Proc. Indian natn. Sci. Acad. B 45 No. 6 pp 589–595 (1979)

Studies in Lamiaceae III: The Taxonomic Value of Leaf Architecture in *Salvia* L.

M L GUPTA and S BHAMBIE
Department of Botany, Kurukshetra University, Kurukshetra, 132 119, India

(Received 12 January 1979)

Leaf architecture of nine species of *Salvia* L. has been studied with a view to assess its diagnostic value in systematics. As there is considerable overlapping in the shape, size and absolute number of vein-islets and vein-endings in different species and even within the leaves of almost similar size of a species, minor venation pattern cannot be of systematic value in the genus *Salvia* (*sensu estricto*). Only *S. officinalis* and *S. coccinea* can be identified from others on the basis of venation as the former has a bundle sheath even on ultimate vein-endings and the latter has frequent detached veins. However, if the architecture of leaf is taken into consideration as envisaged by Hickey (1973) different species can be identified.

Key Words: **Venation pattern, Lamiaceae, Leaf architecture**

Introduction

Foster (1961) emphasized the need for extensive and intensive study of the venation pattern in the leaves of angiosperms. Recently Hickey (1973) and Dilcher (1974) have stressed that the architectural pattern of dicotyledonous leaves is significant in dealing with the systematics of angiosperms particularly at the species level. The present paper deals with the leaf architecture of nine common species of *Salvia* L.

Materials and Methods

The fresh leaves of *S. coccinea* Juss. ex Murr. (V. no. 37), *S. farinacea* Benth. (V. no. 38), *S. leucantha* Cav. (V. no. 40), *S. officinalis* L. (V. no. 41), *S. plebia* R. Br. (V. no. 43), *S. splendens* Ker-Grawl (V.no. 42), *S. glutinosa* L. (V. no. 39), *S. lanata* Roxb. (V. no. 44) and *S. aegyptiaca* L. (V. no. 36) were collected from Nainital and Kurukshetra. Voucher specimens have been prepared and deposited in the Department of Botany, Kurukshetra University, Kurukshetra. The leaves were cleared following the technique of Paliwal and Kakkar (1969) and stained with safranin in 50% xylol for permanent preparations. Bits measuring 2×2 mm from different parts of lamina were examined. An average of ten readings was recorded in this manner for ten leaves and

**Present address*: Department of Biology, D. N. College, Hissar 125001

Table 1 *Various features of*

S. No.	Name of Taxa	Area of leaf mm²	Leaf shape	Leaf apex	Leaf base	Leaf margin	Size and course of 1° vein	Texture of leaf	Angle of 2° vein	Angle of 3° vein
1.	*Salvia aegyptiaca*	550	ovate	acute	cordate	obtuse serrate	stout and straight	char- taceous	20–50	65–90
2.	*S. coccinea*	1175	wide ovate	,, ,,	lobate	,,	,,	coriace- ous	35–45	75–90
3.	*S. farinacea*	1335	ovate lance- olate	,,	acute	acute- serrate	,,	char- taceous	25–25	75–90
4.	*S. glutinosa*	2154	,,	,,	obtuse	obtuse serrate	,,	,,	30–60	70–110
5.	*S. leucantha*	945	,,	,,	,,	acute- serrate	,,	coriace- ous	40–90	60–90
6.	*S. officinalis*	122	oblong linear	,,	acute	,,	stout and curved	char- taceous	25–40	70–90
7.	*S. plebia*	1106	narrow ovate	,,	,,	obtuse serrate	stout and straight	,,	30–40	60–90
8.	*S. splendens*	1500	ovate	acumi- nate	obtuse	accute serrate	,,	,,	40–50	50–110
9.	*S. lanata*	—	obovate oblance- olate	acute	acute	,,	,,	coriace- ous	—	—

the mean value calculated. Absolute vein-islet number and absolute vein-termination number were calculated by the formula given by Gupta (1961). The terminology followed is after Hickey (1973).

