

TRICHOMES IN *SALVIA* (LABIATAE) AND THEIR TAXONOMIC SIGNIFICANCE*

V. SINGH, MEENA SHARMA AND D. K. JAIN

School of Plant Morphology, Meerut College, Meerut

ABSTRACT

Structure, development and distribution of trichomes on the floral appendages of 12 species of *Salvia* have been studied. A total of 17 types of nonglandular and glandular trichomes have been recognised. They provide good taxonomic criteria on specific level and on the basis of types of trichomes and their distribution a key has been devised to distinguish various species of *Salvia* investigated.

INTRODUCTION

Various types of hairs and glands are present on both vegetative and floral parts of the members of Labiatae. The volatile and ethereal oils which give characteristic aroma to the plants of this family are secretions of these glands. A detailed investigation of the structure and development of floral trichomes in different taxa of Labiatae has been initiated with a view to assess taxonomic significance of these structures. The present paper deals with the structure and development of floral trichomes in 12 species of *Salvia*.

MATERIALS AND METHODS

The taxa included in this investigation are listed in table 1. The flower buds were fixed in F.A.A. and later preserved in 70% ethanol. Customary methods of dehydration, infiltration and embedding were followed. Both transverse and paradermal serial sections were cut at 6-10 microns and stained with safranin-fastgreen combination.

OBSERVATIONS

Structure: Both non-glandular and glandular trichomes of 17 types have been observed in the species of *Salvia* investigated. A brief description of each type is given below:

TYPE I—NONGLANDULAR UNICELLULAR TRICHOMES

Type Ia: *Prickly unicellular papillae:* Conical, stiff, papilliform, tapering above

with acute or blunt apex; walls thick, smooth; contents translucent or evanescent (Fig. 2).

Type Ib: *Bluntly conical unicellular papillae:* Short, conical with swollen base; apex blunt or with a button-shaped tip; vacuole large subsidiary cells forming a rosette, inserted on epidermal surface or borne on a more or less protuberant emergence; walls thick, smooth or wavy; contents thin (Fig. 3).

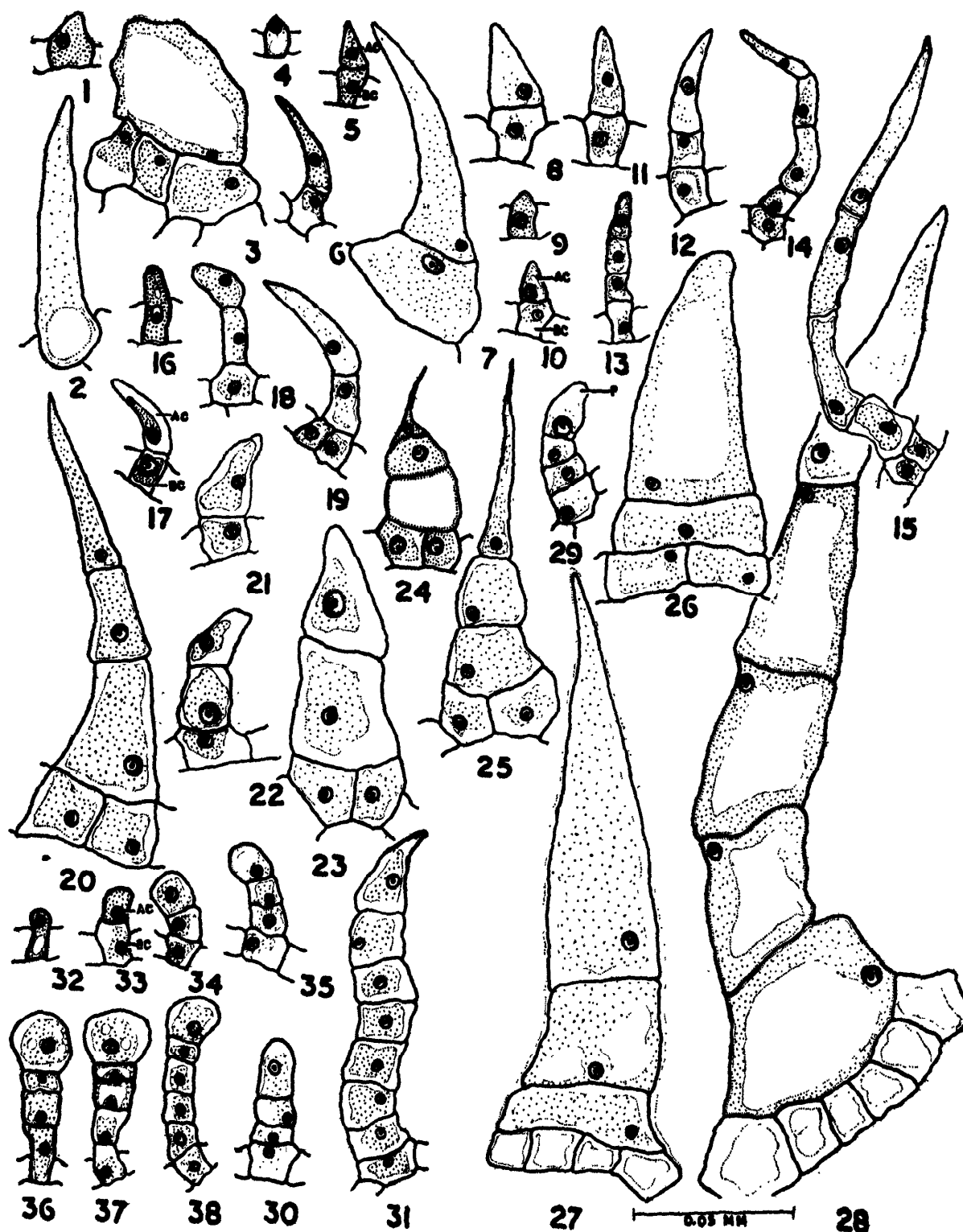
TYPE II—NON-GLANDULAR UNISERiate FILIFORM TRICHOMES

