dicotyledonous leaves.

The leaves of modern angiosperms are characterized by the presence of a fine angular reticulum of veins that fill in the intercostal areas of the leaf skeleton. The presence of such fine reticula are found only in the gymnosperm *Gnetum* and in some pteriodyphytes such as *Dipteris conjugata*.

Foster (1952), believes that it was C. von Ettigshausen (1861) who for the first time put in comprehensive effort to systematize the classification of venation patterns. In his classification the categorization proceeded in a logical fashion from the configuration of the primary veins to the areolation. Although his system were utilized by paleobotanists like Exsquerreux (1878), Berry (1916), Hollick ([1936) and others used few of his terminology to describe the configuration of the lower order veins, it did not become widespread as it was over-elaborate and took into account a number of features which have no taxonomic utility. Kerner (1895) formulated a classification of venation considering only the primary and secondary veins. Although it was partly derived from that of von Ettingshausen, and found its application in Krussmann's *Handbuch der Laugegehe* (1960) it too did not find many takers. Goebel (1905) and Troll (1938) developed a classification primarily dealing with the developmental morphology of venation, which did not find acceptance by other workers. Lam (1925) in his monograph on the Sapotaceae of East Indies put forward an independent classification of some elements of the leaf architecture. He dealt with the characteristics of secondary and tertiary venation, their angular relationships, curvature, path both inside and near the leaf margins, branching pattern and vein junctions, which were adopted by Hickey (1973) who put forward an inclusive, coherent and detailed classification of the architecture of dicotyledonous leaves. Hickey and Wolfe (1975) undertook a prodigious study of the leaf architecture belonging to most major groups of extant dicotyledonous angiosperms, which was utilized by Hickey and Doyle (1976) to work out the phylogenies and systematics of Lower Cretaceous leaves. A number of workers have utilized the venation pattern either alone or in conjugation with other characters to elucidate taxonomic and phylogenetic relationships in various plant groups at different levels of plant classification (Levin 1929;Hagerup 1950;Hayes *et al.*, 1959; Hall and Melville 1951 1964; Cutler, 1965; Simola and Liisa 1968; Paliwal and Kakkar 1969; Kakkar 1971; Seghal, Lalita and Paliwal 1974;Tanai 1978;Hickey and Wolfe (1975,1976).

Melville (1969), from extensive studies on leaf venation of fossils and living genera put forth a hypothesis that the leaf of flowering plants provide a large body of evidence suggesting that the angiospermic leaf originated from the Permian Glossopteridae. He showed *Glossepteris* like

venation patterns are encountered in several living angiosperms. Furthermore, he has suggested that the Glossopteridean leaf is characterized by a *syndrome* of vein junction patterns and vein islands which are associated together only in Glossopteridae and in the more primitive angiosperms which constitute his *Glossopterid syndrome*. Alvin and Chaloner (1970), however, raised serious doubts to the glossopteridean origin of the angiospermic leaf. They pointed out that Foster had convincingly argued as noted by Melville (1969), that some of the primitive living Ranales with an open (dichotomising) venation pattern represent a primitive state within the angiosperms. They argue that if a monophyletic origin is accepted for the angiosperms the reticulate venation evolved within the group, furthermore they argue that such development must have occurred during the Mesozoic, rather than already being possessed by their *putative* Permian ancestors. Hickey and Doyle (1977) acknowledged the remains of small pinnately veined simple leaves from the Neocomian equivalent as the oldest bonafide angiospermic remains. Eight leaf genera have been described by them from the Potomac Group occurring in Zone I (roughly equivalent to the Barremian-Aptian] stages. While the dicot like genera include *Ficophyllum, Proteophyllum, Vittiphyllum, Celastrophyllum* and *Rogersia two* of these genera are with monocot like leaves and are assigned to *Acaciaephyllum* and *Plentaginopsis.*

Based on their study Hickey and Wolfe (1976), determined that the primitive leaf of the dicotyledonous angiosperms were simple, symmetrical, having an entire margin, with a pinnate venation and the secondary veins being camptodromous, '*first rank*' level of vein organization and minor vein orders that are poorly differentiated or random. The Lower Cretaceous leaves such as *Ficophyllum, Rogersia* and *Celastrophyllum* embody these characters. Among extant dicots the primitive order Magnoliales and some other orders of the subclass Magnoliideae show leaves with such characteristics. Thus, fossil evidences clearly indicate the dicotyledonous leaves of other morphologies and architecture has been derived from such primitive leaves. Hickey and Doyle (1976) have emphasized that one should consider these leaves of the first rank condition as representing an early state of evolution through which the leaves of other groups passed, as well as the level achieved by leaves of the modern Magnoliales.

One of the most distinctive features of the genus *Acer* is its leaf architecture. Petioled and opposite leaves are diagnostic to the genus and many workers since the time of Pax (1885) have utilized it for the classification of the genus with a large number of specific epithet like *A.acuminatum, A. barbinerve, A. palmatum, A.oblongum, A.cissifolium, A. macrophyllum* to name a few being derived from foliar characters.

Tanai (1978), made extensive studies on the vein architecture of both living and extinct species of the genus *Acer* and has made a thorough Taxonomical reinvestigation of the genus based upon these characteristics. The leaf architecture and the venation pattern of the different species of *Acer* of the Darjiling-Sikkim Himalayas has been alphabetically described below following the classification proposed by Hickey and Doyle (1976).

8.2. SYSTEMATIC TREATMENT OF THE LEAF ARCHITECTURE AND VENATION PATTERN OF THE SPECIES OF *Acer* OF DARJILING –SIKKIM HIMALAYAS.

Acer acuminatum Wallich ex D.Don.

Leaves simple, opposite, exstipulate, deciduous, petiolate; petiole purplish red with swollen base and median longitudinal groove on upper side finely pubescent, 3-8.5 cm long; young lamina membranous, lower surface pubescent covered by whitish hairs later turning dark green and glabrous at maturity, mature with glandular hairs, lamina symmetrical, 6-12 x 5.5-12 cm; palmately 3-5 unequal lobed with basal lobes often insignificant, lobes ovate- caudate; acuminate with a long slender tail or acumen; base symmetrical, cuneate to rounded; margin toothed, serrate, teeth simple or compound being uni to biserrate, apical angle acute, serration of C1 type, irregular; texture membranous when young , chartaceous at maturity; base inflated; unicellular conical trichomes distributed on the veins and lamina on the lower surface,165.42-312.76 x 21.42 –45.23 μm; uniseriate clavate hairs on the larger veins, head 23.80-26.18 x 19.04-21.42μm body 41.61-57.14 x14.28-16.67μm; venation palmate, actinodromous, perfect basal with the presence of 5 major veins; 1° veins moderate, straight; angle of divergence of 2°veins acute moderate, upper veins more acute than lower, thickness weak, course curved uniformly, branched; intersecondary veins composite; 3°veins weak, angle of origin RO type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein distinct; quaternary veins moderate, course orthogonal; quinternary veins moderate, random to orthogonal, highest order vein 4°, highest vein order showing excurrent branching 4°; marginal ultimate venation incomplete ; veinlets curved, branched 1-3 times, number of free vein endings in each areole 2-6, predominantly 2-4, average number being 8.34± 1.21; areoles imperfect, random, polygonal sometimes quadrangular, few small areoles formed by joining of veinlets, circular, ranging from 1.3- 2.41 x 0.6x-1.31 mm, small circular areoles with diameter of 0.53 mm; vein islet number 3.42 ± 1.90. (Plate 8.2.a)

Stomata hypostomatic; anomocytic surrounded by 6-7 cells; Stomatal frequency 388.02 ±26.95; Stomatal Index 9.68 ± 3.67; Stomatal complex 15.49 –18.49 x 11.25-12.87μm; guard cell 15.49 –18.49 x 5.37– 6.24μm, inner wall thickness ca 0.99-1.36μm; pore length 6.62-8.85μm; few large stomata towards the veins 17.15- x 25.01 x 16.24-17.62 μm.(Fig.8.1.a)

Acer campbellii Hiem.

Leaves simple, opposite, exstipulate, deciduous, petiolate; petiole reddish to reddish green with swollen base and median longitudinal groove on upper side, 5-10 cm long; young leaves reddish pendulous turning green at maturity; lamina symmetrical, 6-12.5 x 11.5-14 cm; palmately 5-7 unequally lobed, lobes showing a high degree of variation, lanceolate to oblong; acuminate; base symmetrical, cordate to truncate; margin toothed, serrate, teeth simple, apical angle acute, serration of C1 type, more or less regular; texture membranous when young, chartaceous to coriaceous at maturity; base inflated; unicellular conical trichomes distributed on the primary vein and sometimes on 2° veins 171.4 - 473.82 X 19.04-39.09 μm along with uniseriate clavate hairs, head 27.38 - 38.09 x 27.38-28.57 μm , body 66.67-80.95 x 16.64-19.08 μm; multiserriate hairs present in tufts at the vein axils, white, upto ca 0.5-1.8 mm long; ; venation palmate, actinodromous, perfect basal with the presence of 7 major veins; 1° veins moderate, straight; angle of divergence of 2°veins acute moderate, upper veins more acute than lower, thickness moderate, course curved uniformly, branched; intersecondary veins composite; 3°veins moderate, angle of origin RO type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein distinct; quaternary veins moderate, course orthogonal; quinternary veins moderate, random to orthogonal, highest order vein 4°, highest vein order showing excurrent branching 4°; marginal ultimate venation incomplete ; veinlets curved, branched 1-3 times, number of free vein endings in each areole 1-15, predominantly 4-8, average number being 6.39± 1.77; areoles imperfect, random, pentagonal to polygonal sometimes quadrangular, few small areoles formed by joining of veinlets, circular, ranging from 0.8- 2.21 x 0.5x-1 mm, small circular areoles with diameter of 0.23 mm; vein islet number 4.15 ± 1.90. (Plate 8.1. i ; 8.2. b)

