

MORPHOLOGICAL STUDIES IN *SWERTIA* LINN. (GENTIANACEAE): EPIDERMAL STRUCTURES

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ABSTRACT

Eighteen species of the genus *Swertia* have been studied for their cuticular structures. Important characters have been discussed and efforts have been made to identify the species on the basis of cuticular characters. Ontogeny of stomata in a few species have also been studied.

INTRODUCTION

Swertia Linn. belongs to the family Gentianaceae; mostly they are herbs and represented by many species in India. However, cuticular studies of this family are lacking. Only a few taxa, viz. *Canscora decussata*, *C. diffusa*, *Hoppea dichotoma*, *Enicostema littorale*, *Gentiana pedicellata* and *Nymphoides cristatum*, have been studied for their cuticular structures by PANT AND KIDWAI (1969). Recently, we have described the cuticular structures in eighteen species of *Gentiana* (TRIVEDI & UPADHYAY, 1983). In the present investigation, the cuticular structures of eighteen species of *Swertia* Linn. have been studied.

MATERIAL AND METHOD

The material for the present investigation was largely obtained from the National Botanic Research Institute, Lucknow and from the herbarium of Botany Department, Lucknow University, Lucknow. Fresh material was obtained through the courtesy of Dr. B. N. Mehrotra, Botanist, Central Drug Research Institute, Lucknow which was largely collected from Kedar Nath, Uttar Kashi. For obtaining the cuticle usual method of maceration was followed. For the ontogeny of stomata young leaves were fixed in F. A. A. Peels of such leaves were stained by 1 per cent Acetocarmine.

OBSERVATIONS

Swertia Linn.

Stomata occur either on the lower surface or on both the surfaces of the leaf; when they occur on both the surfaces, frequency of stomata is always higher on the lower surface. Stomata are regularly distributed on the foliar surfaces; they are usually anomocytic, rarely paracytic. Epidermal cells are usually irregular with slightly or highly sinuate walls. In some species epidermal cells have various shapes. Epidermal cells over the veins are elongated or rectangular. Marginal cells are usually smaller than the remaining epidermal cells. They are either thin-walled or thick-walled. Trichomes have been observed in a few species. They are usually unicellular, long or short, or with one or two septa and with striations. Papillae at the margin of the leaves have been observed in all the investigated species. In most of them the papillae are distributed all over the surface while in some striated papillae are common on the

upper surface. Cuticular striations in the guard cells as well as in epidermal cells are commonly noticed in most of the species. Striations also occur at the trichome bases along the length of trichomes and on the papillae. Cells size, stomatal size, stomatal frequency and index of 18 species of the genus *Swertia* have been given in table 1.

Important cuticular characters of the eighteen species of *Swertia* have been examined and these are given as below:

SPECIFIC DESCRIPTION AND TAXONOMIC NOTES

SECTION A

Leaf hypostomatic

1. ***S. macrosperma***

Text-fig. 1

Stomata paracytic; epidermal cells irregular with slightly sinuate walls; margins with slight projections; striations sparse.

2. ***S. cordata***

Text-fig. 2

Stomata paracytic; epidermal cells irregular with highly sinuate walls; margins with slight projections; striations absent.

Remarks: The two species show similar epidermal characters but in *S. macrosperma* the epidermal cells are slightly sinuate and striated while in *S. cordata* they are highly sinuate and cuticular striations are completely absent.

3. ***S. tetragona***

Text-fig. 3

Stomata paracytic, irregularly distributed; larger; epidermal cells of various shapes with straight walls, margins slightly papillate; papillae 2-4 μm long.

4. ***S. paniculata***

Text-figs. 4, 6

Stomata small, much crowded, paracytic; epidermal cells, various shapes with slightly sinuate walls; marginal papillae small with pointed ends, about 10 μm long; small papillae 2-5 μm long with striations occur on the upper surface; cuticular striations, arising from guard cells frequent.

