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## RESEARCH ARTICLE

### STOMATAL ABNORMALITIES IN THE FOLIAR EPIDERMIS OF SOME SCROPHULARIACEAE

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#### ABSTRACT

Various abnormal stomata distributed among 60 species of 39 genera of Scrophulariaceae are recorded. These are categorized into 5 major types viz., contiguous stomata, stomata with single guard cells, stomata with both guard cells degenerated, heteromorphic stomata and stomata with polar deposits. The probable factors and reasons leading to the formation of such stomata in the foliar epidermis have been discussed.

## INTRODUCTION

Gertz (1919) was one of the earliest to report a number of abnormal stomata in the leaves of *Avena*, *Cucurbita*, *Phaseolus*, *Secale* etc. Farooqui (1979) who reviewed the occurrence of abnormal stomata in several angiospermic families highlighted their morphological importance and remarked that they should be noted and recorded by workers undertaking epidermal studies. The earlier major contributions on the foliar epidermis in the family Scrophulariaceae (Solereider, 1908; Metcalfe and Chalk, 1950, 1979; Nyawuame and Gill, 1993; Lersten and Curtis, 1997; Kaplan and Inceoglu, 2003; Sosa, 2005; Al-Hadeethy et al., 2014) could not give any indication of stomatal abnormalities existing in the members of this family. In the course of investigation of the foliar epidermis of 60 species belonging to 39 genera of Scrophulariaceae several interesting patterns of stomata are recorded.

## MATERIALS AND METHODS

Leaf materials of 60 species belonging to 39 genera of family Scrophulariaceae were collected from different localities and sources (see Table-1) and preserved in FAA. Samples were taken from different regions of young and mature leaves. Epidermal peels and scrapes were obtained and studied by techniques employed by Mohan Ram and Nayyar (1974) and Theunissen (1989).

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## OBSERVATIONS AND DISCUSSION

The species wise distribution of these abnormal stomata are presented in Table-1. The various abnormal stomata observed in this study are classified into 5 major types. These are:

**1. Contiguous stomata:** Stomata where two or more stomata joined directly by the walls of the guard cells. The variations recorded are:

a) **Juxtaposed stomata:** Twin stomata joined directly by the lateral walls (Fig. 1, 2). These are observed in 21 species studied.

b) **Obliquely posed stomata:** The polar end of stoma is contiguous with the side of another stoma. These are observed in 24 taxa studied (Fig. 3, 4).

c) **Superposed stomata:** Contiguous stomata joined at the polar ends (pole to pole contiguity). These are observed in 7 species studied (Fig. 5).

Several theories have been put forwarded to explain the formation of contiguous stomata. According to Bunning (1956) stomata are spaced out from one another due to their mutual inhibitory influence during development so that new stomata do not differentiate continuously; if this influence is not there, stomata become contiguous. But this has been rejected by Shah and Gopal (1971) who attributed budding for the formation of contiguous stomata. Pant and Kidwai (1967) believe that contiguous stomata are formed due to an inducing influence around a particular stoma.

Table 1. Various kinds of stomatal abnormalities observed in the present investigation in the family Scrophulariaceae

