



FOLIAR ARCHITECTURE OF INDIAN *Spilanthes* Jacq.: MEMBERS OF THE TRIBE HELIANTHEAE OF SUB FAMILY ASTEROIDEAE

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ABSTRACT

Flowers and fruits are transient part while leaf is a permanent part of a plant. The gross form of angiosperm leaves include features like size, shape, nature of margins, form of the apex, base, petiole, positioning of glands and nature of venation. The cleared leaves have the potential diagnostic characters within their venation. The taxonomic distribution of venation types and associated anatomical characters are of systematic importance as it is constant in most sections or subsections. Venation patterns of four plants of Asteroideae belonging to the genus *Spilanthes* Jacq. has been studied. It has been recorded that they are pinnate brochidodromous though the leaves of different species are morphologically different. Several foliar architectural characters recorded with respect to the major and minor veins are also found to be of taxonomic importance.

KEYWORDS : *Spilanthes*, venation pattern, brochidodromous

INTRODUCTION

The genus *Spilanthes* Jacq. (Asteraceae) belong to the tribe Heliantheae of sub family Asterales, is widely distributed in the tropical and subtropical regions of the world. The natural habitat of this genus is damp areas like the banks of lakes, ponds, puddles, soils near drains and sewage discharge areas. It is commonly known as the tooth ache plant, eyeball plant and spot plant.

Around 60 species of genus *Spilanthes* have been reported from different regions of the world (1). Out of these, five species occur in India namely *S. acmella* (L.) L., *S. oleracea* L., *S. calva* L., *S. paniculata* L., and *S. mauritiana* (A.Rich. ex Pers.) DC. (2). *S. calva*, *S. paniculata* and *S. mauritiana* grow wildly whereas *S. oleracea* is rare in occurrence and *S. acmella* is an acutely threatened species (3). Later many of the species of *Spilanthes* are shifted to various genera namely *Acemella*, *Adenostemma*, *Eclipta*, *Heliopsis*, *Isocarpha*, *Jaegeria*, *Melampodium*, *Salmea*, *Verbesina*, *Wollastonia*, *Zinnia* (4). The genus *Spilanthes* has a great economic value for the presence of Alkamides and different alkaloids, glycosides, flavonoids, tannins, anthraquinones, saponins and cardiac glycosides (5).

In plant systematics, morphology of stem, root, leaf, flower and fruit play a key role in identification of plants. The foliar architecture in recent years is gaining much importance in identification of living as well as fossil angiosperm species (6,7,8,9,10). A very few work have been done on leaf architectural pattern of the members of Asterales. Annamani and Prabhakar gave the venation pattern of 15 plants of Asterales (11). Foliar anatomy was used in establishing the taxonomic relationship between twelve species of Asteraceae (12). The present study highlights the foliar anatomical characters of *Spilanthes* spp. & use these characters as an additional taxonomic tool for identification of members of this genus.

MATERIALS AND METHODS

Specimens of tribe Helianthae of subfamily Asteroideae were personally collected from different districts of West Bengal and identified with the help of local floras. The voucher specimens have been kept at the Departmental herbarium of University of Kalyani (KLN). The specimens are listed in Table 1. Fully matured leaves with petioles are preserved in FAA solution (formaldehyde: acetic acid: 70% alcohol) in a ratio of 5:5:90 (v/v) for further use. Ten leaves of each species collected from five different plants were cleared following the usual techniques (6).

Table 1. List of specimens collected

| S. No. | Name of Species                   | Localities (in West Bengal)                                         | Field Nos. |
|--------|-----------------------------------|---------------------------------------------------------------------|------------|
| 1      | <i>Spilanthes acmella</i> (L.) L. | Dum Dum Park and Salt Lake, Kolkata; Cooch Behar, Cooch Behar Dist. | 12, 36, 49 |

|   |                                    |                                                                        |            |
|---|------------------------------------|------------------------------------------------------------------------|------------|
| 2 | <i>Spilanthes calva</i> DC.        | Nagrakata, Jalpaiguri Dist.; Cooch Behar, Cooch Behar Dist.            | 129, 134,  |
| 3 | <i>Spilanthes oleracea</i> L.      | Cooch Behar, Cooch Behar Dist.; Kalyani, Nadia Dist.                   | 135, 158   |
| 4 | <i>Spilanthes paniculata</i> Wall. | Dum Dum Park, Kolkata: Samsing, Darjeeling Dist.; Kalyani, Nadia Dist; | 8, 45, 157 |

For the study of vascularisation of lamina, the entire lamina along with the petiole had been soaked in 4% NaOH overnight and transferred to chloral hydrate (13) and finally stained in 1% aqueous safranin solution. Through gradual dehydration permanent slides were prepared and mounted in Canada balsam. For representation of the vein orders upto 3° higher magnification of the microscope has been used. For higher order venation a suitable median portion of the lamina, 1/3 from apex and 2/3 from base of the lamina, has been selected and the vascular pattern drawn from the 3° onwards under mirror type camera lucida.

