaries to basal pairs as 8-10. Intersecondary and inramarginal veins are absent. Tertiaries are of both interangular and joining veins (Fig.61A.a).

Minor venation is massive ending up to 6° of veins (Fig.61B.a). Areoles are well developed, formed by 5° of veins and are variously shaped.

Free vein endings are of two types, unbranched and branched (Fig.61B.c_1&c_2). Free vein endings are associated with parenchymatous sheath cells. Vein end frequency is found to be 3.5/mm^2 and areole frequency is 35.2/mm^2.

Marginal venation is looped, formed by 4° of veins (Fig.61B.b).

Trichomes are of only nonglandular type (Fig.61B.d_1&d_2). Nonglandular trichomes are of both acicular (Fig.61B.d_1) and 5–12 armed stellate forms (Fig.61B.d_2).

Stomata are of anomocytic (Fig.61B.e), but anisocytic, brachyparacytic and contiguous stomata are also observed.

Crystals are of druses and diamond–shaped of various size (Fig.61B.f). Crystals are present in stem, petiole and in rarest case on lamina.

UPGMA MORPHOMETRIC ANALYSIS OF STUDIED TAXA (Fig. 62)

UPGMA morphometric characters analysis has been done based on 91 character states (Table 2) to highlight the relationship among the studied members. The main goal of this study was to describe and compare the leaf architecture and the internodal, nodal and petiolar anatomy of 61 species of the family Sterculiaceae. All of the species of Sterculiaceae share both simple lamina with entire or toothed/serrate margin. The differences among the species included the venation pattern, course of secondary veins, presence or absence of inter-secondary veins, tertiary vein pattern, the number of branches in vein-lets, the marginal ultimate venation, etc. including the contents and dermal features. Studies of leaf architecture are very useful because different dicotyledonous taxa have consistent patterns of leaf architecture that are recognized at different taxonomic levels, from subclass to species (Dilcher, 1974; Hickey, 1979). Foliar anatomical data are often useful for solving problems of differentiating closely related taxa or for supporting morphological homologies (Stuessy, 1990).

The members of Indian Sterculiaceae are in general with diversified morphological characters as observed in the present study. The tree immediately divided into two more or less equal halves, viz. Clade I comprising of the first two tribes, viz. Tribe I Sterculieae and Tribe II Helictereae of Bentham and Hooker (1862–1883) except *Melhania magnifolia* of Tribe Dombyeae which included amongst the members of Sterculiaceae. This finding is well corroborated with the view of Bentham and Hooker (1862–1883). Notably, most of the genera in this clade grouped together except very few. However, no such clear cut separation has been noticed between the members of these two tribes. The members of the genus *Sterculia* show much diversified morpho–anatomical features, viz. leaves are either simple (lobed or unlobed) or compound, with shapes varying from ovate, broadly ovate, oblong, broadly elliptic obovate, elliptic-oblong, etc, the minor venation pattern comprises both massive and lax types whereas the marginal venation types includes both incomplete as well as looped forms, number of vascular traces varies from few to numerous at different topographic levels of the petiole, etc. and thus spread almost throughout the clade. On the other hand, the members of *Pterospermum* are highly conservative in many of the morpho–anatomical features, viz. leaves are simple (lobed or unlobed) with shapes varying from ovate, broadly ovate, oblong, etc, the minor venation pattern comprises only massive type whereas the marginal venation types includes both incomplete as well as looped forms,

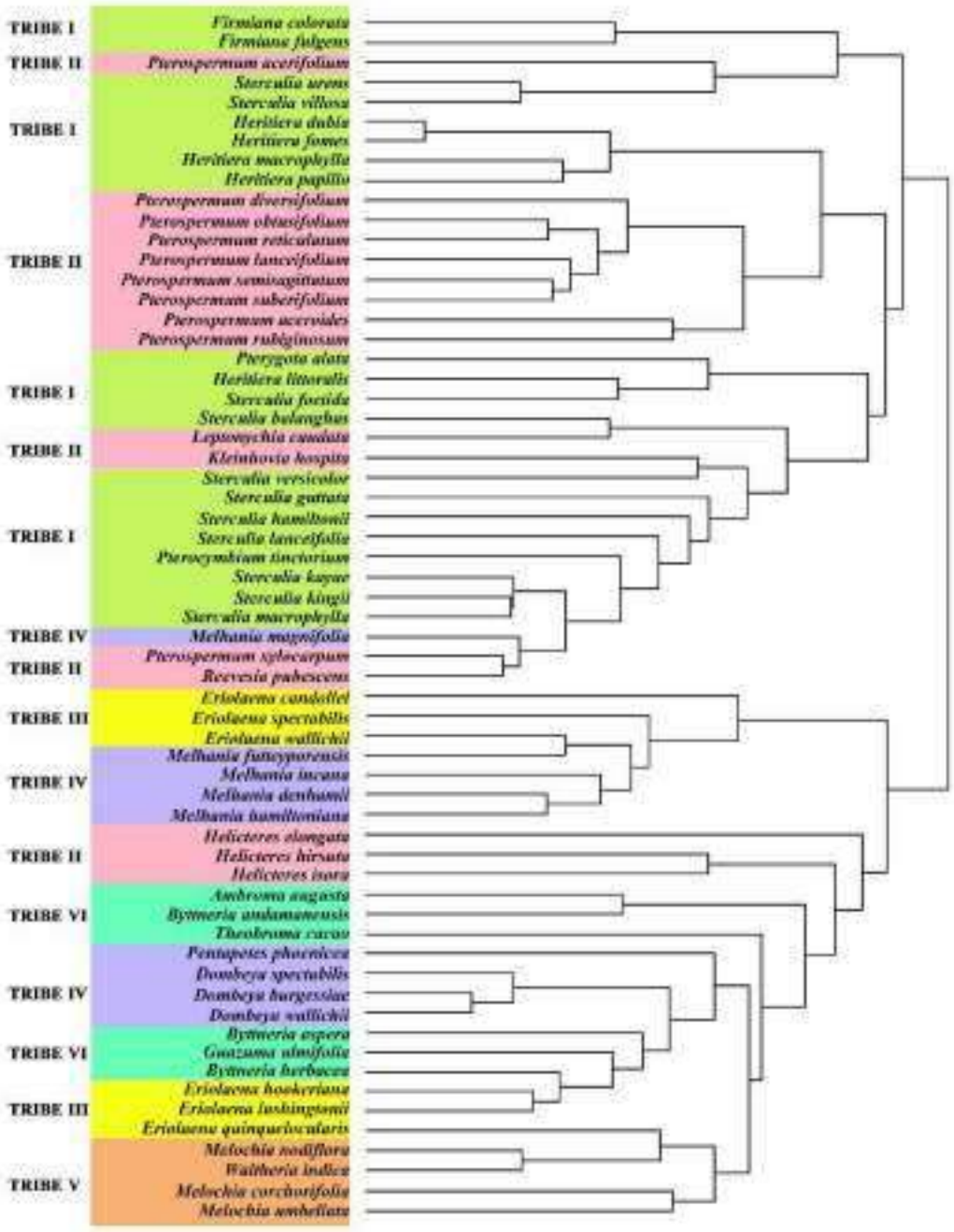

Fig. 62. UPGMA dendrogram showing relationship among the mebers of Sterculiaceae based on morpho–anatomical characters (false colour composition showing taxa under different tribes)

[Tribe I. Sterculieae, Tribe II. Helictereae, Tribe III. Eriolaeneae, Tribe IV. Dombeyeae, Tribe V. Hermannieae, Tribe VI. Buettnerieae]

number of vascular traces varies from few to numerous at different topographic levels of the petiole, etc. and thus grouped together under a distinct clade except *Pterospermum acerifolium* and *P. xylocarpum*. Both the later taxa posses some characters like presence of peltate leaves, broad stipules, etc. in *P. acerifolium* and presence of crystals in *P. xylocarpum* which are not common in the other members of the genus. Likewise, the members of *Heritiera* also exhibit conserved characters, viz. fringed scales, presence of accessory vascular bundles at different topographic levels of petiole, etc. and thus segregated under a distinct clade except *Heritiera littoralis*. The later species shows more affinity towards *Pterygota alata* and *Sterculia foetida* as all the three species have some features in common, viz. number of vascular traces few to numerous, presence of accessory vascular bundles in the petiole, etc. *Leptonychia caudata* is more close to *Sterculia balanghas* because of presence of accessory vascular bundles in petiole, nature of stipules, etc. Both the taxa, *Kleinhovia hospita* and *Sterculia versicolor* appears closer as they possess few characters in common as presence of mucilaginous cavities, sclerenchymatous bundle sheath, presence of similar type of crystals, etc. *Pterocymbium tinctorium*, *Reevesia pubescens*, *Pterospermum xylocarpum*, *Melhania magnifolia*, *Sterculia macrophylla*, *S. kingii* and *S. kayae* are separated from rest of the clade due to certain characters like leaves are simple with shapes varying from ovate, broadly ovate, oblong, etc, the minor venation pattern comprises massive type whereas the marginal venation type includes both incomplete and looped, number of vascular traces varies from few to numerous at different topographic levels of the petiole, etc.

