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Leaf Architectural Studies in the Asteraceae-II

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ABSTRACT

Leaf architectural studies have been made in 15 genera and 25 species belonging to 6 tribes of the Asteraceae. Major venation pattern conforms to pinnate craspedodromous (simple and semi), pinnate camptodromous with festooned brochidodromous secondaries, acrodromous and actinodromous. Qualitative leaf features and numerical data regarding the venation pattern are charted. Areoles of different sizes and shapes are observed. Tracheids occur either solitary or in groups. Grouped tracheids are either uniseriate, biseriate or multiseriate. Isolated free vein endings are observed in *Centratherum phyllolaenum*. Bundle sheath is prominent in *Xanthium strumarium*. Secretory cavities are observed in the lamina of *Tricholepis amplexicaulis*.

INTRODUCTION

Asteraceae is one of the largest dicotyledonous families comprising 950 genera and 20,000 species (Willis, 1973), Banerjee and Deshpande (1973). Banerjee (1978a, 1978b) and Ravindranath and Inamdar (1982) studied leaf architecture of some Asteraceae. The present work describes leaf architecture in 15 genera and 25 species of the Asteraceae.

MATERIALS AND METHODS

The material of the 15 genera and 25 species of the Asteraceae was collected from different localities of Gujarat State (see Table 1). 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 was taken with the help of Carl-Zeiss photomicroscope I using ORWO NP 15 film. Terminologies as defined by Hickey (1973) and Hickey and Wolfe (1975) were followed.

OBSERVATIONS

Leaf morphology. Leaves simple or compound. Shape ovate, oblong, elliptic and filiform. Base acute, obtuse or cuneate. Apex acute or obtuse. Margin entire, serrate or erose,

Table 1. Qualitative leaf features of Asteraceae II

S. No.	Name of the taxa	Shape	Base	Apex	Margin	Texture	Primary vein size	Interse-c ondary vein	Predominant tertiary vein origin angle	Marginal ultimate venation	Venation pattern
1	*Adenostemma lavenia* L.	ovate	acute	acute	entire	membra-naceous	stout	simple	A-A, A-R, A-O	incomplete	Festooned brochidodromous
2	*Artemisia vulgaris*	pannati-sect filiform	acute	acute	entire	membra-naceous	stout	simple	A-A, R-A	looped	Simple craspedo-dromous
3	*Bidens bipinnata* auct non L.	ovate	obtuse	acute	serrate	charta-ceous	stout	simple	R-R, A-A	fimbriate	Semi-craspedo-dromous
4	*Blumea ampletans* DC.	elliptic	acute	acute	serrate	coriaceous	massive	absent	R-R, A-O, R-A	incomplete	Semi-craspedo-dromous
5	*B. belangeriana DC.*	elliptic	obtuse	obtuse	serrate	coriaceous	moderate	absent	R-R, R-A, A-A	incomplete	Semi-craspedo-dromous
6	*B. bifoliata* (L.) DC	elliptic	acute	obtuse	serrate	membra-naceous	stout	absent	A-O, A-R, R-R	incomplete	Semi-craspedo-dromous
7	*B. eriantha* DC. (Burm. f.)	elliptic	acute	acute	serrate	coriaceous	stout	simple	A-A, R-A	incomplete	Semi-craspedo-dromous
8	*B. lacera* (Burm. f.) DC	elliptic	cuneate	obtuse	serrate	membra-naceous	moderate	absent	R-A, R-R	incomplete	Simple craspedo-dromous
9	*B. laciniata* (Roxb.) DC	elliptic	acute	acute	serrate	membra-naceous	stout	absent	R-A, A-A	incomplete	Semi-craspedo-dromous
10	*B. malcolmii* (Cl) Hk.f.	elliptic or lan-ceolate	acute	acute	serrate	coriaceous	massive	composite	A-A, R-A, R-O	incomplete	Semi-craspedo-dromous
11	*B. membranacea* DC.	elliptic	acute	acute	serrate	membra-naceous	stout	absent	R-R, A-R	incomplete	Semi-craspedo-dromous
12	*B. mollis* (D. Don) Merr	elliptic	acute	acute	serrate	coriaceous	moderate	composite	R-R, R-A	incomplete	Semi-craspedo-dromous
13	*B. oxyodonta* DC.	elliptic	obtuse	acute	serrate	coriaceous	stout	absent	R-R, A-O	incomplete	Semi-craspedo-dromous

