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LEAF ARCHITECTURAL STUDIES IN THE ASTERACEAE-I

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Abstract

Leaf architectural studies have been made in 22 genera and 25 species belonging to 8 tribes of the Asteraceae. Leaves are oblong, ovate or elliptic. Base acute, obtuse or lobate. Apex acute, acuminate, attenuate or labate. Margin is lobed, wavy or serrate. Average size of the fully mature foliage leaves vary from species to species. Major venation pattern conforms to pinnate-craspedodromous, pinnate-camptodromous with festooned brochidodromous secondaries, acrodromous and palinactinodromous types. Marginal ultimate venation is either incomplete, looped or fimbriate. Number of primary veins vary according to the type of venation pattern. The number of secondaries on one side of the primary vary from species to species and even within the same species. Highest vein order is noticed up to 5^{o}. Areoles are formed by tertiary and higher order veins. Bundle sheath is noticed in some species. Loop formation, isolated free vein endings and isolated tracheids are observed. Tracheids are uni,bi-or multi-seriate. Secretory cavities are observed at the margins of *Tagetes patula*. Qualitative features and numerical data on leaf architecture are compiled.

Introduction

Radford et, al. (1974) have pointed out that leaves are generally neglected organs in taxonomic and comparative morphological studies due to the lack of detailed classification of their features. The arrangement of veins in the lamina is an important component of the study of leaf architecture. Ettingshausen (1861) proposed the venation pattern terminologies for angiosperms which were systematized and made precise by Hickey (1973). Melville (1976) gave venation pattern terminologies for both monocots and dicots. In an attempt to study the vasculature of leaves, Foster (1950) published data on the feathery venation that is characteristic of Quiinaceae. Foster (1950, 1961, 1966, 1970, 1971) also made a detailed survey of leaves with dichotomous venation. In recent past attempts have been made to study the leaf architecture of some dicotyledonous families (Sehgal & Paliwal, 1974; Jain, 1975; Singh et, al., 1978; Tyagi & Kumar, 1978; Inamdar & Murthy, 1978; Inamdar & Shenoy, 1981a, 1981b; Avita et, al., 1981 etc.). Banerjee & Deshpande (1973) and Banerjee (1978) made a cursory reference to the foliar venation of

Table 1. **Qualitative leaf features of Asteraceae**

S. No.	Name of taxa	Shape	Base	Apex	Margin	Taxture	Primary vein size	Intersecondary vein	Predominant tertiary vein origin angle	Marginal ultimate venation	Major venation pattern
1	*Acanthospermum hispidum* D.C.	Elliptic	Acute	Acute	Serrate	Coriaceous	Stout	Compositae	R-A, A-A	Incomplete	Semi Craspedodromous
2	*Ageratum conyzoides* L.	Ovate	Obtuse	Acuminate	,,	,,	Moderate	,,	A-A, R-R	,,	,,
3	*Blainvella rhomboides* cass.	Elliptic		Acute	,,	,,	,,	,,	R-R, R-A	,,	,,
4	*Bidens biternata* (Lour.) Merr & Sherff	Ovate		,,	,,	,,	Stout	Absent	R-R, R-A	Fimbriate	Simple craspedodromous
5	*Chrysanthemum indicum* L.	,,	Acute	Obtuse	Lobed	,,	Massive	Simple	R-R, R-A	Looped	Paliactinodromous
6	*Dhalia pinnata* Cav.	,,		Acute	Serrate	Membranaceous	Moderate	Compositae	R-R	Fimbriate	Semi Craspedodromous
7	*Eclipta alba* L.	Elliptic			Wavey	Coriaceous	,,	,,	R-R, R-A	Incomplete	Festooned brochidodromous
8	*Emilia sonchifolia* Linn.	,,	,,	Obtuse	,,	Membranaceous	Stout	,,	A-A, R-A, R-O	Looped	Simple craspedodromous
9	*Erigeron asteroides* Roxb.	,,	,,	Acute	Serrate	Coriaceous	Massive	Simple	A-A, R-R	Incomplete	Semi Craspedodromous
10	*Guizotia abyssinica* Cass	Oblong		,,	,,	,,	,,	Compositae	A-A, R-R	,,	,,

