Indian Journal of Plant Sciences ISSN: 2319–3824(Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jps.htm
2015 Vol. 4 (4) October-December, pp. 121-126/Naskar
Research Article

CHARACTERIZATION OF SCROPHULARIACEAE BASED ON GROSS MORPHOLOGY AND PETIOLE ANATOMY

***Saikat Naskar**
PG Department of Botany, Barasat Govt. College,
Barasat, Kolkata- 700124
**Author for Correspondence*

ABSTRACT

The family Scrophulariaceae *s.l.* has been treated differently by different taxonomists. In modern phylogenetic based classifications many traditional members of Scrophulariaceae have been placed under different families. Therefore in the present study gross morphological and petiole anatomical characters have been used to characterize the family Scrophulariaceae *s.l.* to understand the morphological and petiole anatomical distinctness among the families which are disintegrated from Scrophulariaceae *s.l.*

INTRODUCTION

Scrophulariaceae is considered as a problem family. It was treated variously by plant taxonomists. Scrophulariaceae s.l. is the largest family under Lamiales and has worldwide distribution from tropical to temperate regions. This family is recognisable by its bilaterally symmetric flowers, axile placentation with numerous ovules, capsular fruits and seed with endosperm. But, Scrophulariaceae shares these important morphological characters with related families. Due to absence of any morphological synapomorphic characters the monophyly of this family was in question.

Bentham (1876) classified Scrophulariaceae into three subfamilies, viz. Pseudosolaneae, Antirrhinoideae and Rhinanthoideae where Pseudosolaneae was defined as a link with Solanaceae. Pennell (1935) suggested that the similarity of Scrophulariaceae with Solanaceae is actually derived independently within Scrophulariaceae. Therefore he eliminated subfamily Pseudosolaneaea and placed its genera to Antirrhinoideae. Melchior (1964) the included the families Orobanchaceae, Globulariaceae, Selaginaceae, Plantaginaceae and Lentibulariaceae within Scrophulariaceae.

Olmstead *et al.*, (2001) and Oxelmen *et al.*, (2005) showed that Scrophulariaceae is a polyphyletic family on the basis of molecular evidences. Olmstead *et al.*, (2001) recognized five distinct monophyletic groups within traditional Scrophulariaceae *s.l.*, which are Calceolariaceae, Orobanchaceae, Scrophulariaceae *s.s.*, Stilbaceae, and Veronicaceae. The clades identified by Olmstead *et al.*, (2001) as Scrophulariaceae *sensu stricto* and Veronicaceae (=Plantaginaceae *sensu* APG II) are equivalent to the 'scroph I' and 'scroph II' clades, respectively according to APG II (2003).

Tank *et al.*, (2006) roughly segregated Scropulariaceae *s.l.* into seven families based on their observations on previous molecular phylogentic studies. These families are Scrophulariaceae *s.s.*, Veronicaceae [=Plantaginaceae *sensu* APG II], Orobanchaceae, Phrymaceae, Stilbaceae, Linderniaceae and Calceolariaceae. According to one of the more recent monographic work on the families and genera of vascular plants edited by Kubitzki (2004), Scrophulariaceae is divided into ten tribes by Fischer (2004).Therefore the present study is intended to find out the morphological characters to define the molecular based circumscription of Scrophulariaceae. Petiole anatomical characters are also used for this purpose.

MATERIALS AND METHODS

The taxa for the present study (Table 1) were collected from West Bengal and two specimens from Uttarakhand. Taxa were identified following standard literatures. In some cases identity was confirmed by the e-Flora of China. The voucher specimens were deposited at the herbarium of Barasat Govt. College.

Gross Morphological Study-

Gross morphological study was conducted from both fresh and dry materials. Dry materials were kept in warm water for 1 h before dissection. All parts of the plant body were measured carefully. Illustrations were made by free-hand drawing from living and dry specimens.