Type IIa: *Bicelled hair:* Foot: 1-celled, projected, somewhat swollen. Body: 1-celled, slightly curved; apex tapering, acute or subacute; walls moderately thick, smooth or wavy (*S. aegyptiaca*); contents translucent or evanescent (Fig. 7).

Type IIb: *Pyriform filiform hair:* Foot: 1-celled, projected. Body: 1-celled, pyriform, short, narrowed to both ends; apex rounded; lateral walls slightly thick, smooth; contents thin or dense, translucent (Fig. 8).

Type IIc: *Simple filiform hair:* Foot: 1-2-celled, slightly projected. Body: uniseriate, filiform, 2-many celled, tapering with acute or subacute apex; cells of varied length, occasionally 1 or 2 basal cells broader than long, the terminal cell relatively long, constricted at the cross-walls; lateral walls

*Research contribution No. 165 from the School of Plant Morphology, Meerut College, Meerut.



Figs. 1-38. Non-glandular trichomes of *Salvia* species: 1-3. Unicellular papillae. 1, 2. A trichome initial and a mature prickly unicellular papilla respectively from sepals of *S. officinalis*. 3. A mature bluntly conical unicellular papilla from pedicel of *S. lanata* with a rosette-like girdle around the foot. 4-38. Uniseriate hairs. 46-. Developmental stages of bi-celled hairs from sepals of *S. aegyptiaca*. 7. Bicelled hair from sepals of *S. coccinea*.

straight or slightly concave or convex, thin or thick, smooth; contents translucent or dense (Figs. 14, 15, 19).

Type II d: Conical filiform hair: Foot: 1-2-celled, projected. *Body:* uniseriate, usually 2-4-celled, curved, conical; apex acute or obtuse; basal cell usually broader, others elongated, remotely constricted at the cross-walls; lateral walls straight or slightly concave, smooth or wavy, thin or moderately thick; contents translucent (Fig. 20).

Type II e: Falcate filiform hair: Foot: 1-2-celled, projected. *Body:* 2-many celled; cells longer than broad, terminal cell longest with obtuse apex; cross-walls thin or thick, sharply constricted; lateral walls straight or slightly biconcave or biconvex; smooth or slightly wavy, moderately thick; contents thin and translucent (Fig. 23).

Type II f: Flagellate filiform hair: Foot: 1-celled, slightly projected. *Body:* uniseriate, filiform, 2-3-celled; cells of various length, usually cylindrical 1 or 2 basal cells isodiametrical, thinly constricted at cross-wall; terminal cell much elongated, flagellate, tapering to a pointed tip; lateral walls thin or slightly thick, smooth; contents translucent (Figs. 24, 25).