Rest four tribes, viz. Tribe III Eriolaeneae, Tribe IV Dombeyeae, Tribe V Hermannieae, Tribe VI Buettnerieae are included under Clade II showing their affinities. The relationship of species under respective genera well corroborated and grouped together however, the relationship of the genera and the tribes are not reflecting through this morphometric analysis based on mostly foliar architecture and anatomical features and thus appended under different subclades.

However, in general, as most of the species under different studied genera grouped together showing close affinity among them, thus, the UPGMA morphometric analysis is very much useful at generic level as well as to some extent also at tribal level as has been observed in the present study.

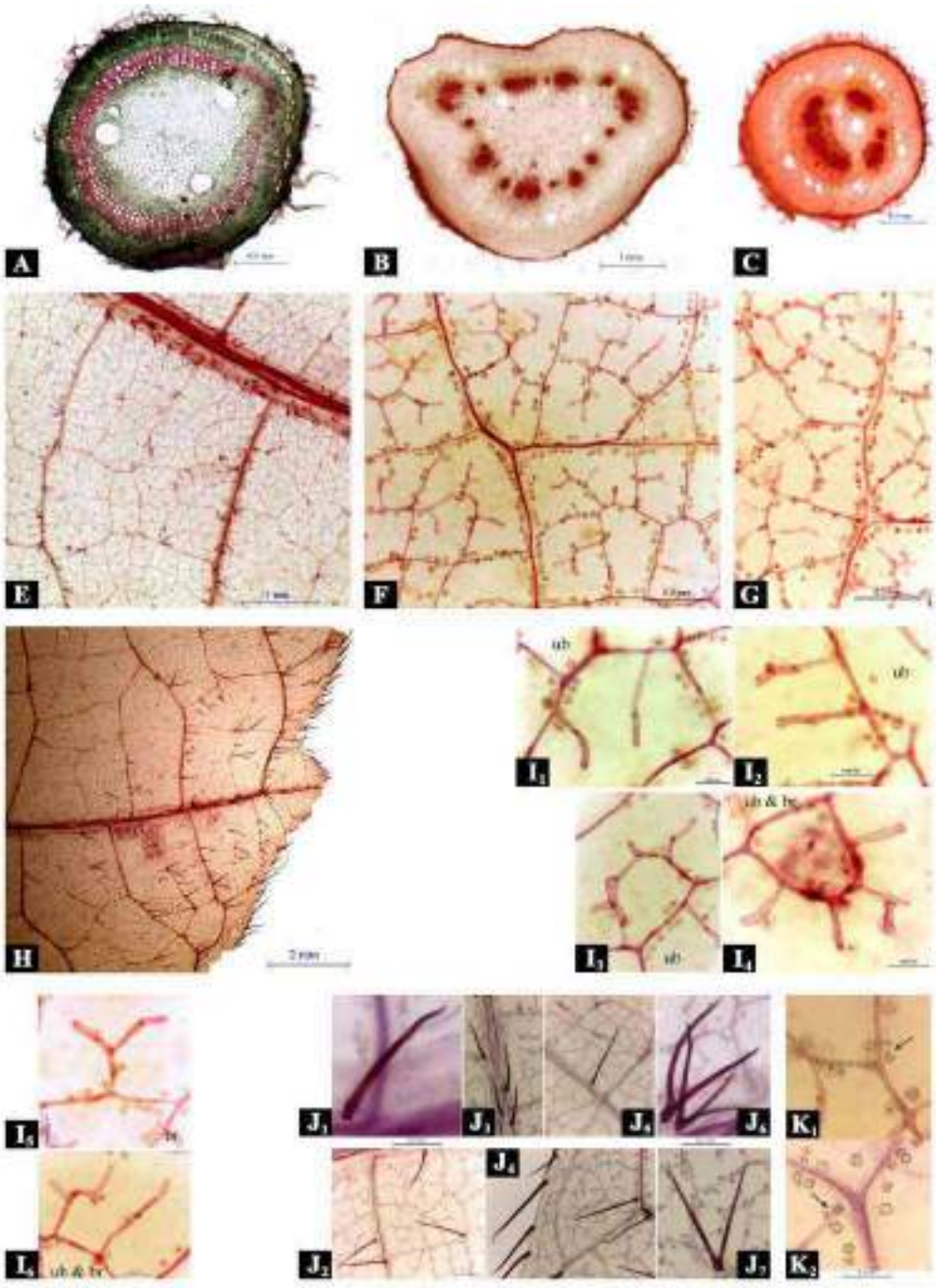

Fig.63. ***Abroma augusta:*** **A.** T.s. of internode; **B & C.** T.s. of petiole: **B.** Proximal (5–veined leaf), **C.** Middlle (3–veined leaf); **E – G.** Minor venation; **H.** Marginal venation (5–veined leaf); **I_1 & I_6.** Free vein endings: **I_1 & I_2.** Unbranched–ub, **I_2 – I_6**. Branched–br; **J_1 & J_7.** Trichomes: **J_1 – J_5.** Simple acicular, **J_6 & J_7.** Stellate; **K_1 & K_2.** Crystals (arranged along the veins & vein ends, marked with arrows)

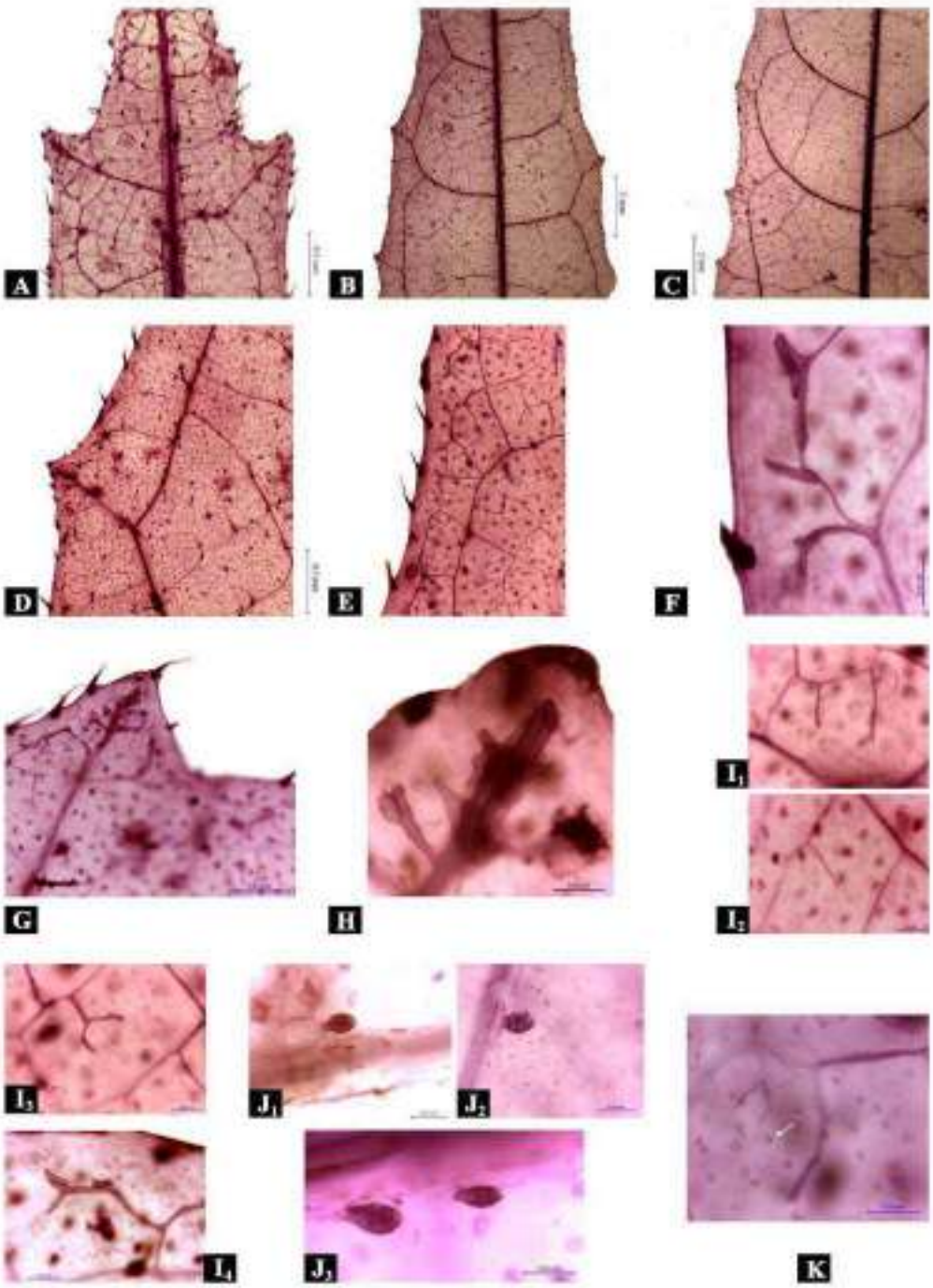

Fig.64. ***Byttneria herbacea:*** **A - C.** Minor & marginal venation; **D & E.** Close view of margin and marginal teeth; **F.** Enlarged view of margin; **G.** Marginal tooth; **H.** Aggregation of tracheids in marginal tooth; **H.** Marginal venation; **I_1 - I_4.** Free vein endings: **I_1 & I_2.** Unbranched, **I_3 & I_4.** Branched; **J_1 - J_3.** Glandular trichomes; **K.** Crystals (arranged along the veins & vein ends, surface - marked with arrows)