Sl. No.	Name of the species	Locality Source	Contiguous stomata			S.G.	D.G.	H.S.	S.P. D
			J.P.	S.P.	O.P.				
1	<i>Verbascum chinense</i>	AU, Visakhapatnam	+	-	+	-	-	+	+
2	<i>Angelonia gardneri</i>	Bangalore	-	-	-	-	-	+	+
3	<i>Angelonia grandiflora</i>	AU, Visakhapatnam	-	+	-	-	+	-	+
4	<i>Angelonia salicariifolia</i>	Bangalore	-	-	-	-	-	+	+
5	<i>Calceolaria mexicana</i>	SVU, Tirupathi	-	-	-	-	-	+	+
6	<i>Antirrhinum majus</i>	AU, Visakhapatnam	+	-	+	-	-	+	-
7	<i>Cymbalaria muralis</i>	AU, Visakhapatnam	-	-	-	-	-	-	+
8	<i>Kickxia ramosissima</i>	BSI, Coimbatore	-	+	-	-	-	+	+
9	<i>Linaria dalmatica</i>	BSI, Kolkata	-	-	-	-	-	-	+
10	<i>Linaria vulgaris</i>	BSI, Coimbatore	-	+	-	-	-	+	-
11	<i>Schweinfurthia sphaerocarpa</i>	BSI, Coimbatore	-	-	-	-	-	-	-
12	<i>Freylinia lanceolata</i>	BSI, Kolkata	+	-	+	-	-	+	-
13	<i>Halleria elliptica</i>	BSI, Kolkata	+	+	+	-	-	+	-
14	<i>Halleria lucida</i>	BSI, Kolkata	+	+	+	-	-	+	-
15	<i>Phygelius capensis</i>	BSI, Kolkata	+	-	+	-	-	+	+
16	<i>Russelia floribunda</i>	Bangalore	-	-	-	-	-	-	+
17	<i>Russelia sarmentosa</i>	BSI, Kolkata	-	-	-	-	-	+	+
18	<i>Scrophularia calycina</i>	BSI, Coimbatore	-	-	-	-	-	+	-
19	<i>Scrophularia canescens</i>	BSI, Kolkata	-	-	+	-	-	-	+
20	<i>Scrophularia nodosa</i>	BSI, Coimbatore	-	-	+	-	-	+	+
21	<i>Scrophularia polyantha</i>	BSI, Coimbatore	+	-	-	-	-	+	+
22	<i>Wightia gigantea</i>	BSI, Coimbatore	-	-	+	-	-	+	+
23	<i>Sutera glandulosa</i>	BSI, Coimbatore	-	-	-	-	-	-	+
24	<i>Mazus rugosus</i>	BSI, Coimbatore	+	-	+	-	+	+	+
25	<i>Mimulus gracilis</i>	BSI, Coimbatore	-	-	+	-	-	+	+
26	<i>Limnophila rugosa</i>	East Godavari	-	-	-	-	-	-	+
27	<i>Lindenbergia urticaefolia</i>	BSI, Coimbatore	-	-	-	-	-	+	+
28	<i>Stemodia viscosa</i>	BSI, Coimbatore	-	-	+	-	-	+	+
29	<i>Bacopa monnieri</i>	AU, Visakhapatnam	-	-	-	+	-	+	+
30	<i>Dopatrium junceum</i>	SVU, Tirupathi	-	-	-	-	-	-	+
31	<i>Mecardonia procumbens</i>	Warangal	+	-	-	-	-	+	+
32	<i>Peplidium maritimum</i>	BSI, Coimbatore	+	+	+	-	-	-	+
33	<i>Artanema longifolium</i>	BSI, Kolkata	-	-	+	-	+	+	+
34	<i>Lindernia antipoda</i>	Warangal	-	-	-	-	-	-	+
35	<i>Lindernia caespitosa</i>	AU, Visakhapatnam	-	-	-	-	-	+	+
36	<i>Lindernia parviflora</i>	Warangal	-	-	+	-	-	+	+
37	<i>Lindernia ruellioides</i>	BSI, Kolkata	-	-	-	-	-	-	+
38	<i>Torenia cordifolia</i>	Bangalore	+	-	-	+	-	-	+
39	<i>Torenia grandiflora</i>	AU, Visakhapatnam	-	-	-	-	-	-	+
40	<i>Capraria biflora</i>	BSI, Kolkata	+	-	-	-	-	+	+
41	<i>Digitalis ferruginea</i>	BSI, Kolkata	+	-	+	-	-	+	+
42	<i>Digitalis grandiflora</i>	BSI, Kolkata	-	-	-	-	-	-	+
43	<i>Digitalis laciniata</i>	BSI, Kolkata	+	-	+	-	-	-	+
44	<i>Digitalis lanata</i>	BSI, Kolkata	+	-	+	-	-	+	+
45	<i>Digitalis lutea</i>	BSI, Kolkata	-	-	-	-	-	+	+
46	<i>Digitalis purpurea</i>	AU, Visakhapatnam	+	-	+	-	-	+	+
47	<i>Hemiphragma heterophyllum</i>	AU, Visakhapatnam	-	-	-	-	-	-	-
48	<i>Picrorhiza kurroa</i>	BSI, Coimbatore	-	-	-	-	-	+	-
49	<i>Scoparia dulcis</i>	Kambalakonda, Visakhapatnam	-	-	+	-	-	-	-
50	<i>Veronica perfoliata</i>	BSI, Coimbatore	-	-	-	-	+	+	-
51	<i>Veronica speciosa</i>	BSI, Coimbatore	-	-	-	-	-	+	+
52	<i>Wulfenia amherstiana</i>	BSI, Coimbatore	-	-	-	-	-	-	+
53	<i>Centranthera hispida</i>	Tirupathi Hills	-	-	+	-	-	+	+
54	<i>Melasma arvense</i>	BSI, Coimbatore	-	-	-	-	-	-	+
55	<i>Striga densiflora</i>	East Godavari	-	-	-	-	-	-	+
56	<i>Euphrasia officinalis</i>	BSI, Coimbatore	+	-	-	-	-	+	+
57	<i>Euphrasia stricta</i>	BSI, Coimbatore	+	-	+	-	-	+	+
58	<i>Pedicularis perrottetii</i>	BSI, Coimbatore	+	+	+	-	-	-	+
59	<i>Pedicularis pyramidata</i>	BSI, Coimbatore	+	-	+	-	-	+	+
60	<i>Pedicularis tubiflora</i>	BSI, Coimbatore	+	-	-	+	+	-	+