(continued)

S. No.	Name of the taxa	Shape	Base	Apex	Margin	Texture	Primary vein size	Intersecondary vein	Predominant tertiary vein origin angle	Marginal ultimate venation	Venation pattern
14	*Caesulia axillaris* Roxb.	elliptic	acute	acute	serrate	chartaceous	stout	composite	A-O	incomplete	Semi-craspedodromous
15	*Centratherum phyllolaenum* DC.	broadly elliptic	acute	acute	serrate	chartaceous	stout	absent	R-R, R-A	incomplete	Semi-craspedodromous
16	*Cyathocline purpurea* (Don) O. Ktze	oblong pannatisect	acute	acute	serrate	chartaceous	moderate	absent	A-A	incomplete	Simple craspedodromous
17	*Eupatorium odoratum*	ovate	obtuse	acute	smooth	coriaceous	stout	simple	R-R, A-R	incomplete	Acrodromous
18	*Lagascea mollis* Cav.	ovate	acute	acute	erose	coriaceous	moderate	simple	R-R, A-R	incomplete	Festooned brochidodromous
19	*Sphaeranthus indicus* L.	oblong	obtuse	obtuse	serrate	coriaceous	stout	composite	R-R	incomplete	Simple craspedodromous
20	*Spilantes paniculata* Wall.	oblong	acute	acute	erose	coriaceous	massive	simple	R-R, R-A	incomplete	Festooned brochidodromous
21	*Tricholepis amplexicaulis*	ovate	acute	acute	narrowly projected	coriaceous	stout	composite	R-R, R-O	incomplete	Semi-craspedodromous
22	*Vicoa auriculata* Cass	linear-lanceolate	acute	acute	regular spacing	membranaceous	stout	absent	R-R, A-R	incomplete	Festooned brochidodromous
23	*V. cernua* Dalz	elliptic	acute	acute	serrate	membranaceous	moderate	absent	R-R	incomplete	Semi-craspedodromous
24	*Vernonia cinerascens* Sch. Bip.	ovate	obtuse	obtuse	serrate	membranaceous	stout	composite	R-R, A-R, A-A	incomplete	Semi-craspedodromous
25	*Xanthium strumarium* L.	broadly ovate	acute	acute	serrate	coriaceous	moderate	composite	R-R	incomplete	Actinodromous

Texture chartaceous, coriaceous or membranaceous. The average, size of the fully mature leaf is vary from species to species. Secretory cavities are observed in the lamina of *Tricholepis amplexicaulis* (Pl. 2:E).

Major venation pattern. Major venation pattern is pinnate craspedodromous, pinnate camptodromous with festooned brochidodromous secondaries, acrodromous or actinodromous. In pinnate craspedodromous type single primary vein originate from base of the leaf lamina and traverse towards its apex. The thickness of the primary vein gradually decreases from base to the apex. The primary vein gives rise to secondary veins on either side in opposite, sub-opposite or alternate fashion. Secondaries after originating from the primary traverse towards the margin. If the secondaries directly terminate at the margin the venation pattern is simple craspedodromous (Pl. 1 C). Secondaries branch just inside the margin, with one arm terminating at the margin and the other join the super-adjacent secondary. This is called semicraspedodromous (Pl. 1 A). In pinnate camptodromous type secondaries do not terminate at the margin, but join together in a series of prominent arches. Primary loops having a set of secondary loops outside and forms festooned brochidodromous type (Pl. 1 D). In acrodromous type (Pl. 1 B) single primary vein gives rise two strongly developed secondaries which run in convergent arches. Arches are not recurved at the base. In actinodromous type (Pl. 1 E) 3 primary veins originating from a single point and run towards the apex in divergent fashion. Secondary veins give rise to tertiary veins. The origion of angle and the distribution is different in different species and even within the same species. Species-wise details of angle of origion are given in Table I. Intersecondary veins are present which are thinner than the secondaries and thicker than the tertiaries which originate from the primary (Pl. 1 A,D, at arrows).

Minor venation pattern. Tertiary veins give rise to quartarnaries (4° veins) and quartarnaries to quintarnaries (5° veins). Highest vein order is noticed upto 6°.

