TAXONOMIC AND PHYLOGENETIC CONSIDERATIONS

The family Acanthaceae is included in the order Personales by Bentham and Hooker (1862-1883) along with the families *viz.* Scrophulariaceae, Pedaliaceae, Bignoniaceae, Gesneriaceae, Columelliaceae, Lentibulariaceae and Orobanchaceae. The Personales is a taxon of the sympetalous alliance delimited by zygomorphic corolla, posterior stamen often reduced to staminode, ovules often more than four. Amongst these, the Acanthaceae is generally characterized by the usual presence of bracts, bractioles, jaculated seeds and often elastically dehiscent loculicidal capsule. These authors divided families into five main tribes *viz.* Thunbergieae, Nelsonieae, Ruelieae, Acantheae and Justicieae.

Engler and Diels (1936) included the Acanthaceae in their order Tubiflorae, a large order of herbaceous plants with gamopetalous corolla, floral parts usually in four isomerous whorls or with an oligomerous gynoecium, stamens epipetalous, hypogynous and ovules being unitegmic. These authors included as many as 22 families with regular or irregular corolla. In Englerian treatments, it is Wettstein who accepted the order Tubiflorae with much circumscription as given by Engler. Wettstein (1935) recognized total 23 families in his order Tubiflorae wherein he placed the families *viz.* Acanthaceae and Scrophulariaceae. Melchoir (1964) included family Acanthaceae in his suborder Solanineae of the order Tubiflorae. He considered other 14 families in this suborder. Interestingly he also placed family Scrophulariaceae in this suborder. He also followed essentially Lindau’s treatment (1895) that recognized four subfamilies in the Acanthaceae and referred the genus *Thunbergia* to his subfamily Thunbergioideae along with *Meynia* and *Psudocalyx*. Van Tiegham (1908) considered the subfamily Acanthoideae (*sensu* Lindau) as the true Acanthaceae and recognized an independent family Thunbergiaceae encompassing rest of the families of Lindau (*loc. cit.*). Rendle
(1959) included Acanthaceae also in his order Tubiflorae more or less with similar circumscription. Benson (1957) referred the Acanthaceae to the order Scrophulariales more or less with similar circumscription as given by Bentham and Hooker (1862-1883). He characterized the family Acanthaceae by corolla lobes rolled up lengthwise in the bud, capsule springing open elastically often on a special stalk of ovary tissue.

Hutchinson (1969) included Acanthaceae in his order Personales alongwith Scrophulariaceae, Salpiglossidaceae, Gesneriaceae, Orobanchaceae, Lentibulariaceae and Columelliaceae. Later, Hutchinson (1973) also created the order similarly. In his opinion, the order Personales embraced more advanced families including Acanthaceae and Scrophulariaceae, with increasing zygomorphy of the corolla, a progressive reduction in the number of stamens and with alternate to opposite leaves. Takhtajan (1968) referred the family to his order Scrophulariales which included the families with zygomorphic corolla and also with regular corolla. He mentioned inclusion of Mendonciaceae and Thunbergiaceae in his Acanthaceae. He emphasized a common origin for the orders víz., Scrophulariales and Polemoniales. Takhtajan (1997) recognized total 15 families in his order Scrophulariales wherein he included the family Acanthaceae. The family Acanthaceae in further divided into 3 subfamilies víz., Nelsonioideae, Thunbergioideae and Acanthoideae. He emphasized the morphological features especially number of ovules per locule, funicular, jaculators, absence or presence of endosperm in the seeds and occurrence of cystoliths. He opined further that the subfamily Nelsonioideae is a connectedly between Scrophulariaceae and Acanthaceae.

Cronquist (1968) kept the family Acanthaceae in his order Scrophulariales alongwith other 11 families. He thought the order Scrophulariales related to and derived from the order Polemoniales. He considered the Acanthaceae linked to the Scrophulariaceae by transitional forms. In his revised system (1981) he mentioned the circumscription of the order Scrophulariales. In his opinion, the Acanthaceae is diverged from the
Scrophulariaceae primarily in their exclusively dehiscent fruit and specialized funiculus.