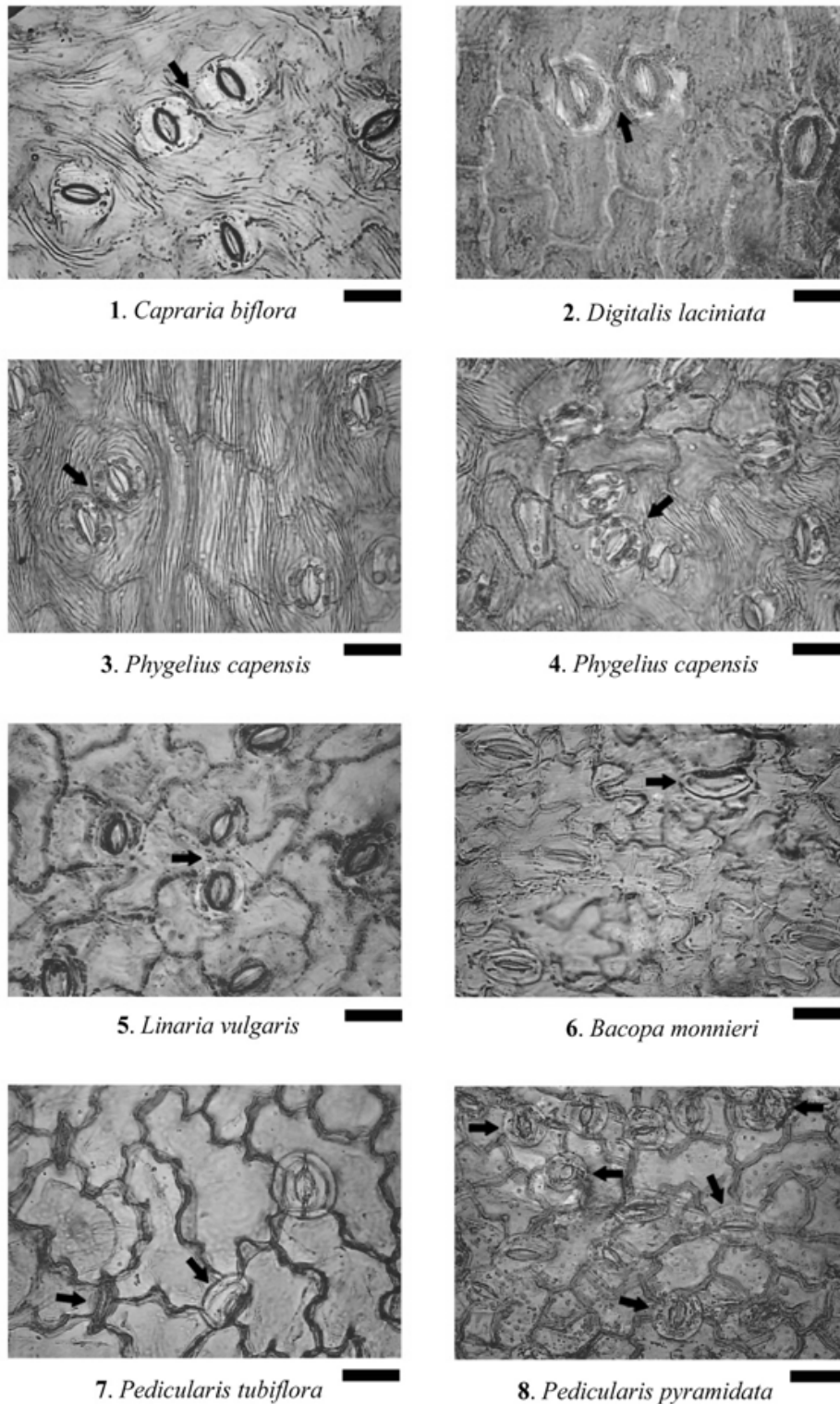
D.G.: Degenerating stomata; H.S.: Heteromorphic stomata; J.P.: Juxtaposed; O.P.: Obliquely posed; S.G.: Single guard cell; S.P.: Superposed; S.P.D.: Stomata with polar deposits

