J. Indian bot. Soc. 50 : 189-196, 1971.

# VASCULARIZATION OF COROLLA OF THE COMPOSITAE<sup>1</sup>

## By K. S. MANILAL<sup>2</sup>

Department of Botany, University of Calicut

#### Abstract

The vascular anatomy of the corolla of 66 species of the family Compositae is described. The petals in this family are basically 3-traced. The members of this family exhibit all grades from the full development of all the vascular bundles in the corolla in certain species to their complete elimination in others. A greater degree of variation in the vasculature is found in the ray-corollas than in the disk-corollas. The corollas of the ray-florets in certain species of the tribe Asteroideae are entirely devoid of vascular bundles while those in certain species of the tribe Helianthoideae have all their vascular bundles fully developed. In general the reduction in the vascular bundles of the corolla has been faster than the organ itself. The tubular, ligulate and bilabiate corollas are mere modifications of the tubular type.

#### INTRODUCTION

The corolla of the Compositae presents interesting features concerning the reduction and amplification of its vascular supply in their various taxa. Except for the work of Koch (1930a 1930b) no attempt seems to have been made to explain on an anatomical basis the evolutionary trends seen in corolla of Compositae. The present paper is based on a comparative study of 54 genera and 66

The author is thankful to Dr. Y. D. Tiagi for guidance; to Prof. B. S. Saksena (University of Saugar) for his keen interest and providing all facilities; to Prof. V. Puri for permission to consult the library of the school of Plant Morphology, Meerut to Prof. M. B. Raizada for the identification of most of the material studied and to Prof. B. K. Nayar for encouragement. species belonging to 12 tribes of the family compositae.

### MATERIAL AND METHODS

The following species have been studied :

- Tribe I. Vernonieae. Vernonia cinerea Lees, V. patula (Dryand.) Merrill.
- Tribe II. Eupatorieae.—Ageratum conyzoides Linn., Eupatorium triplinerve vahl., Mikania cordata (Burm. f.) B. L. Robinson.
- Tribe III. Asteroideae. Solidago virgaaurea Linn., S. odora Ait., Cyathocline purpurea (Don) Kuntze, Brachycome assamica Clarke, Aster molliusculus wall. A. thomsoni Clarke, A. asperulus Nees, A. amellus var. bassarabicus DC., Erigeron canadensis Linn., Conyza stricta Willd.
- Tribe IV. Inuloideae.--Blumea oxyodonta DC., B. eriantha DC., Laggera flava

<sup>1.</sup> Accepted for Publication on April 8, 1971.

<sup>2.</sup> Present address : Department of Marine Biology, University College of N. Wales, Menai Bridge, Anglesey, U.K.

Benth. L. aurita schultz-Bip., Sphaeranthus indicus Linn., Anaphalis adnata DC., Gnaphalium indicum Linn. G., pulvinatum Delile, Caesulia axillaris Roxb., Inula cuspidata Clarke, I. indica Linn., Pulicaria angustjfolia DC.

- Tribe V. Helianthoideae.-Lagasca Mollis Cav., Acanthospermum hispidum DC., Xanthium strumarium Linn., Siegesbeckia orientalis Linn., Eclipta prostrata (Linn.) Linn., Sclerocarpus africanus Jacq., Blainvillea acmella (Linn.) Philipson, Spilanthes acmella Linn., Ximensia encelioides Cav., Verbesina oncophora Robinson & Seaton, Helianthus annuus Linn., H. annuus (var. Russian giant), Tithonia diversi folia Gray., Zinnia elegans Jacqu., Glossocardia bosvallea (Linn. f.) D.C., Bidens biternata (Lour.) Merr. & Sherff., Chrysanthellum indicum DC., Galinsoga parviflora Cav., Tridax procumbens Linn.
- Tribe VI. Helenieae.—Flaveria repanda Lag., Gaillardia pulchella var. picta Gray, Tagetes erecta Linn.
- Tribe VII. Anthemideae.—Cotula anthemoides Linn., Artemesia scoparia Waldst. & Kit., A. vulgaris Linn.
- Tribe VIII. Senecionideae.—Emilia sonchifolia DC.
- Tribe IX. Calenduleae. Calendula officinalis Linn.
- Tribe X. Cynaroideae. -- Echinops echinatus Linn, Cnicus wallichii Hook, Tricholepis glaberrima DC., Volutarella ramosa (Roxb.) Santapau.
- Tribe XI. Mutisieae. Gerbera jamesonii Hook.
- Tribe XII. Cichorieae. Cichorium intybus Linn., Taraxacum officinale Wigg., Lactuca macrorhiza Hook., Prenanthes brunoniana Wall., Sonchus oleraceus S. arvensis Linn., Launaea aspleniifolia DC.