Type II g: Pedestallated filiform hair: Foot: Many-celled, borne on a protuberant emergence. *Body:* uniseriate, 4-5 celled; cross-walls sharply constricted; lateral walls straight, concave or convex, wavy, moderately thick; contents thin or evanescent (Fig. 28).

Type II h: Papillate filiform hair: Foot:

1-celled, projected. *Body:* uniseriate, 2-3-celled, lower 1 or 2 cells usually isodiametrical, sharply constricted at cross-walls; lateral walls biconcave; end cell relatively longer than broad globular with a small tooth-like papilla at the apex; contents dense, granular (Fig. 29).

Type II i: Rostrate filiform hair: Foot: 1-celled, projected. *Body:* uniseriate, 3-many-celled; terminal cell rostrate, oblong with rounded apex; other cells of body vary in size, generally broader than long, isodiametrical, constricted at the cross-walls; lateral walls straight or slightly concave or convex, thin, smooth; contents thin, translucent (Figs. 30, 31).

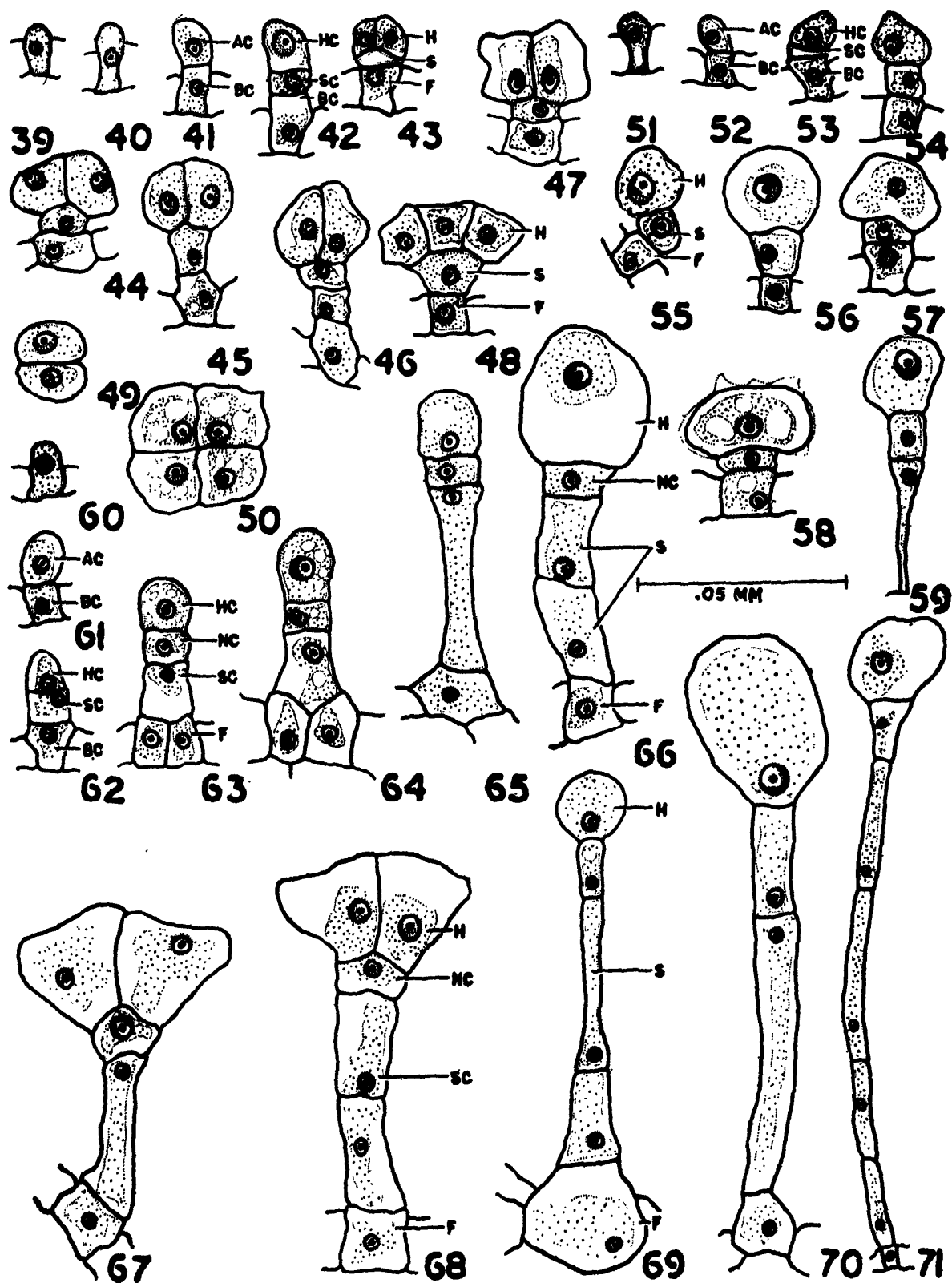
Type II j: Capitate filiform hair: Foot: 1-celled, projected, broad. *Stalk:* 3-5-celled; cells broader than long, constricted at the cross walls; lateral walls straight or slightly concave or convex, thin; contents thin, vacuolated. *Head:* unicellular, broader than the stalk, swollen to an oblong-ovoid or ovate form; contents thin or dense (Fig. 38).