5. ***S. angustifolia***

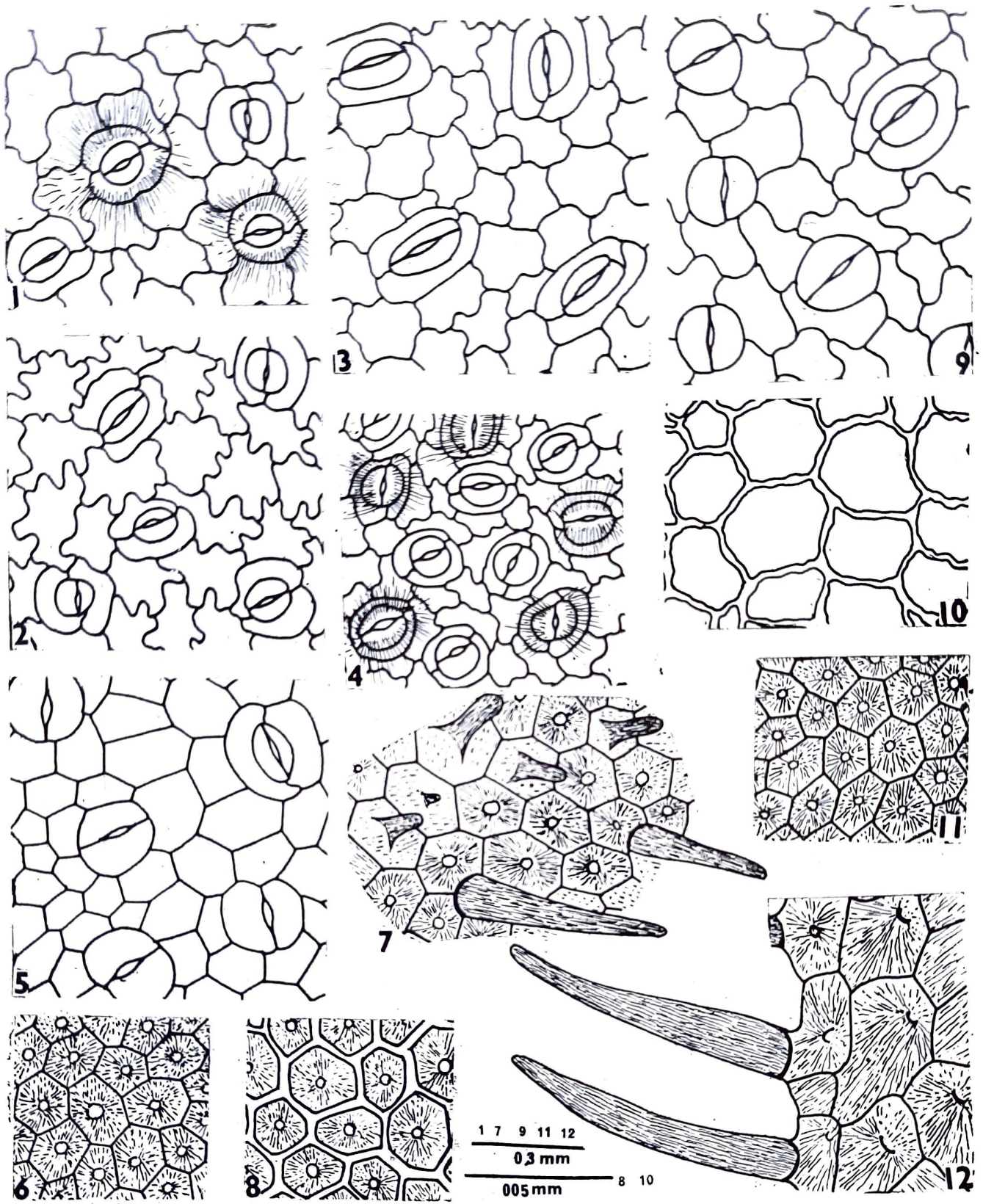
Text-figs. 5, 7-8

Stomata anomocytic and paracytic, frequency of anomocytic stomata high, epidermal cells penta- to polygonal with straight walls; trichomes long, unicellular with pointed ends about 130-140 μm long with rounded ends; distributed all over the foliar surface.