The materials were fixed in 70% ethyl alcohol or F. A. A. Customary methods of microtechnique were followed. Serial transverse sections of florets were cut at thicknesses ranging from  $12-30 \mu$  and stained with crystal violet and ery-throsin. vascular supply of the corolla was also studied by clearing in lactic acid or 5 per cent solution of potassium hydroxide.

## OBSERVATIONS

In Compositae there are 3 types of corollas, viz., tubular, bilabiate and Typically the tubular ligulate. 5-fid corolla has at its base five vascular traces. Each of these is compound (VV), formed by the fusion of adjacent marginal bundles of the adjoining petals. They run upward through the corolla tube and separate into their constituents just below the sinuses of the petal lobes. The marginal bundles of a petal may unite at its apex to form an arch as in Vernonia (Fig. 1) Solidago, Brachycome, Aster, Conyza, Blumea, Inula, Sphaeranthus, Anaphalis, Caesulia, Lagasca, Xanthium, Siegesbeckia, Sclerocarpus, Bidens, Galinsoga Tridax, Zinnia, Ximensia, Acanthospermum, Flaveria, Tagetes, Cotula (bisexual florets), Emilla, Calendula, Echinops, Tricholepis and Volutarella or may not unite at the apex as in Eupatorium (Fig. 2), Mikania, Solidago, Cyathocline, Aster molliusculus, Blainvillea and Chrysanthellum. In Ageratum (Fig. 3), Laggera, Gnaphalium & Spilanthes the marginals remain more or less suppressed or the compound marginals bundles fail to separate into their constituents ending blindly below the sinuses of the petal lobes.

The tubular 5-fid corolla of *Cnicus* (Fig. 4) also has five compound vascular bundles which separate into their constituents below the sinuses of the petal lobes, the marginal of each petal lobe uniting at its apex. The petals in this separate from each other at different levels ; as a result different petal lobes are unequal in their length. Usually one of the lobes is much longer than the others.

The tubular corolla is 4-fid in *Eclipta* (Fig. 5), *Glassocardia* and *Erigeron* and is supplied with four compound bundles which divide below the sinuses of the corolla lobes. The 2 marginals of a petal lobe unite at its apex.

In Helianthus, Tithonia, Gaillardia and Verbesing the tubular corolla has 10 vascular bundles. Of these, five are the dorsal bundles of the petals (D). The other five are compound marginal bundles of the petals (VV) which separate into their constituents (V) below the sinuses of the corolla lobes. The two marginals and the dorsal bundle in a petal lobe in Helianthus unite at its apex (Fig. 6) while in Verbesina (Fig. 9) the dorsals disappear at various levels in the corolla tube. The compound marginal bundles may give out several secondary marginal bundles (SM) in the basal region of the corolla as in Helianthus (var. Russian giant) and Tithonia (Fig. 7) or at the apical region as in the outer florets of Gaillardia (Fig. 8).

In several disk-florets of Sclerocarpus (Fig. 10), Acanthospermum and Artemesia (Fig. 11), apart from the five compound marginal bundles the corolla may possess 1 or 2 fully or partially developed petal dorsals.

In Gerberg, the corolla of both the disk and ray florets is bilabiate. In the disk-corolla, the 2-lobed posterior lip is as long as the 3-lobed anterior lip and has five compound bundles which divide below the sinuses of the petal lobes. The marginals of a petal lobe unite at its apex. (Fig. 12). In the ray-corolla the 2-lobed posterior lip is much smaller than the 3lobed anterior lip. It is supplied with eight vascular bundles, five compound marginal bundles and three anterior petal dorsal. The dorsal and the two marginal bundles of a petal lobe unite at its apex. A few secondary marginal bundles given off by the compound marginals may also join them at the apex (Fig. 13).