Observations

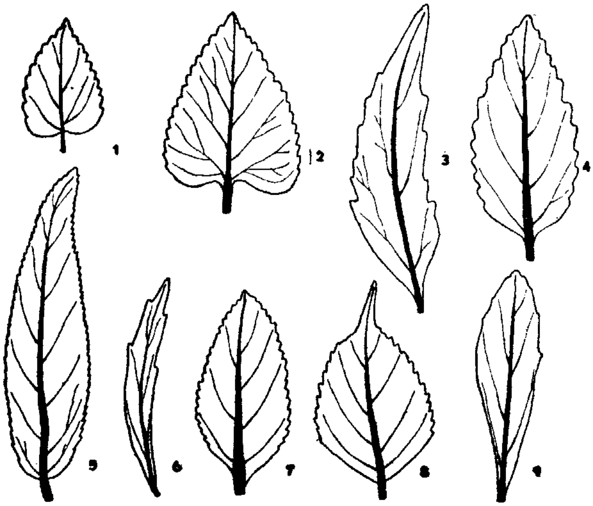
The leaves of all the investigated species of *Salvia* are simple, symmetrical, petiolate and opposite decussate; shape of leaves varies from oblong linear to wide ovate in the different taxa; margins are acute serrate or obtuse serrate; apices are acute with exception of *S. splendens* where it is acuminate (figures 1–9); bases of the laminae are acute, obtuse or lobate; and texture varies from chartaceous to coriaceous (table 1).

The veins of the 1°, 2° and 3° are considered to constitute the major venation of a leaf and the veins of the subsequent categories constitute the minor venation (Ettinghausen 1861). The major venation is of the pinnate camptrodromous type. The primary vein is stout and after emerging from the petiole it runs straight but in the case of *S. officinalis* and a few leaves of *S. farinacea* and *S. glutinosa* the midrib becomes slightly curved towards the apex. The secondaries arise along both sides of the primary vein in an opposite or subopposite manner and traverse straight towards the margins. The number of the secondaries is *leaf architecture in* Salvia

Marginal ultimate venation	Areole developement	Areole arrangement	Areole shape	Average size of areole in sq. mm.	No. of areole/ sq. mm.	Veinlets entering into areole/ sq. mm.	Vein ending termination/ sq. mm.	Absolute vein-islets number	Absolute number of vein endings
looped	well developed	random	variable	0.11	9	7.7	9.3	4950	5115
,,	,,	,,	,,	0.07	14	7.0	8.2	16450	9635
,,	,,	,,	,,	0.10	9.2	7.5	10.4	3871	13884
,,	,,	,,	,,	0.10	9.6	9.6	16.3	20678	35114
,,	,,	,,	,,	0.07	13.6	11.1	16.1	12825	15214
,,	,,	,,	,,	0.05	20.3	18.0	31.3	2476	3818
,,	,,	,,	,,	0.07	14.5	13.7	20.2	16450	23341
,,	,,	,,	,,	0.16	6.1	5.0	7.6	9150	12100
—	—	—	—	—	—	—	—	—	—

variable within the same species. The angle of divergence of secondary vein is narrow acute in the apical region and moderate to wide acute in the basal region in all the species. The secondaries do not terminate along the margins; they, however, turn upward and gradually diminish along the margins, where they are connected with the supra-adjacent secondaries by a series of cross veins. Their ultimate branches form distinct marginal loops (figure 11). However, many veinlets come out of the loop and appear as free vein-endings near the margins (figures 11, 14, 15). The next finer branches of the secondary veins and those branches of primary vein which have thickness equal to the secondary veins constitute the tertiary veins. The angle of origin of the tertiary vein on the admedial side is acute and on the exmedial side is at right angles.