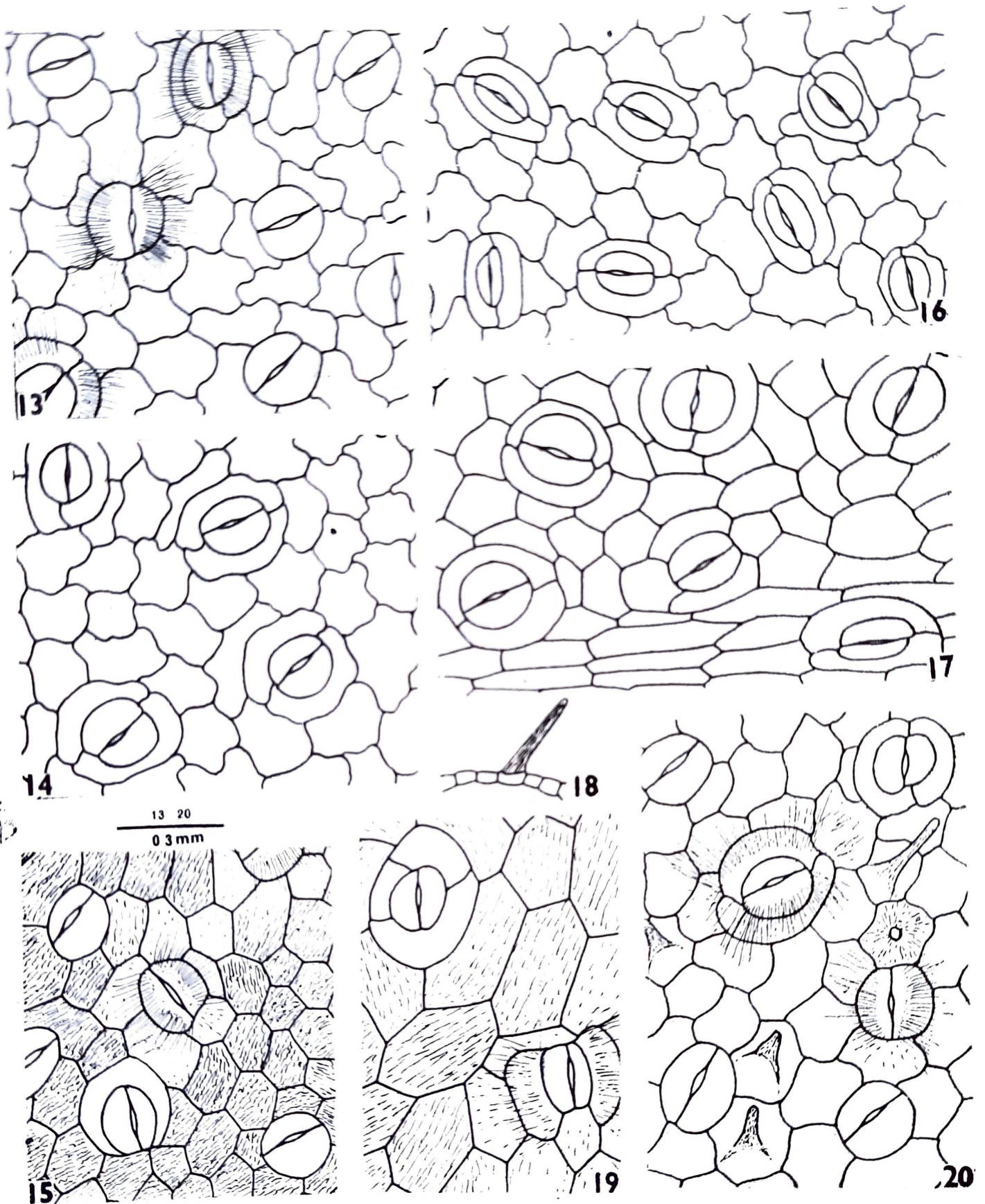
6. ***S. corymbosa***

Text-fig. 9

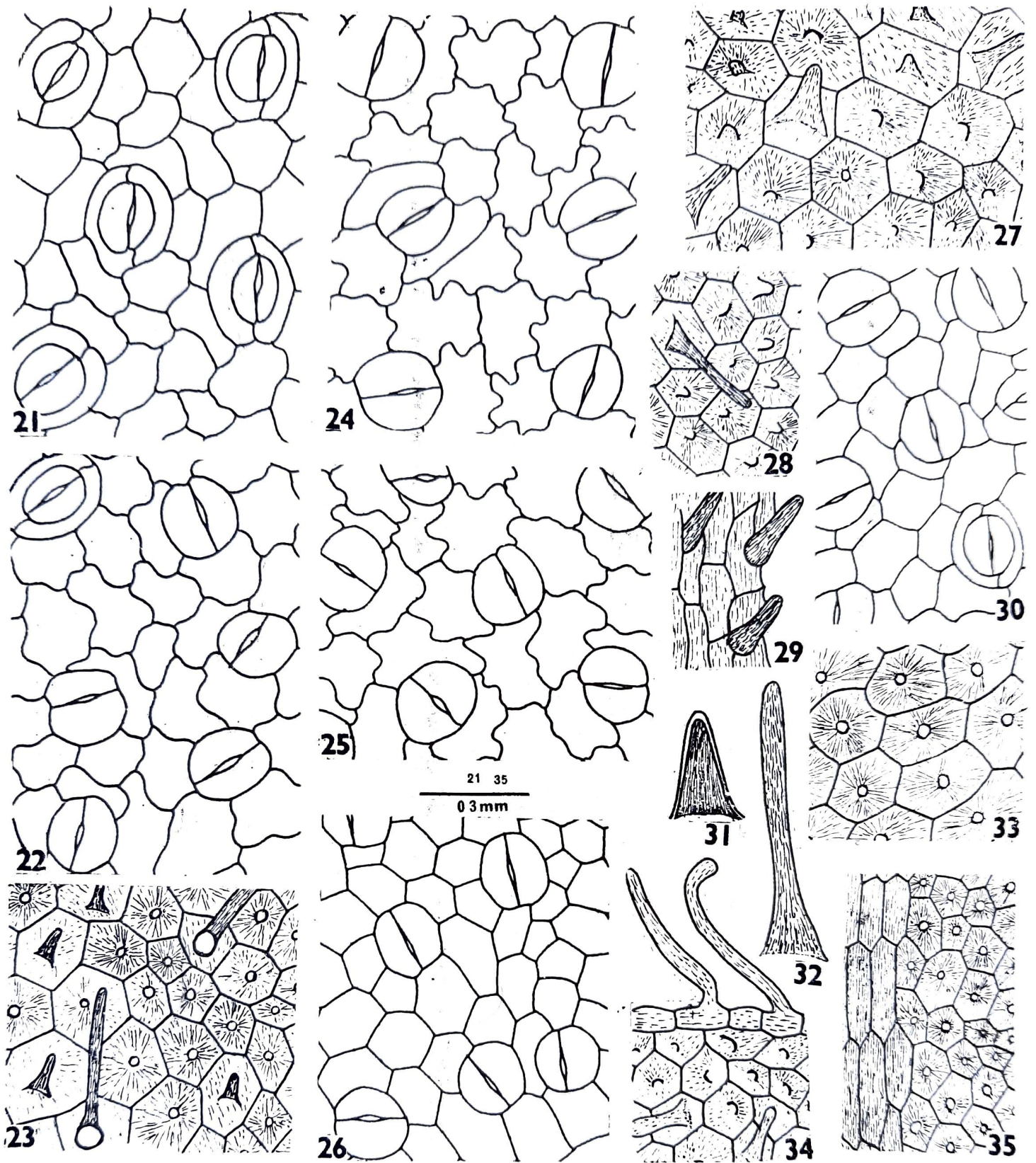
Stomata anomocytic and paracytic; epidermal cells irregular with slightly sinuate walls; cuticular striations frequent, arising from the guard cells; marginal papillae about 10 μm , sparsely arranged with pointed ends.



