VIII. SUMMARY AND CONCLUSIONS
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The foliar epidermal features, vessel elements, leaf architecture, palynology, and fruit morphology of 40 species belonging to 26 genera have been investigated with a view to refine circumscription and delimitation of taxa at different levels of taxonomic hierarchy, to establish evolutionary trends and to understand the phylogeny within the family.

The 40 taxa selected for the present investigation belong to conventionally established taxonomic tribes, Lagasceae, Melampodieae, Ambrosieae, Zinnieae, Verbesineae, Coreopsideae, and Galinsogeae.

The foliar epidermal features, vessel elements, leaf architecture, palynology and fruit morphology are investigated by conventional methods coupled with light and electron microscopy. 43 parameters (including qualitative and quantitative ones) are included for the present study.

The distribution of stomata on both surfaces of leaves highly variable, but the pattern of variation is taxon-specific. The leaves of some genera are hypostomatic, whereas in majority of cases leaves are amphistomatic. The stomata are distributed all over leaf surface without any definite pattern of orientation.
The stomatal indices and densities are high on the abaxial than on the adaxial surface of the leaf. The stomatal indices are found to be constant for a species, eventhough they are collected from different geological conditions. Stomatal frequency values are highly variable and proved to be of little taxonomic value.

The different types of stomata, anomocytic, anisocytic, diacytic, polocytic and hemiparacytic have been encountered during the present investigation. The most frequent type in the tribe is anomocytic. The abnormal stomatal variations encountered are (1) persistent stomatal cell (2) single guard cell with or without pore (3) aborted guard cells (4) contiguous stomata (5) cytoplasmic connection between near by stomata (6) guard cells unusually narrow (7) guard cells of unequal size and (8) adjacent stomata with common subsidiary cells.

The leaves are simple and opposite in majority of species investigated. In a few taxa they are either pinnately or palmately lobed. Regular odd pinnate leaves are noticed in some species. The important leaf, leaflet forms noticed are elliptic, narrow oblong, narrow ovate, lanceolate, narrow oblanceolate, wide ovate, ovate - lanceolate and ovate with either palmately lobed, pinnately lobed, pinnatisect, bipinnatisect or bipinnatifid leaves. The margin is either entire, lobed, toothed or crenate. In majority of the taxa, the venation pattern is Acrodromous type. Other types encountered are semicraspedodromous and Actinodromous types. Marginal ultimate venation is looped in
most of the taxa under study. Intramarginal veins are observed in taxa belonging to the subtribe Coreopsideae.

The reliability of palisade ratio as taxonomic character is emphasized by the present study. This criterion is more useful in delimiting the taxa at intra-specific levels than at generic level. At many instances, more or less same palisade ratio values repeat in many unrelated taxa, and this parameter can be used only in a holistic way, with more reliable criteria. It is interesting to note that comparatively high palisade ratio values are noticed in taxa coming under Coreopsideae - a subtribe considered to be advanced by many authors.

Histochemical localisation of different metabolites has been done on the foliar epidermis of 38 taxa. The different metabolites localised in the foliar epidermis are starch, insoluble polysaccharides, sulphated and carboxylated polysaccharides, cellulose, polyphenols, proteins and lipids.

The histochemical localisation of various metabolites shows considerable diversity in the foliar epidermis. One to twenty starch grains are encountered in the guard cells of the majority of taxa.

The epidermal cell wall except the middle lamellar portion shows positive staining reaction for cellulose with iodine potassium iodide - sulphuric acid test. Both the stomata and the epidermal cells respond similarly to the $I_2\cdot KI - H_2SO_4$ test.
With PAS reaction subsidiary cells are not distinguished from other epidermal cell. Toluidine blue '0' gives differential staining reactions for polyphenols, and sulphated and carboxylated polysaccharides. Perigenous subsidiary cells show positive reaction for sulphated and carboxylated polysaccharides, while mesogenous subsidiary cells react positively for polyphenols.

Phenolic deposits are of frequent occurrence in the epidermal cells, trichomes and guard cells of many taxa. However, their concentration in the cells in different taxa shows remarkable difference, which may be due to the influence of different environmental factors. Higher concentration of phenolics is detected in some taxa, which are grown in the temperate region.

The reaction with Mercuric Bromophenol blue varies with species. Proteins are present in the cell walls, and in the nuclei of epidermal cells, subsidiary cells, trichomes and guard cells of all the taxa. Plastids of the guard cells are also stained for proteins. In some taxa, the nuclei are surrounded by 5 to 7 protein bodies.

Lipid granules are observed in the cytoplasm of guard cells, subsidiary cells and epidermal cells of most of the species.
Regarding the vessel elements, the shape, size, nature and arrangement of inter vessel pitting and perforation plates in node, internode and roots of 39 taxa have been investigated. Inspite of the diversity in shape, the cylindrical form is predominant in all the taxa. There appears to be a relation between the size and shape of vessels and growth habit. Shrubby plants have relatively shorter and broader vessels whereas herbaceous taxa have longer and narrower vessel elements. Very short, moderately short and medium sized vessels are commonly observed in the internode and root of most of the taxa. In node, extremely short and very short type of vessels are most commonly observed.