## 2. Stomata with a single guard cell


These are found in three species of Scrophulariaceae. The single guard cell is bean shaped with a differential wall thickening, on the side of the notch. The pore may or may not be present (Fig. 6, 7). Stomata with single guard cell are formed due to degeneration of one of the guard cells so that a normal pore is present. These may be also formed due to failure of the guard cell mother cell to divide further and its direct conversion into a single guard cell without forming a pore.

Stomata with single guard cell have been reported earlier in Solanaceae (Ahmad, 1964); Convolvulaceae (Pant and Banerji, 1965b); Bignoniaceae (Jain, 1978), Malvaceae (Inamdar and Chohan, 1969); Cucurbitaceae (Pant and Banerji, 1965a); Euphorbiaceae (Rao and Raju, 1975a, b); Apocynaceae (Baruah and Nath, 1996); Boraginaceae (Vijaya Kumar and Hanumantha Rao, 1996) and Lamiaceae (Swarna Gowri and Hanumantha Rao, 2004).

**3. Stomata with both guard cells degenerated:** Aborted stomata with both the guard cells degenerated are of common

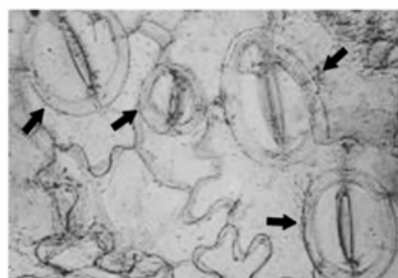
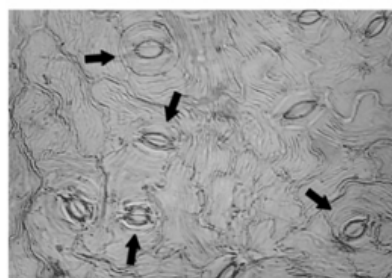
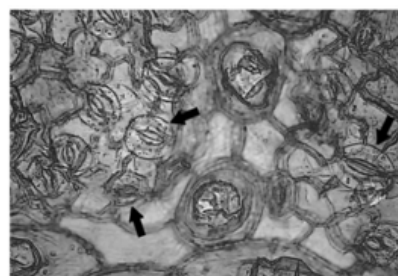
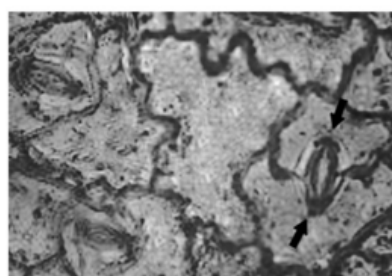
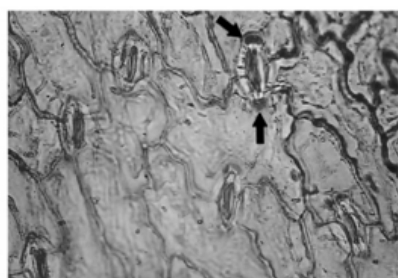
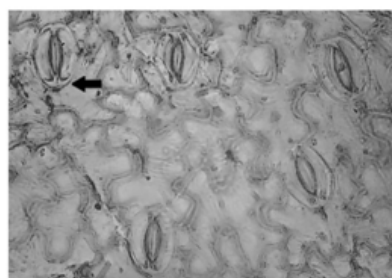
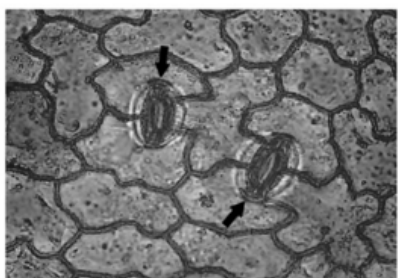
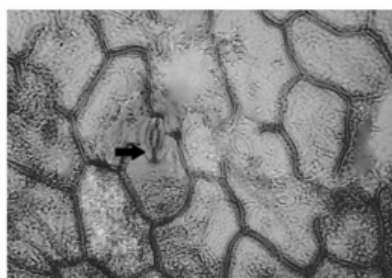