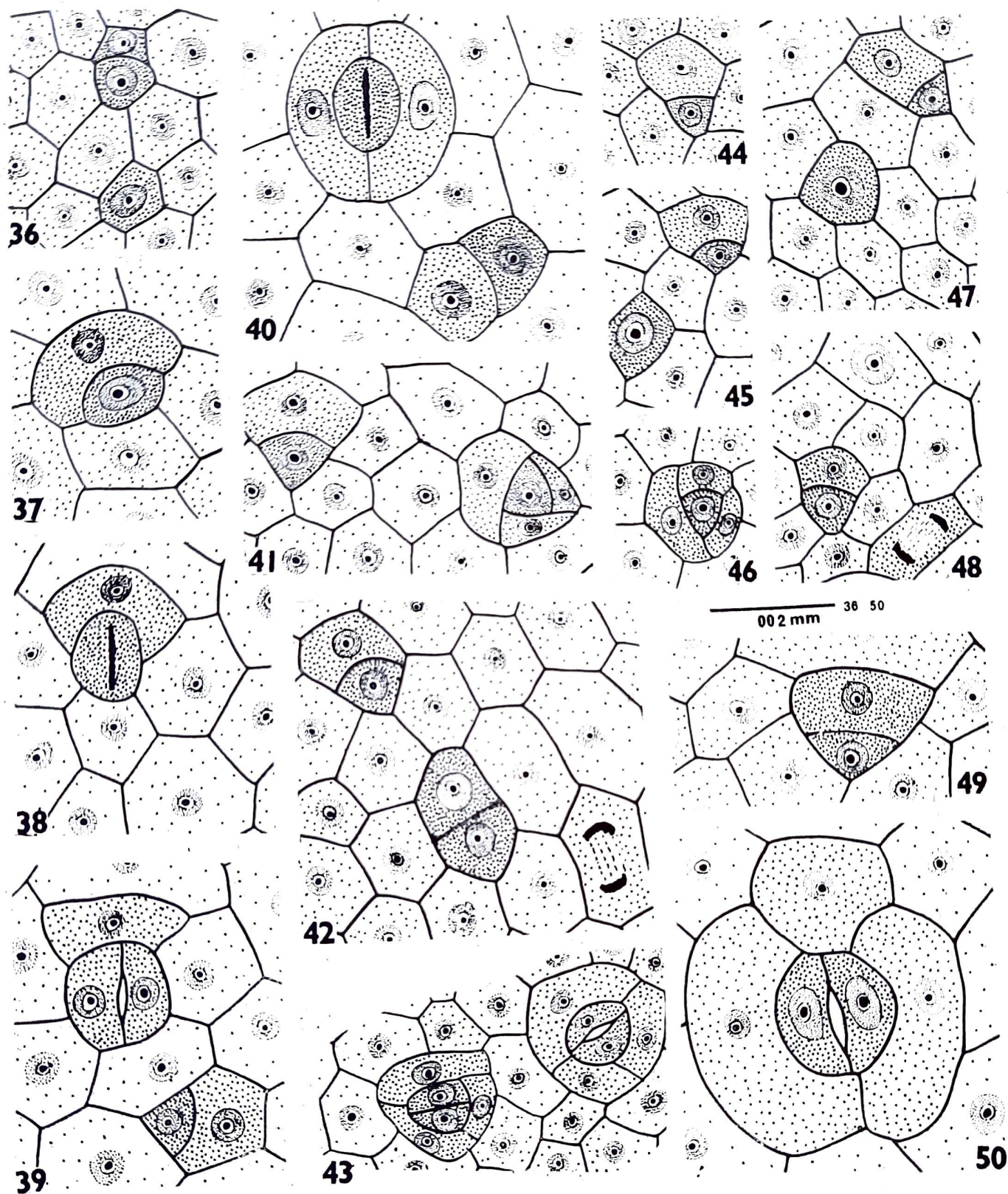
Figs. 1-12; Fig. 1—*S. macrocarpa*. Lower epidermis showing paracytic stomata and striations arising from guard cells. Fig. 2—*S. cordata*. Lower epidermis showing irregular epidermal cells and paracytic stomata. Fig. 3—*S. tetragona*. Stomata and epidermal cells. Fig. 4—*S. paniculata*. Lower epidermis showing small, crowded stomata with striations arising from guard cells. Fig. 5—*S. angustifolia*. Lower epidermis showing penta-hexagonal epidermal cells and anomocytic stomata. Fig. 6—*S. paniculata*. Upper epidermis showing penta-hexagonal cells with striations. Fig. 7—*S. angustifolia*. Upper epidermis showing striations in papillae. Fig. 8—*S. angustifolia*. Upper epidermis showing thick pentagonal cells with striations. Fig. 9—*S. corymbosa*. Epidermis showing anomocytic stomata and irregular cells. Fig. 10—*S. purpurascens*. Epidermal cell showing slightly sinuate walls. Fig. 11—*S. purpurascens*. Upper epidermal cells showing striations. Fig. 12.—*S. purpurascens*. Marginal cells showing long striated unicellular trichomes.