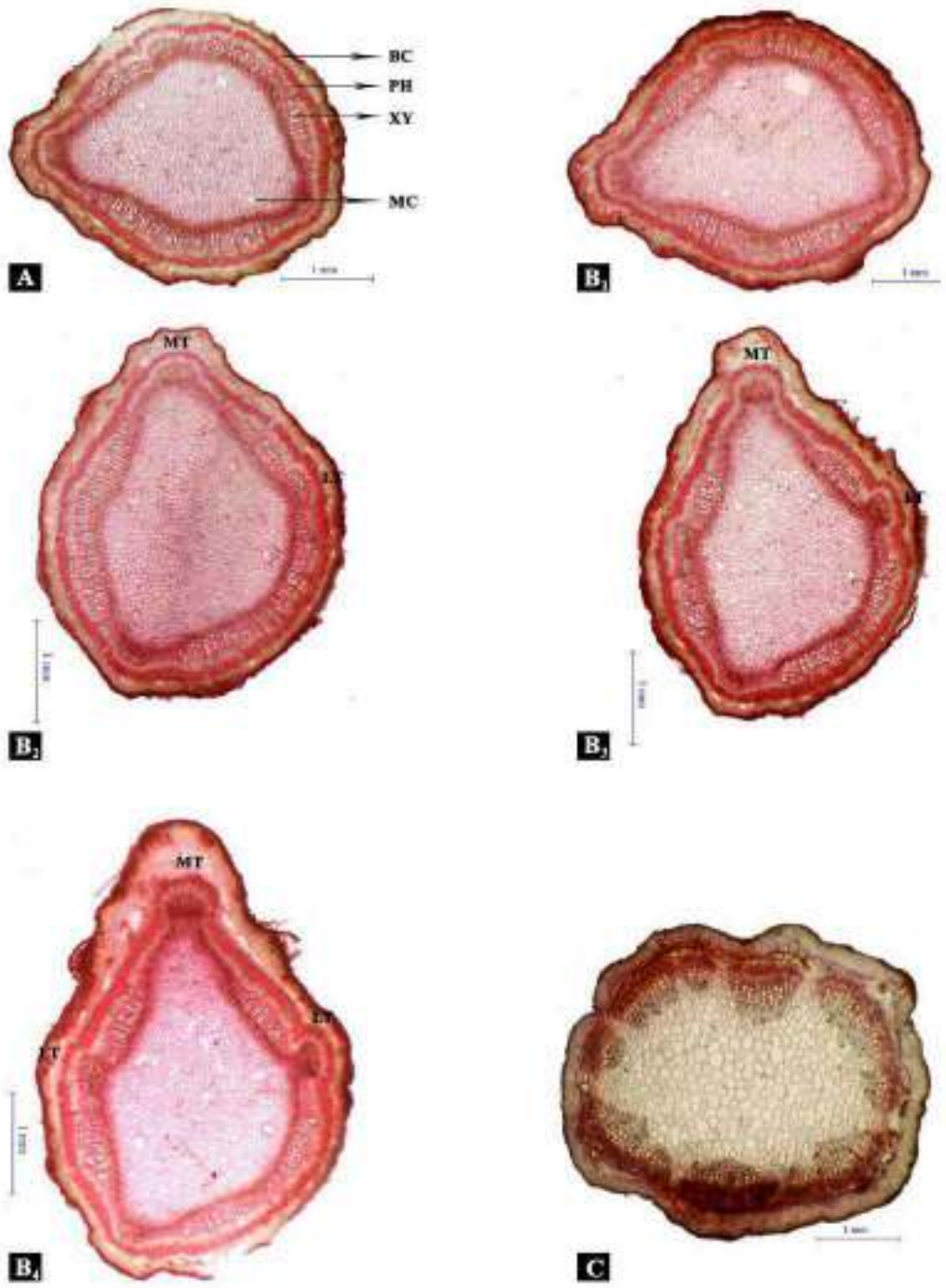

Fig.65. ***Kleinhovia hospita:*** **A.** T.S. of internode; **B_1 - B_4.** T.S. of node; **C.** T.s. of petiole (Proximal end) [BC - Bundle cap, PH - Phloem, XY - Xylem, MC - Mucilagenous cavity, MT - Median trace, PT - Peripheral trace]

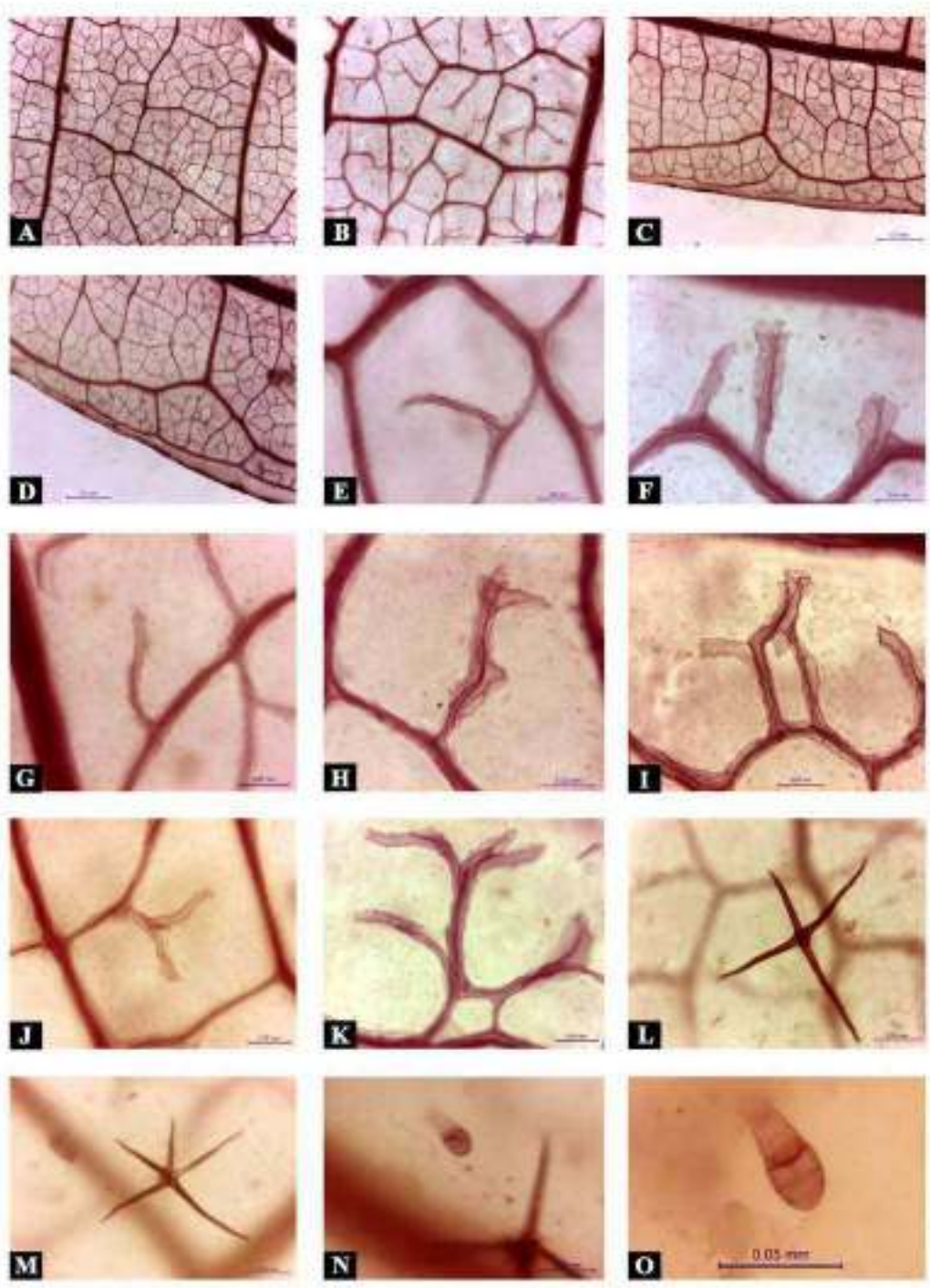

Fig.66. ***Leptonychia caudata:*** **A & B.** Minor venation; **C & D.** Marginal venation; **E - K.** Free vein endings: **E - H.** Unbranched, **I - K.** Branched, **L - O.** Trichomes: **L & M.** Stellate, **N & O.** Glandular