Bremekamp (1953, 1955) elevated the subfamily Thunbergioideae and Mendoncioideae to independent familial ranks.

Lindau (1895) divided Acanthaceae into four subfamilies, viz., Nelsonioideae, Mendoncioideae, Thunbergioideae and Acanthoideae, on the basis of the type of fruits, the number of ovules, and the presence or absence of retinacula and their shape.

Nees (in De Candolle’s *Prodromus Systematis Naturalis Regni Vegetabilis*, 1847) recognized two groups in Acanthaceae: Anechmatacantheae (without retinacula) and Echmatacantheae (with retinacula). Anechmatacantheae has two tribes Thunbergieae and Nelsonieae, which together into Lindau’s Thunbergioideae, Nelsonioideae and Mendoncioideae. Echmatacantheae has nine tribes comprising Lindau’s Acanthoideae.

Van Tieghem (1908) constituted three subfamilies viz., Nelsonioideae, Mendoncioideae and Thunbergioideae of Lindau into a new subfamily Thunbergiaceae, and Acanthaceae (*sensu* Van Tieghem). Wettstein (1935) divides Acanthaceae into two subfamilies: Thunbergioideae and Acanthoideae, which correspond respectively to Van Tieghem’s Thunbergiaceae, and Acanthaceae and Nees’ Anechmatacantheae and Echmatacantheae.

Bremekamp (1953, 1955, 1965) is of the opinion that Lindau’s Thunbergioideae and Mendoncioideae show greater affinity to Bignoniaceae and Pedaliaceae than to the latter’s Acanthoideae, and that Lindau’s Nelsonioideae is nearly related to the tribe Rhinantheae (family Scrophulariaceae) and should, therefore, be transferred to Scrophulariaceae. Thus, Bremekamp (1953, 1955, 1965) raises Thunbergioideae and Mendoncioideae to family rank and transfers Nelsonioideae to Scrophulariaceae. The family Acanthaceae *sensu* Bremekamp, therefore, consists only of Lindau’s subfamily Acanthoideae. Bremekamp divides his
Acanthaceae into two subfamilies, Acanthoideae (with five tribes) and Ruellioideae (with seven tribes).

The preceding resume of the taxonomic treatments of the family Acanthaceae and its alliance clearly suggest that there has been no unanimity of opinions in regard to the placement of the Acanthaceae in the various earlier and contemporary systems of plant classifications. A remarkable diversity of opinions is noticed with respect to the tribal, subfamilial, familial and ordinal ranks. There are certain criteria which split certain groups or entities, while there are others that lump them together into larger groups.

Although vegetative anatomical evidence can be employed for taxonomic evaluation and phylogenetic appraisal, they have their own limitations as an effective tool in such considerations. In addition to his own observations on the family Acanthaceae, the present investigator intends to use data from investigations of earlier workers for a more comprehensive discussion of the problem. Evidence from other domains of plant morphology is freely drawn in this evaluation. Conclusions are based as reasonably as can be arrived at.