Higher order veins after their ramification fuse to form a fimbriate vein (Pl. 2 C, at arrows) which runs just inside the margin. Fimbriate vein is observed in *Bidens biternata*. In *Artemisia vulgaris* higher order veins join together to form looped type of margin (Pl. 2 B, at arrows). In remaining species, the marginal ultimate venation is incomplete (Pl. 2 A, at arrows).

Areoles (Pl. 2 D) are the smallest area of leaf blade surrounded by prominent veins. The areoles are well developed. The shape of the areoles may be triangular, quadrangular or irregular. The size of the areoles varies from species to species and even within the same species.

Vein endings. Higher order veins after their ramification end either blindly or with terminal tracheids. The number of veinlets entering into the areole is not constant feature. Vein endings may be simple or branched. Simple vein endings are either linear or curved. Branched once are devided dichotomously once or twice symmetrically or asymmetrically.

Vein endings form loops (Pl. 2 G,H,I) which are formed by the union of ultimat

vein endings or the union of terminal tracheids.

Tracheids. Tracheids which show an increase in cell diameter and which are variable in shape normally present on the vein tips. They may be solitary or in groups. Solitary tracheids are narrowly elongated (Pl. 3 A, C, E) or broadly isodiametric (Pl. 3 B). Grouped tracheids are arranged in uniseriate (Pl. 3 F), biseriate (Pl. 3 G) and multiseriate (Pl. 3 D, H) fashion. They may be either juxtaposed (Pl. 3 H) or superimposed (Pl. 3 F, G).

Isolated free vein endings. Isolated free vein endings which are disjunct from the veins are observed in *Centratherum phyllolaenum* (Pl. 3 I).

Bundle sheath. Bundle sheath (Pl. 2 F) is observed in *Xanthium strumarium* which ensheaths all category of veins including tracheids. The parenchymatous bundle sheath cells are arranged in a direction parallel to the veins.

DISCUSSION

According to Hickey and Wolfe (1975) in the Asterales venation pattern conforms to pinnate brochidodromous type. According to Banerjee and Deshpande (1973) and Banerjee (1978a, 1978b) the venation pattern is craspedodromous in *Launea*, *Sonchus* and *Amberboea*. The latter authors are of the opinion that *Sonchus* and *Launea* represent extremely open type of venation pattern. However, it is rather difficult to say that *Launea* and *Sonchus* are starting plants since open craspedodromous type of venation is exhibited by many members of the Asteraceae. Ravindranath and Inamdar (1982) reported pinnate craspedodromous, pinnate camptodromous with festooned brochidodromous secondaries, acrodromous and palinactinodromous type of venation pattern in some members of the Asteraceae. During the course of present studies five types of venation pattern is noticed. The venation types observed are pinnate craspedodromous (simple and semi) pinnate camptodromous with festooned brochidodromous secondaries, acrodromous and actinodromous.

Leaf characters such as the number of secondaries on one side of the primary, the size and shape of the areoles, number of veinlets and vein terminations entering into the areole are vary from species to species and even within the same species. Gupta (1961) reported that the vein-islet number and vein termination number are inversely proportional to the area of the lamina. Nicely (1965) observed significant variations within the leaf as regards the size and shape of the areoles and number of vein endings in each vein-islet. Sehgal and Paliwal (1974) also concluded that no direct correlation could be established between the size of the areole and the number of vein endings and their tips per areole. The present observations also supports those of Nicely (1965) and Sehgal and Paliwal (1974).

Kasapligil (1951), Foster and Arnott (1960) and Hebest (1972) reported the presence of isolated veins. Isolated free vein endings disjunct from the veins are observed in *Artemisia vulgaris*. Bundle sheath is observed in *Xanthium strumarium*.