The veins of the next finer order are quaternary or 4° vein. They along with the 5° veins are randomly oriented and form a reticulum. Thus the veins of 4° and 5° along with the free veinlet endings constitute the minor venation pattern of the leaf. The veins of 1° to 4° are covered with distinct bundle sheath in all the species except in *S. officinalis* where it is present even on the ultimate vein endings (figure 14). The smallest areas formed by these veinlets are known as vein-islets or areoles. They are meshes of

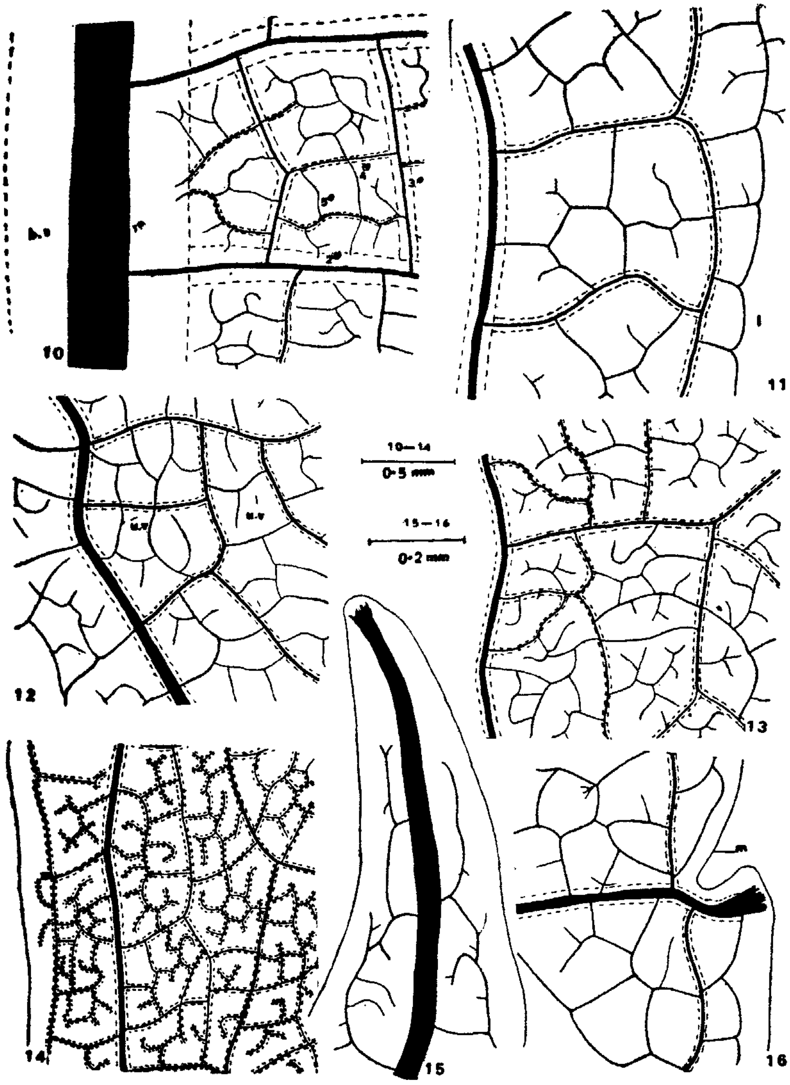


Figures 1–9 Outline drawings of the leaves of *Salvia aegyptiaca*, *S. coccinea*, *S. farinacea*, *S. glutinosa*, *S. leucantha*, *S. officinalis*, *S. plebia*, *S. splendens* and *S. lanata* respectively

variable size ranging from quadrangular to irregular shapes. They usually contain one to many blind vein-endings. Most of the vein-endings are unbranched but a few of them are branched one to three times. The branching is more frequent in *S. leucantha* (figure 10), *S. plebia* (figure 13) and *S. farinacea*. Table 1 shows the data on major and minor venation pattern along with important aspects of the leaf architecture. The number of vein-endings and vein-endings termination per areole is highly variable and overlapping. In table 2 the variations in the minor venation pattern among different leaves of *S. farinacea* are presented. Isolated veinlets or unconnected veinlets were observed at certain regions in *S. coccinea* only (figure 12).