Stomata hypostomatic; anomocytic surrounded by 5-7 cells, sometimes 4; Stomatal frequency 493.82 ±36.95; Stomatal Index 19.51 ± 4.67; Stomatal complex 15.87-25.39 x 11.27-20.63μ; guard cell 15.87-19.04 x 5.71– 9.37μ; pore length 7.9-6.35μ.(Fig 8.1. b)

Acer caudatum Wallich

Leaves simple, opposite, exstipulate, deciduous, petiolate; petioles greenish pubescent with swollen base and a longitudinal groove on the upper surface, 5-10 cm long; young lamina light green with brownish wooly hairs on the lower surface turning dark green at maturity with hairs on the veins and vein axils; mature lamina symmetrical, 7-14 x 6-13 cm; palmately 5 sometimes 7 unequally lobed, ovate caudate; acuminate; base symmetrical, broadly cordate; margin toothed, broadly serrate, serration compound, biserrate, apical angle acuminate,

serration of D1 type, irregular; texture membranous when young, coriaceous at maturity; unicellular conical trichomes distributed on primary vein 90.47-238.09 x 23.80-35.72 μm ; and occur in tufts at vein axils upto ca 0.6mm; uniserriate clavate hairs on vein axils on younger leaves, head 21.42 -23.68 x 14.28-17.56 μm; body 41.67 - 43.23 x11.90- 13.09 μ; venation palmate, actinodromous, perfect basal with the presence of 5 major veins; 1° veins moderate, straight; 2°veins angle of divergence acute moderate, more acute towards apex, thickness moderate, course curved uniformly, branched; intersecondary veins composite; 3°veins weak, angle of origin RO type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein order distinct; quaternary veins weak, course orthogonal; highest order vein of leaf 6°, highest vein order showing excurrent branching 6°; marginal ultimate venation incomplete ; veinlets curved, usually branched 1 or sometimes 2 times , number of free vein endings in each areole 1-4, predominantly 2-4, average number being 3.09 ± 1.12; areoles imperfect, oriented, pentagonal to polygonal, few quadrangular, areoles small, ranging from 0.3-0.6 x 0.29-0.42 mm numerous small circular areoles formed by fusion of veinlet endings, circular areoles 0.091-0.13 mm in diameter; vein islet number 20.60 ± 2.30. (Plate 8.2. c)

Stomata occurring only on the lower epidermis; anomocytic surrounded by 5-6 cells Stomatal frequency 313.98 ± 32.18; Stomatal Index 15.69 ± 3.81; Stomatal complex 19.24-22.91 x 15.07-18.84 μm; guard cell 19.24-22.91 x 6.90 – 7.59μ, inner wall thickness ca 1.24-1.52 μm; pore length 12.31-13.34 μm.(Fig. 8.1.c)

Acer hookeri Miquel

Leaves simple opposite, exstipulate, deciduous, petiolate; petiole reddish with swollen base and median longitudinal groove on upper side, 3-5 cm long; leaves yellowish green to reddish green when young turning green at maturity; mature lamina ovate, symmetrical, 5-14 x 4-8 cm, usually unlobed, sometimes with two small lateral lobes; acuminate; base symmetrical, shallowly cordate; margin serrate, teeth compound, biserrate, acuminate, serration of D1 type, irregular; texture membranous when young, chartaceous when mature; uniseriate hairs on primary veins of young leaves absent in mature leaves, head 26.19-27.38 x 13.80-14.28 μm, body 38.04 - 42.85 x 11.90-13.80 μ; multiserriate hairs on vein axils whitish in young leaves later turning orange reaching lengths upto ca 2.5 mm; venation palmate, actinodromous, perfect, basal, with the presence of 5 major veins; 1° veins moderate, straight; 2°veins angle of divergence acute moderate, upper veins more acute than lower, thickness moderate, course curved uniformly, branched; intersecondary veins composite; 3° veins moderate, angle of origin RR type,

percurrent, slightly convex towards the mid rib to retroflexed towards margin to forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein order distinct; quaternary veins weak, course orthogonal; quiternary veins weak, random to orthogonal, highest order vein of leaf 5°, highest vein order showing excurrent branching 4°; marginal ultimate venation incomplete ; veinlets usually 1,rarely 2 in each areole, curved, branched 1-3, number of free vein endings in each areole 2-6, average number 4.58 ± 1.83; branches of adjacent veinlets often fused with each other or with quitenary veins forming smaller areoles; areoles imperfect, random, pentagonal to polygonal sometimes quadrangular, 0.62-1.2 x 0.430.62 mm, few small areoles formed by joining of veinlets circular, with diameter of 0.19 mm vein islet number 9.12 ± 2.91. (Plate 81.1. e; 8.2. d)

Stomata hypostomatic, anomocytic surrounded by 4-6, usually 6 cells Stomatal frequency 677.26 ±46.95; Stomatal Index 19.51 ± 4.67; Stomatal complex 15.87-20.24 x 11.27 - 20.63μm; guard cell 15.87-19.04 x 5.71– 9.37μm, inner wall thickness ca 1.24-1.84μm; pore length 4.76-6.35μm. (Fig. 8.2.d)

Acer laevigatum Wallich

Leaves simple, opposite, exstipulate, petiolate; petiole green to reddish, with swollen base and median longitudinal groove on the upper side, 1-1.5 cm long; young leaves light green turning dark green at maturity; mature lamina symmetrical to asymmetrical, 7-15.5 x3-4.5 cm; usually unlobed, but sometimes palmately 2-3 lobed, lobes unequal, median lobe usually lanceolate-oblong with lateral lobes being smaller, acuminate; base symmetrical to asymmetrical, rounded; margin entire to distantly serrulate when young, entire when mature, teeth when present simple, uniserriate, apical angle acute, serration of C1 type; texture membranous when young chartaceous at maturity; uniseriate clavate hairs on the primary veins of young leaves, head 26.53-27.38 x 21.42-23.80 μm, body 59.34-62.38 x11.09-13.92 μm; multiserriate hairs present at vein axils of young leaves, whitish in colour reaching length upto ca 1.5 mm; venation palmate, actinodromous, imperfect, marginal, with 3 major veins; major veins 1° veins moderate, straight; 2°veins angle of divergence acute moderate, more or less uniform, course curved uniformly, branched; intersecondary veins composite; 3°veins moderate, angle of origin RA type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher vein order distinct; quaternary veins moderate, course orthogonal; quiternary veins moderate, orthogonal, highest order vein of leaf 5°, highest vein order showing excurrent branching 5°; marginal ultimate venation incomplete; veinlets 1 in each areole, curved, branched 1-5 times , predominantly 4 times, number of free vein endings in each

areole 1-15, predominantly 2-18, average number being 9.58 ± 4.33; areoles imperfect, oriented, pentagonal to polygonal sometimes quadrangular,0.38-0.72 x 0.28-0.4, few small areoles formed by joining of veinlets circular with diameter 0.17-0.23 mm; vein islet number 18.32 ± 4.32. (Plate 8.1. g; 8.2.e)

Stomata hypostomatic; anomocytic surrounded by 4-6 cells with isolated larger stomata distributed around the veins being surrounded by 7-8 cells; Stomatal frequency 718.47±42.46; Stomatal Index 16.27 ± 3.24; Stomatal complex 7.94 -17.58 x 10.12 -14.56 μm; guard cell 7.94-21.90 x 4.13 – 6.35, inner wall thickness ca 1.24-1.48 μm; pore length 5.06 -8.74μ; isolated large stomata around veins 24.87 x 18.84 μm. (Fig. 8.1.e)

Acer oblongum Wallich

Leaves simple, opposite, evergreen, exstipulate, mature petiolate; petiole pubescent when young with a shallow median longitudinal groove, being glabrous later, light green, 2-6 cm long; young lamina pubescent, pinkish yellow when young, covered with short wooly unicellular trichomes ca 0.5-3 mm x 57.23-71.42 μ on veins and lamina on both surfaces; glabrescent and green at maturity, lamina symmetrical, 5-17 x 3-7 cm, unlobed, oblong – elliptic, upper surface glossy green, lower greenish white, glaucous, acuminate, base symmetrical, obtuse to rounded; margin smooth entire; texture pubescent, membranous when young, chartaceous when mature; venation palmate, actinodromous, imperfect, reticulate, with 3 basal veins; 1° veins stout, straight; 2°veins angle of divergence acute moderate, more or less uniform, thickness moderate, course curved uniformly, loop forming branches joining at obtuse angle, branched; intersecondary veins composite; 3°veins angle of origin OR type, percurrent, forked; relationship with midvein oblique, angle decreasing upwards, predominantly alternate, higher order vein indistinct; quaternary veins moderate, course orthogonal; marginal ultimate venation fimbriate; veinlets none rarely one in some areoles linear and unbranched; areoles well developed, oriented quadrangular to pentagonal, small in size, 0.16-0.27 x 0.15-0.25 mm; vein islet number 110.88 ± 19.99 . (Plate 8.1. c; Plate 8.2. f)

Stomata hypostomatic; anomocytic surrounded by 5-8 cells, usually 6; Stomatal frequency 388.01 ± 29.36; Stomatal Index 11.67 ± 3.39; Stomatal complex 19.05-22.38x 15.87–20.53μm; guard cell 19.05-22.38 x 5.35-9.52μm, inner wall thickness 2.12-4.36 μm; pore length 9.51-14.2μ.(Fig. 8.1.f)