Figs. 13-20; Fig. 13—*S. purpurascens*. Lower epidermis showing irregular epidermal cells and anomocytic stomata with striations. Fig. 14—*S. nervosa*. Lower epidermis showing paracytic-stomata. Fig. 15—*S. chirata*. Epidermis showing anomocytic stomata and epidermal cells with striations. Fig. 16—*S. dilatata*. Epidermis showing paracytic stomata. Fig. 17—*S. affinis*. Lower epidermis showing large paracytic stomata. Fig. 18—*S. dilatata*. Trichomes arising from the marginal cells. Fig. 19.—*S. alternifolia* Upper epidermis showing paracytic and anisocytic stomata. Fig. 20.—*S. alternifolia*. Lower epidermis showing paracytic and anomocytic stomata with striations and papillae all over the surface.



Figs. 21-35; Fig. 21—*S. trichotoma*. Lower epidermis showing paracytic stomata. Fig. 22—*S. cuneata*. Lower epidermis showing anomocytic stomata. Fig. 23—*S. nervosa*. Upper epidermis showing striated epidermal cells, papillae and trichomes. Fig. 24—*S. alternifolia*. Epidermis showing anomocytic stomata. Fig. 25—*S. speciosa*. Epidermis showing anomocytic stomata. Fig. 26—*S. alata*. Epidermis showing anomocytic stomata and pentagonal straight walled epidermal cells. Fig. 27—*S. dilatata*. Upper epidermis showing papillae and striations. Fig. 28—*S. trichotoma*. Upper epidermis showing striated epidermal cells and trichomes. Fig. 29—*S. chirata*. Small trichomes on the large veins. Fig. 30—*S. petiolata*. Epidermis showing anomocytic and paracytic stomata. Fig. 31—*S. alata*. Small striated papillae. Fig. 32—*S. bimaculata*. Unicellular striated trichome. Fig. 33—*S. cuneata*. Upper epidermal cells showing striations. Fig. 34—*S. alternifolia*. Upper epidermis showing striations, small papillae and trichomes. Fig. 35—*S. affinis*. Upper epidermis showing elongated cells on the venal region and pentagonal cells on the remaining surfaces with striations.



Figs. 36-50; Fig. 36—*S. paniculata*. Protoderm cell and triangular meristemoid. Fig. 37—*S. paniculata*. Showing meristemoid and a large cell after division of protoderm cell. Fig. 38—*S. purpurascens*. Guard cell mother cell showing parallel division. Fig. 39—*S. purpurascens*. Mature stoma with two guard cells and a subsidiary cell. Fig. 40—*S. angustifolia*. Guard cell mother cell showing a parallel division. Fig. 41—*S. petiolata*. Triangular cell surrounded by three subsidiary cells. Fig. 42—*S. alternifolia*. Showing various stages of division of protoderm cell and formation of a meristemoid. Fig. 43—*S. cuneata*. Guard cell-mother cell showing median division and a mature anisocytic stomata. Fig. 44—*S. alternifolia*. Showing a triangular meristemoid and a large subsidiary cell. Fig. 45—*S. alternifolia*. Protoderm cell and a meristemoid after division. Fig. 46—*S. petiolata*. Triangular meristemoid surrounded by three unequal subsidiary cells. Fig. 47—*S. alternifolia*. Protoderm cell and a small meristemoid and a very large subsidiary cell. Fig. 48—*S. purpurascens*. Protoderm cell showing division and formation of a triangular meristemoid. Fig. 49—*S. paniculata*. Showing large subsidiary cell after division. Fig. 50—*S. paniculata*. Mature paracytic stoma showing a pair of guard cells and two subsidiary cells and an encircling cells.

