long. Sepals 5, entire, free near to the base, lanceolate, acute, scarious margined, 3-nerved from the base, glabrous, (0·4—) 0·5—0·7 × (0·12—) 0·15—0·17 cm. Petals 5, white, obovate, glabrous, 0·5—0·7 cm. long, nearly as long as the calyx, deeply 2-partite, segments oblanceolate, obtuse, 0·4—0·6 cm. long. Stamens 10 ; filaments linear, dilated at base, glabrous, 0·4—0·5 cm. long; anthers oblong, rusty-brown, 0·08—0·1 cm. long. Ovary sessile, ovoid-ellipsoid, glabrous, 0·16 —0·19 cm. long; styles 3, filiform, 0·15—0·2 cm. long. Young capsules 6-valved.

Nepal : W. Nepal, Pokhra, alt. 970m., 25·5·68, *Vartak* 462 (Holotype-CAL).

Distribution.—Known only from Nepal Himalaya.

Closely allied to *Stellaria sikkimensis* Hook. f., but is easily recognizable by white appressed hairs of the vegetative parts, few-flowered cymes, larger flowers, broadly scarious margined glabrous bracts, glabrous sepals as long as petals, and 6-valved capsules.

A specimen, *Vartak* 692 (CAL), from Ghodepani in Nepal, may be referable to this species, although it has nearly glabrous stems with elongated internodes, much larger glabrate or thinly hairy leaves, and longer pedicels which are dilated at the top.

J. Indian bot. Soc. **50** : 217–225, 1971.

MORPHOLOGICAL STUDIES IN THE FAMILY CONVOLVULACEAE

III. ZONATION IN THE SHOOT APEX AND LEAF INITIATION[1]

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Abstract

The apical summit organisation and leaf histogenesis of *Ipomoea batatas* Lamk., *I. purpurea* Roth., *I. pes-caprae* Linn. and *I. quamoclit* Linn. have been studied. Tunica is two layered in all except *I. quamoclit* when it is 3 or 4 layered. Zones of tunica and corpus initials, flank meristem and rib meristem are well marked. Initiation of leaf starts with the periclinal divisions in cells of the second and third layer of the tunica. In cases where tunica layers are more than two the corpus cells

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I take this opportunity of expressing my deep sense of gratitude to my esteemed teachers, Dr Y. S. Murty for sympathetic guidance and encouragement throughout the course of this work and Professor V. Puri for taking unfailing interest in this work, numerous valuable suggestions and critically going through the manuscript.

contribute a little towards the leaf buttress formation. Apical and sub-apical cells differentiate early in ontogeny. The marginal growth is of 'middle type' of sub-marginal type of Hara (1957).

INTRODUCTION

In the solution of Morphological and anatomical problems, the role of ontogenetic studies has been stressed in the past. A study of the shoot apex and its organisation and ontogeny of the leaf in angiosperms has received special attention. In the study of shoot apex organisation valuable contributions have been made by Gifford (1951, 1954), Kasapligil (1951), Millington and Günkel (1950), Philipson (1954 a, b) and Popham (1951). The early ontogeny of leaf in angiosperms has been intensively studied by Boke (1941, 1951, 1952), Esau (1942), Ball (1941), Foster (1936), Hara (1957), Philipson (1947).

A perusal of the literature reveals that except a report on the organisation of shoot apices in some members of Convolvulaceae by Ganguli (1956) there is no other literature at hand on the shoot apex organisation and ontogeny of the leaf in the family. Therefore, the present study has been undertaken to study these aspects in more datails in the family Convolvulaceae.

MATERIALS AND METHODS

The present study includes the shoot apex organisation of *Ipomoea batatas*, (Lamk). *I. purpurea* (Roth), and *I. pes-caprae* (Linn), and *I. quamoclit* Linn.) and the early ontogeny of leaf in *Ipomoea batatas*, *I. purpurea* and *I. quamoclit*. The material was collected locally and killed and fixed in F.A.A. Usual process of dehydration and embedding was followed and the microtome sections were stained in haematoxyline-fast green and tannic acid, ferric chloride combinations.