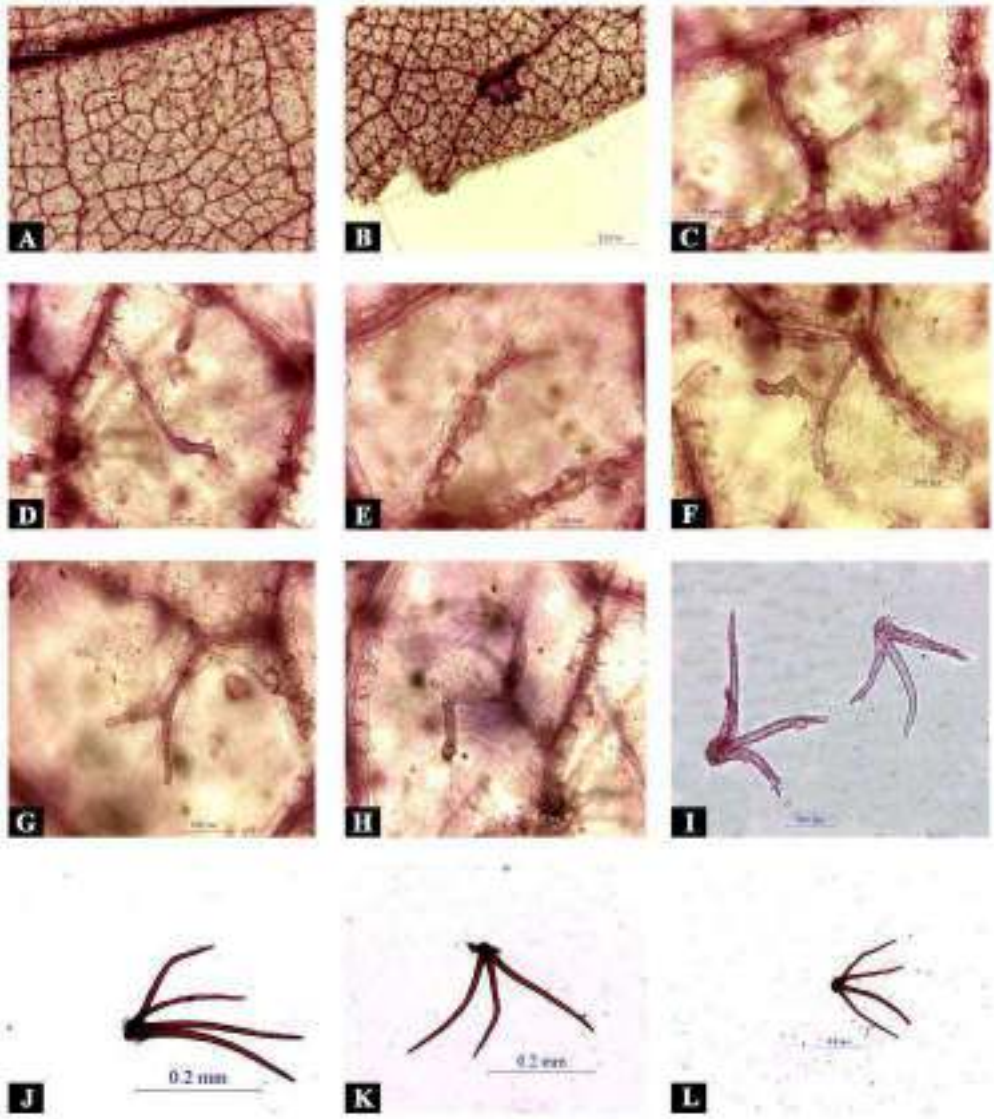

Fig.67. ***Melhania magnifolia:*** **A.** Minor venation; **B.** Marginal venation; **C - H.** Free vein endings: **C & D.** Unbranched, **E - H.** Unbranched; **I - L.** Trichomes (stellate)

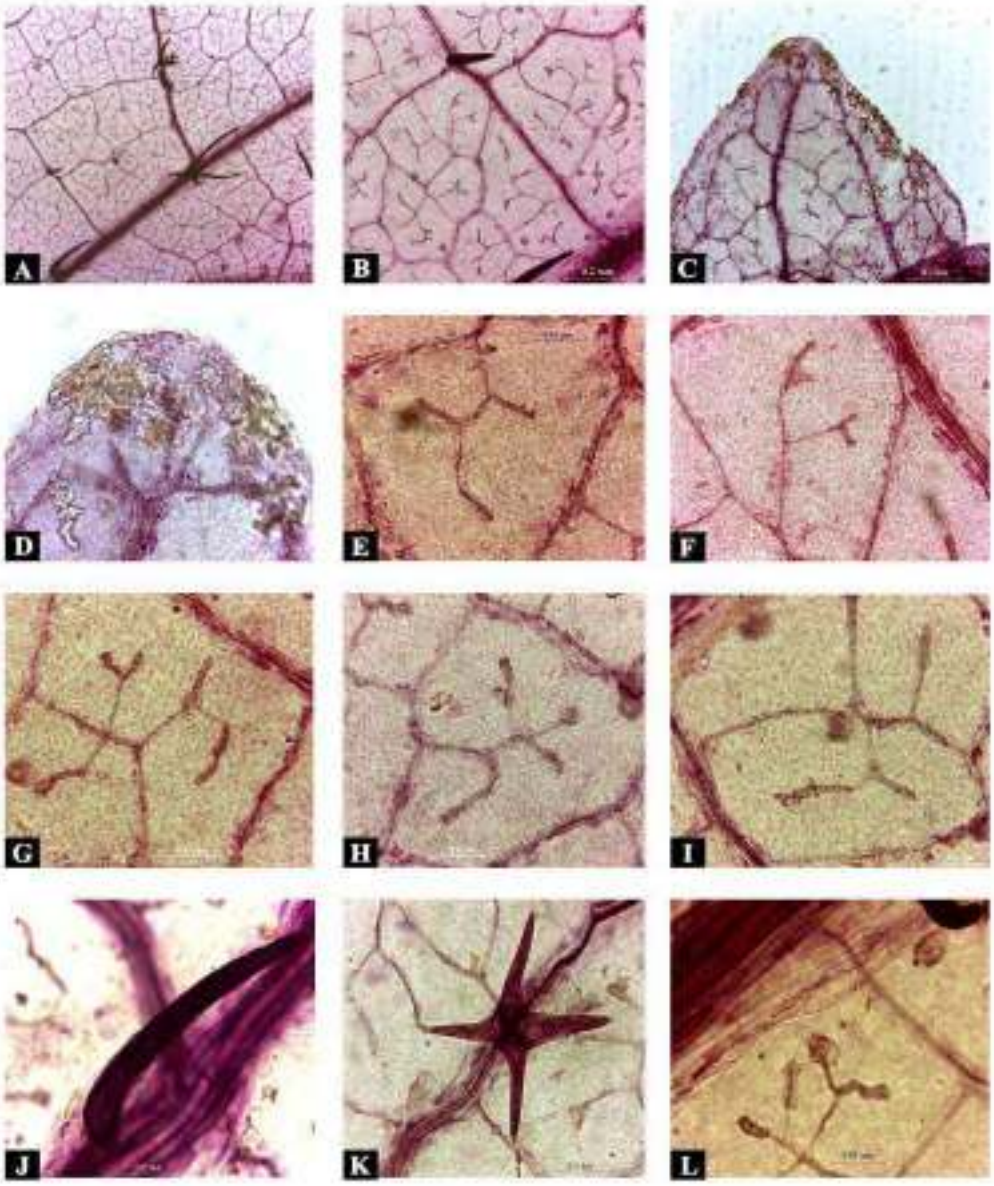

Fig.68. ***Pentapetes phoenicea:*** **A & B.** Minor venation; **C & D.** Margin & marginal teeth; **E - I.** Free vein endings: **E - H.** Branched, **I.** Unbranched & branched; **J - L.** Trichomes: **J.** Acicular, **K.** Stellate, **L.** Glandular