Figures 1 - 8

- 1, 2: Juxtaposed type of contiguous stomata in *Capraria biflora* and *Digitalis laciniata*,  
 3: Obliquely posed type of contiguous stomata in *Phygelius capensis*,  
 4: Obliquely posed type of contiguous stomata (Triplet) in *Phygelius capensis*,  
 5: Superposed type of contiguous stomata in *Linaria vulgaris*,  
 6: Stomata with single guard cell in *Bacopa monnieri*,  
 7: Stomata with degenerated guard cell and single guard cell in *Pedicularis tubiflora*,  
 8: Heteromorphic stomata (Circular, oval, nearly circular) in *Pedicularis pyramidata*,  
 Scale bar: 1 - 8:  = 15µm.


occurrence on the abaxial epidermis of some members (5 species) of Scrophulariaceae. Only a cuticular thickening remains around the stomatal pore (Fig. 7). Possibly these are formed due to disintegration of both the guard cells. Such stomata were earlier reported in Solanaceae (Ahmad, 1964),

Rubiaceae (Pant and Mehra, 1965); Acanthaceae (Ahmad, 1974); Boraginaceae (Vijaya Kumar and Hanumantha Rao, 1996) and Lamiaceae (Swarna Gowri and Hanumantha Rao, 2004).

9. *Calceolaria mexicana*10. *Scrophularia nodosa*11. *Pedicularis pyramidata*12. *Mazus rugosus*13. *Pedicularis tubiflora*14. *Bacopa monnieri*15. *Digitalis grandiflora*16. *Centranthera hispida*

## Figures 9 - 16

- 9: Heteromorphic stomata (Giant, large, small) in *Calceolaria mexicana*,  
 10: Heteromorphic stomata (Oval, elliptic, nearly circular), (Giant, large, small) in *Scrophularia nodosa*,  
 11: Heteromorphic stomata (Giant, large, small) in *Pedicularis pyramidata*,  
 12, 13: Stomata with polar nodules in *Mazus rugosus* and *Pedicularis tubiflora* respectively,  
 14: Stomata with polar nodular outgrowths in *Bacopa monnieri*,  
 15: Stomata with polar caps in *Digitalis grandiflora*,  
 16: Stomata with polar rods in *Centranthera hispida*.

Scale bar: 9-16:  = 15µm

**4. Heteromorphic stomata:** Normal stomata are homomorphic with ellipsoidal or bean shaped cells. However distinct stomata (like oval, nearly circular, circular) are found in addition to the normal ones, with in the same surface of the species (37) indicating their heteromorphic nature (in shape and size) (Fig. 8-11).

**5. Stomata with polar deposits:** These are found in the majority of the species (49) of present study. Polar deposits in different forms like polar nodules (Fig. 12, 13), polar nodular

outgrowths (Fig. 14), polar caps (Fig. 15) and polar rods (Fig. 16) are observed. In the present study the abnormal stomata are found in higher frequency in the mature leaves than the young ones and this observation further confirms earlier reports by Ahmad (1964), Kannabiran (1974) and Farooqui (1979). It is further observed that most of the abnormal types of stomata reported earlier in different families of angiosperms (Farooqui, 1979) are present among the members of the family Scrophulariaceae.