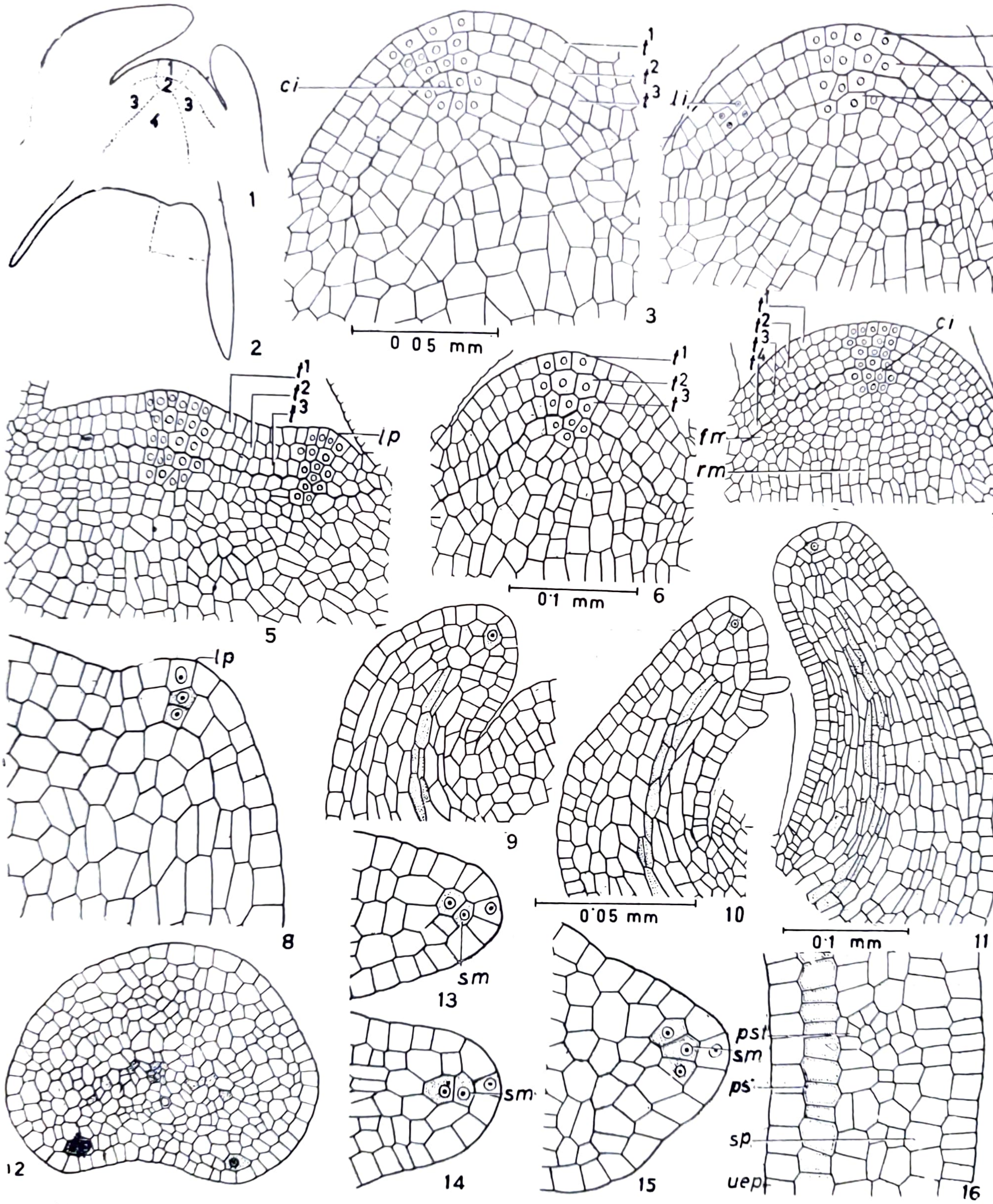
OBSERVATION

Shoot apex organisation.—The apical summit organisation of *Ipomoea batatas*, *I. pupurea*, *I. pes-caprae* and *I. quamoclit* has been studied. The growing points in all the species show some variation in shape and size. At the maximal stage of plastochron the apices are dome-shaped or slightly flat in outline. The various measurements of the different species studied at maximal phases are given in the table below :

As determined by the plane of cell division, differences in cell size, cell shape and cell contents the shoot apex shows the following zonation (Fig. 1).