Table 2. Numerical data on the venation pattern of Asteraceae II

S. No.	Name of the taxa	Leaf area in mm^2	No. of 2° veins along one side of midrib	Angle between P & 20 vein	No. of areoles for mm^2	Veinlets entering areole for mm^2	Vein ending termination for mm^2	Average size of areoles in mm^2	Absolute veinislets in thousands	Absolute vein termination No. in thousands	Highest vein order	No. of primaries
1	*Adenostemma lavenia* L.	320	5	15°	1	5	7	1	0.32	2.29	4°	1
2	*Artemisia vulgaris*	144	3~4	30°	2	10	4	0.5	0.288	0.576	4°	1
3	*Bidens bipinnata* (L.)	72	5~6	30°~35°	1	3	9	1	0.072	0.65	4°	1
4	*Blumea amplectans* DC.	50	4	45°	2	4	8	0.5	0.1	0.4	4°	1
5	*B. belangeriana* DC.	373	7~8	35°~40°	4	4	6	0.25	1.492	2.238	5°	1
6	*B. bifoliata* DC.	211	5	35°~40°	1	9	5	1	0.211	1.06	4°	1
7	*B. eriantha* DC.	356	9~10	20°~25°	2	6	10	0.5	0.712	3.56	4°	1
8	*B. laciniata* (Roxb.) DC.	171	4	20°~30°	1	4	8	1	0.171	1.37	4°	1
9	*B. lacera* (Burm. f.) DC.	910	7~8	45°	1	5	6	1	0.91	5.46	5°	1
10	*B. malcolmii* (Cl.) Hk. f.	662	4~5	25°~30°	1	7	7	1	0.662	4.634	4°	1
11	*B. membranacea* DC.	345	6~7	30°~35°	1	3	6	1	0.35	2.07	4°	1
12	*B. mollis* (D. Don) Merr.	138	6~7	40°~50°	1	6	10	1	0.138	1.38	4°	1
13	*B. oxyodonta* DC.	116	7~8	30°~35°	3	6	10	0.33	0.348	1.16	4°	1
14	*Caesulia axillaris* Roxb.	990	11~13	25°~30°	2	6	8	0.5	1.98	7.92	4°	1
15	*Centratherum phyllolaenum*(DC.)	385	8	30°~35°	2	8	9	0.5	0.77	3.47	5°	1
16	*Cyathocline purpurea* (D. Don)	186	3~4	45°	1	4	6	1	0.19	1.116	3°	1
17	*Eupatorium odoratum*	422	6~7	20°~25°	1	7	2	1	0.422	0.844	4°	3
18	*Lagascea mollis* Cav.	283	3~4	40°~45°	1	7	20	1	0.28	5.66	5°	1
19	*Sphaeranthus indicus* L.	313	4~5	20°	2	5	7	0.5	0.63	2.2	5°	1
20	*Spilantes paniculata* Wall.	64	3~4	15°~20°	2	2	6	0.5	0.128	0.384	4°	1
21	*Tricholepis amplexicaulis*	554	6~7	40°~45°	3	3	6~9	0.23	1.67	4.155	4°	1
22	*Vicoa auriculata* Cass.	200	6~8	20°~25°	1	7	10	1	0.2	2.0	3°	1
23	*V. cernua* Dalz.	1432	12	40°~45°	1	3	6	1	1.432	8.59	6°	1
24	*Vernonia cinerascens* Sch.-Bip.	403	6	15°~20°	1	6	14	1	0.403	5.642	4°	1
25	*Xanthium strumarium* L.	1586	4~5	40°~45°	3	10	3	0.33	4.658	4.658	4°	3

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EXPLANATION OF PLATES

Plate. 1 (A-E). Direct photographs showing the venation patterns of cleared leaves:

A. *Blumea eriantha* 1.5 ×
B. *Eupatorium odaratum* 1.8 ×
C. *Bidens bipinnata* 3.75×
D. *Splianthes paniculata* 4.5 ×
E. *Xanthium strumarium* 1.5 ×

Plate. 2 (A-I). Photomicrographs showing the various aspects of leaf architecture:

A. *Vernonia cinerascens* 200 ×
B. *Eupatorium odaratum* 385 ×
C. *Bidens bipinnata* 100 ×
D. *Artemisia vulgaris* 40 ×
E. *Tricholepis amplexicaulis* 100 ×
F. *Xanthium strumarium* 240 ×
G. *Blumea blengeriana* 250 ×
H. *Blumea blengeriana* 350 ×
I. *Tricholepis amplexcaulis* 250 ×