Table 1. Taxa of Scrophulariaceae *s.l.* for Present Study-

Specimen	Tribe (*sensu* Fischer, 2004)	Collection place	Collection date	Collection numbers
Bacopa monnieri (L.) Wettst.	Gratioleae	Maslandapur, 24 Pags (N), W.B.	07.02.2015	C31
Mecardonia procumbens (Mill.) Small.	Gratioleae	Maslandapur, 24 Pags (N), W.B.	10.02.2015	C43
Lindernia multiflora (Roxb.) Mukerjee	Lindernieae	Maslandapur, 24 Pags (N), W.B.	14.02.2015	C45
Lindernia crustacea (L.) F. Muell.	Lindernieae	Maslandapur, 24 Pags (N), W.B.	14.02.2015	C46
Lindenbergia indica Vatke.	Lindernieae	Barasat, 24 Pags (N), W.B.	24.02.2015	C51
Scoparia dulcis L.	Gratioleae	Maslandapur, 24 Pags (N), W.B.	07.03.2015	C57
Mazus pumilus (Burm f.) Steenis	Mimuleae	Maslandapur, 24 Pags (N), W.B.	07.03.2015	C60
Antirrhinum majus L.	Antirrhineae	Gobardanga, 24 Pags (N), W.B.	12.04.2015	C78
Verbascum thapsus L.	Verbasceae	Lohaghat, Uttarakhand	08.10.2012	C68
Scutellaria sp.	Scutellarioideae	Lohaghat, Uttarakhand	03.10.2012	C69
Pedicularis carnosa Wall.	Rhinantheae	Ranikhet, Uttarakhand	18.09.2011	C70

Petiole Anatomical Study-

Petiole anatomy was obtained from free-hand sections. Some mature and fresh parts of the petiole from each of the plant species were used for anatomical studies. Petiole sections were then stained by 0.1% Phloroglucinol in 6N HCL solution. Petiole section images were captured under Carl Ziess bright filled microscope. Stage and Ocular micrometers were used for measurement. Then using photo editing software outline of images was drawn and regions occupied by vascular tissues were darkened.

RESULTS AND DISCUSSION

Gross Morphological Descriptions-

Gross morphological descriptions and illustrations (Figure 1 – 6) are clearly distinct in the studied species of Scrophulariaceae. Gross morphology is used for the preparation of identification key.

Petiole Anatomy-

In the studied members of Scrophulariaceae s.l. the petiole anatomy was highly variable (Figure 7). The shape varies from cordate to wing shaped. Vascular bundle shapes were also variable. It varies from arc-shaped to round or oval. In some species trichome is absent whether present in others. Table 1 shows the petiole anatomical differences in the studied species.

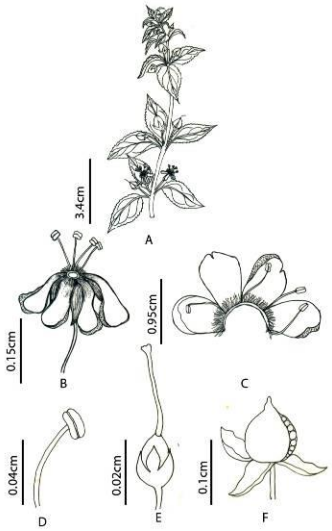

Figure1: *Scoparia dulcis* L. A- flowering twig; B- flower; C- corolla split open; D- stamen; E- carpel; F- fruit.

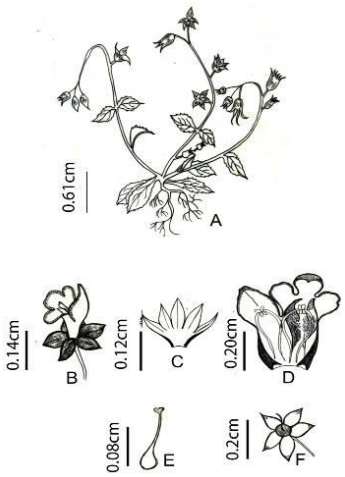

Figure 2: *Majus pumilus* (Burm.f.) Steensis. A- flowering twig; B- flower; C- corolla split open; D- stamen; E- carpel; F- fruit.

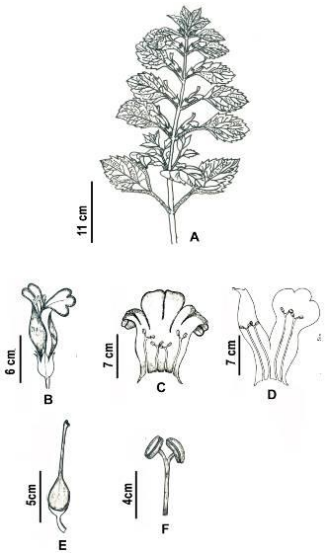

Figure 3: *Lindenbergia indica* Vatke. A- flowering twig; B- flower; C- corolla split open; D- calyx; E- carpel.