Discussion

Carlquist (1961) has stated that leaves have many features of potential taxonomic significance. One of them is venation pattern which has been stressed by Foster (1961) on the basis of the classical work of Ettinghausen (1861). Hickey (1973) dealing with the architecture of leaf has pointed out the importance of major and minor venation patterns along with other features like shape, base, apex, texture, margin, etc. However, importance of minor venation alone in the leaves of certain taxa belonging to Compositae and Rubiaceae has been regarded as an important diagnostic character (Carlquist 1959, 1961). Levin (1929) emphasized that vein-islet number is nearly constant for a species and can be used as a valuable specific character. Gupta (1961) has proposed vein-islets and veinlet termination number are inversely proportional to the leaf area and their absolute numbers are constant in a fully mature leaf of a particular species. Varghese (1969) also pointed out that vein-islet and vein-endings in a unit area is more or less constant. A careful study of the minor venation pattern of Calycanthaceae by Nicely (1965) demonstrated that there is variation in shape, size of areole and type of vein-endings. Banerji and Das (1972) pointed out that these variations are more pronounced in the apical region of the petal of *Acer*. This contention has gained further support by the detailed study of 150 species of *Euphorbia* (Sehgal & Paliwal 1974) and 15 species of *Salix* (Singh et al. 1976) where it has been shown that minor venation pattern cannot be of much help in the identification of species. In both these studies it has been emphasized that it can be of major value if characters like petiolar anatomy, dermotypes, etc., are taken into consideration. The present observations on nine species of *Salvia* support this inference. Table 1 depicts the overlapping in the shape, size and absolute number of vein-islets and vein-endings in different species of *Salvia*. Hence, these characters cannot be of any systematic



Figures 10–16 Minor venation pattern. *10*, *S. leucantha*; *12*, *S. coccinea*; *13*, *S. plebia*. *14*, *S. officinalis*; *11*, *15*, *16*, *S. splendens*; **b.s.**, bundle sheath, **l**, loops; **m**, margin; **u.v.**, unconnected 1°–5°, veins of first to fifth order

value at least in the genus *Salvia*. Nearly hundred mature leaves of *S. farinacea* have been studied to verify the findings of Gupta (1961). Table 2 shows that the variations in the vein-islets and vein-termination number are so frequent that a constant for a particular species cannot be determined. Therefore, it is apparent that absolute number of vein-islets and vein-endings cannot serve in the identification of *Salvia*

Table 2 *Variation in the minor venation pattern of* Salvia farinacea

Leaf No.	Leaf area in mm²	Average size of areole in mm²	Areole No. per mm²	Vein-endings per mm²	Absolute No. of areoles	Absolute No. of vein-endings
1.	575	0.10	9.8	11.8	5625	6785
2.	600	0.10	10.0	11.8	6000	7080
3.	1066	0.14	6.9	14.3	7355	15233
4.	1080	0.14	7.1	11.4	7668	12312
5.	1131	0.28	3.6	10.4	4071	11762
6.	1257	0.12	7.9	12.9	9930	16216
7.	1264	0.16	6.0	13.9	7584	17569
8.	1325	0.18	5.4	9.8	7175	12985
9.	1335	0.35	2.9	10.4	3871	13884
10.	1370	0.17	5.9	12.0	8083	16440
11.	1468	0.47	2.1	9.3	3082	13652

species. Similarly, the shape and size of areoles as stressed by Hickey (1973) cannot be used as a reliable taxonomic criterion in such cases. However, if the architecture of leaf as defined by Hickey (1973) is taken into consideration, a key can be prepared for the identification of different species on the basis of venation pattern and gross morphological characters like, leaf shape, base, apex, margin, texture etc. Due to paucity of material only nine species of *Salvia* have been investigated. However, this aspect needs further investigation in the remaining species of this genus.