In the same way, marginal venation pattern and free vein endings have been sketched under high magnification of the microscope (Olympus CX21i and camera UCMOS 10000 KPA of Topcam). Anatomical description has been made (14) along with the foliar venation pattern, (6,7,8,9,10,15,16) accordingly.

OBSERVATIONS

Laminar morphology

The identity of the four species of *Spilanthes* has been established by leaf morphology (Table 2) and venation pattern (Table 3).

Table 2. Leaf Morphology of the four species of *Spilanthes*

| Name of the species | <i>Spilanthes acmella</i> (L.) L.                                                                                                                                    | <i>Spilanthes calva</i> DC.                                                                                                                           | <i>Spilanthes oleracea</i> L.                                                                                                                                                    | <i>Spilanthes paniculata</i> Wall.                                                                                                                   |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Characters          |                                                                                                                                                                      |                                                                                                                                                       |                                                                                                                                                                                  |                                                                                                                                                      |
| Leaves              | Opposite, decussate, simple, ovate to broadly ovate, 2.3-7.5 x 1-5.9 cm; base obtuse, apex acute, margin toothed to coarsely toothed; glabrous on both the surfaces. | Opposite, decussate, simple, broadly ovate, 4 - 6 x 1.4 - 3 cm; base obtuse; apex acute or sub obtuse, margin serrate; hairs sparse on both surfaces. | Opposite, decussate, simple, broadly ovate, 5 - 7 x 2.5 - 3.5 cm; base oblique to truncate, apex acute, margin serrulate; hairs sparse on both surfaces, mainly on upper midrib. | Opposite, decussate, simple, ovate-lanceolate, 2 - 4.2 x 1 - 2.2 cm; base attenuate or cuneate, apex acute, margin serrate, scabrous above and below |

An artificial key to the species is developed as follows:

**Key to the species of *Spilanthes* based on leaf morphology**

1. Leaves ovate lanceolate
2. Base cuneate, margin serrate, serration spacing irregular.....  
*S. paniculata*

1. Leaves broadly ovate
3. Base oblique to truncate, margin serrulate ..... *S. oleracea*

3. Base obtuse
4. Leaf margin serrate; serration spacing regular.....*S. culva*
4. Leaf margin toothed to coarsely toothed..... *S. acmella*

**Venation**

A comparative venation pattern of the leaves of *Spilanthes* are recorded (Table 3 and Figure 1 & 2).