11	*Helianthus annus* L.	Ovate	Obtuse	”	”	”	Stout	”	A-A, A-R	”	”
12	*Helianthus* sps.	”	”	Acuminate	”	Membranaceous	Weak	”	R-R, R-A	”	”
13	*Myriactis wallichii* Less.	Elliptic	Acute	Acute	”	Cariaceous	Moderate	”	R-R, O-A, R-A	Looped	”
14	*Parthenium hysterophorus* L.	Ovate	”	”	Lobed	”	Massive	”	R-R, R-A	Incomplete	Mixed craspedodromous
15	*Sonchus oleraceous* L.	Oblong	Lobate	Obtuse	Serrate	Membranaceous	Moderate	”	A-A	”	Semi Craspedodromous
16	*Splianthus acumell* Murr.	Ovate	Obtuse	Acute	”	Coriaceous	”	”	R-R, R-A, A-A	”	”
17	*Siegesbeckia orientalis* L.	”	Acute	”	Crenate	”	”	”	A-A, R-R	”	”
18	*Solidago virga-aurea* Linn.	Oblong	”	Alternate	Serrate	”	Stout	”	R-O, A-R	”	”
19	*Sclerocarpus africanus* Jacq.	Ovate	Obtuse	Acute	”	”	Moderate	”	R-R, R-A	”	Acrodromous
20	*Tagetes patula* L.	Elliptic	Acute	”	”	”	Massive	Absent	R-R, R-A	”	Festooned brochidodromous
21	*Tagetes* sp.	”	Obtuse	Obtuse	Smooth	Membranaceous	Moderate	Simple	R-R, R-A, A-A	Looped	Acrodromous
22	*Tridax procumbens* Linn.	Ovate	”	Acute	Serrate	”	Weak	Compositae	R-R, R-A	Incomplete	Festooned brochidodromous
23	*Vernonia anthelmintica*	”	Acute	”	”	Coriaceous	”	”	R-R, R-A	”	Semi Craspedodromous
24	*Vernonia cineria* Murr.	Elliptic	”	Obtuse	”	”	Moderate	Simple	R-A, R-R	”	”
25	*Vernonia divergens* L.	”	”	Acuminate	Smooth	Membranaceous	Massive	Compositae	R-A	”	Festooned brochidodromous

the family Asteraceae. The present work has been undertaken on the leaf architecture of 25 species as no detailed report exists. Terminologies as defined by Hickey (1973) and Hickey & Wolfe (1975) are followed.

Material and Methods

Material of twenty-five species (Table I) was collected from the University campus. Leaves were cleared following the method of Rao et, al. (1980). Direct photographs of cleared leaves were taken on an enlarger. The size of the leaves was measured on a graph paper. The average of 5 readings of different leaves were taken for all studies and were tabulated.

Observations

Leaves are simple or compound. The leaf shape may be ovate, oblong or elliptic. Base is acute, obtuse or lobate. Apex is acute, acuminate, attenuate or obtuse. Margin is lobed, wavy or serrate (Fig. 5). The texture of the leaf is coriaceous or membranaceous. Secretory cavities are present at the margin of *Tagetes patula* (Fig. 6).

Major venation pattern is either pinnate-craspedodromous, pinnate-camptodromous with festooned brochidodromous secondaries, acrodromous or palinactinodromous. On the basis of the relative thickness of the veins, they can be classified into several size classes. The primary vein is the thickest which originates from the base of the lamina and traverses towards its apex. The thickness of the primary vein gradually decreases from base towards the apex. Primary vein gives rise to secondaries on either side which are thinner than the primary. They originate either in opposite, sub-opposite or alternate fashion. Their number and the angle of divergence vary from species to species and even within the same species. Secondaries after originating from primary pass towards the margin. They may or may not terminate at the margin. Depending upon the number of primaries and the arrangement of secondaries major venation pattern can be classified into several types and subtypes. In pinnate-craspedodromous type (Fig. 1) single primary vein gives off secondaries which divide dichotomously, with one arm terminating at the margin and the other joining with superadjacent secondary. In pinnate-camptodromous with festooned brochidodromous type (Fig. 2) single primary vein gives rise to secondaries which do note terminate at the margin, but join with superadjacent secondaries and forms prominent loops. Secondaries having a set of secondary loops outside the main brochidodromous loops and forms festooned brochidodromous type. In acrodromous type (Fig. 3) 3-4 primary veins originates from a single point and pass towards the apex in a convergent fashion. In palinactinodromous type (Fig. 4) more than one primary vein originates from one or two points and pass towards the apex in a divergent manner.