TYPE III—GLANDULAR TRICHOMES

Type III a: Peltate glandular hair: Foot: 1-celled. *Stalk:* sunken into the epidermis, 1-2-celled, length of cells varying in different species; cross walls thin, slightly constricted; lateral walls thin or thick, smooth. *Head:* 2-4-celled (multi-celled in *S. splendens*), globose or panduriform, densely cytoplasmic, granular or translucent (Figs. 44-48).

Type III b: Capitate glandular hair with unicellular head and 1-celled stalk: Foot:

8. Pyriform filiform hair from pedicel of *S. splendens*. 9-13, 16-18. Developmental stages of simple filiform hair from pedicel of *S. leucantha*. 14, 15, 19. Simple filiform hairs from pedicel of *S. leucantha*. 20. A conical filiform hair from bract of *S. coccinea*. 21, 22. Developmental stages of falcate filiform hairs from pedicel of *S. splendens*. 23. A mature falcate filiform hair from pedicel of *S. splendens*. 24, 25. Flagellate filiform hairs from pedicel of *S. splendens* and from sepals of *S. glutinosa* respectively. 26, 27. Developmental stages of pedestallated filiform hairs from pedicel of *S. aegyptiaca*. 28. A mature pedestallated filiform hair from pedicel of *S. aegyptiaca*. 29. A papillate filiform hair from pedicel of *S. splendens*. 30, 31. Rostrate filiform hairs from pedicel of *S. splendens*. 32-37. Developmental stages of capitate filiform hairs from sepals of *S. leucantha*. 38. A mature capitate filiform hair from sepal of *S. leucantha*. AC—Apical cell; BC—Basal cell and P—Papilla.



Figs. 39-71. Glandular trichomes in *Salvia* species: 39-50 Peltate glandular hairs. 39, 40. Hair initials from sepals of *S. lanata* and *S. splendens* respectively. 41-42. Two and three-celled stages from sepals of *S. lanata*. 43. A later developmental stage from sepals of *S. lanata*. 44-48. Mature peltate glandular hairs from sepals of *S. lanata*, *S. moorcroftiana*, *S. leucantha*, *S. glutinosa* and *S. splendens* respectively. 49-50. Transsections of heads of peltate

1-celled, slightly projected. *Stalk*: 1-celled, elongated; lateral walls straight or slightly biconcave, thin, smooth. *Head*: unicellular, ellipsoidal or disciform; walls thick, smooth; cytoplasmic contents dense, granular (Figs. 55-59).

Type IIIc: Capitate glandular hair with unicellular head, a short neck cell and elongated stalk cells: Foot: 1-2-celled, broad, projected. *Stalk*: differentiated into a short neck cell and 1-3 elongated stalk cells; neck cell isodiametrical; stalk cell slightly constricted at cross walls. *Head*: unicellular, globose, highly vacuolated; contents translucent (Fig. 66).

Type III d: Capitate glandular hair with 4-celled head, a short neck cell and 1-2 elongated stalk cells: Foot: 1-celled. *Stalk*: differentiated into a short isodiametrical neck cell and 1-2 elongated stalk cells, constricted at cross walls. *Head*: 4-celled, capitate, differentiated from the stalk; contents dense, granular or translucent (Figs. 67, 68).