**Table 3. Venation pattern of four species of *Spilanthes***

| Name of the species                           | <i>Spilanthes acmella</i> (L.) L.                                                                                                                        | <i>Spilanthes culva</i> DC.                                                                                                                                       | <i>Spilanthes oleracea</i> L.                                                                                                                                                     | <i>Spilanthes paniculata</i> Wall.                                                                                                                                                                              |
|-----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Primary vein (1°)                             | Moderate, straight, unbranched                                                                                                                           | Stout, straight, unbranched                                                                                                                                       | Moderate, straight, unbranched                                                                                                                                                    | Stout straight, unbranched                                                                                                                                                                                      |
| Secondary veins (2°) No.                      | 5 - 6 pairs                                                                                                                                              | 3-4 pairs                                                                                                                                                         | 4-5 pairs                                                                                                                                                                         | 4-5 pairs                                                                                                                                                                                                       |
| Angle of divergence.                          | Acute, irregular.                                                                                                                                        | Acute, irregular.                                                                                                                                                 | Acute, irregular.                                                                                                                                                                 | Acute, uniform                                                                                                                                                                                                  |
| Intersecondary veins                          | 3 - 5                                                                                                                                                    | 1-2                                                                                                                                                               | 2                                                                                                                                                                                 | 1 - 2                                                                                                                                                                                                           |
| Tertiary vein (3°)                            | interangular veins and joining veins present                                                                                                             | Only joining veins present                                                                                                                                        | interangular veins and joining veins present                                                                                                                                      | interangular veins and joining veins present                                                                                                                                                                    |
| Arrangement and relationship to mid vein      | Predominantly alternate; oblique to midvein, angle increasing apically.                                                                                  | Predominantly alternate; oblique to midvein, angle decreasing apically.                                                                                           | Predominantly alternate; oblique, angle decreasing apically;                                                                                                                      | Predominantly alternate; approximately at right angle to midvein                                                                                                                                                |
| Pattern                                       | Orthogonal reticulate                                                                                                                                    | Precurrent, forked                                                                                                                                                | Orthogonal reticulate                                                                                                                                                             | Random reticulate.                                                                                                                                                                                              |
| Quaternary veins (4°)                         | Thin and random                                                                                                                                          | Thin and orthogonal                                                                                                                                               | Thin and orthogonal                                                                                                                                                               | Thin and random                                                                                                                                                                                                 |
| Quinternary veins (5°)                        | thin and orthogonal                                                                                                                                      | Thin and orthogonal                                                                                                                                               | Thin and orthogonal                                                                                                                                                               | Thin and orthogonal                                                                                                                                                                                             |
| Highest vein order (as free vein endings)     | 5° to 6° order                                                                                                                                           | 6° to 7° order                                                                                                                                                    | 5° to 6° order                                                                                                                                                                    | 6° to 7° order                                                                                                                                                                                                  |
| Areoles                                       | Imperfect, arranged randomly.                                                                                                                            | Well developed; arranged randomly.                                                                                                                                | Well developed; arranged randomly.                                                                                                                                                | Imperfect, consistent size.                                                                                                                                                                                     |
| Areole shape                                  | Quadrangular and pentagonal;                                                                                                                             | Mostly quadrangular                                                                                                                                               | Pentagonal                                                                                                                                                                        | Variable                                                                                                                                                                                                        |
| Areoles/sq.cm                                 | 580                                                                                                                                                      | 740                                                                                                                                                               | 250                                                                                                                                                                               | 410                                                                                                                                                                                                             |
| No. of free vein endings in an areole         | One, absent in some.                                                                                                                                     | One                                                                                                                                                               | One, rarely two                                                                                                                                                                   | One                                                                                                                                                                                                             |
| Nature of free vein endings within the areole | Unbranched and branched dichotomously, once and sometime twice, consisting of two to three spirally thickened, parenchymatous cell ensheathed tracheids. | Mostly unbranched and rarely branched dichotomously, once and rarely twice, consisting of one to two spirally thickened parenchymatous cell ensheathed tracheids. | Rarely unbranched, mostly branched dichotomously to give scorpioid or dendroid appearance; consisting of parenchymatous cells ensheathed one to two spirally thickened tracheids. | Unbranched and branched dichotomously once and rarely twice, simple, straight or curved; and consisting of 2-3 spirally thickened tracheids covered with barrel shaped thin walled parenchymatous sheath cells. |
| Associated features                           |                                                                                                                                                          |                                                                                                                                                                   | Veins associated with brachysclerides and macrosclerides                                                                                                                          |                                                                                                                                                                                                                 |

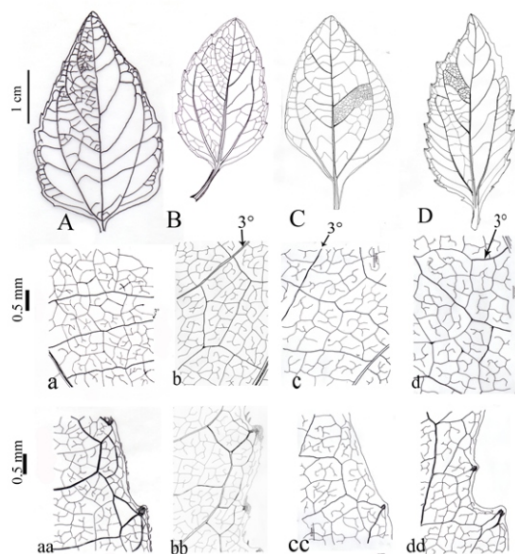


Fig. 1. Venation patterns, marginal venation and free vein endings of *Spilanthes*:  
A - *aaa*. *S. acmella* A. Leaf; a. venation pattern; aa. marginal venation; aaa. Free vein endings;  
B - *bbb*. *S. culva* B. Leaf; b. venation pattern; bb. marginal venation; bbb. Free vein endings;  
C - *ccc*. *S. oleracea* C. Leaf; c. venation pattern; cc. marginal venation; ccc. Free vein endings;  
D - *ddd*. *S. paniculata* D. Leaf; d. venation pattern; dd. marginal venation; ddd. Free vein endings;