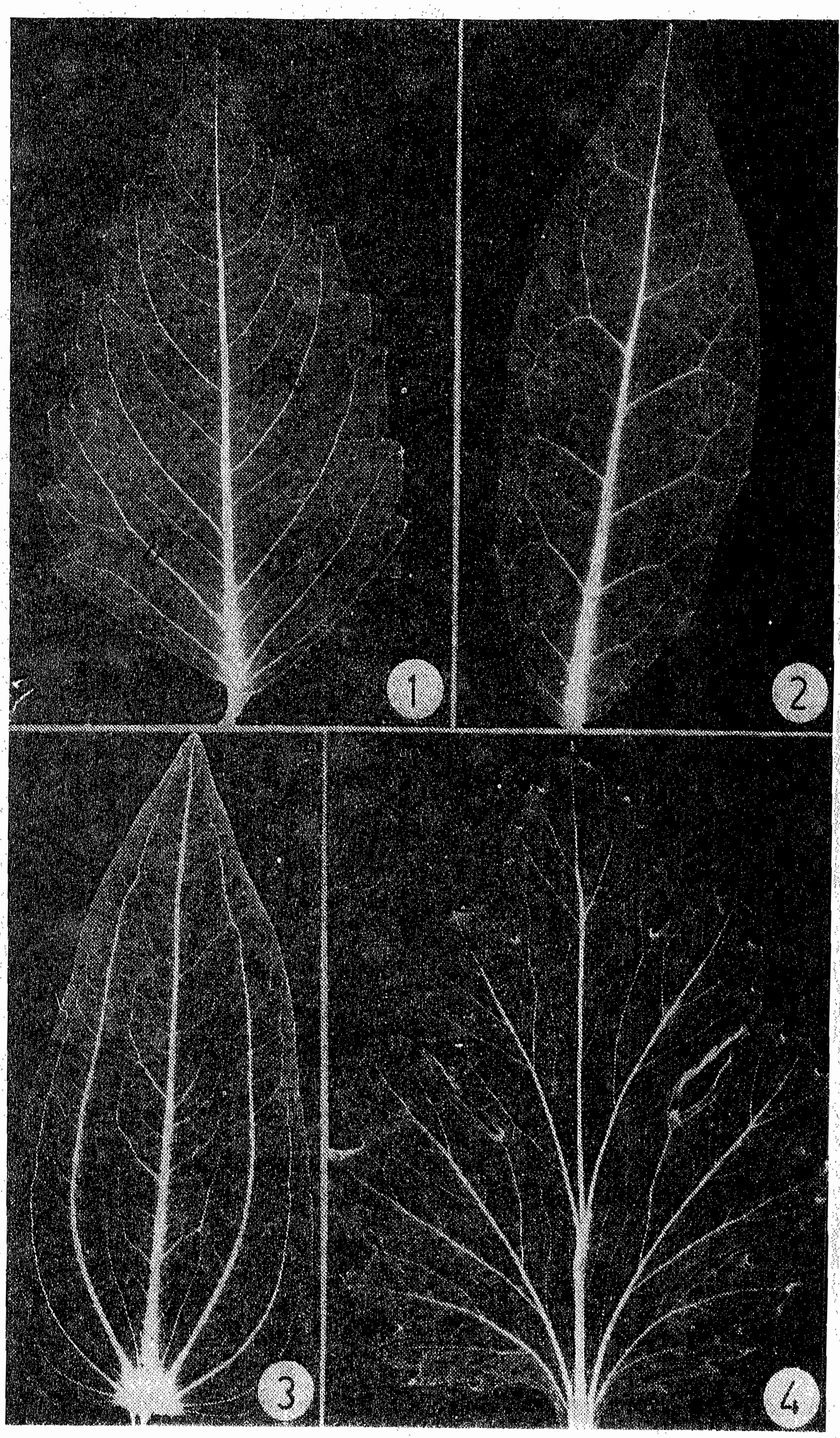

Fig. 1-4. Photographs showing the venation patterns of cleared leaves.