Another point which needs consideration here is the occurrence of detached or unconnected veinlets in *S. coccinea*. Such unconnected veinlets have been reported earlier in *Circaester* (Foster 1963, 1966) and *Pteris* (Nair & Das 1977). Goebel (1905) referred them as incomplete commissural veins which could not develop fully. Nair and Das (1977) on basis of their disposition have considered their occurrence as due to the non-differentiation of the vascular tissue in the basal region of the veinlet and further feel that such a phenomenon can be explained only by developmental studies as envisaged by Foster (1963, 1966). Siade (1959) on the other hand has suggested a theory of vein breakage to explain them. According to him during ontogeny well established connections of minor veins are pulled apart and referred as incomplete veinlets. It is a well-known fact that a considerable increase in the size of leaf lamina is due to enlargement of individual cell. Young leaves of *S. coccinea* lack incomplete veinlets; their occurrence in only mature leaves can be easily explained on the basis of vein breakage theory.

Acknowledgements

We are grateful to Professors V Puri and K Subramanyam for going through the manuscript and giving valuable suggestions; S K Pillai and R S Mehrotra for encouragement, help and facilities. Our sincere thanks are also to Dr V Singh, for identification of some species.

References

Banerji M L and Das S 1972 Minor venation pattern in the Indian Acers; in *Advances in Plant Morphology* pp 51–57 eds Y S Murty et al. (Meerut: Sarita Prakashan)

*Carlquist S 1961 Vegetative anatomy of *Dubautia*, *Argyrosciphium* and *Wilkesia* (Compositae); *Pacif. Sci.* **13** 195–210

—— 1961 *Comparative Plant Anatomy*. New York (Holt, Rinchart and Winston)

Dilcher D L 1974 Approaches to the identification of angiosperm leaf remains; *Bot. Rev.* **40** 1–157

*Ettinghausen C 1861 Die Blatt-Skelete dar Dicotyledonen mit besonderer Rucksiteht auf die untersuchung und Bestimung der fossilan pflanzenreste; ed K K Hofund(Wien: Statsdurckerie)

Foster A S 1961 The phylogenetic significance of dichotomous venation in angiosperms; *Rec. Adv. Bot.* **2** 971–975

*—— 1963 The morphology and relationship of *Circaeaster*; *J. Arnold Arbor.* **44** 299–321

—— 1966 Morphology of anastomoses in the dichotomous venation of *Circaeaster*; *Am. J. Bot.* **53** 588–599

Goebel K 1905 Organography of the Plants; (London: Oxford)

Gupta B 1961 Correlation of tissues in leaves. Absolute vein-islet number and Absolute Termination Number; *Ann. Bot.* **25** 65–70

Hickey L J 1973 Classification of the architecture of dicotyledonous leaves; *Am. J. Bot.* **60** 17–33

Levin F A 1929 The taxonomic value of vein-islet area based upon a study of the genera *Barosme*, *Cassia*, *Erythroxylon* and *Digitalis*; *J. Pharm. Pharmac.* **2** 17–43

Nair N C and Das 1977 Studies on the venation pattern in Ferns IV. Additional observations on *Pteris vittata* Linn; *J. Indian bot. Soc.* **56** 267–274

Nicely K A 1965 A monographic study of the Calycanthaceae; *Castanea* **30** 38–81

Paliwal G S and Kakkar L 1969 The use of hydrogen peroxide for cleaning leaves; *Acta agron. hung.* **18** 406–408

Sehgal L and Paliwal G S 1974 Studies on the leaf anatomy of *Euphorbia* II Venation Patterns; *Bot. J. Linn. Soc.* **68** 173–208

Singh V D, Jain K and Sharma M 1976 Leaf architecture in *Salix*; *J. Indian bot. Soc.* **55** 140–150

Slade B F 1959 The mode of origin of vein-endings in the leaf of *Leriodendron tulipifer*; *New Phytol.* **58** 299–305

Varghese T M 1969 A contribution on the foliar venation of Scrophulariaceae; in *Recent Advances in the Anatomy of Tropical Seed Plants* pp 253–265 ed K A Choudhry (Delhi: Hindustan Publishing Corporation).

* Not seen in original