The present contribution and earlier observations recorded by Solereder (1908), Metcalfe and Chalk (1950), Inamdar (1970), Paliwal (1969), Ahmad (1964, 1975, 1979a, 1979b, 1972, 1974), Selvaraj and Subramanian (1983), Varma and Murthy (1989), Karlstorm (1979), etc. state that diacytic condition of stomata on the foliage leaves is consistent and dominant throughout the family Acanthaceae. The survey of stomatal types in the allied families such as Scrophulariaceae, Orobanchaceae, Lentibulariaceae, Gesneriaceae, etc. show stomatal types other than the diacytic type as of common occurrence. Thus family Acanthaceae with its diacytic stomates is distinct from these related families. The stomatal type thus helps earmark the Acanthaceae from the rest other families in the alliance.
There is fair diversity of trichomes in the family Acanthaceae. This fact is amply substantiated by the earlier workers. (cf. Solereder, 1908; Metcalfe and Chalk, 1950; Pant and Mehera, 1963; Paliwal, 1966; Inamdar, 1970; Ahmad, 1974a, 1974b, 1974c, 1975a, 1975b, 1976, 1978a, 1978b, 1979; Kumar and Paliwal, 1975, 1978, 1982; Singh and Jain, 1975; Karlstom, 1979, 1980, etc.,) and also those of present contribution. The present author observed different ten types of trichomes ranging from papillose, unicellular, bicellular to multicellular. They are either glandular or eglandular. Of these, uniseriate trichomes are of common occurrence which are followed by unicellular types in their dominance. Glandular type is recorded in *Andrographis alata* in combination with other types. Panduriform glandular trichome is also exclusively noted in *Staurogyne zeylanica*. Usually trichomes are smooth, except *Andrographis stillulata*, *Justicia carnea* wherein the body of trichomes is striated and scabrate respectively. Their absence on abaxial surface is noted in e.g. *Andrographis alata*, *Hypoestes sanguniolenta*, *Mackenzia integrifolia* and *Micranthes oppositifolius*. Similarly, they are wanting on adaxial surface in few taxa such as *Justicia wynaddensis*, *Psuderanthemum reticulatum* and *Stenosiphonium parviflorum*. It is interesting to note that the trichome type viz., unicellular, bi-armed, tri-armed to multi-armed all occur in *Strobilanthes kunthianus* exclusively. Thus the structure, form and distribution of foliar trichomes help earmark the acanthaceous taxa. Taxonomic and phylogenetic significance of trichomes has long been recognized by number of workers (cf. Bachmann, 1886; Solereder, 1908; Copper, 1932; Cowan, 1950; Metcalfe and Chalk, 1950; Goodspeed, 1954; Sporne, 1956). According to Carlquist (1961) trichomes are, because of their easy accessibility, perhaps the most important anatomical feature which could be used for taxonomic purpose. Ahmad (1978) studied trichomes in Acanthaceae. He opined that the various trichome features such as shape, size, number of cells, thickening and ornamentations of the wall, type of hair base, etc. play a very useful role in the systematic consideration of various taxa. He further stated that the glandular trichomes are more important
at the tribal and subfamilial levels. The eglandular trichomes are of diagnostic value at generic, specific and varietal levels. Solereder (1908) pointed out that the panduriform glands are characteristic of the subfamily Thunbergioideae, whilst the disc-shaped glands generally found in the rest of the acanthaceous taxa. Ahmad (loc.cit.) further added that the panduriform glandular trichomes are uniformly present in the subfamily Nelsonioideae as well. *Staurogyne zeylanica* of the present account also revealed panduriform glandular trichome which belongs to subfamily Nelsonioideae. Ahmad (loc.cit.) also used the size of head of glandular trichomes to distinguish the species of the genera *Thunbergia, Strobilanthes and Justicia*. He also found the number of cells of the heads taxonomically important in the species of *Strobilanthes, Barleria, Dischoristae and Psuederanthemum*.

The past literature and that of present account on trichomes in the Acanthaceae can help decipher taxonomic placement of some acanthaceous entities. Lindau (1895) divided the family into four subfamilies *viz.*, Nelsonioideae, Thunbergioideae, Mendoncioideae and Acanthoideae. The members of Nelsonioideae and Thunbergioideae have glandular trichomes with panduriform head. The members of Acanthoideae and Mendoncioideae show glandular or disc-shaped heads. This character, nevertheless, does not lend support Bremekamp’s (1965) transfer of the subfamily Nelsonioideae to another family Scrophulariaceae since the glandular trichomes in case of the latter are not panduriform (*cf.* Metcalfe and Chalk, 1950). Similarly, the taxa of subfamily Mendoncioideae bear glandular and non-glandular trichomes fundamentally alike to those of the subfamily Acanthoideae. In other words, the transfer of the subfamily Nelsonioideae to Scrophulariaceae and elevating the subfamilies Mendoncioideae and Thunbergioideae to familial ranks appear not justifiable. This standpoint can be also supported by evidence from stomatal studies in this alliance (Ahmad, 1974; 1974a; Paliwal, 1966; 1967; Kumar and Paliwal, 1975, etc.). Ahmad (loc.cit.) pointed out the taxonomic significance of distribution of eglandular trichomes in the species of