Acer osmastonii Gamble

Leaves simple, opposite, exstipulate, deciduous, petiolate; petiole reddish to green with swollen

base and a longitudinal medial groove on upper surface, slightly pubscent when young glabrous later 1.5-4 cm long; mature lamina symmetrical to asymmetrical, 6-15 x 4-11.5 cm, palmately one to three lobed, leaves of upper canopy rarely 5 lobed, median lobe longest elliptic to obovate; acuminate; base rounded symmetrical to asymmetrical; margin distantly serrate more or less entire towards the base, teeth simple, uniserriate, interval more or less regular towards the upper side, angle of serration acute, serration of C1 type ; texture coriaceous when mature, more or less uniseriate conical hairs on primary and 2° and sometimes 3° veins 133.34-340.76 x 64.28-85.34μm; with tufts of multiserriate hairs in the vein axils reaching length upto 2.5 mm, white; venation actinodromous, perfect basal with 3 prominent veins; primary veins (1° veins) moderate, course more or less straight, branched; secondary (2° veins) moderate, angle of divergence acute moderate, upper pairs more acute than lower, with secondary veins being more well developed towards the margins in case of the lateral primary veins, course curved, loop forming branches enclosed by 3° arches; loop forming branches joining at acute angle; inter-secondary veins composite; intra-marginal vein absent; tertiary (3° veins)show RA type of origin, percurrent, forked, retroflexed, oblique to the mid vein, oblique angle decreasing apically, arrangement predominantly opposite; higher vein orders distinct; quaternary (4° veins) thick course orthogonal; quitenary vein(5° veins) thick course orthogonal, highest order 5°, veins showing excurrent branching; marginal vein incomplete; veinlets 1-2 per areole, curved, branched 1-4 times, predominantly 2-3 times; number of free vein endings in each areole 2-11, predominantly 4-7, average number being 5.91 ± 2.95; areoles well developed, oriented, quadrangular to pentagonal, circular small areoles formed by incurving and fusion of terminal veinlets frequent, areoles 0.48-0.71 x 0.32-0.47 mm few larger in size ranging from 0.8-0.1 x 0.35-0.47mm, circular areoles with diameter of 0.087-0.14 mm, vein islet number 19.01 ± 6.95. (Fig. 8.1.d; 8.2. g)

Stomata occurring only on the lower epidermis; anomocytic surrounded by 4-6 cells, few large isolated stomata; Stomatal frequency 731.92 ±59.78; Stomatal Index 14.29 ± 3.91; Stomatal complex 12.43 – 15.07 x 10.04 –13.82μm; guard cell 12.43 – 15.07 x 4.76– 7.62 μm, inner wall thickness ca 1.24-1.52μm ; pore length 4.29-9.52μm; isolated large stomata 17.08-17.72 x 16.24 –17.24μm .(Fig/. 8.1.g)

Acer palmatum Thunberg ex Murray

Leaves simple, opposite, exstipulate, deciduous, petiolate; petiole reddish to brownish green, glabrous, base swollen, a longitudinal median groove present on upper surface 2.5-3 cm long;

mature lamina symmetrical, 7 –5 unequally lobed, 4-5.5 x 3.5-5 cm, central lobe largest, lobes lanceolate to oblong, yellowish green to reddish green when young, dark green at maturity, glabrous; margin toothed, serrated, teeth compound biserrate, apical angle acute, serration of C1 type; acuminate with elongated acumen; base symmetrical, cordate; texture membranous when young, chartaceous when mature, glabrous, green, lower surface pale, unicellular conical trichomes distributed on the larger veins 128.32-154.56 x 38.09-47.62 μm that also occur in tufts at the vein axils reaching length upto ca 1mm; venation palmate, actinodromous, perfect basal with the presence of 5-7 major veins; 1° veins moderate, straight; 2°veins angle of divergence acute moderate, more or less uniform, thickness moderate, course curved uniformly, branched; intersecondary veins composite; 3°veins moderate, angle of origin RR type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein order distinct; quaternary veins moderate, course orthogonal; quinternary veins moderate, random, highest order vein of leaf 4°, highest vein order showing excurrent branching 3°; marginal ultimate venation incomplete; veinlets curved, usually branched 3-4 times, rarely twice, number of free vein endings in each areole 3-12, predominantly 6-8, average number being 7.38 ± 3.61; areoles imperfect, oriented, quadrangular to pentagonal, few small areoles formed by joining of veinlets circular, most medium in size ranging from 0.49-1 x 0.23-0.71 mm, few large being 1.17-1.4 x 0.4-0.8 mm, small circular areoles with diameter of 0.18 mm; vein islet number 8.22 ± 0.53.(Plate 8.1. h; Plate 8.2.h)

Stomata hypostomatic; anomocytic surrounded by 4-5 cells Stomatal frequency 579.28 ± 39.36; Stomatal Index 17.82 ± 4.31; Stomatal complex 10.12 –18.98 x 13.92–17.72μm; guard cell 10.12 –18.98 x 6.35 x 9.4μm, inner wall thickness ca1.24-2.48 μm; pore length 5.56-7.94 μm. (Fig. 81.1.h)

Acer pectinatum Nicholson

Leaves simple, exstipulate, deciduous, petiolate; petiole reddish to greenish brown, glabrous, base swollen, with a longitudinal median groove on upper surface, 4-8 cm long; lamina symmetrical, 6-14 x 4-8 cm, usually 3-5 lobed, with great variation in degree of lobation, lobes unequal with the central lobe being relatively longer and broader ovate to oblong, light green when young , dark green at maturity, lower surface paler and pubescent when young, more or less glabrous with tufted hairs at the vein axils at maturity; apex acuminate; base deeply cordate; margin toothed, coarsely serrate, tooth compound biserrate, apical angle acuminate, serration of D1 type, irregular; texture subcoriaceous, pubescent on lower surface, upper surface dark green, lower surface paler; unicellular conical trichomes on the major veins and the lower surface of lamina 219.08-428.16 x 45.23-52.32 μm, uniserriate or sometimes biserrate

hairs present on the major and smaller veins, head 39.28-42.85 x 23.80-26.19 μm, body 90.47-95.23 x- 16.42-26.19μm; multiserriate hairs in tufts at the vein axils upto ca 2-3mm long; venation palmate, actinodromous, perfect basal with the presence of 5 major veins; 1° veins moderate, straight; 2°veins angle of divergence acute, moderate, more acute towards apex, thickness weak, course curved , branched; intersecondary veins composite; 3°veins weak, angle of origin RO type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein order distinct; quaternary veins weak, course orthogonal; highest order vein of leaf 6°, highest vein order showing excurrent branching 5°; marginal ultimate venation incomplete ; veinlets curved, usually branched 1 or sometimes 2 times , number of free vein endings in each areole 1-4 predominantly 2-4, average number being 3.09 ± 1.12; areoles imperfect, oriented, pentagonal to polygonal few quadrangular, areoles small ranging from 0.3-0.6 x 0.29-0.42 mm numerous small circular areoles formed by fusion of veinlet endings, circular areoles 0.091-0.13 mm in diameter; vein islet number 21.63 ± 4.61.(Plate 8.2.i)

Stomata hypostomatic, anomocytic surrounded by 4-5 cells Stomatal frequency 758.37 ± 62.98; Stomatal Index 24.07 ± 5.47; Stomatal complex 16.61-22.36 x 10.95 –17.46μ; guard cell 16.61-22.36 x 6.34 x 7.30μ, inner wall thickness ca 1.58-2.38μ thick; pore length 5.56-11.26μ.(Fig.8.1.i)

Acer sikkimense Miquel

Leaves simple, opposite, exstipulate, deciduous, petiolate; petiole light green to red when young, slightly stripped with white, base swollen, longitudinal median groove on upper surface, 2-4.5 cm long; lamina symmetrical, usually unlobed sometimes three lobed with two small lateral lobes, 7-15 x 4-9.5 cm ovate cuspidate, light green to reddish when young, dark green at maturity; acuminate; base cordate, symmetrical; sub entire to finely serrulate, teeth simple, apical angle acute, serration of C1 type, more or less regular; texture membranous when young, shiny, thick , subcoriaceous, glabrous at maturity, dark green; unicellular conical hairs on the major veins, 128.57-340.76 x 33.46- 45.23μm ; multiserriate hairs at the vein axils white when young turning orange at maturity, upto ca 3-4 mm long; venation palmate, actinodromous, perfect basal with the presence of 5 major veins; 1° veins moderate, straight; 2°veins angle of divergence acute moderate, more or less uniform; thickness moderate, course curved uniformly, branched; intersecondary veins composite; 3° veins moderate, angle of origin RR type, percurrent, slightly convex towards the mid rib to retroflexed towards margin, relationship with midvein oblique, angle more or less constant, predominantly alternate, higher vein order

distinct; quaternary veins moderate, course orthogonal; quiternary veins thin, usually orthogonal sometimes random , highest order vein of leaf 5°, highest vein order showing excurrent branching 4°; marginal ultimate venation incomplete ; veinlets usually one in each areole , rarely two or three; curved, branched 1-3, number of free vein ending in each areole 2-10, usually 2-6, average number being 5.96± 1.89; areoles imperfect, random, quadrangular to polygonal , 0.47-1.12 x 0.23-0.37 mm, few small areoles formed by incurving and fusion of some terminal veinlets forming polygonal areoles 0.2-0.28 x0.18-0.19 mm; vein islet number 9.55± 4.14.(Plate 8.1. a; 8.2.j.)