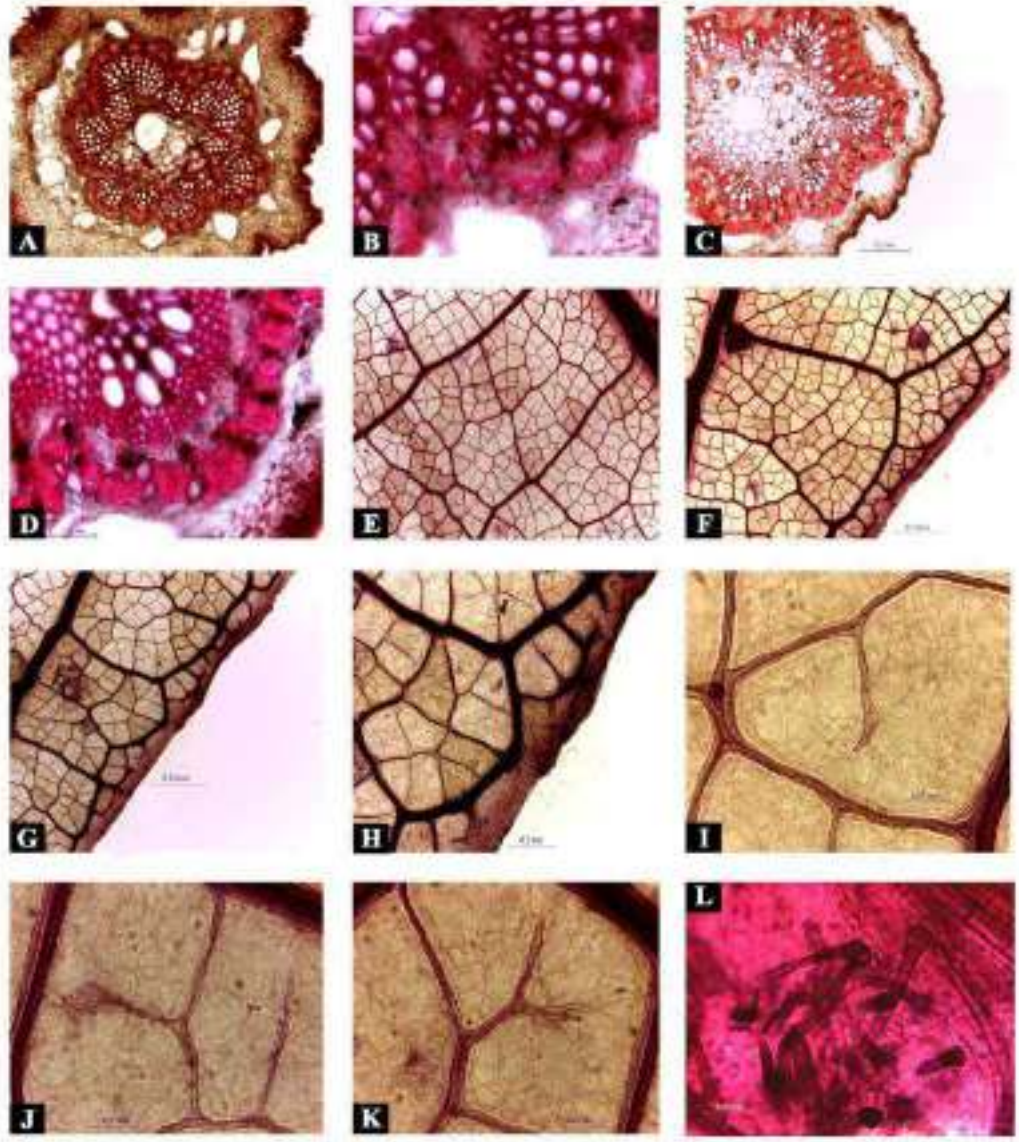

Fig.69. ***Pterocymbium tinctorium:*** **A - D.** Transverse section (T.s) of petiole: **A & B.** Proximal end, **C & D.** After proximal end; **E.** Minor venation; **F - H.** Marginal venation; **I - K.** Free vein endings: **I & J.** Unbranched, **K.** Branched, **L.** Trichomes

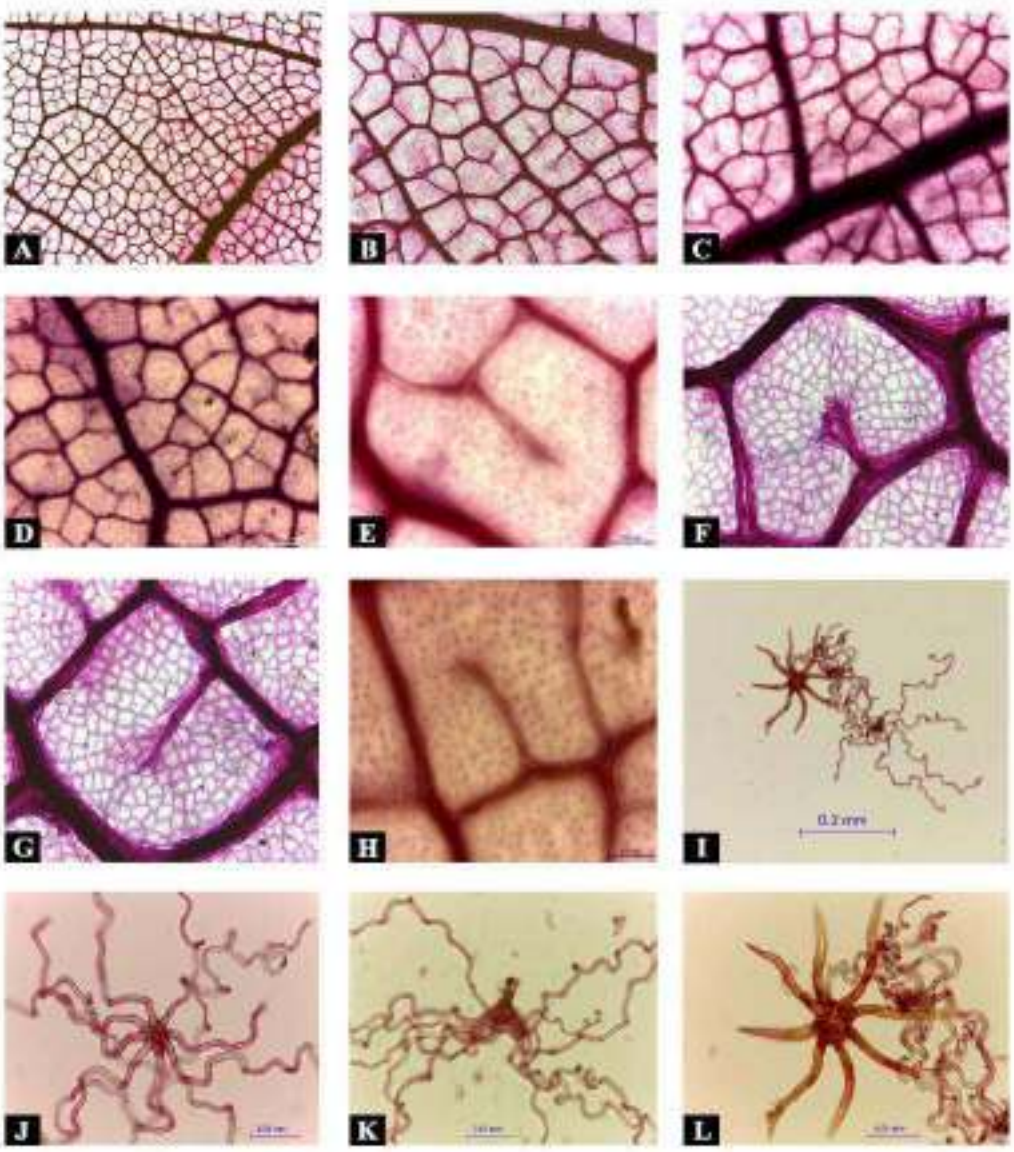

Fig.70. ***Pterospermum lanceifolium:*** **A - D.** Minor venation; **E - H.** Unbranched free vein endings; **I - L.** Trichomes: both form of stellate trichomes