263
Strobilanthes. At the same, he thought this feature significant to distinguish Strobilanthes and the related genera. There are several reports of use of stomatal *vis-à-vis* other epidermal features and also of trichomes in taxonomic delineations, transfer, splitting / lumping and raising them at various taxonomic levels particularly in the Acanthaceae and allegedly related taxa (cf. Paliwal, 1966, 1969; Verma and Murti, 1989; Ahmad, 1973, 1974a, 1974b, 1975a, 1975b, 1976; Kumar and Paliwal, 1978; Inamdar, Bhatt and Chaudhari, 1983; Shendage and Yadav, 2009, etc.).

Wood in Acanthaceae is uniformly characterized by vessels with simple perforation and alternate intervascular pitting wood parenchyma paratracheal, fibers usually septate, etc. (Metcalfe and Chalk, 1950). Datta and Maiti (1971), however, used wood anatomical features to discuss relationship of the tribe Justicieae (*sensu* Bentham and Hooker, 1873). It appears pertinent to note taxonomic treatments received by this tribe. Bentham and Hooker divided Acanthaceae into five tribes, the tribe Justicieae being one of them. The tribe Justicieae is redivided into six subtribes *viz.*, Barlerieae, Andrographideae, Eujusticieae, Diclipterieae, Asystasieae and Eranthemeae, Engler and Diels placed subtribe Barlerieae outside the tribe Justicieae. *Ecbolium* is kept under Odontonimeae (De Dalla, Torve and Harms, 1900-1907), whereas Bentham and Hooker (*loc. cit.*) referred it to the subtribe Eujusticieae under the tribe Justicieae. The genus *Barleria* is distinctive wood anatomically by absence or scarcity of multiseriate rays with only vertically elongated cells. This is an unique feature that helps distinguish the genus *Barleria* from other genera of Acanthaceae (*cf.* Metcalfe and Chalk, 1950; Datta and Maiti, 1971). There are few more features which are notable, for example, scarcity of pore chains and pore clusters, occurrence of very few pores per chain (less than four) and diffused porous wood. Thus all these features render the genus *Barleria* isolated from other genera of the tribe Justicieae. Thus wood anatomical evidence supports a classification by Engler and Diels. On the contrary, it does not lend support to the treatment given by Bentham and Hooker (1873). Wood
anatomically the genus *Ecbolium* shows closeness to the tribe Eujusticieae. It is to be remembered that cytological (Datta and Maiti, 1970) and floral anatomical (Datta and Maiti, 1969) evidence suggested disbanding the genus *Barleria* from the tribe Justicieae. At the same, placement of *Ecbolium* under the tribe Justicieae is supported. This can be supported wood anatomically (Datta and Maiti, 1969).

Carquist and Scott (1988) studied wood anatomy of Acanthaceae. They summarized wood anatomical features of the family. According to them, these features match very closely by the woods of Scrophulariaceae, Gesneriaceae, Peballiaceae, Martyniaceae, Bignoniaceae and Myoporaceae. They indicated closeness between the two genera *viz.*, *Thunbergia* and *Mendoncia* on the basis of interxylary phloem, acicular crystals in rays and axile parenchyma, and large gelatinous fibers in phloem. They do not support separation of *Thunbergia* and *Mendoncia* from the Acanthaceae.

Datta and Maiti (1969) studied anatomy of the tribe Justicieae. As stated elsewhere, the genus *Barleria* has been recommended for separation from tribe Justicieae (*cf.* Datta and Maiti 1970, 1971). The floral anatomical evidence is also *at par*. The genus *Barleria* exhibits distinctive features such as: (a) oblique direction of the calyx traces, (b) presence of both commissural-marginal and direct marginal traces for sepals, (c) formation of a very high annular disc supplied by a large number of bundles, (d) five staminal and five petaline traces, (e) formation of four opposite sepal lobes and five imbricate petal lobes, (f) formation of four stamens, two of which are fertile and 4-celled in the early stage, (g) division of petal-midrib traces into three. These features obviously render the genus *Barleria* to treat it outside the tribe Justicieae.