Tunica	Zone 1	Two to five layers.
Corpus	Zone 2	Central zone (Mother cells zone).
Flank meristem	Zone 3	Radiating zone, one on either side of the central zone as seen in median longitudinal section.
Rib-meristem	Zone 4	At the sub-jacent level

The peripheral layers which constitute the surface of the summit consists of two to five layers of cells, two or three in *Ipomoea batatas*, (Figs. 3, 4), *I. pas-caprae* (Fig. 5), *I. purpurea* (Figs. 5, 6), and four or five in *I. quamoclit* (Fig. 7). The various layers of this zone have been named from periphery inward as t^1, t^2,



FIGS. 1–16. Figs. 1, 2. Outline diagrams showing different zones and leaf primorium respectively. Figs. 3, 4. *I. batatas*. Median longitudinal section of shoot apices. Figs. 5–7. Same of *I. pes-caprae*, *I. purpurea* and *I. quamoclit*. Figs. 8–16. *I. batctas*. Figs. 8–11. Median longitudinal sections of leaf primordium showing different stages of apical growth of leaf. Figs. 12–15. Vertical transverse sections of young lamina showing marginal and sub-marginal growth of leaf. Fig. 16. Same showing different zones of maturation.

Ci, corpus initials; fm, flank meristem; li, leaf initial; ps, palisade; pst, procambial strands; rm, rib meristem; smi, sub-marginal initials; sp, spongy parenchyma; t^1, t^2, t^3, t^4, tunical layers; Uep, upper epidermis; 1-4, zones of tunica, corpus initials, flank meristem, rib meristem respectively.

t^3, and t^4. In t^1 all the divisions are anticlinal, while in t^2, t^3, and t^4 they are generally anticlinal, but in relation to leaf initiation they may also divide periclinally (Figs. 4, 5). The predominantly anticlinal divisions in the tunica layers account for increase in surface area of the apex. The cells of the tunica layers at the tip of the dome-shaped apex are bigger than those on the sides (Fig. 6) and measure from 6 to 16 μ, stain less deeply than the latter and constitute the initial cells of the tunica layers.

The corpus or the second zone is well differentiated and represented by a group of central initials. The cells of the corpus divide in all planes and are bigger than the tunica cells varying from 12 to 20 μ or more. As a rule the central cells are bigger, take a lighter stain than the outer ones and constitute the initials of the corpus. In *I. quamoclit* the corpus zone is not so distinct as in other cases.