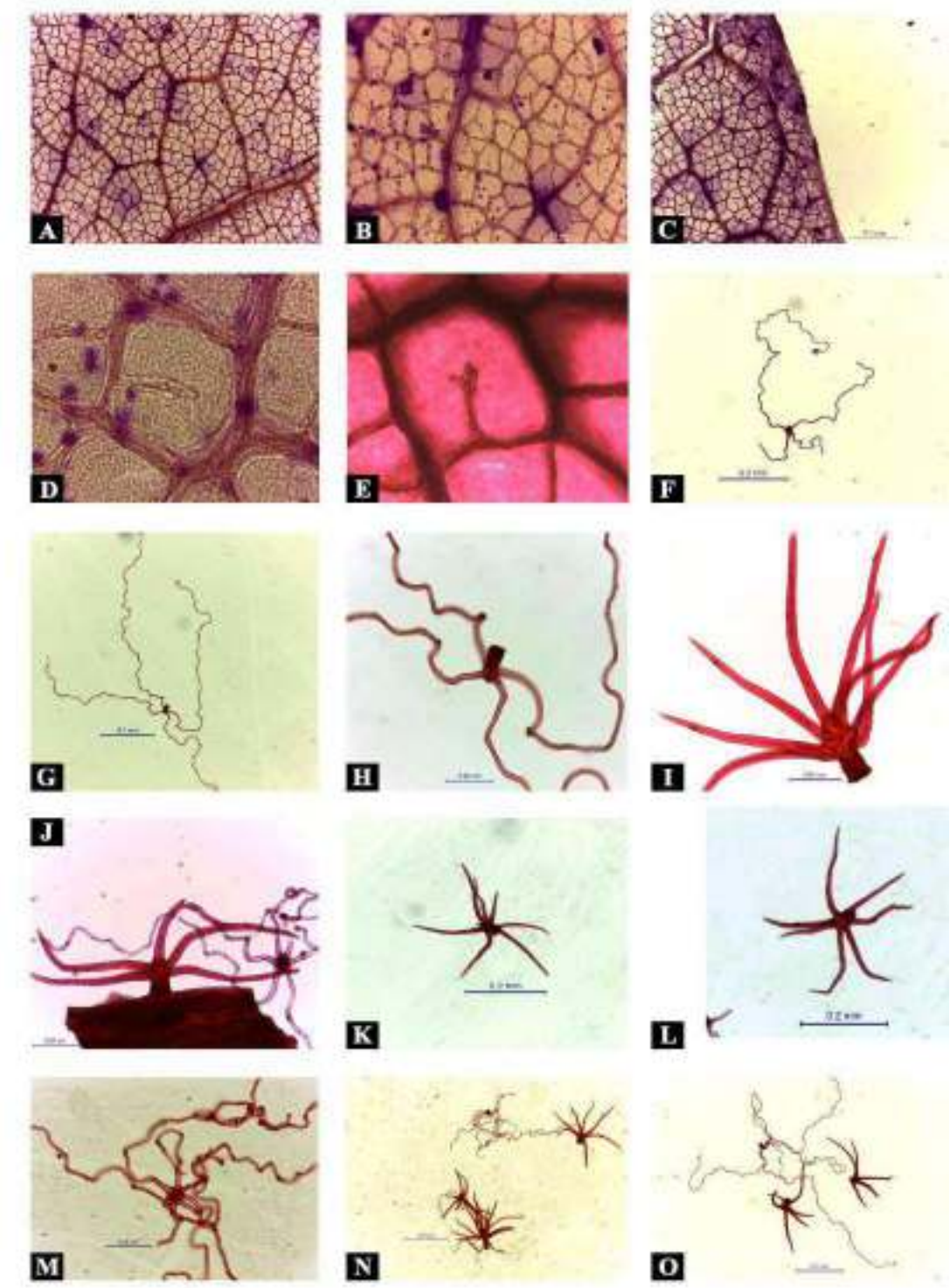

Fig.71. ***Pterospermum reticulatum:*** **A & B.** Minor venation; **C.** Marginal venation; **D & E.** Free vein endings: **D.** Unbranched, **E.** Branched; **F - O.** Trichomes (two forms of stellate types)

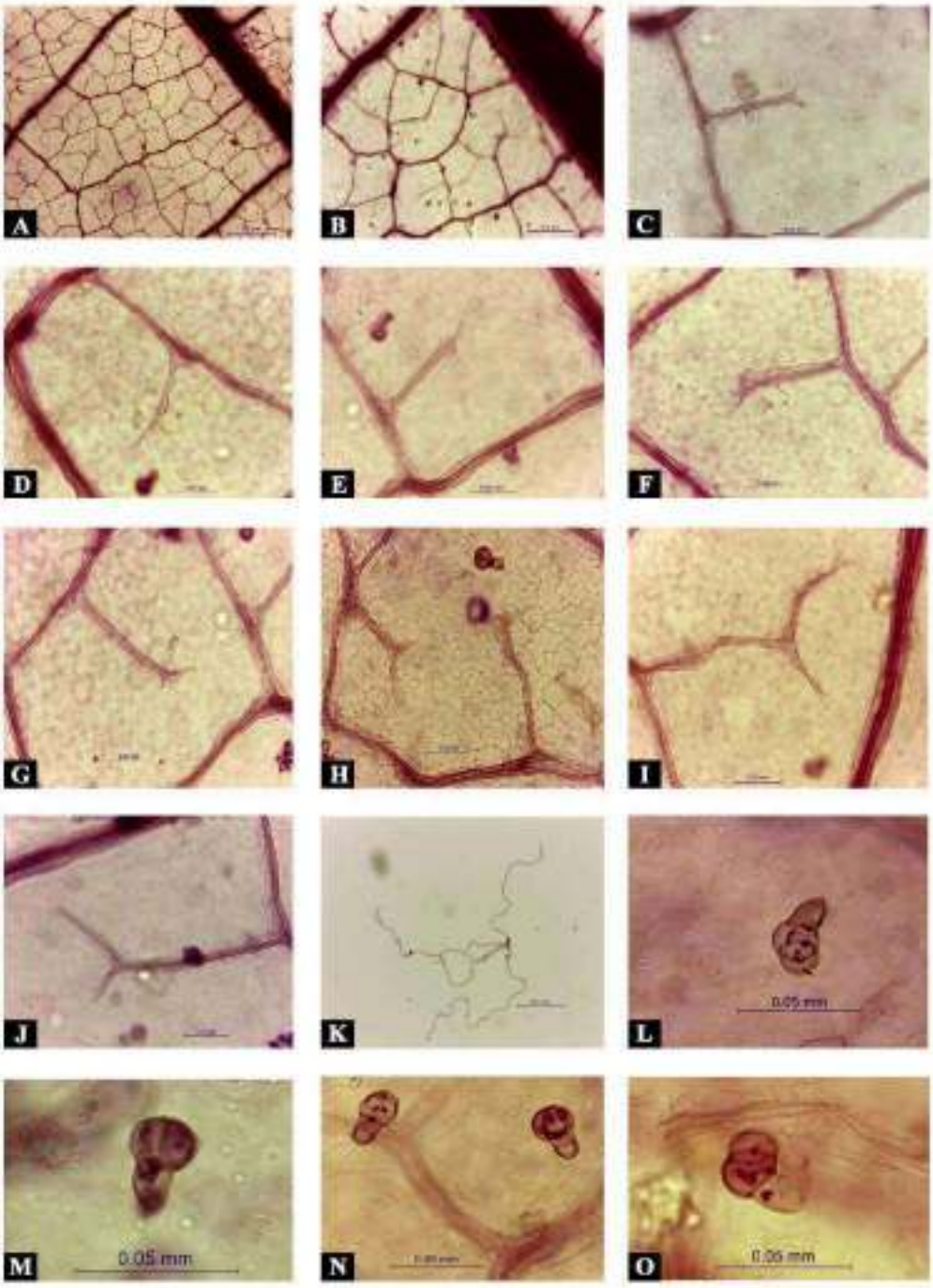

Fig.72. ***Pterospermum rubiginosum:*** **A & B.** Minor venation; **C - J.** Free vein endings: **C - G.** Unbranched, **H.** Unbranched & branched, **I & J.** Branched; **K & O.** Trichomes: **K.** Stellate, **L - O.** Glandular