The ligulate corollas of Ximensia (Fig. 14) and Helianthus and several raycorrollas of Tridax have 11 vascular bundles five dorsal bundles of the petals, four compound marginals and two marginal bundles of the posterior petals.

The odd posterior compound marginal bundle in these species separates into its constituents before it enters the corolla, at the top of the ovary-wall. The splitting of the ligulate corolla occurs between these two free marginals (Fig. 14). The remaining four compound marginals also divide near the apex of the corolla. In the apex of the middle lobe of the corolla its dorsal bundle fuses with its two marginals while the bundles in either of the flanking lobes variously unite with one another.

The ray-corollas of *Tithonia* (Fig. 15) and *Helianthus annuus* var. Russian gaint may have more than 11 vascular bundles. The extra bundles in these are the secondary marginals of the compound ventral bundles.

In the ray-corollas of Brachycome, Galinsoga and Zinnia also, the posterior compound bundle separates into its constituents before it enters the corolla with the other 4 compound bundles. Apart from these bundles three petal-dorsals are present in Brachycome (Fig. 16), while I anterior petal dorsal alone is seen in Galinsoga (Fig. 17). In Zinnia (Fig. 18) the ligulate corolla has no dorsal bundle. In these taxa all or some of the compound ventrals may divide near the apex of the corolla. The marginals of a petal lobe generally unite at its apex (Figs. 16, 18).

The ray-corollas of Aster, Cichorium, Taraxacum, Lactuca, Prenanthes, Launaea and Sonchus have five vascular bundles all of which are compound. The posterior compound bundle divides just below the split of the ligule. Other bundles may divide near the apex. In Cichorium (Fig. 19<sup>\chi</sup>, Taraxacum, Lactuca, Prenanthes and Launaea the free marginals of a petal lobe unite at its apex, while in Aster (Fig. 20), and Sonchus (Fig. 21), they usually fail to do so.

In the ray florets of Seigesbeckia, Sclerocarpus, Verbesina, Blainvillea, Bidens and Flaveria the corolla has five compound bundles. In Sigesbeckia and Sclerocarpus the dorsals of one or two anterior petals may also be present. The corollas in these split on one side of the posterior compound bundle (Figs. 22-24). In Siegesbeckia (Fig. 22) and Sclerocarpus some of the compound bundles divide near the apex of the corolla. The marginal bundles of a petal lobe may unite at its apex or remain free. In Verbesing the two compound bundles near the margins of the ligule, after entering the corolla immediately separate into their constituents (Fig. 23). In Blainvillea (Fig. 24) Bidens and Flaveria none of the five compound bundles do so.

In the ray-corolla of *Glossocardia* there are only four compound bundles and three dorsal bundles (Fig. 25). The odd posterior compound bundle is lost and the corolla splits at this region. All these seven bundles terminate blindly near its apex.

In the ray-florets of Pulicaria; Inula, Calendula, Acanthospermum and several ray-florets of *Aster* and *Solidago* the corolla has four compound bundles only (Figs. 26-30). The odd posterior compound bundle is lost and the corolla spilts at this region.

In Calendula the two compound bundles nearest to the marginals of the ligule divide immediately after entering the corolla (Figs. 28-29). The other two divide near the apex. The two marginals of a petal lobe may unite at its apex in Pulicaria (Fig. 26) and Inula. Although the petal dorsals are generally missing in these taxa, isolated pieces of dorsal bundles unconnected above and below are observed in some ray-corollas of Inula (Fig. 27) and Calendula (Fig. 29). In Acanthospermum (Fig. 30) and several florets of Aster and Solidago all the four compound bundles terminate without splitting.

The corolla of most of the ray-florets of Aster (Fig. 31) and Eclipta have just three compound bundles. These terminate without splitting. The ligulate corolla in Chrysanthellum (Fig. 32) has two compound bundles only while in Artemesia (Fig. 33) it has a solitary compound bundle. The ligulate corolla of Solidago, Erigeron and Artemesia may have one or two compound bundles. No dorsal bundles are present in them.