7. **S. purpurascens**

Text-figs. 10-13

Stomata mostly anomocytic occasionally paracytic; epidermal cells irregular with slightly sinuate walls; polygonal and straight walls, on the upper surface; trichomes long, unicellular with pointed ends, about 50-60 μm long, frequent on veins and margins, small papillae about 5-10 μm long, with cuticular striations.

8. **S. nervosa**

Text-figs. 14, 23

Stomata paracytic, subsidiary cells not distinct, epidermal cells irregular with slightly sinuate walls; upper epidermal cells penta- or hexagonal with straight walls; papillae all over the upper surface, short with rounded ends, 10-30 μm long; cuticular striations all over the upper surface; trichomes long, unicellular with striations, about 100-150 μm long, occur on veins and margins.

9. **S. bimaculata**

Text-fig. 32

Stomata paracytic, subsidiary cells not distinct, epidermal cells irregular with slightly sinuate walls; papillae small and long distributed all over the surface, about 10-40 μm long; trichomes unicellular, about 100-150 μm long; cuticular striations, commonly seen arising from the guard cells.

10. **S. dilatata**

Text-figs. 16, 18, 27

Stomata paracytic, subsidiary cells not distinct, epidermal cells irregular with slightly sinuate walls; upper epidermal cells penta- or hexagonal with straight walls; papillae all over the upper surface, short with rounded ends, 10-30 μm long, cuticular striations all over the surface, trichomes occur on veins and margins, long, unicellular with striations about 100 to 150 μm long.

11. **S. trichotoma**

Text-figs. 21, 28

Stomata paracytic; epidermal cells of various shapes with slightly sinuate walls; small papillae distributed all over the upper foliar surface; trichomes short and long, unicellular, about 50 to 100 μm long with striations.

Remarks—Trichomes and papillae in 3 species, viz., *S. alternifolia* and *S. bimaculata* and *S. trichotoma* are similar in structure and distribution. These species differ from each other in structure of epidermal cells and type of stomata.

SECTION B

Leaf amphistomatic

12. **S. petiolata**

Text-fig. 30

Stomata mostly anomocytic and paracytic, rarely anisocytic; epidermal cells of various shapes with straight walls; margins with slight projections.

13. **S. chirata**

Text-figs. 15, 29

Stomata anomocytic or enclosed in the epidermal cells without any specialized subsidiary cells; epidermal cells comparatively larger, margins papillate; papillae with rounded ends, about 15 μm long.

14. **S. cuneata**

Text-figs. 29, 33

Stomata anomocytic and paracytic and rarely anisocytic; epidermal cells irregular with sinuous walls; margin papillate, papillae small with pointed ends, about 10-12 μm long; striations frequent on both the surfaces.

15. **S. alternifolia**

Text-figs. 19, 20, 24, 34

Stomata anomocytic and paracytic; epidermal cells irregular with sinuate walls; upper epidermal cells penta- or hexagonal with striations, trichomes, unicellular 150-200 μm long, small unicellular trichomes also observed on upper surface, 60-100 μm long; papillae distributed throughout the upper foliar surface, about 10-20 μm long.

16. **S. alata**

Text-figs. 26, 31

Stomata paracytic; epidermal cells of various shapes with straight walls; margin papillate; papillae frequent, about 40 μm long.

17. **S. affinis**

Text-figs. 17, 35

Stomata paracytic; epidermal cells irregular with sinuate wall, [elongated epidermal cells occur on the veins; penta- or hexagonal on upper surface with striations, margins papillate; papillae small 10-50 μm long with pointed ends.

18. **S. speciosa**

Text-fig. 25

Stomata anomocytic; epidermal cells irregular with sinuate walls; marginal papillae small, 5-10 μm long; trichomes and cuticular striations absent.

IMPORTANT CUTICULAR CHARACTERS OF THE GENUS *SWERTIA*

For identification of investigated species of *Swertia* cuticular characters are listed below. It is not possible to sort out individual species of *Swertia* on the basis of any one single cuticular character, but combinations of cuticular characters do help in identifying the species.

SECTION A

Leaf hypostomatic

S. macrosperma

S. paniculata

S. purpurascens

S. bimaculata

S. cordata

S. angustifolia

S. nervosa

S. trichotoma

S. tetragona

S. corymbosa

S. dilatata

SECTION B

Leaf amphistomatic

<i>S. petiolata</i>	<i>S. alata</i>	<i>S. chirata</i>
<i>S. cuneata</i>	<i>S. alternifolia</i>	<i>S. trichotoma</i>
<i>S. speciosa</i>		

Trichome long and/or unicellular

<i>S. angustifolia</i>	<i>S. purpurascens</i>	<i>S. dilatata</i>
<i>S. alternifolia</i>	<i>S. bimaculata</i>	<i>S. trichotoma</i>
<i>S. affinis</i>		