## REFERENCES

- Ahmad K.J. 1964. On stomatal abnormalities in Solanaceae. *Sci. and Cult.* 30: 349-351.
- Ahmad K.J. 1974. Cuticular studies in some Nelsonioideae (Acanthaceae). *Bot. J. Linn. Soc.* 68: 73-80.
- Al-Hadeethy M., Manthipha K., Al-Mshhdani A., Pimwadee P., Al-Khesraji T., Barusrux S. and Al-Jewari H. (2014). Anatomical study of some characters in certain species of genus *Verbascum* L. in North and middle of Iraq. *Direct Res. J. Biol. Biotechnol.* 1(1): 3-13.
- Baruah A. and Nath S.C., 1996. Stomatal diversities in *Catheranthus roseus* (L.) G. Don. Some additional information. *Phytomorphology*, 46(4): 365-370
- Bunning E. 1956. General processes of differentiation. In : The Growth of Leaves, Ed. F.L. Milthorpe, London.
- Farooqui P. 1979. On the occurrence of abnormal stomata in some plants. *Curr. Sci.* 48: 841- 849.
- Gertz O. 1919. Uber septiarta stomazellen. *Ber dt. Bot. Ges.* 37: 329-334.
- Inamdar J. A. and Chohan A. J. 1969. Epidermal structure and stomatal development in some Malvaceae and Bombacaceae. *Ann. Bot.* 33: 865-878.
- Jain D.k. 1978. Studies in Bignoniaceae II. Foliar epidermal structure. *J. Indian Bot. Soc.* 57:161-174.
- Kannabiran B. (1974). Stomatogenesis in the leaves of *Clerodendron phlomidis* L.F. *Curr. Sci.* 43: 321-322.
- Kaplan A. and Inceoglu O. (2003). Leaf anatomy and morphology of 14 species belonging to Turkish Rhinanthae (Scrophulariaceae) tribe. *Israel Journal of Plant Sciences.* 51(4): 297-305.
- Lersten N. R. and Curtis J. D. (1997). Anatomy and distribution of foliar idioblasts in *Scrophularia* and *Verbascum* (Scrophulariaceae). *American Journal of Botany.* 84(12):1638-1645.
- Metcalfe C.R. and Chalk L. (1950). Anatomy of Dicotyledons. Vol. I. Clarendon Press, Oxford, U.K.
- Metcalfe C.R. and Chalk L. (1979). Anatomy of Dicotyledons. 2nd ed. Vol. I. Clarendon Press, Oxford.
- Mohan Ram H.Y. and V. Nayyar, 1974. A rapid method of obtaining epidermal peels in plants by treatment with Cupric sulphate and HCL. *Stain Technol.* 49: 114-116.
- Nyawuame, H. G. K. and Gill, L. S. 1993. Cuticular studies and their bearing on the taxonomy of some Scrophulariaceae. *Feddes Repertorium*, 104(1-2): 41-50.
- Pant D.D. and Banerji R. 1965a. Ontogeny of stomata and hairs in some cucurbits and allied plants. *J. Indian Bot. Soc.* 44(2): 191-197.
- Pant D.D. and Banerji R. 1965b. Epidermal structure and development in stomata in some Convolvulaceae, *Senckenberg. Biol.* 46: 155-173.
- Pant D.D. and Kidwai P. F., 1967. Development of stomata in some Cruciferae. *Ann. Bot.* 31: 513-521.
- Pant D.D. and Mehra B. 1965. Ontogeny of stomata in some Rubiaceae. *Phytomorphology*, 15: 300-310.
- Rao P. N. and Raju V. S. 1975a. Development and diversity of stomata in *Micrococca mercurialis* Benth. *Curr. Sci.* 44: 594-596.
- Rao P. N. and Raju V. S. 1975b. Little known features in the foliar epidermology of some Euphorbiaceae. *Curr. Sci.* 44: 750-752.
- Shah G. L. and Gopal B. V. 1971. Structure and development on the vegetative and floral organs in some members of stomata Caesalpiniaceae. *Ann. Bot.* 35: 754-759.
- Solereider H. 1908. Systematic Anatomy of Dicotyledons. Clarendon Press. Oxford.
- Sosa M. D. L. M. (2005). Anatomia foliar y caulinar en especies de *Stemodia* (Scrophulariaceae). *Bol. Soc. Argent. Bot.* 40(1-2):1-14.
- Swarna Gowri V. and Hanumantha Rao B. 2004. Stomatal abnormalities in the foliar epidermis of some Lamiaceae. *J. Swamy Bot. Cl.* 21: 67-70.
- Theunissen J. D. (1989). An improved method for studying grass leaf epidermis. *Stain Technol.* 64(5): 239-242.
- Vijaya kumar K. and Hanumantha Rao B. 1996. Stomatal abnormalities in the foliar epidermis of some Boraginaceae. *J. Swamy Bot. Cl.* 13: 39-44.

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