1. *Dahlia pinnata* x 1.5
2. *Vernonia divergens* x 2
3. *Tagetes* sps. x 1.5
4. *Chrysanthemum indicum* x 1.4

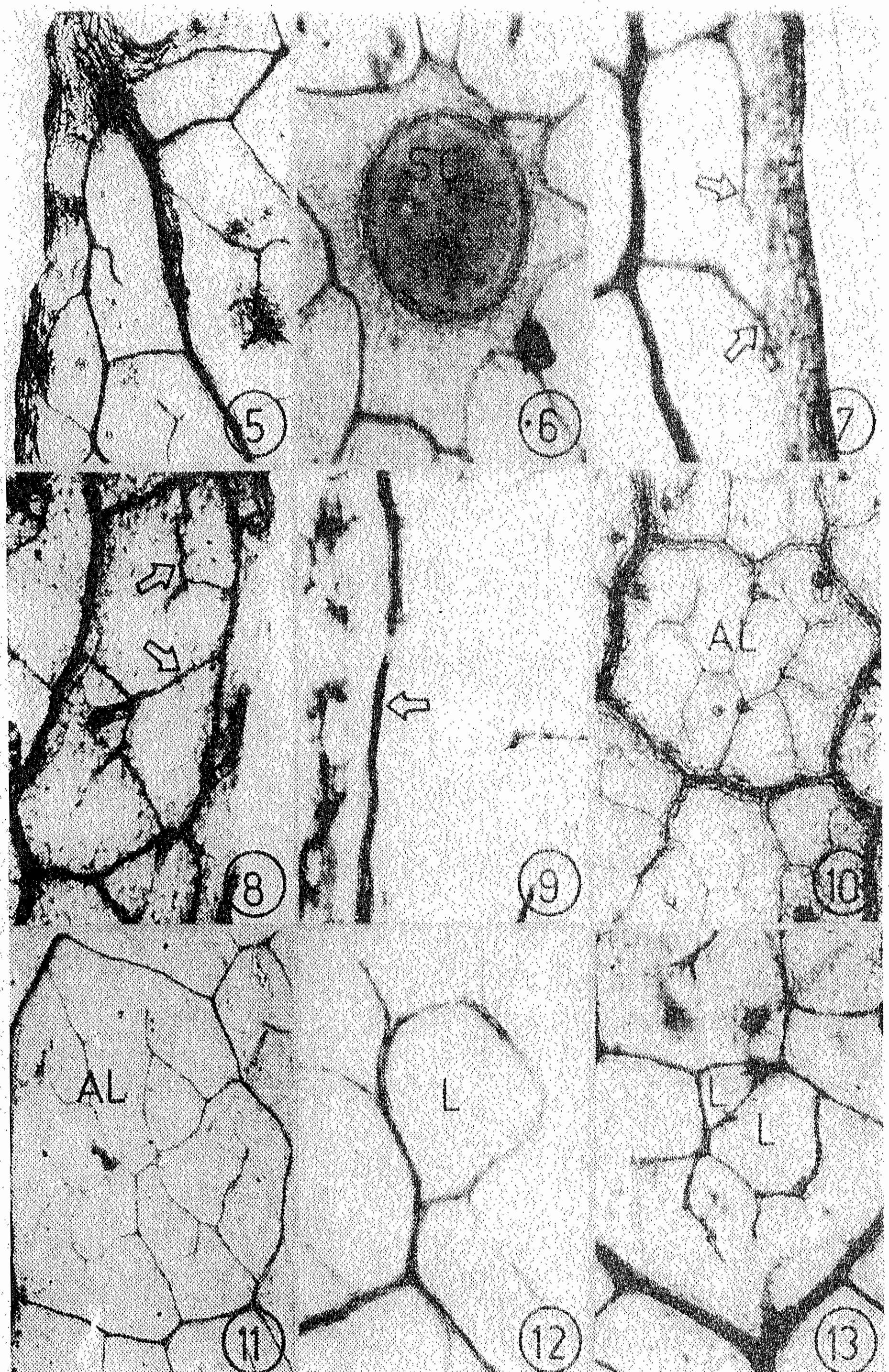

Fig. 5-13. Photomicrographs showing various aspects of leaf architecture.