Stomata hypostomatic, anomocytic surrounded by 4-5 cells Stomatal frequency 513.82 ± 32.18; Stomatal Index 16.42 ± 5.91; Stomatal complex 15.18-18.74 x 12.65–16.46 μm; guard cell 15.18-18.74 x 5.65 – 8.46μm, inner wall thickness ca 1.24-1.84μm; pore length 7.32-10.12μm.(Fig. 8.1.j)

Acer stachyophyllum Thunberg

Leaves simple, opposite, exstipulate, deciduous, petiolate; petiole yellowish to reddish brown, pubescent when young glabrescent at maturity, swollen base with median longitudinal groove on upper surface 2 - 3 cm long; lamina unlobed to palmately unequally 3-lobed with small basal lobes, ovate, to 5.5 - 8.5 x 3.5 - 6 cm; deeply acuminate with long acumen, base caudate to rounded, pubescent, more or less glabrous with tufts of unicellular conical hairs on vein axils upto ca 1-2mm; greenish yellow when young turning green at maturity, with 3 basal veins; deeply biserrate, venation palmate, actinodromous, perfect basal with the presence of 3 major veins; 1° veins moderate, slightly curved; angle of divergence of 2°veins acute moderate, upper veins more acute than lower, thickness moderate, course curved uniformly, branched; intersecondary veins composite; 3°veins moderate, angle of origin RO type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein distinct; quaternary veins moderate, course orthogonal; quinternary veins moderate, random to orthogonal, highest order vein 5°, highest vein order showing excurrent branching 5°; marginal ultimate venation incomplete ; veinlets curved, branched 2-3 times, number of free vein endings in each areole 4-16, predominantly 6-9, average number being 9.34± 1.32; areoles imperfect, random, polygonal sometimes quadrangular, ranging from 1.8- 2.56 x 0.8x-1.51 mm, small circular areoles with diameter of 0.63 mm; vein islet number 3.52 ± 1.60. (Plate 8.2. k)

Stomata hypostomatic, anomocytic surrounded by 6, sometimes 5 or 4 cells, Stomatal frequency 423.39 ± 46.18; Stomatal Index 17.42 ± 3.91; Stomatal complex 16.46 – 22.61 x 12.53–15.12μ; guard cells 16.46 – 22.61 x 6.28- 7.24μm, inner wall thickness ca 1.48-1.84;

pore length 9.52-15.89μm.(Fig. 81. k)

Acer sterculiaceum Wallich

Leaves simple, opposite, exstipulate, petiolate; petiole green pubescent swollen at base with a longitudinal groove at the upper surface,4-14.5 cm long; lamina palmately 3-5 unequally lobed, 9-14.5 x 7.5x11 cm, lobes ovate to oblong; acuminate, base cordate, margin toothed, distantly serrate, teeth simple, apical angle acute, serration of C1 type, more or less regular, texture pale brownish yellow when young with lamina undulated along veins, membranous, translucent, tomentose on both surfaces, glabrous, thick green coriaceous when mature; unicellular conical trichomes present on the major veins 138.09- 340.47 x 30.95-33.34 μm ; uniserriate hairs on the major veins, head 26.19-30.95 x 23.89-33.34 μm, body 74.86- 88.38 x 19.04-21.34 μm, conical trichomes in tufts at the basal axils reaching length upto ca 1-1.8 mm; venation palmate, actinodromous, perfect basal with the presence of 5 major veins; 1° veins moderate, slightly curved; 2°veins angle of divergence acute moderate, upper veins more acute than lower, thickness moderate, course curved uniformly, branched; intersecondary veins composite; 3°veins angle of origin RO type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein order distinct; quaternary veins moderate, course orthogonal; quinternary veins moderate, random to orthogonal, highest order vein of leaf 6°, highest vein order showing excurrent branching 4°; marginal ultimate venation incomplete ; veinlets curved, branched 1-3, number of free veinlets in each areole 1-4, predominantly 1-2, average number being 3.09± 0.77,aeroles imperfect, random, pentagonal to polygonal sometimes quadrangular, few small areoles formed by incurving and fusion of some terminal veinlets circular, large ranging from 0.24-0.61 x 0.21-0.46 mm, small circular areoles with diameter of 0.15-0.2 mm; vein islet number 48.45 ± 7.14 (Plate 8.1.f; 8.2.l)

Stomata hypostomatic, anomocytic surrounded by 5 or sometimes 6 cells; Stomatal frequency 382.56 ± 28.36; Stomatal Index 8.51 ± 2.79; Stomatal complex 16.45-20.47 x 11.30–12.31μm; guard cell 16.45-20.47 x 5.15 – 5.63μ, inner wall thickness ca 1.24-2.4μm; pore length 12.06 – 13.82μm.(Fig. 8.1. l)

Acer thomsonii Miquel

Leaves simple' opposite' exstipulate, petiolate; petiole ridged and furrowed, green with swollen base; lamina symmetrical, palmately 3 lobed, rarely unlobed, 13-17.5 x 10-15 cm, median lobe largest, elliptic to suborbiculate, lateral lobes small, acuminate; base broadly cordate symmetrical, margin distantly serrate being more or less entire in the basal portion, interval more

or less regular, teeth simple, uniserrate, apical angle acute, serration of C1 type; membranous when young, coriaceous at maturity, dark green; unicellular conical trichomes distributed on the major veins and the margin of the lamina 119.03 - 423.86 x 33.34-48.24μm ; uniserriate hairs on the major veins, head 38.04-42.86 x 30.95- 32.32μm, body 54.96-83.34 μm; venation palmate, actinodromous, perfect basal with the presence of 5 major veins; 1° veins weak, straight; 2°veins angle of divergence acute weak, more or less uniform, course curved uniformly, branched; intersecondary veins composite; 3°veins angle of origin RO type, percurrent, forked; relationship with midvein oblique, angle more or less constant, predominantly alternate, higher order vein distinct; quaternary veins moderate, course orthogonal; quinternary veins moderate, random to orthogonal, highest order vein of leaf 6°, highest vein order showing excurrent branching 4°; marginal ultimate venation incomplete ; veinlets curved, branched 1-3 times, number of free veinlets in each areole 1-15, predominantly 4-8, average number being 6.39± 3.77; areoles imperfect, random, pentagonal to polygonal sometimes quadrangular, few small areoles formed by joining of veinlets circular, most large in size ranging from 0.8- 2.21 x 0.5x-1 mm, small circular areoles with diameter of 0.23 mm; vein islet number 43.43 ± 11.88. (Plate 8.1.b; 8.2.m)

Stomata hypostomatic; anomocytic surrounded by 4-6, usually 5 cells; Stomatal frequency 283.35 ± 24.51; Stomatal Index 7.14 ± 2.81; Stomatal complex 15.18 -19.74 x 12.65 – 18.98μm; guard cell 15.18 -19.74 x 5.08 – 8.41μ, inner wall thickness ca 1.24-2.13 μm; pore length 7.93-11.13μm.(Fig. 8.1.m)

8.3. DISCUSSION:

The major characteristics of the leaf architecture and the venation pattern encountered in the different species of the genus occurring in the Darjiling-Sikkim Himalayas have been enumerated in Table 8.1.(a) and 8.1.(b)

8.3.1 LEAF SHAPE

In *Acer* it has been reported that most of the species possess simple leaves with only a small group of east Asian species like *Acer griseum* (Franchet) Pax, *A. maximowiczianum* Miq., *A, mandshuricum* Maxim. *A.sutchuenense* Franchet, and one North America species *A.negundo* exhibiting pinnately compound leaves. All the species belonging to the Darjiling-Sikkim Himalaya possess simple leaves which are either unlobed to 5-7 lobed. The different species of *Acer* of this region can be placed into three broad types based on the number of the lobes of the leaves *viz.*

Group I: Simple unlobed leaves are exhibited by *A.oblongum*. *A. laevigatum* on the other hand predominantly posses unlobed leaves but there are the occurrence of 2-3 lobed leaves in which the basal lobes remain small. Such lobed condition of the leaves are very common in the young saplings. Similarly conditions are observed in case of *A.hookeri, A.sikkimense* and *A.stachyophyllum*. While the leaves are usually unlobed 3-lobed condition with small basal lobes are of common occurrence.

Group 2: Palmately 3-5 lobed: In case of *A.acuminatum, A.pectinatum, A.sterculiaceum, A.thomsonii* and *A.osmastonii* the leaves are 3-5 lobed. In *A. osmastonii* 3 lobed condition is the predominant condition, however unlobed, 2 lobed and 5-lobed conditions are observed. Similarly in case of *A.pectinatum and A.thomsonii* though the 3-lobed condition is of common occurrence, 5 lobed condition with 2 small basal lobes is also common. Similarly the 3- 5 lobed condition though prevalent in *A. thomsonii* specimens with unlobed leaves can sometimes be encountered.

Group 3: Palmately 5-7 lobed: *A.caudatum, A.campbellii* and *A.palmatum* show predominantly 7 lobed conditions although 5-lobed conditions of the leaves are also encountered in these species.

Thus, the different species show a variation in the number of lobes of the leaves with all the species in the region showing palmate lobation. High variation in the lobes of the leaves is encountered even in the same species as mentioned above.