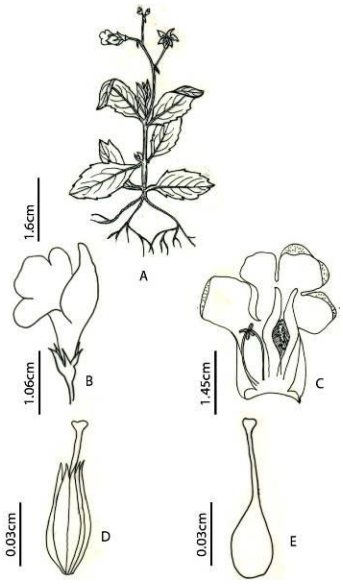

Figure 4: *Lindernia multiflora* (Roxb.) Mukerjee. A- flowering twig; B- flower; C- corolla split open; D- calyx; E- carpel.

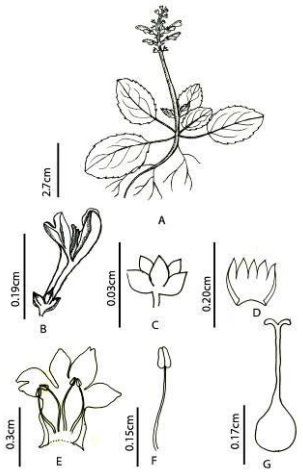

Figure 5: *Scutellaria sp*. A- flowering twig; B- flower; C- calyx; D- calyx split open; E- corolla split open; F- stamen; G- carpel.

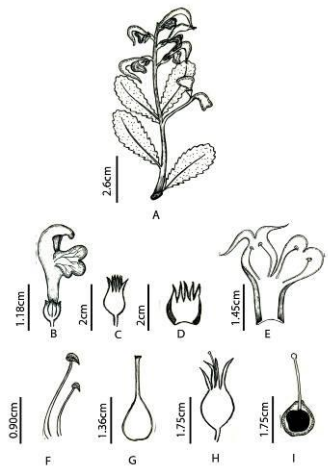

Figure 6: *Pedicularis carnosa* Wall. A- flowering twig; B- flower; C- calyx; D- stamen; E- carpel.

Indian Journal of Plant Sciences ISSN: 2319–3824(Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jps.htm
2015 Vol. 4 (4) October-December, pp. 121-126/Naskar
Research Article

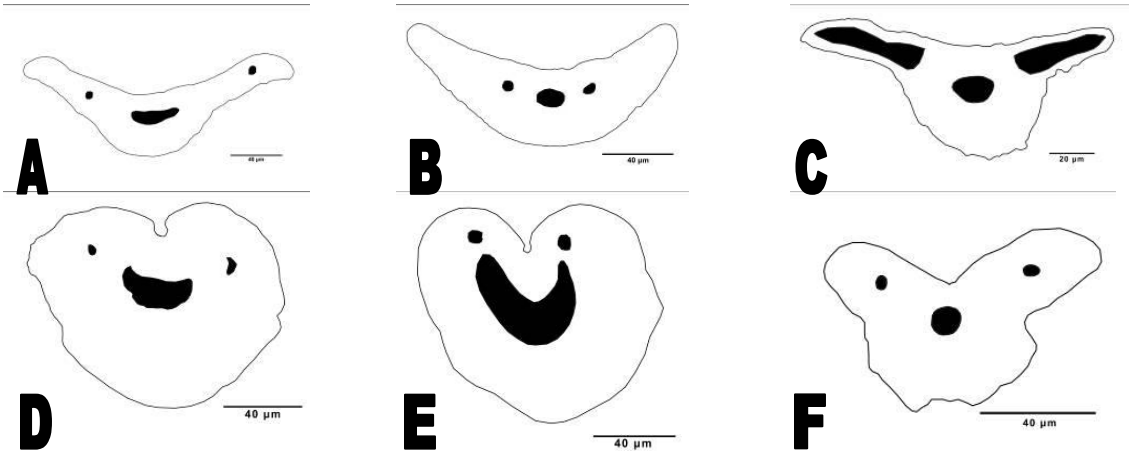

Figure 8: Petiole anatomy in Scrophulariaceae *s.l.*

A- *Mecardonia procumbens*;
B- *Bacopa monnieri*;
C- *Mazus pumilus*;
D- *Scoparia dulcis*;
E- *Scutellaria* sp.;
F- *Lindernia multiflora*.