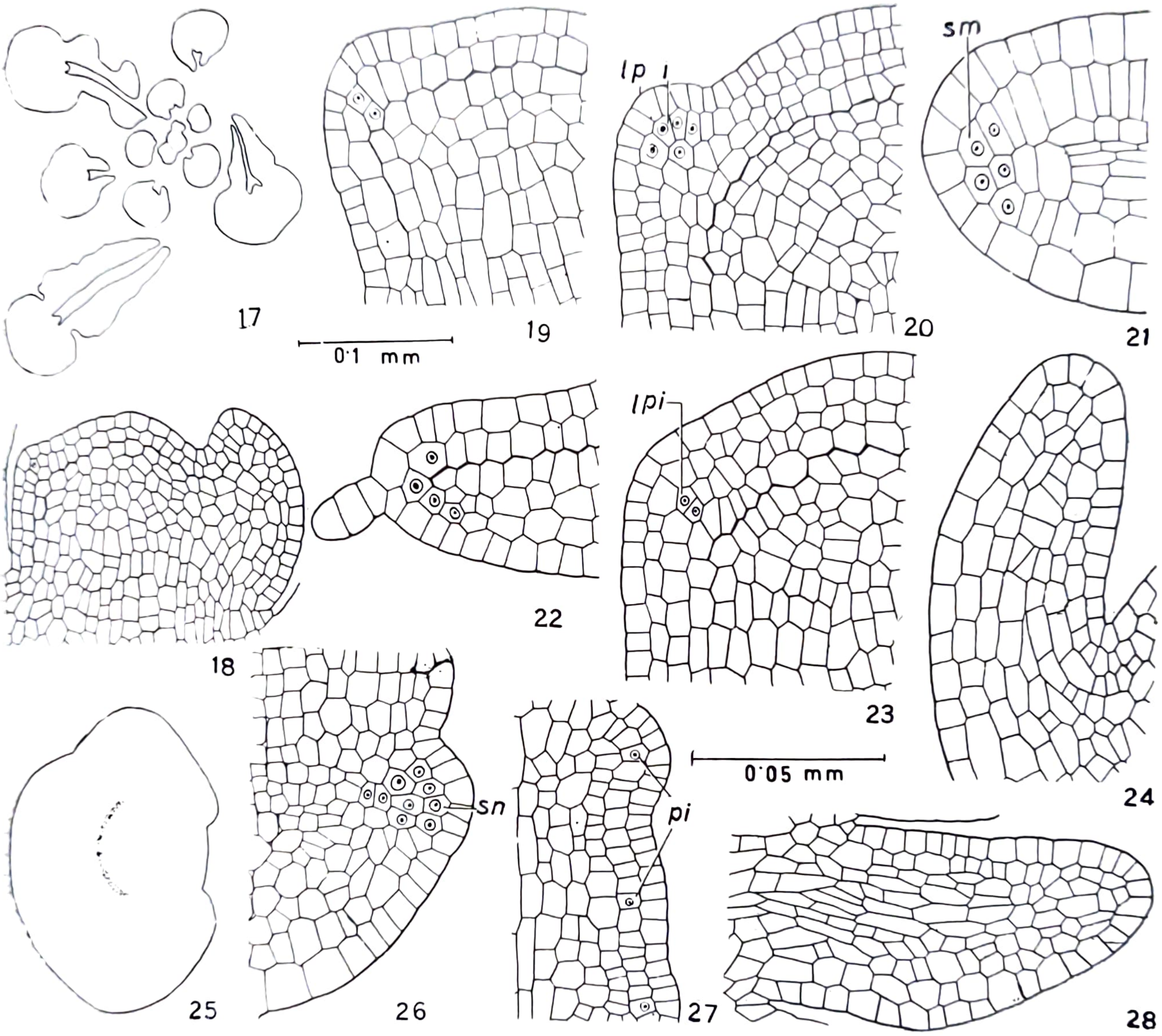
The third zone is the peripheral zone or the flank meristem. The cells of this zone are arranged in files of three to five which radiate out from the periphery of the central initial cells. The cells of this zone are large, vacuolated and divide in all planes contributing to the young developing leaf, cortex and the procambium.

The rib-meristem is the last zone occurring just below the corpus and between the flank meristem. The cells of this zone are mostly rectangular and become large and more vacuolated as they move away from the summit. They take light stain and are arranged in linear rows, contributing towards the formation of the pith (Figs. 3–7).

Species	Height of the shoot apex at maximal phase	Diameter of the shoot apex	Number of tunica layers	Breadth of the tunica layer cells at the apex	Breadth of the tunica layer cells at the sides
1. *Ipomoea batatas*	90–100μ	245–300μ	2 or 3	12–16μ	8–10μ
2. *Ipomoea pes-caprae*	30–40μ	200–320μ	2 or 3	6–10μ	4–6μ
3. *Ipomoea purpurea*	60–100μ	165–180μ	2 or 3	10–16μ	8–12μ
4. *Ipomoea quamoclit*	65–80μ	180–250μ	4 or 5	10–14μ	6–10μ

Ontogeny of the leaf.—The histogenesis of the leaf of *Ipomoea batatas, I. purpurea*, and *I. quamoclit* has been studied. The development in the two species, *I. batatas* and *I. purpurea* studied is similar but in *I. quamoclit* it differs in some minor details. Therefore, only *Ipomoea batatas* is described in detail and attention will be drawn to differences wherever necessary.