5. *Dahlia pinnata* x 40
6. *Tagetis patula* x 100
7. *Vernonia divergens* x 100
8. *Myriactis wallichii* x 40
9. *Bidens biternata* x 120
10. *Tagetes* sps. x 40
11. *Tagetes palula* x 40
12. *Vernonia divergensa* x 92
13. *Solidago virga-aurea* x 100

(AL: areole, L: loop, SC: secretary cavity)

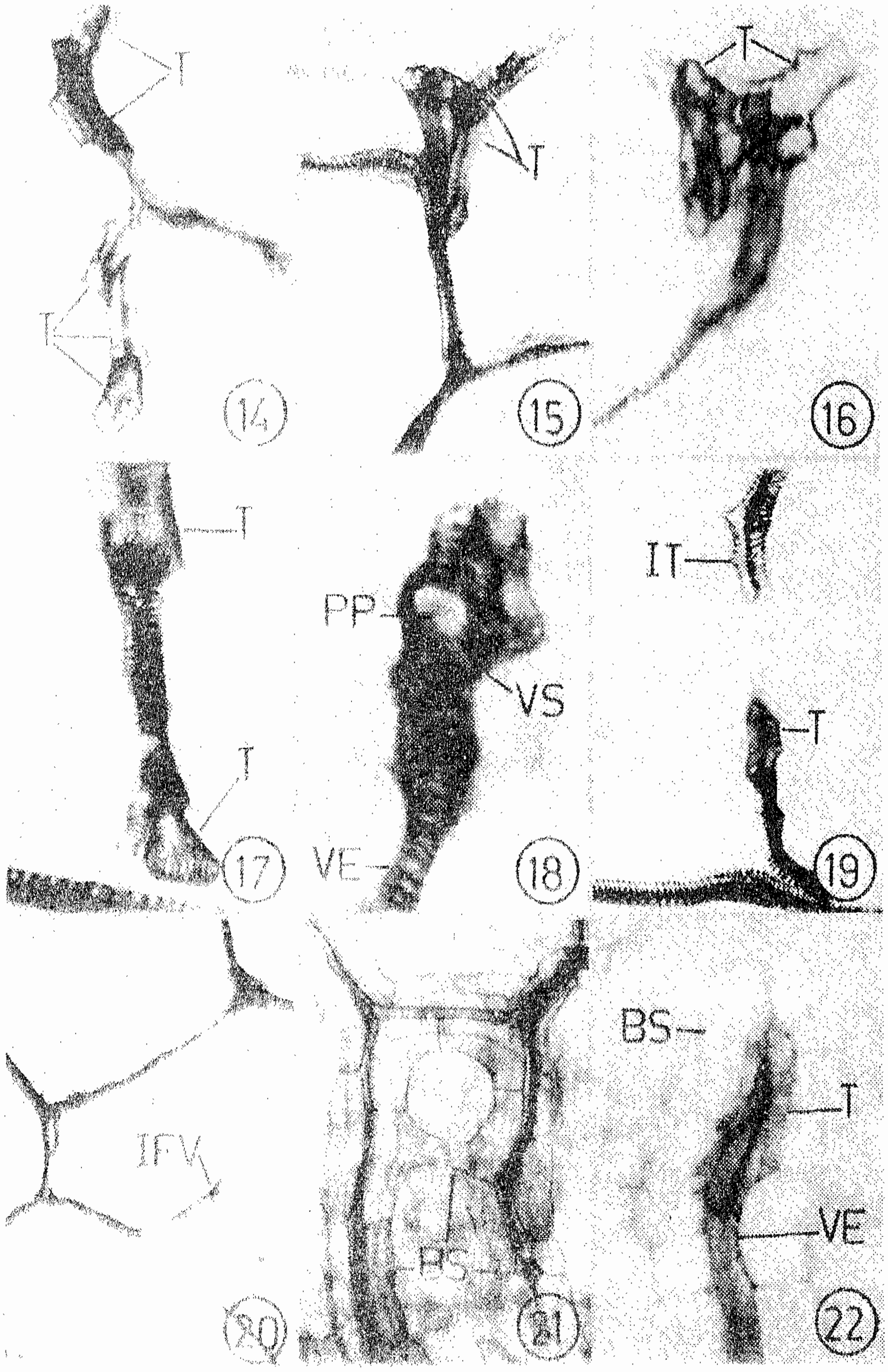

Fig. 14-22. Photomicrographs showing various aspects of leaf architecture.