From fossil evidence and the change of the form of the fossil species *A.tricuspidatum* from the late Oligocene to the Early Pliocene Walther (1972) has concluded that the 5-lobed condition evolved from the 3-lobed conditions as the 3-lobed species were initially more abundant than the 5-lobed species and secondly in case of *A.tricuspidatum* broadening of the leaf of this 3-lobed species is observed which has led Walther to conclude the origin of 5-lobed condition due to this sudden broadening of the leaf base. Thus, if this conclusion is to be accepted, the truly unlobed forms of Group I like *A.oblongum* and the 7-lobed like *A.palmatum* may represent the advanced forms along two directions with the along with the transitional forms as far as the lobation of the leaves are concerned. The probable evolutionary lines of the different types of the leaves of *Acer* has been given in Fig. 8.2

The leaves of all the species exhibit a symmetrical lamina except in *A.laevigatum* and *A.osmastonii* where the two lobed leaves exhibit assymetrical lamina. All the species exhibit acuminate leaf apex but exhibit a wide variation in the nature of their leaf bases. The most

common type of leaf base is the cordate type that may be broad as in *A.caudatum, A.thomsonii, A. palmatum, A.sterculiaceum, A.stackophyllum, A.sikkimense, A.pectinatum* or shallow in *A.hookeri.* In *A.campbellii* the base is cordate to truncate with the base being rounded in *A.laevigatum, A.oblongum* and *A.osmastonii* to cuneate to rounded in *A.acuminatum.*

8.3.2 LEAF MARGIN

The leaf margin was entire in *A.oblongum.* In *A.laevigatum* entire to serrulate. Serrulate margins were observed in *A.sikkimense.* In all the other species exhibit toothed margins being uniserrate in *A.campbellii, A.osmastonii, A.sterculiaceum* and *A.thomsonii.* On the other hand *A.caudatum, A.hookeri, A.palmatum, A.pectinatum* and *A.stachyophyllum* showed biserrated conditions. In the case of *A.acuminatum* both uni and biserrate conditions were observed. The majority of the species that included *A.campbellii, A.laevigatum, A.osmastonii, A.palmatumA.pectinatum, A.sikkimense,A.sterculaecium* and *A.thomsonii* showed the C1 type of serration with acute apex while the rest i.e. *A.acuminatum, A.caudatum, A.hookeri* and *A.stachyophyllum* showed the D1 type of serration with acuminate apex.

8.3.3. MAJOR VENATION PATTERN

All the species showed the palmate actinodromous type of major veins being of the perfect basal type in eleven of the thirteen species. It was however of the imperfect marginal type in *A.laevigatum* and imperfect reticulate type in case of *A.oblongum.* The number of major veins entering the base of the leaf ranged from 3 – 7. While it was 3 in *A.laevigatum, A.oblongum* and *A.osmastoniii* ; it was 5 in *A.acuminatum, A.hookeri, A.pectinatum* and *A.sterculiaceum* being usually 5 but sometimes 3 in *A.stachyophyllum* and usually 5 but sometimes 7 in *A.palmatum; A. campbellii* and *A.caudatum* possess 7 basal veins. Thus species like *A. laevigatum* and *A. osmastonii* support the view that the simple leaf in case of *Acer* may have evolved from simple leaves with palmately trilobed lamina as they frequently exhibit trilobed, bilobed and unlobed lobes but possess three basal imperfect marginal venation in *A.laevigatum* and imperfect reticulate in the case of *A.oblongum.*

8.3.4. MINOR VENATION PATTERN:

The 1° veins were moderate in the majority of the species except *A.oblongum* where it remained stout and *A.thomsonii* where it remained stout. All the species showed a straight course for the 1 °. The 2° in 11 of the 13 species showed a moderate size being weak only in *A,acuminatum* and *A. pectimnatum.* All other species except *A. sterculiaceum* and *A.thomsonii* showed acute angle of divergence. In these two specie the angle of divergence remained oblique. Composite intersecondary veins were composite in all the species studied. Higher order veins remained

distinct in all species except *A.oblongum.* In these species the angle based on the angle of origin four groups could be recognized *viz.*

1. RO type : It included *A.acuminatum, A,campbellii, A.caudatum, A.pectinatum, A.stachyophyllum, A.sterculiaceum* and *A. thomsonii.*
2. RR type: It included *A.hookeri, A.laevigatum, A.palmatum* and *A.sikkimense.*
3. RA type was observed in *A.laevigatum* and *A.osmastonii*
4. OR type: Only *A.oblongum* showed this type of origin..

The marginal ultimate venation was incomplete in the 11 of the 12 species being fimbriate only in *A.oblongum.* Based upon the number of free veinlets the different species could be divided into three broad groups

Group I: Number of free veinlets 0 or rarely 1: Only *A.oblongum* belonged to this group

Group II: Number of free veinlets upto 6 usually 2-4 per aerole: It includes *A. acuminatum, A.caudarum, A.hookeri, A.pectinatum* and *A. sikkimense.*

Group **III**: Number of free veinlets more than 6 upto 16 in each aerole: This group includes *A.campbellii, A.laevigatum, A.osmastonii, A.palmatum, A.sterculiaceum* and *A.thomsonii.*

The aeroles were quadrangular to polygonal. The vein islet number was lowest in *A.stachyophyllum* where it was 3.52 being highest in *A.oblongum* where it was as high as 110.89.

8.3.5. STOMATA

All the species exhibited hypostomatic condition with the stomata being of the anomocytic type. Slight variations wer observed in the number of epidermal cells surrounding the stomatal complex that ranged from 4- 8 in different species and even in the same species. Based on the stomatal frequency the different species could be grouped into three classes i.e.

Class I: Somatal Frequency upto 400 (Low): The species occurring in the uppermost reaches like *A.sterculiaeum, A.acuminatum, A.stachyophyllum* and *A.caudatum* and those in the lowermost reaches like *A.thomsonii* and *A.oblongum* belonged to this class. These species in the higher reaches are constantly and those in the lower reaches being to higher temperature ranges subjected to winds which may the possible reason for them having lower number of stomata.

Class II: Stomatal Frequency between 400-600 (Moderate): *A.sikkimense, A,campbellii* and *A.palmatum* belong to this class.

Class III: Stomatal Frequency above 600 (High): *A.pectinatum, Ahookeri, A.osmastonii* and *A. laevigatum* showed a stomatal frequencies of more than 600 with the highest being for *A.pectinatum* which was 758.37 ± 62.98. This group included those species occurring in the

temperate to the upper temperate regions where rain fall remains high.

Species like *A.campbelli, A.laevigatum* , *A.*oblongum and *A.osmastonii* show some large sized stomata that remain isolated at the regions close to the veins.

8.3.4. LEAF APPENDAGES:

Three types of appendages were found to be associated with the leaves of the different species of *Acer.* These included a) Unicellular conical trichomes b) Uniseriate clavate hairs and c) Mulitserriate hairs.

The different species show some variations with respect to the distribution of the appendages. In general it can be said the young leaves of most of the species remain pubescent to a degree with the leaves of many turning glabrescent at maturity. While the unicellular conical hairs are more or less of universal occurrence very young leaves, they only occur on the veins of mature leaves in species like *A.acuminatum, A.campbellii, A.caudatum, A.oblongum, A.osmastonii,A.stachyophyllum* and *A.sterculiaceum.* In *A.thomsonii* they remain distributed throughout the leaf margins and in *A.pectinatum* throughout the leaf lamina. Only *A.campbelli, A.ostmastonii, A.sikkimense, A.hookeri, A* and *A, pectinatum* possess multiserriate haris on their vein axils which are often white when young but turn reddish to orange at maturity in *A.osmastonii, A.sikkimense* and *A.hookeri.*

Small uniserriate hairs with a globular head and a unicellular body occur on the veins of most of the species. While in most they are found to occur on the major veins in they are found on the some of the minor veins in *A. pectinatum* and *Acaudatum.*

Table: VIII Major Characteristic of the Leaves of different species of *Acer* of the Darjiling-Sikkim Himalayas

Name of the species	Curvature	Balance		Form	Shape	Apex	Base	Margin				Texture at maturity	Size of lamina		Major venation		
		Lamina	Base					Type	Series	Serration Type	Apical angle		Length	Breadth	Type	Pattern	No. of Major veins
A. acuminatum	Convex	Sym.	Sym.	Simple Pal. 3-5L	Unequal Ovate-Caud	Acuminate with long acumen	Cuneate – Rounded	Toothed	Coarse Uni. / Bi	D1	Acuminate	Chartece	6-12	5 5-12	Palm. Acin.	Perfect Basal	5
A.campbellii	Convex	Sym.	Sym.	Simple Pal. 5-7L	Unequal Lanc-oblo	Acuminate	Cordate-truncate	Toothed	Simple Uni.	C1	Acute	Chartce – Coria	6-12.5	11 5-14	Palm. Actin	Perfect Basal	7
A. caudatum	Convex	Sym.	Sym.	Simple Pal 5-7 L	Unequal Ovate-Caud	Acuminate	Broadly Cordate	Toothed	Bi	D1	Acuminate	Coria.	7-14	6-13	Palm. Actin	Perfect Basal	7
A. hookeri	Convex	Sym.	Sym.	Simple Pal Un- 3L	Unequal Ovate	Acuminate	Shallow cordate	Toothed	Bi	D1	Acuminate	Chart	5-14	4-8	Palm. Actin.	Perfect Basal	5
A. laevigatum	Convex	Sym./ Asym.	Sym / Asym.	Simple Un. - 2-3	Unequal Lan.-Obl.	Acuminate	Rounded	Entire/ Serrulate	Uni.	C1	Acute	Chart	7-15	3-4.5	Palm. Actin	Imperfect marginal	3
A. oblongum	Convex	Sym	Sym.	Simple Un	Obl - Ellip	Acuminate	Obtuse-Rounded	Entire	-	-	-	Chart	5-17	3-7	Palm. Actin	Imperfect reticulate	3
A.osmastonii	Convex	Sym. / Asym.	Sym / Asym.	Simple 3 –5L, Un.	Unequal Ellip - ovate	Acuminate	Truncate-Rounded	Toothed	Uni.	C1	Acute	Chart	6-15	4-11.5	Palm. Actin	Perfect Basal	3
A.palmatum	Convex	Sym.	Sym.	Simple Pal.7- L	Unequal Lan.-obl.	Acuminate	Cordate	Toothed	Bi	C1	Acute	Chart.	4-5.5	3 5-5	Palm. Actin.	Perfect Basal	5-7
A.pectinatum	Convex	Sym.	Sym.	Simple 3-5 L	Unequal Ovate- obl.	Acuminate	Cordate	Toothed	Bi	C1	Acute	Sub-coraia.	6-14	4-8	Palm Actin.	Perfect Basal	5
A.sikkimense	Convex	Sym.	Sym.	Simple Un/ Pal.3 L	Unequal Ovate-cusp.	Acuminate	Cordate	Entire/ Toothed	Uni-Serru.	C1	Acute	Sub-corac.	7-15	4-9 5	Palm. Actin	Perfect Basal	5
A. stachyophyllum	Convex	Sym.	Sym.	Simple Un/Pal.3L	Unequal Ovate	Acuminate	Cordate	Coarsely Toothed	Bi	D1	Acuminate	Chart	5-8	4-6.5	Pal Actin.	Perfect Basal	5-3
A.sterculiaceum	Convex	Sym.	Sym	Simple Pal.3-5 L	Unequal Obl, - ovate	Acuminate	Cordate	Toothed	Uni.	C1	Acute	Coria	9-14 5	7.5-11	Palm. Actin.	Perfect Basal	5
A. thomsonii	Convex	Sym	Sym	Simple 3-5 lobed rare un	Unequal Elliptic – Sub-orbicul	Acuminate	Broadly cordate	Toothed	Uni	C1	Acute	Corac.	13 5-17	10-15	Palm Actin	Perfect basal	5