Table 1: Petiole Anatomical Variation in the Members of Scrophulariaceae *S.L.*

	TAXA					
CHARAC-TERS	***Scoparia dulcis***	***Majus pumulis***	***Mecardonia chemidroides***	***Bacopa monneri***	***Antirhinn-um majus***	***Scutelaria* sp.**
Petiole shape	Cordate shaped	Short wing shaped	Thick wing shaped	Wing shaped	Wing shaped	Cordate shaped
Number of vascular bundle	3	3	3	3	3	3
Vascular bundle shape	Horizontal-ly elongated to u-shaped	Round-ed	oval	Horizonta-lly elongated	rounded	arc-shaped
Number of vascular bundle/ crescent	1	1	1	1	1	1
Trichome	Absent	Present	Absent	Absent	Present	Present

Scrophulariaceae *s.l.* is now circumscribed differently after molecular phylogenetic analyses. Most of present studied species are now treated under different families. *Bacopa*, *Lindenbergia*, *Mecardonia*,

Scoparia, Antirrhinum are now treated under Plantaginaceae; *Lindernia* under Linderniaceae; under Phrymaceae; *Scutellaria* under Lamiaceae and *Pedicularis* Orobanchaceae. Only *Verbascum* is retained under Scrophulariaceae *s.s.* Still taxonomists have unable to find out any morphological synapomorphic characters within these families.

Scrophulariaceae *s.l.* are roughly segregated on the basis of some gross morphological and petiole anatomical traits. Following is an identification key based on gross morphology and petiole anatomy characters.

1a.	Flowers zygomorphic or rarely actinomorphic; leaves opposite decussate or rarely opposite to whorled ; exstipulate; plants herbaceous (bast fibers were absent) ……..	2
1b.	Flowers zygomorphic ; leaves opposite decussate, exstipulate; plants woody (bast fibers were present) ……	*Verbascum thapsus* (Scrophulariaceae s.s.)
2a.	Flowers zygomorphic or rarely actinomorphic; inflorescence in most cases racemose, but sometimes cymose ; calyx aestivation imbricate or sometimes valvate, corolla 2 lipped ……..	3
2b.	Flowers zygomorphic ; inflorescence racemose; calyx aestivation valvate …….	*Scutellaria* (Lamiaceae)
3a.	Flowers zygomorphic or rarely actinomorphic; leaves opposite decussate or rarely opposite to whorled ; petal 5, 2 lipped corolla ……	4
3b.	Flowers zygomorphic ; leaves alternate; calyx campanulate , actinomorphic, valvate ……	*Pedicularis* (Orobancaceae)
4a.	Flower in terminal , subsecund racemes; upper lip erect ovate, 2 fid, lower much larger, spreading, 3 fid, throat with 2 lobed palate ……..	*Majus* (Phrymaceae)
4b.	Flower axillary or racemose …….	5
5a.	Ebracteate ; Sepals -5, almost free to the base or connate in campanulate calyx, without wings or keel. Petals 5, connate in a 2- lipped corolla; tube cylindric, upper lip outermost, erect, concave, notched or 2-fid, lower wider 3 lobbed, Spreading ……	*Lindernia* (Linderniaceae)
5b.	Bracteate or ebracteate ; Petals 5 connate in a 2-lipped corolla, tube cylindric, 3 lobed ; or petals 4 , connate in rotate corolla throat densely beared, lobes obtuse, subequal ……	*Bacopa, Lindenbergia, Mecardonia, Scoparia, Antirrhinum* (Plantaginaceae)

ACKNOWLEDGMENT
I would like to thanks Principal, Barasat Govt. College and Head, Department of Botany, Barasat Govt. College, Kolkata for providing me space and facilities to complete the present research work. I would also like to thanks my students who help me to collect the specimens for present study.

REFERENCES
Angiosperm Phylogeny Group II (2003). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnean Society* **141** 399–436.
Bentham G (1876). Scrophulariaceae. *In: Genera Plantarum,* Edited by Bentham G and Hooker JD (Reeve and Co., London, UK) **2** 913-980.
Fischer E (2004). Scrophulariaceae. *In: The Families and Genera of Vascular Plants,* Edited by Kubitzki K (Spinger) **VII** 333-432.
Melchior H (1964). *Syllabus der pflanzenfamilien* II, (Gebrtider Borntraeger, Berlin, Germany).
Olmstead RG, dePamphilis CW, Wolfe AD, Young ND, Elisons WJ and Reeves PA (2001). Disintegration of the Scrophulariaceae. *American Journal of Botany* **88** 348-361.
Oxelman B, Kornhall P, Olmstead RG and Bremer B (2005). Further disintegration of Scrophulariaceae. *Taxon* **54**(2) 411-425.
Pennell FW (1935). The Scrophulariaceae of eastern temperate North America. *Academy of Natural Sciences of Philadelphia Monographs **1** 1-650.*
Tank DC, Beardsley PM, Kelchner SA and Olmstead RG (2006). Review of the systematics of Scrophulariaceae s.l. and their current disposition. *Australian Systematic Botany* **19** 289-307.