Based on diameter, the vessel elements are grouped into 7 classes (Radford et al., 1974). Regarding the diameter of vessel element very small, moderately small and medium sized vessel diameters are commonly noticed in the internode, node and root.

Perforation plates are simple in majority of the taxa. Reticulate perforation plates are noticed in a few taxa. Scalariform perforation plates are very rarely observed as in taxa like Xanthium indicum J. Koenig. The perforation plates are either terminal or lateral and are usually two per vessel, but occasionally the number is either reduced to one or increased to three. Tails are observed at one or both the ends of the vessels, Inter-vascular pitting is mostly simple, occasionally they are scalariform, helical or bordered. Possible evolution of simple perforation plates from the reticulate and scalariform types
has been suggested. Among the different characters of vessel elements investigated, the type of perforation plates and pitting have been found to be of systematic and evolutionary significance.

The morphological features of pollen grains of different taxa have been investigated by both light and scanning electron microscopy. Morphological analysis is made mainly based on the aperture character. Ornamentation of the interspinal area exine strata, spine height, size and shape of pollen grains are also taken into consideration as supplementary characters.

Pollen grains are mostly of 3-zonocolporate type. 4-zonocolporate grains are noticed in a few taxa. (2)-zonocolporate grains are rarely observed in taxa such as *Zinnia linearis* Benth. and *Cosmos bipinnatus* Cav..

Endocolpium is 1a-longate in majority of the taxa, but it is circular in *Parthenium hysterophorus* L.

Exine is spinate or spinulate in all the taxa studied except in *Xanthium indicum* J. Koenig where it is scabrate. The inter-spinal exine sculpturing shows considerable variations. Granulate surface pattern is the most common type encountered during the present investigation. Punctate, granulose, rugulate and foveolate surface ornamentations are also noticed in various taxa under study.

Most of the pollen grains belong to medium size class (25-50 μm). Small grains (21 μm) are also noticed as in *Parthenium hysterophorus* L.
Dimorphism of pollen grains has been noticed in a number of species with respect to the number of aperture and exine ornamentation.

Both light microscopic and scanning electron microscopic studies were done on the fruit morphology of 40 species belonging to 26 genera of the tribe Heliantheae. Hilum (attachment point) is the most conservative structure of primary value since it is the point of attachment of the fruit to the mother plant. The position and shape of attachment point vary with taxa. It is either marginal, basal or oblique in position. The surface ornamentation is constant for a species but varies considerably within the genera. Striate, reticuloid, reticulate, rough and mammulose surface patterns are observed for the different taxa under study.

The different achene shapes noticed are oblong, elliptic, oblanceolate, cuneate, obovate, cylindrical and turbinate.

Morphology of the pappus varies greatly in the tribe. Epappose forms to highly specialised paleaceous forms are observed in different taxa.

Based on 37 parameters, an attempt is made to classify the 39 taxa included in the present study using cluster analysis. The results obtained from different methods of cluster analysis are not uniform and are not tallying with the existing classifications. The candidate feels that studies including more genetically controlled parameters would be rewarding.
Based on the observations and discussions the following conclusions are made.

1. The qualitative characters such as types of stomata, nature of vessel elements, particularly the pitting patterns are found to be useful in the circumscription and delimitation of taxa at different levels of taxonomic hierarchy and the quantitative characters such as palisade ratio, stomatal index, vein-islet number/mm², veinlet number/mm² are of little taxonomic value because of overlapping patterns of variability among different taxa.

2. Histochemical localisation of polyphenols, and sulphated and carboxylated polysaccharides proves to be useful in differentiating the mesogenous and perigenous subsidiary cells.

3. The placement of *Lagaracea* Cav. along with Helianthinae memembers (Robinson, 1981) is justifiable.

4. The primitiveness of the subtribe Melampodieae is exemplified through the characters under observation.

5. The palisade ratio values, stomatal index values, palynology and fruit morphology support the intra-tribal transfer of the genus *Parthenium* L. to Ambrosiinae (Stuessy, 1977; Robinson, 1981).
6. The present investigation supports the advanced placement of the subtribe Ambrosieae.

7. The placement of *Zinnia* L. in the subtribe Zinnieae rather than in Ecliptinae is more appropriate.

8. The present findings reveal that Bentham & Hooker's Verbesineae is heterogenous.

9. The most suitable position for *Synedrella* Gaertn., is in the subtribe Ecliptinae (Stuessy, 1977; Robinson, 1981) rather than in the subtribe Coreopsideae.

10. Palynological and fruit morphological studies reveal that in Stuessy's (1977) treatment the transfer of the taxa *Spilanthes* Jacq. from Verbisininae to Galinsoginae is inexplicable.

11. The advanced position of the subtribe Coreopsideae is supported by the present work.

12. The placement of *Guizotia* Cass. in the subtribe Coreopsideae (Bentham & Hooker, 1876; Stuessy, 1977) is supported.

13. The advanced position of the subtribe Galinsogeae is well supported.