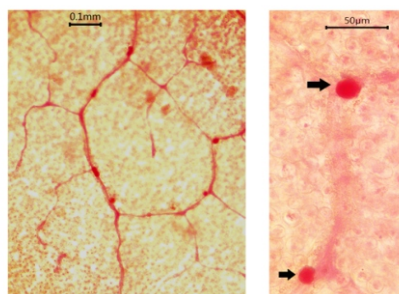


Fig. 2. Venation features of *Spilanthes oleracea*:  
A. Venation pattern showing brachysclerides and macrosclerides as red spots on veins; B. Arrow showing the enlarged view of brachyscleride on veins.

## DISCUSSION AND CONCLUSION

Many authors suggested that the leaves of the plant carry a lot of information about plant species (17,18). Techniques are developing to recognize the plant from their leaves because every plant has a unique leaf. It also serves as a tool to plant biologists and botanists for distinguishing plant species. Classification of plants based on leaves is the fastest and simpler way to identify a plant. For this purpose researchers are establishing database by information technology so that features are extracted and used as a basis for plant identification. Even the image of the leaf is transferred to computer database and the programming is done to extract necessary features automatically using an image processing technique which subsequently recognizes the plant leaf (19).

Excluding the computational approach, the leaf vein features have been used in this study to identify different Indian species of *Spilanthes*. The genus *Spilanthes* comprised of prostrate or erect herbs possessing simple, opposite, ovate to broadly ovate leaves with serrated margins. The type of venation among the genus *Spilanthes* is pinnate brochidodromous. Another interesting feature is with the basal pair of secondaries which extends up to  $2/3^{rd}$  of the lamina. This is the feature observed in the members of the tribe Helianthae with the same venation type. The secondaries are moderately thick and are curved abruptly joining with the superadjacent secondaries in the intramarginal region. Outer secondaries and tertiaries are also present in the basal pair as well as with other pairs forming loops in the intermarginal region. Intersecondary veins are also common among the four species of *Spilanthes* studied. Marginal venation is incomplete in all. (Figure 1 & 2).

Apart from the common characters mentioned above, there are many more diverse characters which are given in Table 3. These characters are found to be of taxonomic value, based on which a key for identification of *Spilanthes* species was developed in this study.

### Key for Identification of the Taxa:

1. Primary veins moderate.

2. Number of secondary veins ( $2^\circ$ ) 5-6 pairs; basal pair sub opposite; Intersecondary veins 3-5; quaternary vein ( $4^\circ$ ) randomly oriented; areoles imperfect, areolar frequency 580 per sq. cm; free vein endings one in each areole or absent in some, unbranched and branched dichotomously once and rarely twice.  
..... *S. acmella*

2. Number of secondary veins ( $2^\circ$ ) 4 – 5 pairs; basal pair opposite; intersecondary veins two; quaternary vein ( $4^\circ$ ) orthogonal in orientation; areoles well developed, areolar frequency 250 per sq. cm; free vein endings one rarely two no empty areole, rarely unbranched mostly to give dendroid or scorpoid free vein endings; veins associated with brachysclerides and macrosclerides  
..... *S. olaracea*

1. Primary veins stout.

3. Number of secondary veins ( $2^\circ$ ) 3 – 4 pairs; irregular; interangular veins absent; tertiary vein ( $3^\circ$ ) made of joining veins; areoles well developed, areolar frequency 740 per sq. cm ..... *S. culva*

3. Number of secondary veins ( $2^\circ$ ) 4 – 5 pairs; uniform; interangular veins and joining veins present; tertiary vein ( $3^\circ$ ) made of interangular and joining veins; areoles imperfect; areolar frequency 410 per sq. cm ..... *S. paniculata*

Although the four species of *Spilanthes* are similar in their major venation pattern but they can be distinguished by the above stated key which limits them to their respective species. Hence such keys based on the minor venation pattern serves as the significant systematic tool which can help to develop the phylogeny of the species.

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