Type III e: Vesicular glandular hair with unicellular head and 1-many-celled stalk: Foot: 1-celled, projected, swollen. *Stalk*: 1-many celled, cells of varying length, much elongated, constricted at cross walls; lateral walls straight, thin or thick, smooth or wavy. *Head*: unicellular, variable in size and shape, spherical-oblong or ellipsoidal, sharply differentiated from the stalk; contents dense, translucent (Figs. 69-71).

Organographic distribution: The distribution of various types of trichomes in the species of *Salvia* investigated is given in

the Table (p. 34).

All the trichome types reported for a taxon (*see table*) are invariably present on the pedicel, bracts and sepals. The papillate filiform hair (type IIh) are, however, restricted only to the pedicels of *S. splendens*. The glandular trichomes of all the types reported along with simple filiform hair (type IIc) have been observed on the petals. The trichomes on the stamens are present only in *S. farinacea*, *S. leucantha*, *S. linearis*, *S. microphylla* and *S. splendens*. They are usually peltate glandular (type IIIa) and are either restricted to the filaments (*S. leucantha* and *S. splendens*) or the anther lobes (*S. farinacea* and *S. microphylla*). However, the capitate glandular hair of type IIIc occur on the filaments of *S. linearis*. Trichomes on the gynoecium have been observed only in two taxa, *S. farinacea* and *S. leucantha*. They are peltate glandular (type IIIc) and are confined only to the style and stigma.

Development: A trichome, either unicellular or multicellular, develops from a protodermal cell. The hair initial can be distinguished from other protodermal cells in early stages of development by its larger size, dense cytoplasm and conspicuous nucleus. Shortly it becomes papillose and protrudes beyond the outer surface of the epidermis (Figs. 1, 4, 9, 16, 32). The unicellular trichomes arise by the arching outwards of the whole or part of the outer wall of the trichome initial so as to form a cylindrical or conical protuberance above the neighbouring surface. The sac-like part of the unicellular trichome protrudes and becomes

glandular hairs of *S. splendens* at 2-celled and 4-celled stages of development respectively. 51-59. Capitate glandular hairs with unicellular head and 1-celled stalk. 51. Hair initial from sepals of *S. splendens*. 52-54. Two and three-celled stages respectively from sepals of *S. splendens*. 55-59. Mature hairs from sepals of *S. splendens*, *S. glutinosa*, *S. officinalis* and *S. farinacea* respectively. 60-66. Capitate glandular hair with unicellular head and 1-3 celled stalk and a short neck cell. 60. Papillate hair initial from bract of *S. officinalis*. 61, 62. Two and three-celled stages respectively from bract of *S. officinalis*. 63-65. Later developmental stages from bract of *S. microphylla*. 66. A mature hair from sepal of *S. microphylla*. 67-68. Capitate glandular hairs from sepals of *S. glutinosa* with 4-celled head. 69-71. Vesicular glandular hairs from sepals of *S. glutinosa*. AC—Apical cell; BC—Basal cell; HC—Head cell; SC—Stalk cell; NC—Neck cell; F—Foot; S—Stalk; H—Head.

the body and the part embedded in the epidermis acts as the foot. In type Ia, the hair initial curves upwards and protrudes beyond the outer surface of the epidermis. During maturation, there is axiate elongation of the trichome and thinning of the cytoplasm. In type Ib, the hair initial swells up greatly resulting in the formation of a large vacuole. The subsidiary cells form an annular or rosette-like girdle around the foot.

In uniseriate filiform hairs, the hair initial elongates axially and then divides by a periclinal wall into a basal cell and an apical cell (Figs. 5, 6, 10, 11, 17, 21, 33). The basal cell remains undivided and matures into the foot. Occasionally, however, it may divide by an anticlinal wall as to form a two celled foot (Figs. 15, 19, 23-25) as in types IIc, IId, IIe, or it repeatedly divides by anticlinal and oblique walls and form a many-celled foot (Figs. 27, 28) as in type IIg. In type IIa and IIb, where the hair is bi-celled, the apical cell matures and forms the body of the hair. However, when the body of the hair is two celled (types IIc-IIj), the apical cell elongates and divides by a periclinal wall so as to form a lower cell and a terminal cell (Figs. 12, 13, 18, 22, 34). The terminal cell assumes various shapes during maturation depending on the type of the hair. It enlarges to form a unicellular capitate head in type IIj, or becomes rostrate-oblong in type Ili. Where the body of the hair is more than 2-celled, the lower cell shows intercalary cell divisions (Figs. 14, 30, 35). The number of these divisions depends on the number of cells in the body. During maturation, the cells of the body elongate and develop secondary thickenings on the lateral walls. Eventually the cytoplasmic contents of the cells are exhausted.