Apical growth.—The differentiation of leaf primordia on the shoot apex is spiral during the vegetative growth establishing the 5/13 phyllotaxy (Fig. 17). One or two cells of the second tunica layer or in *I. quamoclit* those of second or third tunica layer divide periclinally on one side of the dome shaped shoot apex (Figs. 2, 8, 19, 23). During the differentiation of the leaf, the shoot apex also becomes flat. Repeated divisions in the tunica layer rasult in a protuberance at the corresponding side of the apex, (Figs. 8, 20). Simultaneously with this differentiation, the adjoining cells and the cells of the corpus below the initial cells divide both periclinally and anticlinally and cause an increase in the height of the leaf primordium. Soon after these changes the sub-apical cell differentiates and causes the corpus cells to stop their activity.



FIGS. 17–28. Fig. 17. Outline diagram showing arrangement of leaves in transverse section. Figs. 18–20. *Ipomoea purpurea.* Median longitndinal sections of shoot apices showing leaf initials and leaf primordium. Figs. 21, 22. *I. purpurea.* V. t. s. showing lateral growth of leaf. Figs. 23, 24. *I. quamoclit.* Median longitudinal section showing leaf apical initials and leaf primordium respectively. Figs. 25, 26. *I. batatas* Fig. 25. Outline diagram V. t. s. of young leaf primordium. Fig. 26. A portion of the same in cellular showing marginal growth, Figs. 27, 28. *I. quamoclit.* Transverse section of the young leaf showing apical growth of the pinnae.

lp, leaf primorium; lpi, leaf primordium initial; pi, pinnule initial.

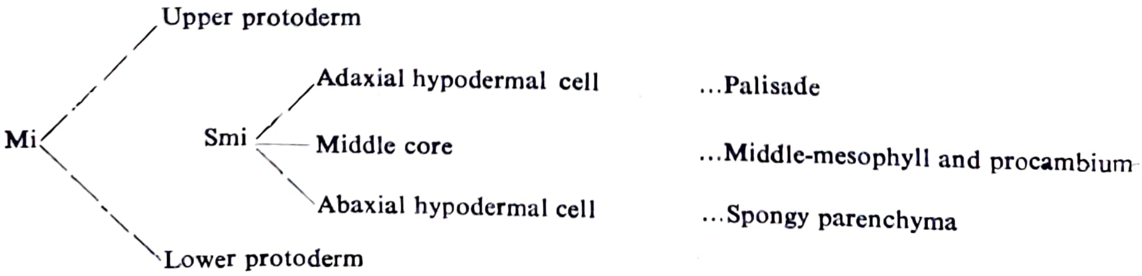
After the differentiation of the sub-apical cell and during the above mentioned changes in the plastochron the identity of the second, third and fourth (*I. quamoclit*) layers is more or less lost. The activity of the sub-apical cell also causes discontinuity of the tunica layers in the leaf primordium.

The sub-apical cell divides both anticlinally and periclinally resulting in the vertical expansion of the leaf buttress.

The vertical divisions in sub-apical cell results in the increase in girth of the primordium. As the leaf buttress increases in height, the procambialization starts in a progressive and acropetal order (Figs. 9–11, 18, 24). The activity of the sub-apical cell continues for sometime but later on it stops, and further increase in height is due to cell elongation and intercalary growth (Fig. 11). The first tunica layer of the shoot apex is in continuation with the leaf primordium and the cells divide only anticlinally. This forms the dermatogen of the leaf (Figs. 9-11).