Singh and Jain (1975) studied floral development of *Justicia gendarussa*. They opined that topographically axile placentation in *Justicia* is parietal ontogenetically as well as anatomical. The ontogenetical evidence is not noticed by the taxonomists in their taxonomic and phylogenetic appraisals.
If considered, it may lead to very different conclusions. Floral ontogenetic studies are, however, very limited in the Acanthaceae. Categorical statement, therefore, cannot be made.

Leaf is perhaps anatomically the most varied organ of angiospermic plants. It is not surprising, therefore, that this organ possesses many anatomical features of potential taxonomic significance (cf. Carlquist, 1961). This opinion by Carlquist (loc.cit.) rightly impressed the mind of present investigator and hence an exclusive topic of research on foliar anatomy of the family Acanthaceae. The foliage leaves of 43 species belonging to 24 genera of the Acanthaceae are undertaken for the present investigation. This investigation divulged a considerable internal diversity especially with respect to the cell contours of epidermis, hypodermis, vascular tissue, conjunctive tissue, mesophyll (palisade and spongy tissue), besides cells inclusions (cystoliths, sphaeraphides, etc.). For the sake of brevity detailed discussion of these features is avoided. However, taxonomic significance can be highlighted. Number of palisade layers, ratio of development of palisade and spongy tissue vary from species to species as dilated earlier. The pattern of vascular tissue is also important. The vascular tissue received in the midrib region is generally resolved into a central arc and vascular bundles. The shape of arc (lunar or horse shoe-shaped) and the characteristic of constant vascular bundles also help distinguish the species studied. Moreover, presence of sclerenchyma associated with the central arc and their number of layers (one or two layers) is also of considerable significance. Even the absence or presence and type of cell inclusions (cystoliths, sphaeraphides, etc.) can be pertinently employed while distinguishing the species of the present account. To the present state of knowledge, there is hardly any publication on foliar anatomy in cross sectional view. Thus internal cellular organization / composition of the foliage leaves in the Acanthaceae have largely ignored to date. The present investigator has thus made a headway in this direction. The anatomical features stated above should be revealed in a larger number of acanthaceous taxa which will aid in reaching
sound and better conclusions from taxonomic and phylogenetic point of view. The importance of leaf anatomy in systematics was realized by Duval-Jorve (1875) particularly in case of grasses. The anatomical features of endodermal sheath, parenchyma sheath and mesophyll are important in this group of plants (Brown, 1958). Govindarajalu (1969a, 1969b) devised a key to distinguish various species of cyperaceous genera *viz.*, *Fuirena* and *Cyperus* based on surface characters and trans-sections of leaves respectively. Paliwal and Kakkar (1970) lend support to the erection of independent family Garryaceae for the genus *Garrya* based on scleride types and other anatomical features. Ayensu (1974) investigated 106 species of the family Velloziaceae and emphasized the patterns of sclerenchyma in the leaves, for example, the vascular bundles partially surrounded by sclerenchyma on the adaxial side in the form of a crescent form or v-shaped and abaxial sclerenchyma either u-or y-shaped. There are also certain other records of utility of leaf anatomy in systematics in other angiospermic plant groups (*cf.* Cowan, 1950; Hayes *et al.*, 1951; Robinson, 1969; Bass, 1969; Metcalfe, 1969, etc.).

Although the leaves provide many anatomical characters of taxonomic significance, they are derived from the blade (lamina). The petioles are generally neglected in anatomical studies. Petiole anatomical data, as with most all other types of data, can also be used. This was indicated well by Metcalfe and Chalk (1950). They pointed out importance of vascular pattern in the petiole of some genera of Acanthaceae. However, there are also anatomical data of the petioles which can be fruitfully employed in systematic thinking. This aspect of anatomy of petiole has been largely overlooked. Schofield (1968) conveniently employed petiolar anatomy of the Guttiferae and related families as their diagnostic features. The present investigator investigated petiolar anatomy of 38 species in the family. The features such as shape of epidermal cells, number of hypodermal layers, occurrence of petiole wings, pattern of vascular supply, cell contours of conjunctive tissue, presence or absence sclerenchyma associated with vascular tissue and cell inclusions
(sphaeraphides, cystoliths, etc.) appeared as taxonomic significance specially at specific levels. Their diagnostic utility is already explained earlier Tayade and Patil (2008) and Shisode and Patil (2008) also found these features useful to distinguish the taxa of family Convolvulaceae and the order Celastrales respectively. Thakur and Patil (2009) also employed them similarly in the euphorbiaceous taxa. The literature survey indicated no petiolar anatomical study in the Acanthaceae. It appears that this study should be taken up which will bring round the role of petiole anatomy and taxonomy of other disputed taxa in the Acanthaceae and its related families.