The initial of glandular hair becomes papillose and vacuolated (Figs. 39, 40, 51, 60) and then divides by a periclinal wall resulting in the formation of an apical cell and a

basal cell (Figs. 41, 52, 61). The former with a denser cytoplasm and a comparatively larger nucleus divides periclinally to form an upper head cell and a lower stalk cell (Figs. 42, 53, 62). At this 3-celled stage, the basal cell usually does not divide and forms a simple foot but in type IIc, it undergoes an anticlinal division to form a 2-celled foot (Figs. 63, 64). The stalk cell elongates and as such forms a 1-celled stalk or it undergoes periclinal divisions where the stalk is 2 or more celled (Figs. 46, 63-71). In types IIc and IId, the stalk cell divides into two unequal cells by a periclinal wall. The upper short cell is the neck cell and the lower elongated cell undergoes successive periclinal division to form 1-3-celled stalk.

The head cell does not divide in types IIb, IIc and IIe but enlarges to form a unicellular head (Figs. 55-59, 66, 69-71). In type IIIa and IIId, it undergoes two vertical divisions at right angle to each other resulting in a 4-celled head (Figs. 44-46, 67, 68). Occasionally in type IIIa, only one vertical division takes place in the head cell and thus the head remains only two celled or it becomes 6-celled by an additional anticlinal division (Fig. 48).

Metabolic byproducts secreted by the glandular hairs accumulate between cell wall and distended cuticle of the head. The pressure exerted by this accumulation ruptures the cuticle and the secretions escape into the atmosphere producing characteristic aroma.

DISCUSSION AND CONCLUSIONS

Metcalf and Chalk (1950) have reported the occurrence of only glandular trichomes on the vegetative parts of the species of *Salvia*. We have, however, observed 12 types of non-glandular and 5 types of glandular trichomes on the floral appendages of the species of *Salvia* investigated by us. Furthermore, Metcalf and Chalk (1950) do not report unicellular trichomes in Labiatae, but

we have observed two types of unicellular trichomes, prickle and bluntly conical on the floral appendages of some species of *Salvia*.

The unicellular trichomes are not differentiated into foot and body; the portion of the cell inside the epidermis acts as the foot and the portion above the epidermis as the body. But the uniseriate filiform hairs are well differentiated into foot and body. The foot is usually broader, swollen and 1-celled and is slightly projected above the epidermis, occasionally being 2-celled (*e.g.* in simple filiform, conical filiform, falcate filiform hairs) or many celled as in pedestallated filiform hairs. The foot is seated on a pedestal composed of several hypodermal cells in the bluntly conical unicellular and pedestallated filiform hairs. The body of the hair consists of one to many cells. The terminal cell of the body is either similar to the other cells of the body or differentiated into a head.

The glandular hairs are always multicelled and are differentiated into foot and body. The latter is further distinguished into stalk and head. The number of cells in the stalk and their length varies in different types. The shape and number of cells in the head are very characteristic and provide distinct criteria in distinguishing various types of glandular hairs. Both, unicellular and multicellular trichomes develop from a single protodermal initial. This is in confirmation with the earlier reports by Netolitzky (1932), Carlquist (1959 a, b), Uphöf (1962), Ramayya (1969, 1972), etc. Uphöf (1962) is of the opinion that the initials of glandular trichomes are usually clavate and round-tipped, while those of non-glandular trichomes are acute. We have not observed any such correlation in the initials of non-glandular and glandular trichomes and recorded both acute and round-tipped initials for both the types. We have, however, observed some correlation between the shape of the terminal cell of the

mature trichome and the distal end of its initial at an advanced stage of development. Such a correlation was also observed by Ramayya (1969) in the trichomes of Compositae.