Marginal growth.—The development of the lamina starts after the formation of the mid-rib portion of the leaf by the differentiation of marginal meristem. The young primordium in transverse section appears as a triangular mass of cells at the time of sub-marginal cell differentiation (Fig. 12). The sub-marginal initials are located on the two flanks of the primordium. In transverse section the marginal and sub-marginal cells appear more towards the adaxial side (Figs. 12, 25, 26). They appear as single cells in transverse section but actually there is a row of marginal and a row of sub-marginal initials on either side of the primordium. The cells of the meristem divide by anticlinal divisions only and give rise to the protoderm. The sub-marginal initials behave uniformly in the other two species of *Ipomoea*, but in *I. quamoclit*, the sub-marginal row of initials are active only at certain places resulting in alternately active and inactive areas of sub-marginal meristem (Figs. 27, 28). This type of growth in the sub-marginal meristem causes development of a pinnately compound leaf.

The sub-marginal initial divides both anticlinally and periclinally. The anticlinal divisions on either side add to the hypodermal tissue on the adaxial and abaxial sides of the leaf (Figs. 13, 15, 21, 22). The derivatives cut off on the adaxial side, divide by anticlinal and periclinal divisions to form the palisade tissue. Derivatives on the abaxial side divide irregularly to form the spongy parenchyma. The periclinal division in the sub-marginal initial contributes to the derivatives of the central core (Fig. 14). These cells differentiate into the spongy parenchyma and procambial strands. The entire internal organisation of the leaf, the palisade, the spongy parenchyma and the veins etc. therefore, owe their origin to the submarginal initial (Fig. 16). The pattern of differentiation and organisation of the various tissues follows the middle type of the sub-marginal type of Hara (1957) which is given as follows :



DISCUSSION

A review of the observations in shoot apex organisation in *Ipomoea batatas*, *I. purpurea*, *I. pes-caprae*, and *I. quamoclit*, reveals that the shoot apices have 2 or 3 tunica layers except *I. quamoclit* where they are 3 or 4. The corpus shows a zonate character in all cases except in *I. quamoclit*. There is a central zone of initial cells of tunica and corpus whose cells are bigger, stain lightly and divide rarely. The flank meristem and rib-meristem are well marked in all cases.

Ganguli (1956), however, studied seven species and reports four layered tunica at the maximal phase of the plastochron changes and 35–50 celled corpus and well differentiated flank meristem and rib-meristem. Although Gifford (1954) has emphasised that the normal number of tunica layers in dicotyledons is two and that the accessory tunica layers should be looked upon as a result of stratification of the corpus. This latter fact has actually been reported in a number of plants viz., *Notophoebe* (Kasapligil, 1951), *Liriodendron* (Millington and Günckel, 1950), *Drimys winterii* (Gifford, 1951) and *Polyalthia* (Ramji, 1960).

The zonation in the shoot apices of dicotyledons as given by Philipson (1954 a, b) is that there is a central zone of initials with lightly stained bigger cells of tunica and corpus, a peripheral zone of smaller cells with dense stain and showing frequent divisions, a meristematic zone, the rib-meristem and a flank meristem. Popham (1951) also considered the usual four zones but his four zones differ in description. He includes, a mantle consisting of surface layer, sub-apical initials occupying the central position of the apex, the central meristem lying below the sub-apical initials and the peripheral meristem surrounding the central meristem which gives rise to the cortex and procambial strands. However, these zones do not differ very much from that of Philipson (1954 a, b).

The present study in species of *Ipomoea* shows that there is no correlation between the size of the apex and the number of tunica layers. In *Ipomoea pes-caprae* the height of the apex is minimum but still the number of tunica layers are two as in other species.

Rouffa and Günckel (1951a) have also expressed similar views on the basis of their studies in Rosaceae. They concluded that in Rosaceae, zonation within the apex is not a characteristic feature. Rouffa and Günckel (1951b) infer that during the development of leaf in Rosaceae there is no fluctuation in the number and stratification of tunica layers. All these observations are interesting in the sense that they are contrary to the various descriptions of the earlier workers (*see* Rouffa and Günckel, 1951 a, b).