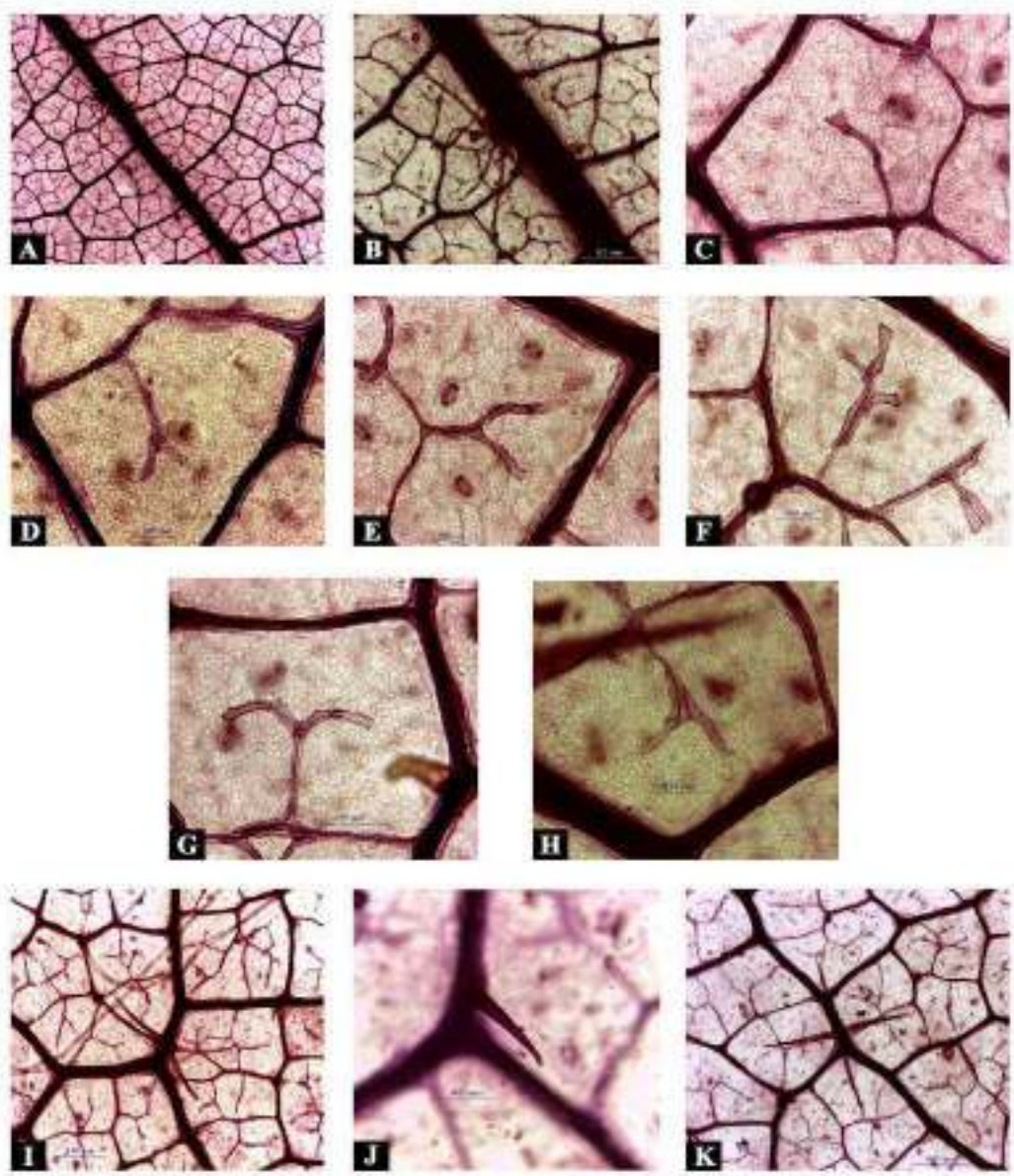

Fig.73. ***Sterculia balanghas:*** **A & B.** Minor venation; **C - H.** Free vein endings: **C.** Unbranched, **D - H.** Branched; **H.** Marginal venation; **I - K.** Trichomes: **I & K.** Stellate, **J.** Acicular

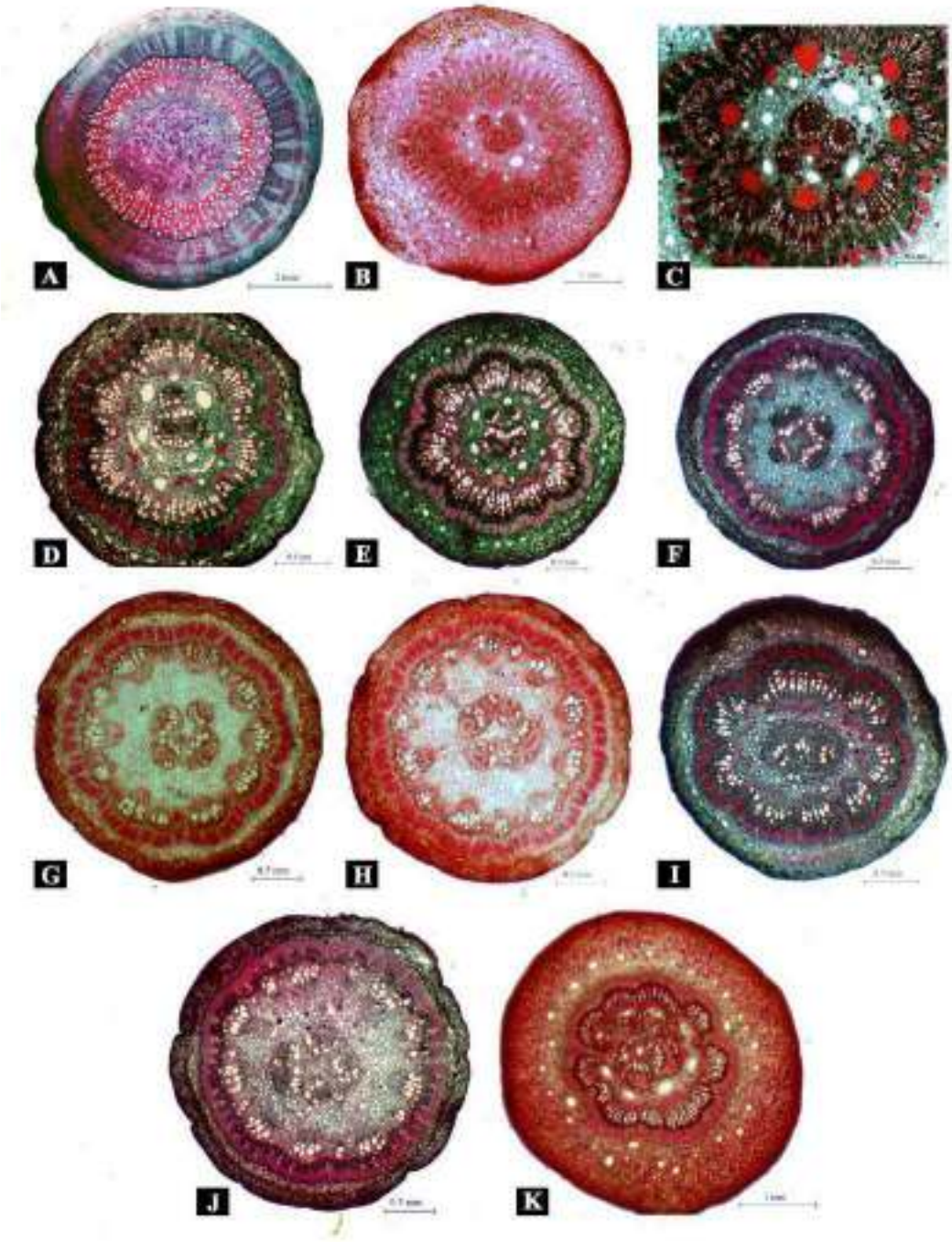

Fig.74. ***Sterculia foetida:*** **A.** T.S. of internode; **B - K.** T.S. of petiole: **B.** Proximal; **C.** Enlarged view of proximal end; **D - I.** Middle parts; **J.** Middle to distal part**; K.** Extreme distal end

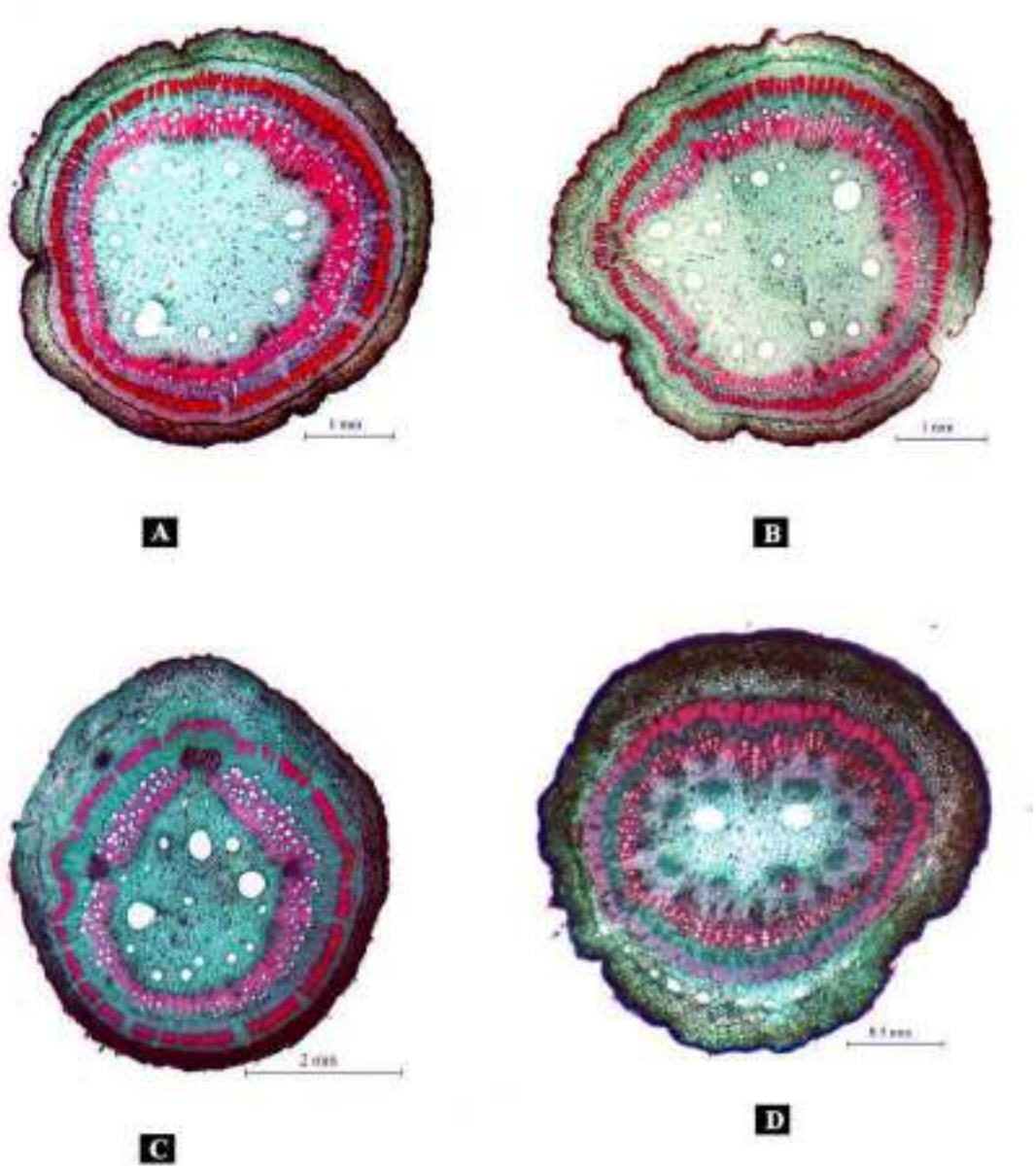

Fig.75. ***Sterculia guttata*****: A.** T.s. of internode; **B & C.** T.S. of node: **B.** Proximal; **D.** T.s. of proximal part of petiole