Table continued……

Name of the species	1° Veins		2° Veins				3° Veins			Higher Vein Order Type	Highest Order Vein	Marginal Ultimate Venation	Branching of veinlets		Areole		
	Size	Course	Size	Course	Angle of divergence	Inter-Secondary Vein	Size	Course	Angle of Origin Type				Degree Of Branching	No.of free Veinlet per areole	Type	Shape	Vein islet Number
A. acuminatum	Moderate	Straight	Weak	Uniformly Curved	Acute	Composite	Weak	Percurrent	RO	Distinct	4°	Incomplete	1-2 times	2-4	Imperfect Random	Quadrangular To polygonal	8 34 ±1 2
A.campbellii	Moderate	Straight	Moderate	Uniformly Curved	Acute	Composite	Moderate	Percurrent	RO	Distinct	4°	Incomplete	1-3 times	1-15	Imperfect Random	Pentagonal to polygonal	4 15 ± 1 90
A. caudatum	Moderate	Straight	Moderate	Uniformly Curved	Acute	Composite	Weak	Percurrent Forked	RO	Distinct	6°	Incomplete	1-2 times	1-4	Imperfect oriented	Pentagonal to polygonal	20 6 ± 1 90
A. hookeri	Moderate	Straight	Moderate	Uniformly Curved	Acute	Composite	Weak		RR	Distinct	5°	Incomplete	1-3 times	2-6	Imperfect random	Pentagonal To polygonal	9 12 ± 2 91
A. laevigatum	Moderate	Straight	Moderate	Uniformly Curved	Acute	Composite	Moderate	Percurrent Forked	RA	Distinct	5°	Incomplete	1-5 times	1-15	Imperfect rand		18 32 ± 4 32
A. oblongum	Stout	Straight	Moderate	Uniformly Curved	Acute	Composite	Moderate	Percurrent Forked	-	Indistinct	-	Fimbriate	-	-	Perfect oriented	Quadrangular Pentagonal	110 88 ± 19 99
A.osmastonii	Moderate	Straight	Moderate	Uniformly Curved	Acute	Composite	Moderate	Curved Forming loop	RA	Distinct	5°	Incomplete	1-4 times	2-11	Imperfect Random	Quadrangular Pentagonal	19 01 ± 6 95
A.palmatum	Moderate	Straight	Moderate	Uniformly Curved	Acute	Composite	Moderate	Percurrent	RR	Distinct	4°		3-4 times	3-12	Imperfect Random	Quadrangular Pentagonal	8 22 ± 0 53
A.pectinatum	Moderate	Straight	Weak	Curved	Acute	Composite	Weak	Percurrent	RO	Distinct	4°	Incomplete	1-4 times	2-4	Imperfect Random	Pentagonal Polygonal	21 63 ± 4 61
A.sikkimense	Moderate	Straight	Moderate	Curved	Oblique	Composite	Moderate	Percurrent	RR	Distinct	5°	Incomplete	1-3 times	2-4	Imperfect Random	Quadrangular Polygonal	9 55 ±4 14
A. stachyophyllum	Moderate	Slightly Curved	Moderate	Uniformly Curved	Acute	Composite	Moderate	Percurrent Branched	RO	Distinct	5°	Incomplete	1-2 times	1-4	Imperfect Random	Polygonal Quadrangular	48 45 ± 7 14
A.sterculiaceum	Moderate	Slightly curved	Moderate	Uniformly curved	Oblique	Composite	Moderate	Percurrent Forked	RO	Distinct	6°	Incomplete	1-3 times	2-16	Imperfect Random	Pentagonal Polygonal	23 52 ± 1 60
A thomsonii	Weak	Straight	Weak	Uniformly Curved	Oblique	Composite	Moderate	Percurrent Forked	RO	Distinct	6°	Incomplete	1-3	1-15	Imperfect Random	Polygonal	32 43 ± 11 88

TABLE 8.2. MAJOR CHARACTERISTICS OF THE STOMATA IN THE DIFFERENT SPECIES OF *Acer*.

NAME OF THE SPECIES	STOMATAL FREQUENCY	STOMATAL INDEX	STOMATA							
			TYPE	NO. OF SURROUNDING EPIDERMAL CELLS	STOMALTAL COMP		GUARD CELL			
					LENGTH µ	BREADT	LENGTH µ	BREADT	THICKNESS OF INNER WALL	LENGTH OF PORE
A.pectinatum		24.07 ± 5.	Hypostomati Anomocytic	4-5	16.61-22.36	10.95 – 17.46	15.49-18.48	6.34 7.30	1.58-2.38	5.56-11.26
A.acuminatum	338.02± 26.9	9.68±3.67	Hypostomati Anomocytic	6-7	15.49-18.48	11.25-12.87	15.87-25.38	5.37 – 6.24	0.99-1.36	6.62-8.85
A. campbellii	493. 82±36.9	19.51±4.6	Hypostomati Anomocytic	5-7 sometim 4	15.87-25.38	11.27-20.63	19.24-22.91	5.71-9.37	1.2-2	7.9-6.35
A.caudatum	313.18±32.1	15.69±3.8	Hypostomati Anomocytic	5-6	19.24-22.91	15.07-18.84	15.87-20.24	6.90-7.59	1.24-1.52	12.31-13.34
A. hookeri	677.26±46.9	19.51±4.6	Hypostomati Anomocytic	4-6 usually 6	15.87-20.24	11.27-20.63	7.94-17.58	5.71-9.37	1.24 – 1.84	4.76-6.35
A.laevigatum	718.47±42.4	16.27±3.2	Hypostomati Anomocytic	4-6	7.94-17.58	10.12-14.56	19.05-22.38	4.13-6.35	1.24-1.48	5.06-8.74
A. oblongum	388.01±29.3	11.67±3.3	Hypostomati Anomocytic	5-8 usually 6	19.05-22.38	15.87-20.53	12.43-15.07	5.35-9.52	2.12-4.36	9.51-12.2
A.osmastonii	731.92±59.7	14.29±3.9	Hypostomati Anomocytic	4-6	12.43-15.07	10.04-13.82	10.12-18.98	4.76-7.62	1.24-1.52	4.29-9.52
A.palmatum	579.28±39.3	17.82±4.3	Hypostomati Anomocytic	4-5	10.12-18.98	13.92-17.72	16.61-22.36	6.35-9.4	1.24-2.48	5.56 7.94
A.pectinatum	758.37±62.9	24.07±5,4	Hypostomati Anomocytic	4-5	16.61-22.36	10.95-17.46	15.18-18.74	6.34-7.3	1.58-2.38	5.56-11.26
A.sikkimense	513.82±32.1	16.42±5.9	Hypostomati Anomocytic	4-5	15.18-18.74	12.65-16.46	16.46-22.61	5.65-8.4	1.24-1.84	7.32-10.12
A.stachyophyllum	423.39±46.1	17.42±3.9	Hypostomati Anomocytic	6 or sometin 4-5	16.46-22.61	12.53-15.12	16.45-20.47	6.28-7.2	1.48-1.84	9.52-15.98
A. sterculiaceum	382.56±28.3	8.51±2.79	Hypostomati Anomocytic	5 sometimes	16.45-20.47	11.30-12.31	15.15-19.74	5.15-5.63	1.24-2.4	12.06-13.82
A.thomsonii	283.35±24.5	7.14±2.81	Hypostomati Anomocytic	4-6 usually 5	15.15-19.74	12.65-18.98	15.49-18.48	5.08-8.41	1.24-2.13	7.93-11.13