Papillae marginal and/or over the surface

<i>S. tetragono</i>	<i>S. paniculata</i>	<i>S. angustifolia</i>
<i>S. alata</i>	<i>S. corymbosa</i>	<i>S. purpurascens</i>
<i>S. chirata</i>	<i>S. dilatata</i>	<i>S. cuneata</i>
<i>S. alternifolia</i>	<i>S. bimaculata</i>	<i>S. trichotoma</i>
<i>S. affinis</i>	<i>S. speciosa</i>	

Stomata predominantly anomocytic

<i>S. petiolata</i>	<i>S. alata</i>	<i>S. purpurascens</i>
<i>S. chirata</i>	<i>S. cuneata</i>	<i>S. speciosa</i>

Stomata anomocytic to paracytic

<i>S. bimaculata</i>	<i>S. alternifolia</i>	<i>S. cuneata</i>
<i>S. purpurascens</i>	<i>S. corymbosa</i>	<i>S. petiolata</i>

Stomata predominantly paracytic

<i>S. macrosperma</i>	<i>S. cordata</i>	<i>S. tetragona</i>
<i>S. paniculata</i>	<i>S. nervosa</i>	<i>S. dilatata</i>
<i>S. trichotoma</i>	<i>S. affinis</i>	

Marginal sclerenchyma and/or sclereids

<i>S. angustifolia</i>	<i>S. alternifolia</i>
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Stomata anomocytic to paracytic and anisocytic

<i>S. petiolata</i>	<i>S. cuneata</i>
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DEVELOPMENT OF STOMATA

Developmental stages of the stomata have been observed in some species, viz. *S. paniculata*, *S. angustifolia*, *S. purpurascens*, *S. alternifolia*, *S. petiolata* and *S. cuneata*. Studies on stomatal development revealed that there are three types of stomata in these plants, *S. paniculata* (paracytic), *S. angustifolia* (anomocytic and paracytic), *S. petiolata* and *S. cuneata* (paracytic, anomocytic and anisocytic). These types of stomata develop anomo-mesoperigenously, para-mesogenecusly and aniso-mesogenecusly.

In young leaves protoderm cells are scattered, which can be easily distinguished from remaining cells in the presence of prominent large nucleus and dense cytoplasm.

Anomo-mesoperigenous (Text-figs. 36-39)—Protoderm cell divides to form a large cell and a small—the meristemoid. The large cell functions as a subsidiary cell. The small triangular cell functions as the meristemoid or as direct guard cell-mother cell without any division. The guard cell-mother cell divides by a parallel wall to form two guard cells. Thus, mature stomata have two guard cells and surrounded by a subsidiary cell and a neighbouring cell.

Para-mesogenous (Text-figs. 40, 42, 44, 47)—Protoderm cell divides to form triangular smaller cell and a large cell. Triangular cell functions as meristemoid, and divides by a wall at right angle to the first to form two cells. By the formation of an other vertical wall three celled stage is formed. The median one functions as guard cell-mother cell whereas two, one on each side of the guard cell-mother cell, functions as subsidiary cells. The guard cell mother cell divides to form two guard cells. The large cell behaves like encircling cell either at right to the subsidiary cell or parallel to them. Thus mature stomata have a pair of guard cells and two subsidiary cells and an encircling cell.

Aniso-mesogenous (Text-figs. 41, 43, 46, 48, 50)—Small triangular cell which functions as meristemoid cuts off segment from three faces, resulting four segments one central cell functions as guard cell-mother cell and surrounding three segments function as subsidiary cells. Guard cell-mother cell through a median division-forms the guard cells. The stomata so formed have a pair of guard cells and three subsidiary cells of which one is smaller.

DISCUSSION

METCALFE AND CHALK (1950) reported stomata "without specialized subsidiary cell" in many genera of family Gentianaceae. They observed anisocytic stomata only in *Gentaurium umbellatum* Gilib. SOLEREDER as early as 1908 had observed stomata "with distinct subsidiary cells" in some taxa of this family. Recently, PANT AND KIDWAI (1969) reported anomocytic and anisocytic stomata in six species, viz., *Canscora decussata*, *C. diffusa*, *Enicostema littorale*, *Gentiana pedicellata*, *Hoppea dichotoma* and *Nymphoides cristatum* of this family. However, we have observed paracytic and anisocytic stomata, besides the common anomocytic stomata within the genus *Swertia*. Paracytic and anisocytic stomata show distinct subsidiary cells. This is, further, proved by the ontogenetic studies. All the investigated species show common characters such as thin cuticle, irregular cells with sinuous walls, papillae, unicellular long trichomes, or one to two-celled short trichomes and striations arising from the guard cells or spread over the entire foliar surface.

The investigated species of the genus *Swertia* can be distinguished from each other on the basis of cuticular characters, such as distribution of stomata over the foliar surface, shape and size, epidermal cells stomatal index and frequency distribution of papillae and trichomes over the foliar surfaces and presence or absence of cuticular striations. Detailed characters of all 18 species of this genus studied are given in table 1.