In the ray-florets of *Cyathocline* (Fig. 34), *Conyza*, *Gnaphalium* (Fig. 35), *Lagg-era*, *Sphaeranthus*, Anaphalis and *Blumea* (Fig. 36) the corolla is completely devoid of any Vascular bundles. In the ray (female) floret of *Cotula* the corolla itself is absent (Fig. 37)

# DISCUSSION

The petals in the family Compositae are fundamentally 3-traced in contrast to the general 1-traced condition in the



FIGS. 1-13. Cleared disk-corollas cut longitudinally and spread open to show their vasculature. Fig. 1. Vernonia cinerea. Fig. 2. Eupatorium triplinerve, Fig. 3. Ageratum conyzoides Fig. 4. Cnicus wallichi. Fig. 5. Eclipta prostrata. Fig. 6. Helianthus annuus. Fig. 7. Tithonia diversifolia. Fig. 8. Gaillardia pulche'la. Fig. 9. Verbesina oncophora. Fig. 10. Sclerocarpus africanus. Fig. 11. Artemesia vulgaris. Figs. 12, 13. Gerbera jamesonii. Cleared bilabiate-corollas cut longitudinally and spread open to show their vasculature. Fig. 12. A disk-corolla. Fig. 13. A ray-corolla.

D, Dorsal bundle; SM, Secondary marginal bundle; V, Ventral bundle; VV, Compound ventral bundle.

angiosperms. In the various species of this family all transitions from a condition in which all the three bundles are present in a petal to their total absence are seen. The adjacent marginal bundles of the adjoining marginals of the petals have without exception become fused at least in the lower region, more commonly up to the sinuses of the corolla lobes to form compound marginal bundles (cf. Koch, 1930a; Eames, 1931). Generally, the two marginal bundles of a petal unite at its apex to form an arch.

The reduction and suppression of the bundles in the corolla exhibit varied trends. In Helianthoideae, the bundles in the corolla in general are well developed, more so in the ray-florets than in the disk. Thus, in the disk-and rayflorets of Helianthus and Tithonia the dorsal and marginal bundles of the petals are fully developed. In the rayflorets the marginal bundles even give out a number of secondary branches (Fig. 15). In Siegeskeckia, Sclerocarpus, Glossocardia, Galinsoga, Tridax, Ximensia, etc., although the dorsal bundles are fully developed in the ray-corollas they are almost absent in the disk-corollas. Further, all stages of reduction of the dorsal bundles leading to their total elimination are met with in the ray-corollas of different species. Thus the raycorolla of Ximensia (Fig. 14) Helianthus, Tithonia and Tridax possesses all the five dorsal bundles while that of Brachycome (Fig.16) has three and that of Siegesbeckia (Fig.22) and Sclerocarpus has only two of them. In Galinsoga (Fig. 17) the ray corolla has a solitary dorsal bundle. All the dorsal bundles are missing in the ray-corolla of Zinnia (Fig.18) and Aster (Fig.20). On the other hand in Solidago, Erigeron Artemesia, Chrysanthellum, Conyza, Blumea, Laggera,

Gnaphalium, Cyathocline etc., the reduction of the vascular bundles in the corollas of the peripheral florets has been much greater than in those of the diskflorets. All the five compound bundles are fully developed in the disk-corollas of Acanthospermum, etc. but only four of them are seen in their ray-corollas (Fig. 30) while only 3 of them are found in most of the ray-corollas of Aster molliusculus (Fig. 31). Their number is reduced to two or one in Chrysanthellum (Fig. 32), Solidago, Erigeron, Artemesia (Fig. 33) etc. In Cyathocline (Fig. 34), Gnaphalium (Fig. 35), Blumea (Fig. 36), Conyza, Laggera, Anaphalis, Sphaeranthus etc., the corolla of the ray-floret is entirely devoid of vascular bundles. Evidently the suppression of the vascular bundles here has been faster than the organ itself. It is only after so much reduction of vascular bundles that the corolla itself has become almost completely suppressed in certain forms like the female florets of Xanthium and the ray-florets of Cotula (Fig. 37). The suppression of the vascular bundles of the corolla before the suppression of the corolla itself is in conformity with the condition in other floral organs in Compositae (Manilal, 1963). The relative conservatism of vascular bundles versus the organ it supplies was discussed at length by Puri (1951) who stressed the need for a judicial approach to tackle such problems of evolutionary morphology.