TABLE 8.3. DIFFERENT TYPES OF APPENDAGES ON THE LEAVES OF *Acer* L OF THE DARJILING SIKKIM HIMALAYA

Name of the Species	UNICELLULAR TRICHOME(μ)			UNISERRIATE HAIRS(μ)					MULTISERRIATE HAIRS	
	LOCATION	LENGTH	BREADTH	LOCATION	HEAD		BODY		LOCATION	LENGTH
					LENGTH	BREADTH	LENGTH	BREADTH		
A. acuminatum	Major veins lamina	165-312	21.41-45.23	Pri and Sec Vein	23.8-26.18	19.04-21.42	41.61-57.14	14.28-16.7	-	-
A.campbellii	Primary and Sec. veins	171.4-433	19.04-39.04	Pri. and Sec veins.	27.38-38.09	27.38-28.57	66.67-80-96	16.64-19.08	Vein axil	0.6 mm
A. caudatum	Pri.vein	90.47-238.09	23.80-35.72	Pri. and Sec Vein	21.62-23.68	16.24-17.56	41.67-43.23	11.09-13.09	-	-
A. hookeri	-	-	-	Pri. Vein	26.19-27.38	13.80-14.28	38.04-92.85	11.90-13.80	Vein axil	Upto 2.5mm
A. laevigatum	-	-	-	Pri. Vein	26.53-27.38	21.42-23.80	59.34-62.38	11.09-13.92	Vein axil	Upto 1 mm
A. oblongum	Lamina and Axils	0.5-3mm	57.23-71.42	-	-	-	-	-	-	-
A.osmastonii	Vein axils	133.35-340.76	64.28-83.34						Vein axil	Upto 2.5mm
A.palmatum	Vein axils	128.32-154.56	38.09-47.62							
A.pectinatum	Major vein Lamina	219.09-428.16.	45.23-53.32	Major vein	39.28-42.85	23.80-26.19	90.47-95.23	21.42-26.19	-	-
A.sikkimense	Primary vein	128.57-340.78	35.45-42.23	-	-	-	-	-	Vein axil	Upto 2-3mm
A. stachyophyllum	Vein axil	1-2mm	-	-	-	-	-	-	-	-
A.sterculiaceum	Pri. and Sec Veins	138.09-340.47	30.95-33.34	Pri. and Sec veins	26.19-30.95	23.89-33.34	74.86-88.58	19.04-21.54	-	-
A. thomsonii	Major vein and lamina margin	19.03-42.86	33.34-48.24	Pri. and Sec vein	38.04-42.86	30.95-32.32	54.96-83.34	17.86-21.23	-	-

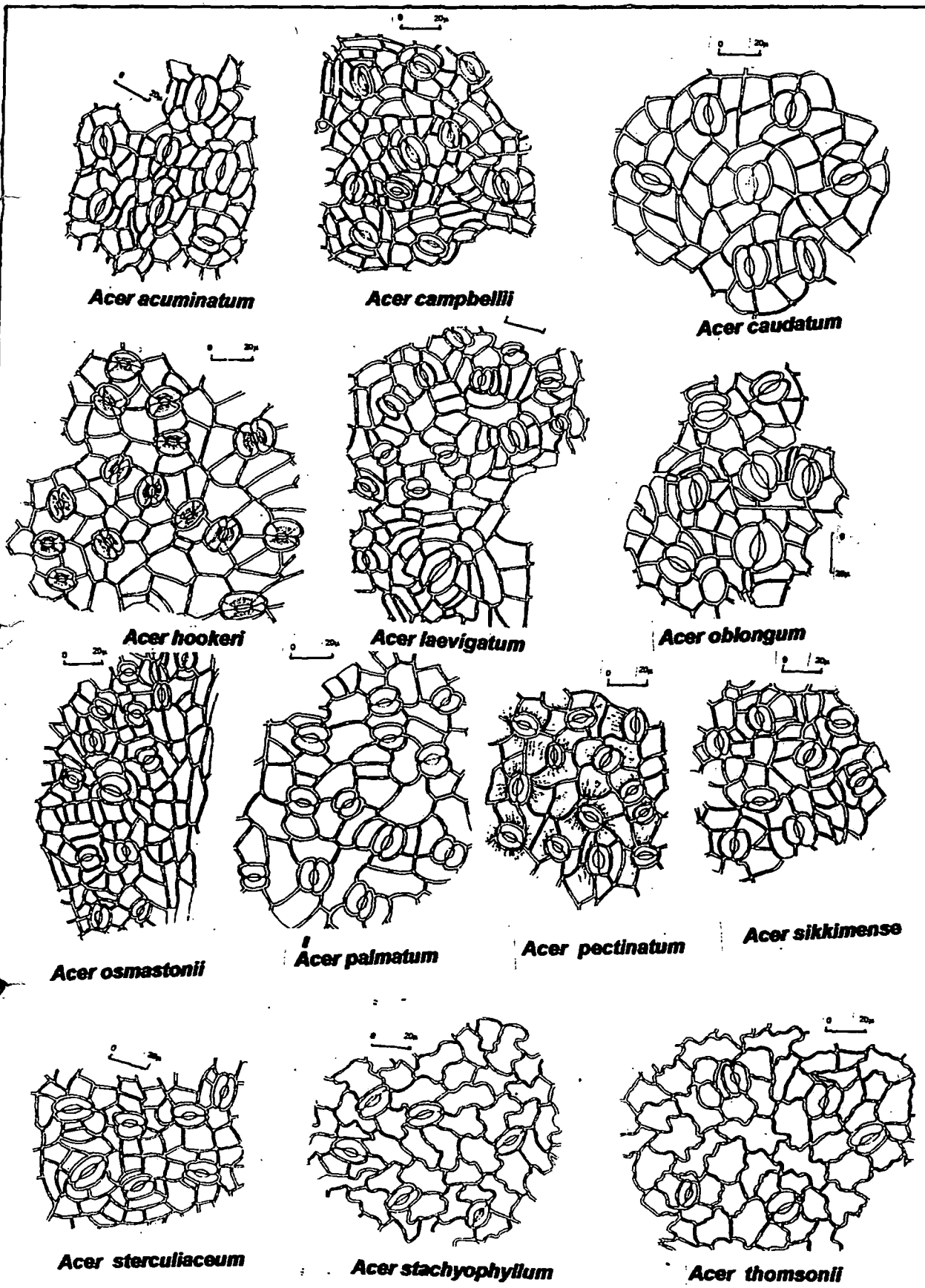


FIGURE 8.1. CAMERA LUCIDA DRAWING OF THE LOWER SURFACE OF LEAF SHOWING STOMATA OF DIFFERENT SPECIES OF *Acer L.*

Fig. 8.2. SCHEMATIC REPRESENTATION OF THE BASIC LEAF TYPES IN THE GENUS *Acer* AND THEIR PROBABLE EVOLUTIONARY TRENDS

(Adapted from *Maples of the World.*)

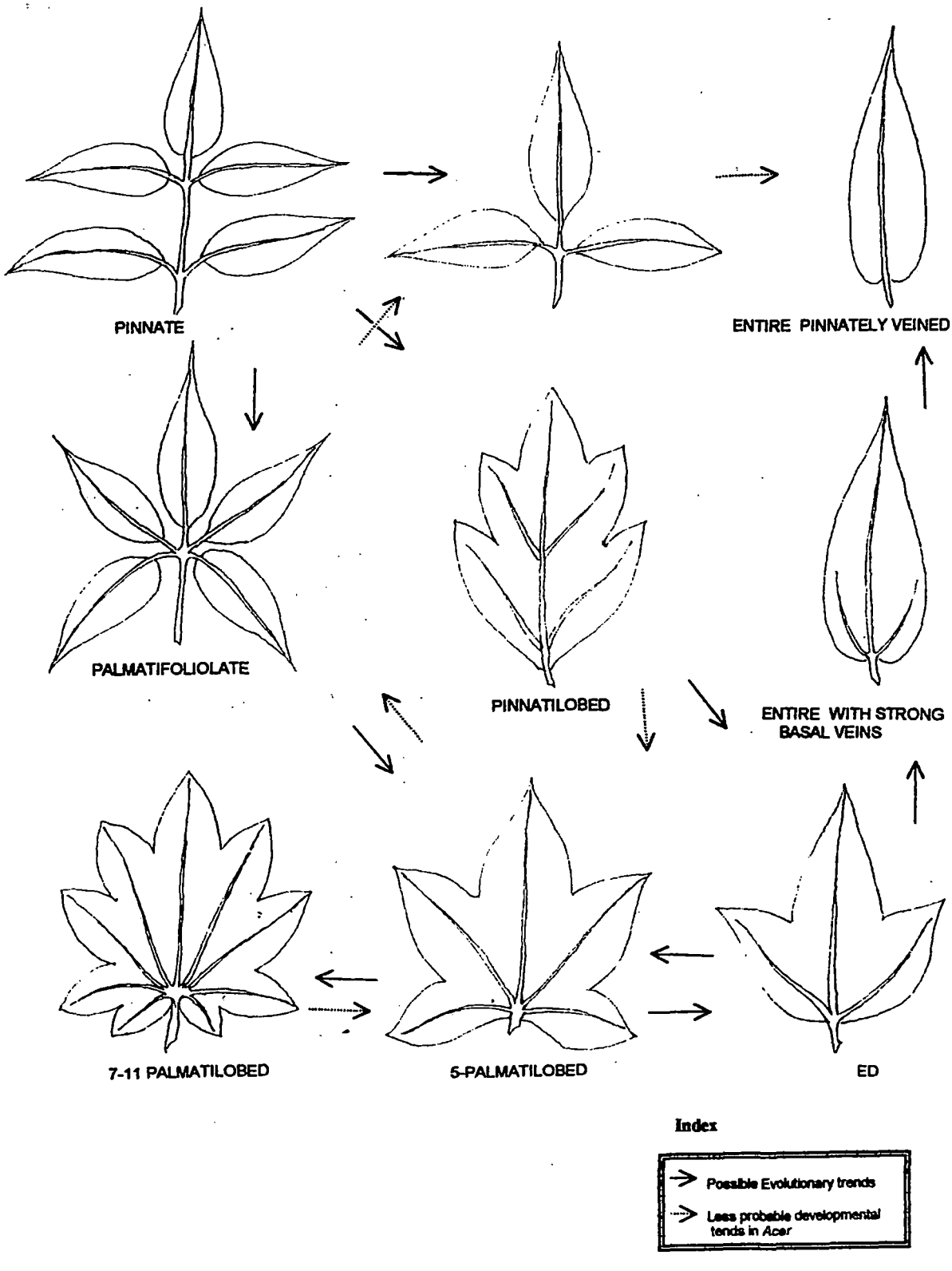
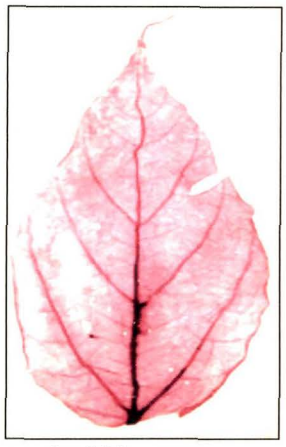
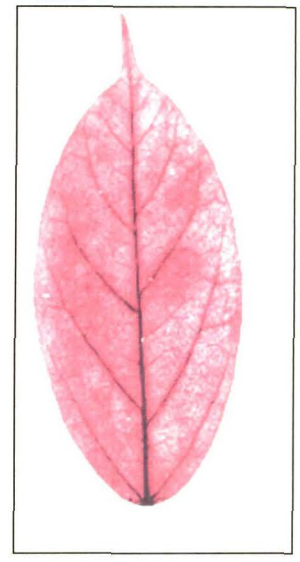