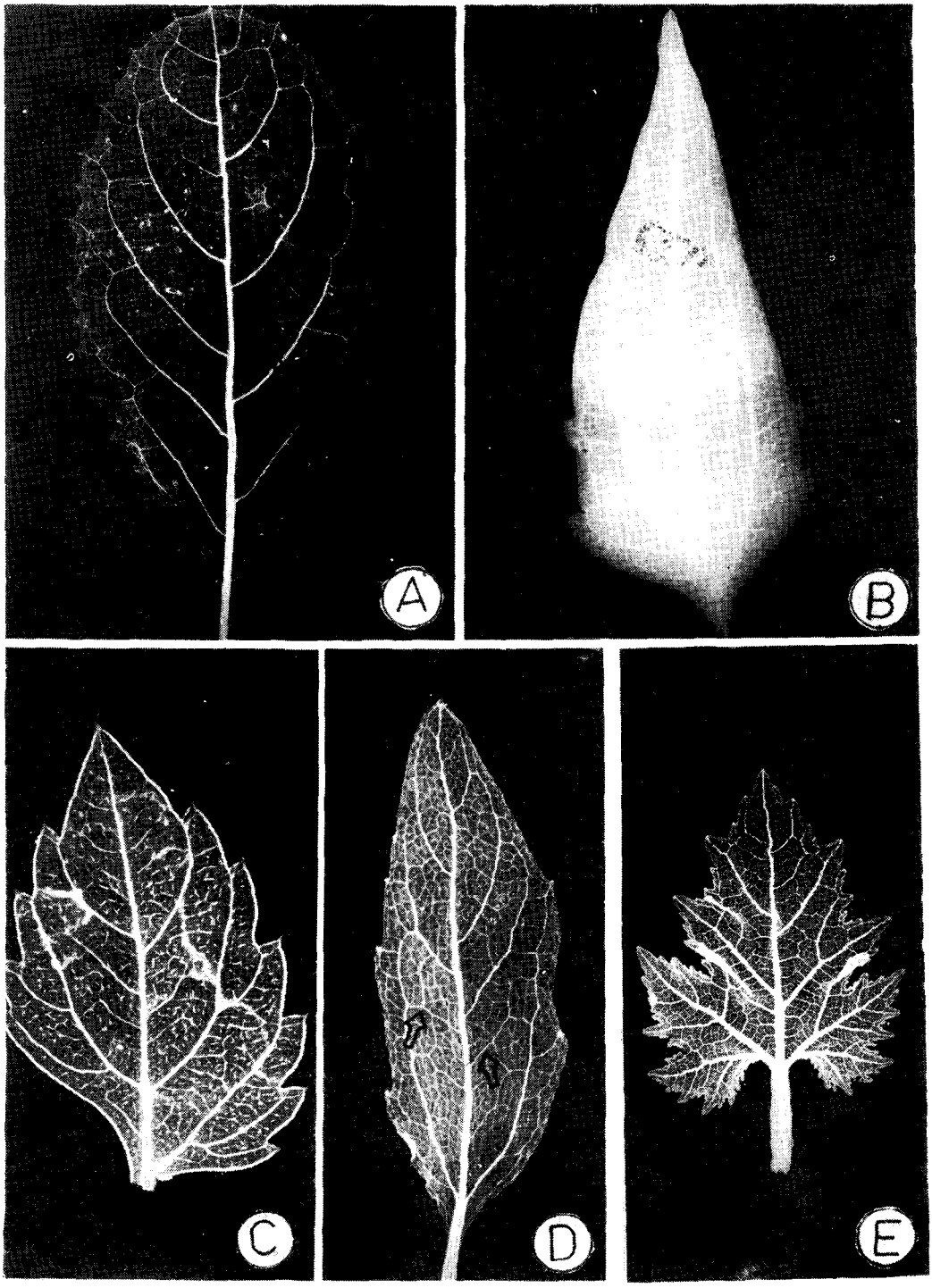
(AL: Areole; Sc: Secretory cavity; BS: Bundle sheath; N: Loop)

Plate. 3 (A-I). Photomicrographs showing the various types and arrangements of tracheids:

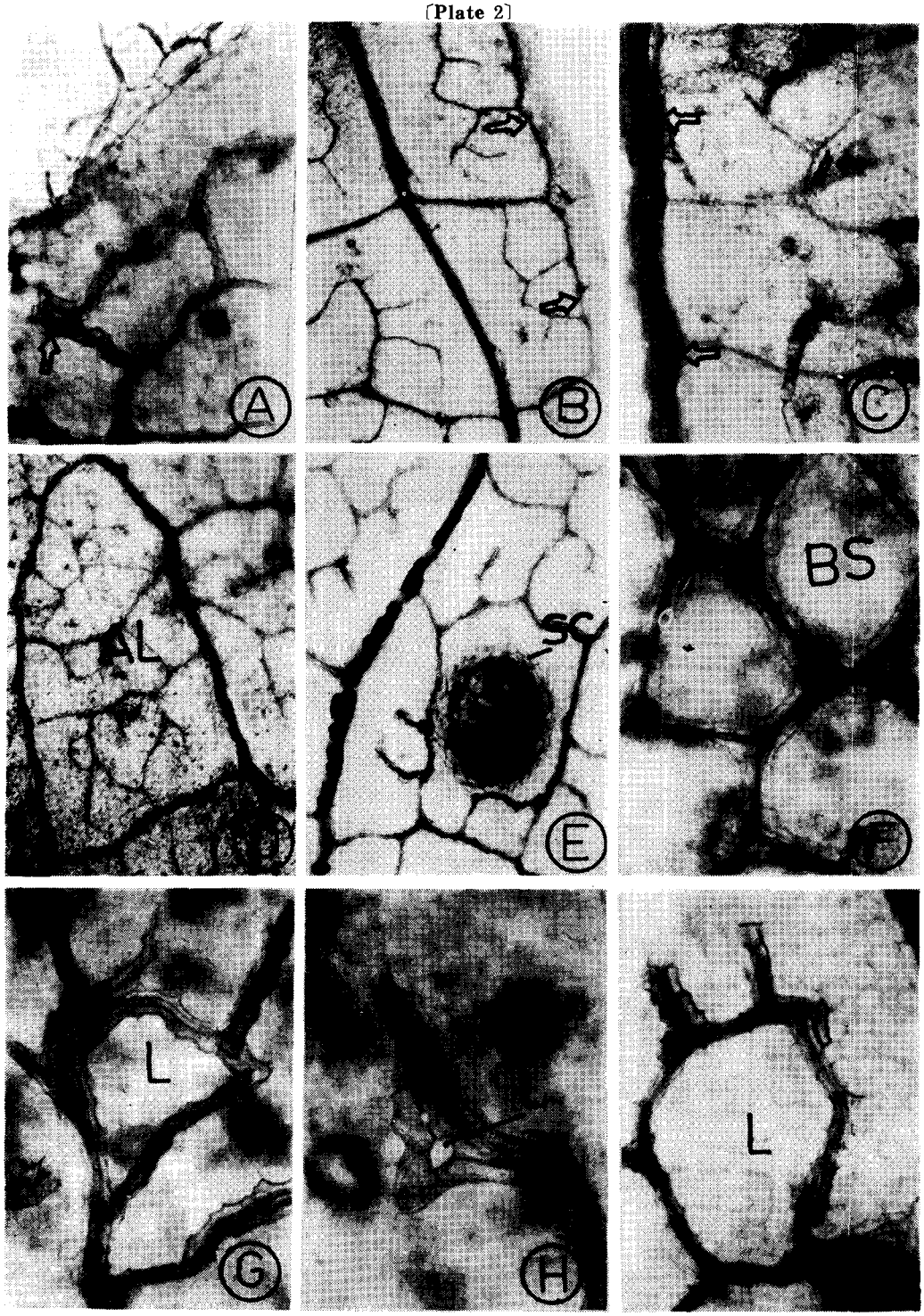
A. *Blumea bifoliata* 600 ×
B. *Blumea bifoliata* 600 ×
C. *Blumea bifoliata* 600 ×
D. *Blumea bifoliata* 500 ×
E. *Vernonia cinerascens* 500 ×
F. *Tricholepis amplexicaulis* 600 ×
G. *Tricholepis amplexicaulis* 600 ×
H. *Blumea blengeriana* 400 ×
I. *Centratherum phyllolaenum* 400 ×

(T: Tracheid; IFV: Isolated free vein ending)

[**Plate 1**]



[**Plate** 2]



[Plate 3]