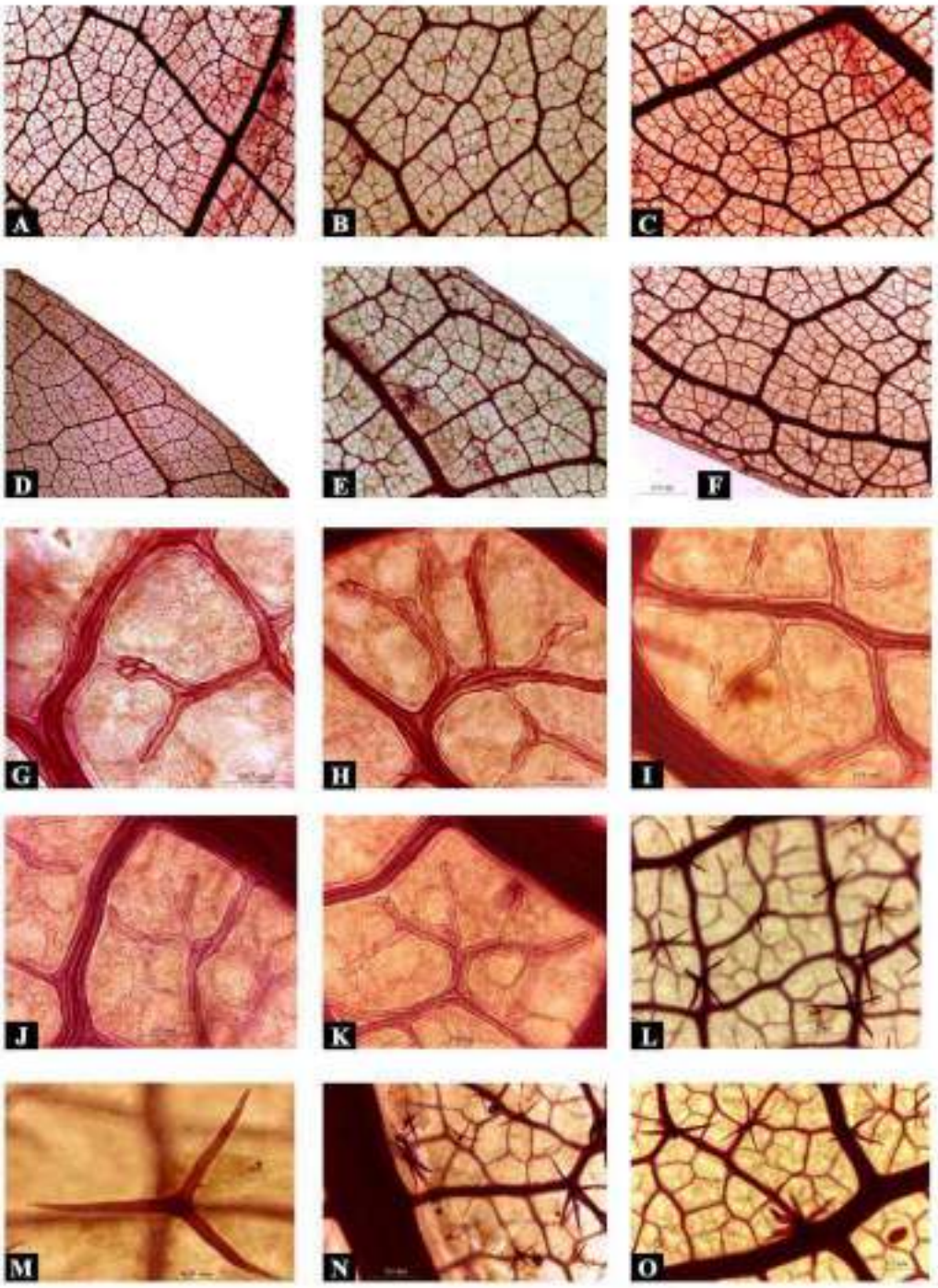

Fig.76. ***Sterculia hamiltonii:*** **A - C.** Minor venation (different views); **D - F.** Marginal venation (different views); **G - K.** Free vein endings: **G & H.** Unbranched, **I - K.** Branched; **L - O.** Stellate and acicular trichomes

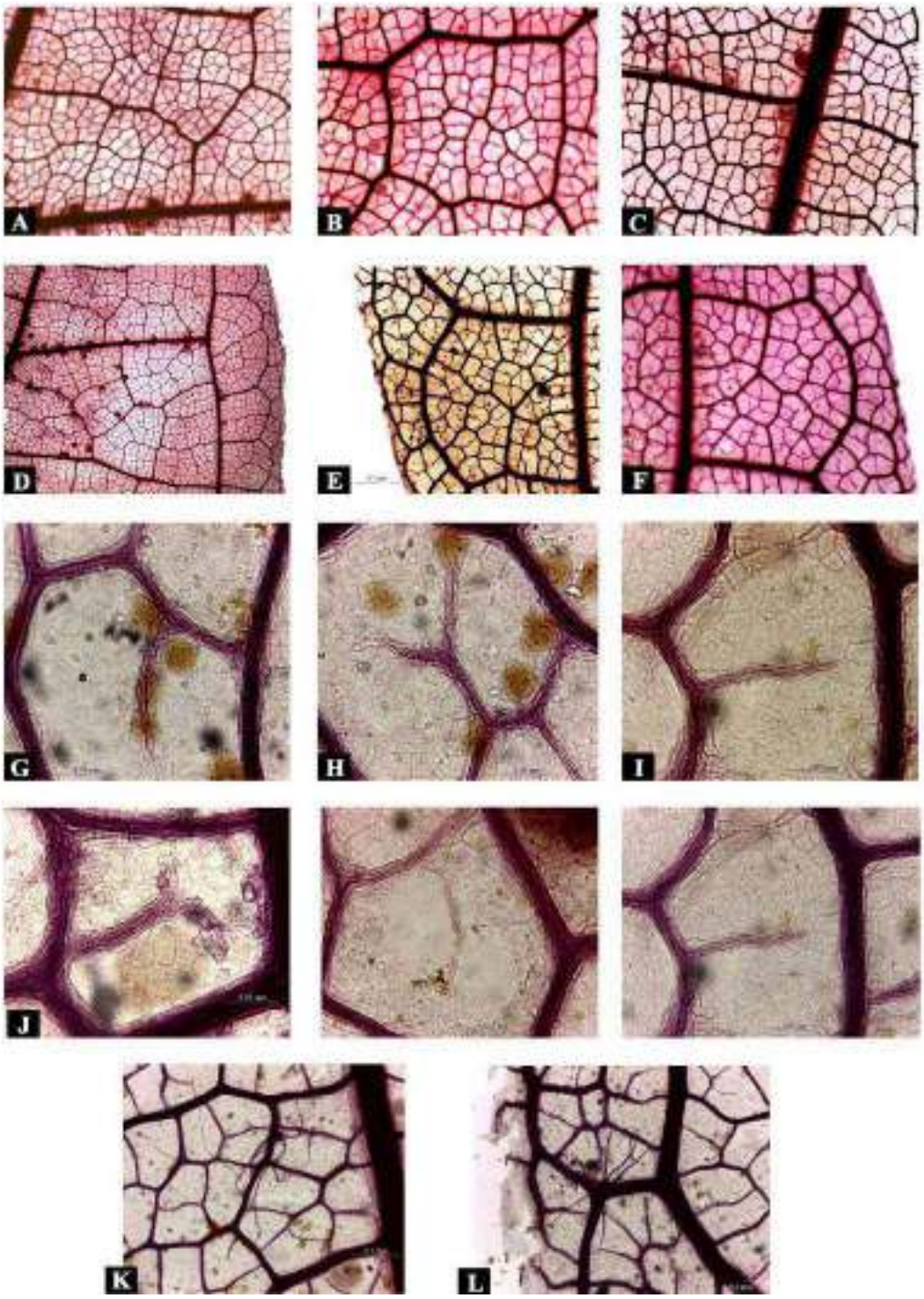

Fig.77. ***Sterculia kingii:*** **A - B.** Minor venation (different views); **D - F.** Marginal venation (different views); T.s. of petiole: **G - J.** Free vein endings: **G - I.** Unbranched, **J.** Branched; **K & L.** Stellate trichomes