PLATE 8.1. MAJOR VEIN PATTERN OF SOME OF THE SPECIES OF *Acer* l. OF THE DARJILING –SIKKIM HIMALAYA.

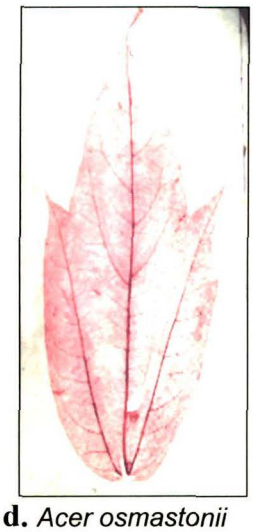


a. *A.sikkimense*

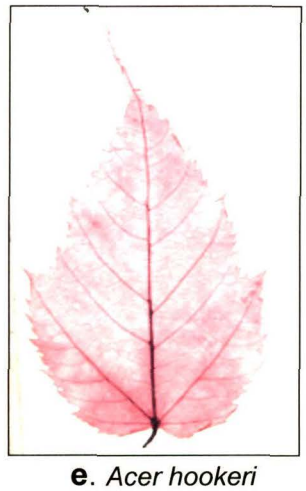
b. ***Acer thomsonii***



c. *Acer oblongum*

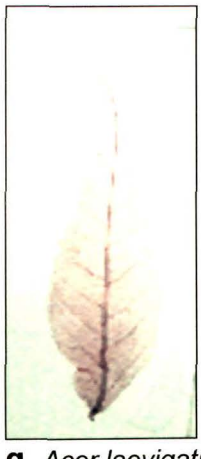


d. *Acer osmastonii*

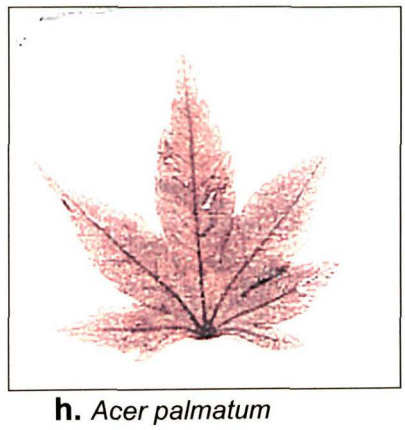


e. *Acer hookeri*

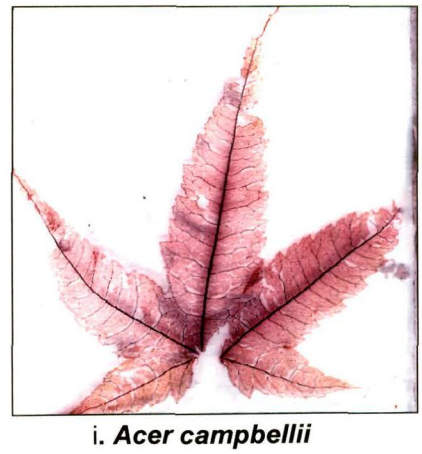
f. *Acer sterculiaceum*



g. *Acer laevigatum*

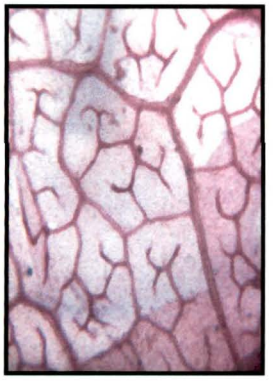


h. *Acer palmatum*

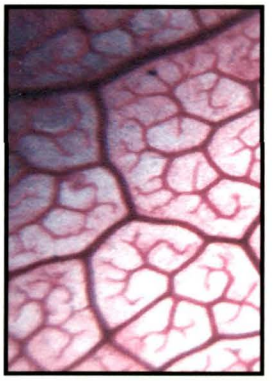


i. ***Acer campbellii***

PLATE 8.2. PORTION OF LEAF SHOWING MINOR VEINATION PATTERN IN THE DIFFERENT SPECIES OF *Acer* OF THE DARJILING SIKKIM HIMALAYA.

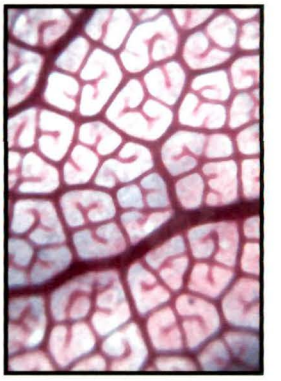


a. *Acer acuminatum*

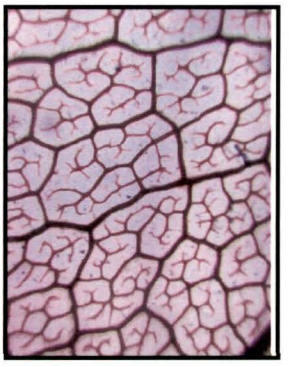


b. *Acer campbellii*

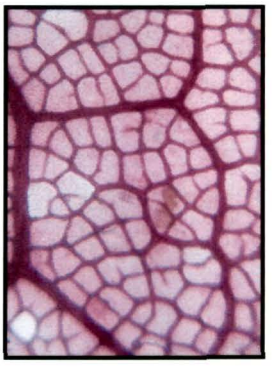
c. *Acer caudatum*



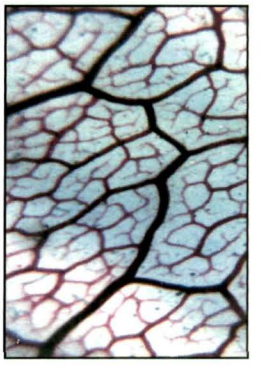
d. *Acer hookeri*



e. *Acer laevigatum*

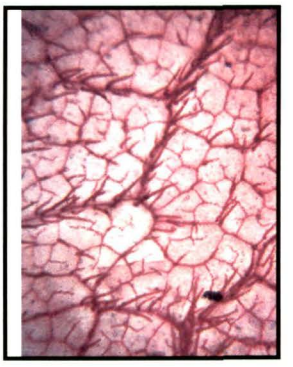


f. *Acer oblongum*

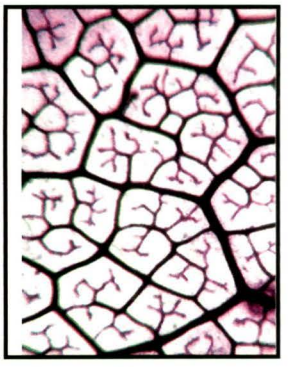


g. *Acer osmastonii*

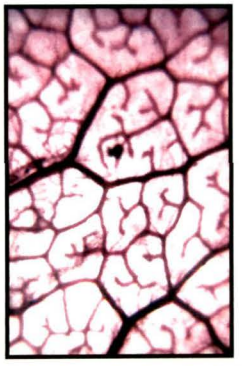
h. *Acer palmatum*



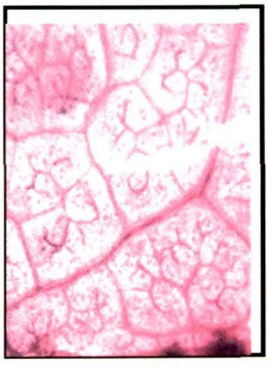
i. *Acer pectinatum*



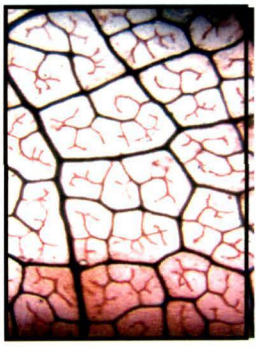
j. *Acer sikkimense*



k. *Acer stachyophyllum*



l. *Acer sterculiaceum*



m. *Acer thomsonii*