14. *Solidago virga-aurea* x 350
15. *Solidago virga-aurea* x 350
16. *Solidago virga-aurea* x 600
17. *Solidago virga-aurea* x 640
18. *Solidago virga-aurea* x 920
19. *Solidago virga-aurea* x 400
20. *Solidago virga-aurea* x 160
21. *Tagetes* sps. x 208
22. *Parthenium hysterphorus* x 500

(T: tracheid, PP: perforation plate, VS: Vessel, VE: Vein ending, IT: isolated trachied, IFV: Isolated free vein ending, BS: Bundle sheath)

Intersecondary veins (Fig. 1 at arrows) are present between two secondaries which are thinner than the secondaries and originate from primary vein.

Minor veins which are of the next category of veins originating from the secondaries or tertiaries form the minor venation pattern. Highest vein order is observed up to 5^{o} The orientation of the higher order veins is random. In all the cases the higher order veins are uniseriate. Vein endings may or may not have terminal tracheids.

Marginal ultimate venation is either incomplete (Fig. 7 at arrows), looped (Fig. 8 at arrows) or fimbriate (Fig. 9 at arrows). The higher order veins after their ramification fuse to form a fimbriate vein which runs just inside the margin. Fimbriate vein is observed in *Bidens biternata* and *Dahlia pinnata*. In *Chrysanthemum indicum, Emilia sonchifolia, Myriaetis wallichii* and *Tagetes* sp. marginal ultimate venation is looped. In the remaining species marginal ultimate venation is incomplete.

Areoles of different sizes (Figs. 10, 11) are formed by the tertiaries and higher order veins. They are mostly irregular in shape. The number of vein endings which cross the areoles vary from species to species and even within the same species. Vein endings may be simple or branched. In branched vein endings both the arms may be equal or unequal.

Loop formation (Figs. 12, 13) is formed by the union of two ultimate vein endings (*Vernonia divergens*) or two terminal tracheids (*Solidago virga-aurea*).

Trachieds on the vein endings show increase in cell diameter. Trachieds are uniseriate (Fig. 13), biseriare (Fig. 14), multiseriate (Fig. 15) or grouped (Fig. 16). Tracheids may be long or short. Normally, they occur on the vein endings, but sometimes in the middle of the vein (Fig. 17). In case of *Solidago virga-aurea* a vessel like element (Fig. 18) is present at the vein ending.

In *Solidago virga-aurea* isolated tracheid (Fig. 19), isolated free vein endings (Fig. 20) are observed which are lying free in the mesophyll tissue.

All the veins including tracheids are ornamented by parenchymatous bundle sheath. Bundle sheath is quite prominent in *Parthenium hysterophorus* (Fig. 21) and *Tagetes* sp. (Fig. 22).

Discussion

According to Banerjee & Deshpande (1973), Banerjee (1978) the venation pattern is craspedodromous in *Launea, Sonchus* and *Amberboa.* These authors considered that