Earlier to this investigation TRIVEDI AND UPADHYAY (1983) studied the cuticular structures of the genus *Gentiana* belonging to the tribe Swertiaeae. In this tribe the two genera *Swertia* and *Gentiana* are placed which are very well represented in the Indian Flora. In *Swertia* the cuticle is slightly thicker than in *Gentiana*. Papillae and cuticular striations are of common occurrence and frequently long unicellular or

Table 1 : Epidermal Characters of investigated species of *Suaeda* Linn.

Name of species	Type of stomata	Epidermal cells in μm	Stomatal size in μm	Stomatal frequency in mm^2	Stomatal index	Papillae or trichome, size in μm	Remarks
1. <i>S. macrosperma</i>	Pa—Lw	20—35 × 15—20	20—40 × 15—25	155	41	Papillae small 5 μm .	Striations commonly + nt
2. <i>S. cordata</i>	Pa—Lw	30—40 × 15—22	35—40 × 20—25	134	43	Papillae small-2-3 μm	
3. <i>S. tetragona</i>	Pa—Lw	50—60 × 15—30	45—50 × 25—40	68	27	Papillae 2-3 μm	
4. <i>S. paniculata</i>	Pa—Lw	20—25 × 15—20	25—30 × 20—25	244	34	Papillae 10 μm	Striation on the upper surface
5. <i>S. angustifolia</i>	An—Pa } Lw	30—35 × 15—20	30—35 × 20—25	122	27	Trichome 130-140 μm papillae 30-45 μm	Striations and papillae over upper surface
6. <i>S. corymbosa</i>	An—Pa } Lw	40—50 × 20—25	25—32 × 20—30	188	34	Papillae 10 μm long	Striations arising from guard cells
7. <i>S. purpurascens</i>	An & Pa—Lw	30—35 × 15—20	15—25 × 15—30	278	26	Trichomes 50-60 μm Papillae 5-10 μm	Papillae all over upper surface, cuticular striations + nt
8. <i>S. nervosa</i>	Pa—Lw	25—35 × 20—25	20—25 × 15—20	133	43	Absent	
9. <i>S. bimaculata</i>	An & Pa—Lw	30—40 × 8—20	25—30 × 30—45	245	42	Trichomes 80-150 μm Papillae 5-15 μm	Striations + nt originating from guard cell
10. <i>S. dilatata</i>	Pa—Lw	50—55 × 30—35	30—35 × 25—35	67	33	Trichomes 100-150 μm papillae 10-30 μm	Striations & papillae all over surface
11. <i>S. trichotoma</i>	Pa—Lw	22—40 × 15—30	30—45 × 35—60	230	42	Trichome 50-160 μm long Papillae 10-15 μm	Striations & papillae all over the surface
12. <i>S. petiolata</i>	An—Pa } Lw & Up	25—32 × 12—22	25—30 × 15—20	Up 44 Lw 288	39	Papillae 2-3 μm long	

13. <i>S. chirata</i>	An Lw & Up	Up 30—40 × 15—30 Lower 25—30 × 10—20	20—35 × 20—30	Up 88 Lw 555	44 Papillae 15 μm long 5 μm broad	Cuticular striations from guard cells
14. <i>S. cuneata</i>	An rarely Pa Lw & Up	20—40 × 10—25	30—40 × 15—25	Up 77 Lw 300	39 Papillae 1020 μm	Striations on both surfaces
15. <i>S. alternifolia</i>	An—Pa Lw & Up	30—45 × 20—30	25—45 × 15—35	Up 88 Lw 388	44 Trichomes small 60-100 μm large 150-300 μm papillae 10-20 μm	Striations and papillae on the upper surface
16. <i>S. alata</i>	An Lw & up	25—30 × 20—25	20—25 × 10—20	Up 55 Lw 244	30 Papillae 40 μm long	
17. <i>S. affinis</i>	Pa Lw & Up	30—50 × 15—30	35—55 × 35—40	Up 44 Lw 244	38 Papillae 50 μm long.	Papillae & striations on the upper surface
18. <i>S. speciosa</i>	An Lw & Up	25—30 × 15—30	25—30 × 15—20	Up 66 Lw 133	33 Papillae 10-15 μm long	Striations on the upper surface

An—Anomocytic; Lw—Lower surface; Pa—paracytic; Up—Upper surface

1-2 septate, uniseriate trichomes are also present on the foliar surfaces in *Swertia*. Only a few species of *Gentiana* do not have these characters. We have also studied the ontogeny of stomata in some species of this genus. The Stomata develop in the mesoperigenous trilabrate manner according to the scheme of PANT (1965) and anomo-mesoperigenous, para-mesogenous, and aniso-mesogenous according to the scheme of FRYNS-CLEASSENS and VAN COTTHEM (1973).

Although the ontogeny of stomata has been discussed in six taxa of this family by PANT AND KIDWAI (1969), yet the genus *Swertia* has not been studied so far, either for the cuticular characters or for the ontogeny of stomata. This is the first detailed account of the cuticular structures and developmental stages of the stomata of this genus.

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