The presence of three types of corollas in this family, namely tubular, ligulate and bilabiate was anatomically confirmed by Small (1917) and Koch (1930a). Small (1917) expressed the opinion that the three types of corollas could be distinguished from each other by the variability of their anatomical characters alone. The present study



FIGS. 14-37. Cleared ray-corollas cut longitudinally and spread open to show their vasculature. Fig. 14. Ximensia enceloides. Fig. 15. Tithonia diversifolia. Fig. 16. Brachycome assamica. Fig. 17. Galinsoga parviflora. Fig. 18. Zinnia elegans. Fig. 19. Cichorium intybus. Fig. 20. Aster amellus. Fig. 21. Sonchus oleraceus. Fig. 22. Siegesbeckia orientalis. Fig. 23. Verbesena oncophora. Fig. 24. Blainvillea acmella. Fig. 25. Glossocardia bosvallea. Fig. 26. Pulicaria angustifolia. Fig. 27. Inula indica. Figs. 28, 29. Calendula officinalis. Fig. 30. Acanthospermum hispidum. Fig 31. Aster molliusculus. Fig. 32. Chrysanthellum indicum. Fig. 33. Artemesia vulgaris. Figs. 34-36. Cleared ray-corollas cut longitudinally and spread open to show the absence of vascular bundles. Fig. 34. Cyathocline purpurea. Fig. 35. Gnaphalium pulvinatum. Fig. 36. Blumea eriantha. Fig. 37. Cotula anthemoides. A ray-floret.

D, Dorsal bundle; SM, Secondary Marginal bundle; V, Ventral bundle; VV, Compound ventral bundle.

does not subscribe to such a view but shows that the ligulate and bilabiate types of corollas are mere modifications of the tubular type.

A single deep sinus on the posterior side in the tubular corolla preceded by the division of the compound marginal bundle below gives rise to the ligulate type as exhibited not by the members of the tribe Cichorieae alone (Fig. 19, 21) but also by several species belonging to other tribes (Fig. 20, cf. Figs. 14, 16). A more advanced type of formation of the ligulate corolla is exhibited by those species where the posterior compound marginal bundle of the petal fail to divide and the splitting of the corolla occurs between two posterior compound marginals (Figs. 22-24).

Similarly, the splitting of the corolla by the two main sinuses one on each side of a posterior and a lateral petal preceded by the splitting of the compound marginal below, results in the bilabiate types as in *Gerbera* (Figs. 12-13 cf. *Cnicus*). Therefore it can be concluded that the bilabiate and ligulate corollas are modifications of the basic tubular type. This is also borne out by the similarity in their fundamental vascular pattern.

## REFERENCES

- EAMES, A.J. 1931. The vascular anatomy of the flower with refutation of the theory of the carpel polymorphism. Am. J. Bot. 18: 147-188.
- KOCH, MINNA F. 1930a. Studies in the anatomy and morphology of Compositae flower I. The corolla. *ibid.* 17: 938–952.

*Ibid.* 17: 995–1010.

- MANILAL, K.S. 1963. Morphological Studies in the Family Compositae. Ph. D. Thesis, Univ. Saugar.
- Univ. Saugar. PURI, V. 1951. The role of floral anatomy in the solution of morphological problems. Bot. Rev. 17: 471-553.

SMALL, J. 1917. On the floral anatomy of some Compositae. J. Linn Soc. Bot. 43: 517-525.

J. Indian bot. soc. 50 : 196-208, 1971.

# STUDIES ON COPROPHILOUS FUNGI IV. SOME CLEISTO-THECIAL ASCOMYCETES<sup>1</sup>

## BY B. C. LODHA

Department of Botany, University of Rajasthan, Jaipur

## Abstract

This paper deals with systematic account of 12 species of cleistothecial Ascomycetes. Of these, five are described as new: Arachniotus hyaliotrichus on rat dung from Jodhpur, Rajasthan; Kernia irregularis on cow dung from Chakrata Hills, U. P.; Preussia cylindrispora on goat dung from Jaipur, Rajasthan; Pseudeurotium

<sup>1.</sup> Accepted for publication on April 29, 1971.