Table 2: Numerical data on the venation patterns of Asteraceae

No.	Name of the taxa	Leaf area in mm^2	No. of 2^0 vein along one side of the primary	Angle between p & 2^0 veins	No. of areoles (vein-islets) for mm^2	No. of veinlets entering into 1 areole	No. of vein ending terminations for areole	Average size of the areole for mm^2	Absolute areole no. in thousands	Absolute vein ending termination no. in thousands	Highest vein order	No. of primary veins
1	*Acanthospermum hispidum* DC.	390	3–4	30^0–35^0	4	5–6	6–10	0.25	1.56	2.145	5^0	1
2	*Ageratum conyzoides* L.	1465	4	30^0–35^0	1	4	8	1	1.47	11.72	4^0	1
3	*Blainvella rhomboides* Cass	572	4–5	30^0–40^0	1	6	12	1	0.572	6.864	5^0	1
4	*Bidens biternata* (Lour) Merrd Sherff.	165	4–6	50^0–55^0	2	3	6	0.5	0.33	0.99	4^0	1
5	*Chrysanthemum indicum* L.	955	4–6	28^0–30^0	1	4	1	1	0.955	0.955	4^0	5
6	*Dahlia pinnata* Cav.	1390	5–7	35^0–55^0	1	4–6	10–14	1	1.39	16.68	5^0	1
7	*Eclipta alba* L.	370	4–6	40^0–45^0	1	3–5	8–12	1	0.37	3.7	4^0	1
8	*Emilia sonchifolia* Linn.	355	3–4	35^0–45^0	1	3	2	1	0.355	0.71	5^0	1
9	*Erigeron asteroides* Roxb.	165	4–5	55^0–60^0	2	3–5	4–6	0.5	0.33	0.825	4^0	1
10	*Guizotia abyssinica* Cass.	1613	5–7	40^0	1	6–8	7	1	1.613	11.3	3^0	1
11	*Helianthus annuus* L.	2640	6–8	50^0–60^0	3	8–10	10–12	0.33	7.92	29.04	5^0	1
12	*Helianthus* sps.	1940	5–6	60^0–65^0	1	4–8	6	1	1.94	11.64	4^0	1
13	*Myriactis wallichii* Less.	500	3–4	45^0–55^0	1.5	2	3	0.7	0.75	1.5	4^0	1
14	*Parthenium hysterophorus* L.	340	4–5	40^0–50^0	3	6	16	0.33	1.02	5.44	4^0	1
15	*Sonchus oleraceous* L.	774	2–3	25^0–30^0	1	3	5	1	0.774	3.87	5^0	1
16	*Spilanthes acmella* Murr.	510	4–6	40^0–45^0	1	4	5	1	0.51	2.55	4^0	1
17	*Siegesbeckia orientalis* L.	2265	6–8	70^0–90^0	1	4–8	10–12	1	2.26	24.91	5^0	1
18	*Solidago virga-aurea* Linn.	1116	4–6	46^0	1.5	5	5	0.7	1.67	5.9	5^0	1
19	*Sclerocarpus africanus* Jacq.	575	3–5	60^0–90^0	1	4–5	10	1	0.575	5.75	4^0	1
20	*Tagetes patula* L.	360	10–12	40^0–50^0	1	4–6	4–10	1	0.36	2.52	3^0	1
21	*Tagetes* sps.	800	2	30^0–35^0	1	4–5	4–6	1	0.8	4	4^0	1
22	*Tridax procumbens* Linn.	620	4–6	45^0–50^0	1	4–5	6–8	1	0.62	4.34	4^0	1
23	*Vernonia anthelmintica* Murr.	875	7–8	52^0–60^0	1	3	7	1	0.88	6.12	4^0	1
24	*Vernonia cinerea* Murr.	530	4–6	50^0–55^0	1	4	10	1	0.53	5.3	4^0	1
25	*Vernonia divergense* L.	1165	6–7	60^0–65^0	1	4	6	1	1.165	7	4^0	1

Launea which exhibits extreme open type of venation pattern be selected as starting plant. The present observation reveals that the Asterarceae exhibits diverse type of venation patterns, i.e. pinnate-craspedodromous, pinnate-camptodromous with festooned brochidodromous secondaries, acrodromous and palinactinodromous. It therefore becomes rather difficult to consider *Launea* as a starting plant since open craspedodromous venation is exhibited by several members of the Asteraceae (Hickey & Wolfe, 1975).

The characters such as number of secondaries, size of areoles, the number of vein endings entering into the areole vary from species to species and even within the same species. The veins which are surrounded by parenchymatous bundle sheath are termed as ornamented by Kakkar & Paliwal (1972). Such ornamentations are observed in some members of the Asteraceae. Gupta (1961) reported that the vein-islet number and veinlet termination number are inversely proportional to the area of the lamina. Nicely (1965) observed the significant variations within the same leaf as regards the size and shape of the areoles and number of vein endings in each vein-islet. The present observations also supports this.

Vein endings may be simple or branched, with or without terminal tracheids. Tracheids are uni-, bi- or multi-seriate. Kasapligil (1951) reported the occurrence of isolated veins in dicotyledonous leaves. Later Foster & Arnott (1960) in *Circaeaster* and Herbest (1972) in *Euphorbia* have noticed the presence of isolated veins. Isolated free vein endings and isolated tracheids are observed in *Solidago virga-aurea.*

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