The initial of glandular hair divides periclinally to form an upper apical cell and a lower basal cell. The former further divides periclinally to form a lower stalk cell and an upper head cell which is in conformity with the observation of Mathur (1961). According to Murthy (1941), however, in *Orthosiphon stamineus* the trichome initial divides transversely into a head cell and a stalk cell. The latter again divides periclinally to form the middle and the basal cells; the middle cell forming the stalk of the gland.

The identification value of trichomes in some Labiatae has already been recognised (Small, 1913; Zornig and Buch, 1926). The present study also reveals that the structure and distribution of trichomes may provide substantial criteria in distinguishing various species of *Salvia*. A key drawn to distinguish various species is given below:

Unicellular papillae present		
Unicellular papillae prickle (Ia) type		
Bicelled hair present	...	<i>S. coccinea</i>
Bicelled hair absent	...	<i>S. officinalis</i>
Unicellular papillae bluntly conical (Ib) type		
Bicelled hair present	...	<i>S. plebeia</i>
Bicelled hair absent	...	<i>S. lanata</i>
Unicellular papillae absent		
Bicelled hair present		
Flagellated filiform hair present	...	<i>S. microphylla</i>
Flagellated filiform hair absent	...	<i>S. aegyptiaca</i>
Bicelled hair absent		
Flagellated filiform hair present		
Capitate glandular hair with both 1-celled and 4-celled head	...	<i>S. glutinosa</i>
Capitate glandular hair with only 1-celled head		
Both unicellular stalk and a stalk with a short neck cell and 1-3 elongated stalk cells present	...	<i>S. moorcroftiana</i>
Stalk always unicellular	...	<i>S. splendens</i>
Flagellated filiform hair absent		
Capitate glandular hair with both uni- and multicellular stalk and 1-celled head		
Conical filiform hair present	...	<i>S. farinacea</i>
Conical filiform hair absent	...	<i>S. linearis</i>
Capitate glandular hair with only unicellular stalk and 1-celled head	...	<i>S. leucantha</i>

TABLE I

Sl. no.	Name of species	Place of collection	TYPES OF TRICHOMES																
			Ia	Ib	IIa	IIb	IIc	IId	IIe	IIf	IIg	IIh	IIi	IIj	IIIa	IIIb	IIIc	IIId	IIIe
1.	<i>S. aegyptiaca</i> Linn.	Dehra Dun	—	—	+	—	+	—	—	—	+	—	—	—	+	+	+	—	—
2.	<i>S. coccinea</i> Juss. ex Murr.	Dehra Dun	+	—	+	—	+	+	—	—	—	—	—	—	+	+	+	—	—
3.	<i>S. farinacea</i> Benth.	Dehra Dun	—	—	—	—	+	+	—	—	—	—	—	—	+	+	+	—	—
4.	<i>S. glutinosa</i> Linn.	Gulabkoti (Garhwal)	—	—	—	—	+	—	—	+	—	—	—	—	+	+	+	+	+
5.	<i>S. lanata</i> Roxb.	Chakrata	—	+	—	—	+	—	—	+	+	—	—	—	+	+	+	—	—
6.	<i>S. leucantha</i> Cav.	Mussoorie	—	—	—	—	+	—	—	—	—	—	—	+	+	+	—	—	—
7.	<i>S. linearis</i> Ruiz & Pav.	Dehra Dun	—	—	—	—	+	—	—	—	—	—	—	—	+	+	+	—	—
8.	<i>S. microphylla</i> H. B. & K.	Dehra Dun	—	—	+	—	+	+	—	+	—	—	—	—	+	+	+	—	—
9.	<i>S. moorcroftiana</i> Wall. ex Benth.	Simla	—	—	—	—	+	—	—	+	+	—	—	—	+	+	+	—	—
10.	<i>S. officinalis</i> Linn.	Purandhar	+	—	—	—	+	—	—	—	—	—	—	—	+	+	+	—	—
11.	<i>S. plebeia</i> R. Br.	Meerut	—	+	+	—	+	—	—	+	—	—	—	—	+	+	+	—	—
12.	<i>S. splendens</i> Sello.	Meerut	—	—	—	+	+	+	+	+	—	+	+	—	+	+	—	—	—

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*Not seen in original.