Initiation of leaf in all three members studied is caused by periclinal divisions in the second or third tunica layers. Subsequent divisions in the neighbourhood result in the formation of a foliar buttress. Perhaps this appears to be the most common type for dicotyledons. Similar type of a leaf initiation from the second or third tunica layer has been described in a number of other members (*see* Boke, 1941, 1951, 1952; Esau, 1942; Philipson, 1947; Ball, 1941; Foster, 1936 etc.).

Where the number of tunica layers is more than two, the participation of the other layers of tunica varies. Esau (1953) states that the fewer the number of tunica layers the greater will be the contribution of the corpus towards the formation of leaf primordium. In species of *Ipomoea* the tunica is two layered. Here the division in the tunica layers are followed by the divisions in the corpus cells. The corpus cells add tissue as long as the sub-apical initial is not differentiated. While in *Ipomoea quamoclit* where the number of tunica layers is more, the corpus cells do divide but they do not contribute much to the leaf primordium. Girolami (1954) in *Linum usitatissimum* shows that corpus contributes only to the foliar buttress in spite of the fact it has a biseriate tunica. This limitation on the contribution of corpus in *L. usitatissimum* according to Girolami (1954) is due to the early differentiation of the sub-apical initials. In species of *Ipomoea*, corpus does contribute to the leaf primordium but only to a little extent and further growth is due to sub-apical cells.

The marginal growth in leaf lamina has received much attention. There is a general agreement that the outermost layers of cells at the margin represent an independent histogen and they contribute to the dermatogen of the leaf (see Foster, 1936; Esau, 1953).

Regarding the activity of the sub-marginal initial, in the members studied, it may be recalled that the marginal cell forms the dermatogen, while the sub-marginal cell cuts off the adaxial, abaxial and middle cells. The middle layer further contributes, to the formation of the middle mesophyll and the procambium. Such a type of development has also been found in *Pelargonium zonale* (Nöack, 1922), *Nicotiana tabacum* (Gifford, 1953).

Foster (1936) and Gifford (1951) have discussed at some length the various types of mode of marginal growth in leaves. Hara (1957) has reviewed the whole literature and suggested four types of marginal growth in leaves. In the light of present study the marginal growth in the leaf of *Ipomoea* species studied here falls under the 'Middle type' of sub-marginal type. Here the marginal initial forms the dermatogen while the sub-marginal initial contributes to the adaxial palisade layer, and abaxial lower spongy parenchyma by anticlinal divisions while the middle spongy parenchyma and the procambium owe their origin to the cells formed after the periclinal divisions in the sub-marginal initials.

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THE HELOTIALES OF INDIA–XIII

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This paper records three new species of Helotiales collected from Darjeeling Hills in the Eastern Himalayas during 1964. The first 12 contributions on the series (1-12; references to the first 9 papers on the series are included in the references given) give an account of 48 known and 14 new species. The fruit bodies have been described from the fresh material, supplemented with dried and preserved (alcohol-formalin) material. For anatomical study both free hand and microtome sections were prepared. The numbers of species are the serial numbers of the Helotioid flora being studied in this laboratory. The type collections have been deposited in the Herbarium of Punjab University, Chandigarh. A part of the type material of each of these species is also deposited in the Herbarium, Royal Botanic Gardens, Kew, England.

63. **Belonopsis bambusae** Thind & Singh, sp. nov. (Fig. 1)

Apothecia sparsa vel subconferta, ad 2mm lata, superficialia, sessilia, subplana, circa basin hyphis brunneis, septatis, superficialibus cincta. Excipulum ad 70μ crassum, marginem versus tenuius, textura angularis, cellulis subpolyedricis, ad 15 × 8μ, membranis atrobrunneis. Hymenium humectate aquoso-griseum. Asci clavati, 100-140 × 7.2-9μ, octospori, apice rotundati, poro Iodo adjuvante coerulescenti. Ascosporae filiformes, 30-55 × 2.8-4μ, 11-septatae, hyalinae, rectae vel leniter curvulae. Paraphyses simplices, filiformes, crassite. 1.6μ, apice clavato, ad 5.6 μ crasso, infuscatae, conglutinatae.

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