Occurrence of cystoliths in vegetative parts is considered characteristic for the family Acanthaceae. Even their presence is also marked out in some taxonomic accounts (Hutchinson, 1969; 1973; Cronquist, 1988; Rendle, 1959, etc.). It has received attention of many plant anatomists (cf. Metcalfe and Chalk, 1950; Solereder, 1908; Ahmad, 1975; 1976; 1979; Kumar and Paliwal, 1975; 1978; 1982; Lindau, 1895; Selvaraj and Subramanian, 1983; Inamdar, 1970; Chaudhari and Rao, 1990; Tavares and Nerves, 1993; Karlstrom, 1978; 1979; De Anima, 1968, etc.). The earlier and present account revealed different features of cystoliths. They have different shape and size. They occur simple, double, triple or even joined together forming chains and aggregates of varying shapes. The shape, as stated earlier, are round, oval, oblong, conical, arc-shaped and bean-shaped or bent sharply, T-, Y-, or V-shaped. The elongated cystoliths may be spindle or cigar-shaped with both ends blunts/ obtuse, one end blunt and other pointed, or both ends pointed. These features can be conveniently employed in taxonomic distinctions. They can be used in such considerations either exclusively or in conjunction with other endomorphic or exomorphic features of plants. Metcalfe and Chalk (1950) gave a systematic account of cystoliths in the family Acanthaceae. They categorized them into seven different groups based on the features noted above. Accordingly, some particular groups of genera can be recognized containing different types of cystoliths. Ahmad (1975) reviewed briefly the taxonomic significance of
cystoliths in the same family. He supported the groups *viz.*, A, B and G but supported other group partially. However, this is possible to him on the basis of information then available to the author. According to Ahmad (*loc.cit.*), the subfamilies *viz.*, Thunbergioideae, Nelsonioideae and Mendoncioideae are characterized by the absence of cystoliths. He further stated that they are usually present in subfamily Acanthoideae but with few exceptional genera. Ahmad (1975) extended similar observations in some species of *Lepidagathis* and *Barleria*. He noted solitary cystoliths in *Lepidagathis*, whereas they are usually double in the species of *Barleria*. The condition in *Barleria* is confirmed by Shendage and Yadav (2009) while studying 22 species and two varieties of the genus *Barleria*. Ahmad (1975) although pointed out absence of cystoliths in subfamily Thunbergioideae, Kumar and Paliwal (1975), however, observed their presence in one of the species of *Thunbergia* *viz.*, *Thunbergia laevis*. This appears to be an exceptional case.

The sphaeraphides occur sporadically throughout the Angiosperms. Usually they are not considered characteristic of particular plant group or alliance. However, their roll in systematics can be realized. If studied critically, they can be assessed exclusively or in combination with other anatomical features or other cell inclusions. The present investigator noted them in case of 16 species while studying cross-sections of foliage leaves. Out of these, their occurrence is closely associated with the presence of cystoliths in them. Thus they mostly occur in Acanthaceae hand in hand with cystoliths. However, there are two species *viz.*, *Strobilanthes asperimus* and *S. ciliates*, in which they occur exclusively (cystoliths being absent). While studying petiolar anatomy, the present investigator found sphaeraphides in 11 species. They are usually associated with the cystoliths except: taxon *viz.*, *Strobilanthes lupulinus*. Their occurrences in the members of Acanthaceae have been noted earlier (*cf.* Solereder, 1908; Metcalfe and Chalk, 1950; Ahmad, 1979; Selvaraj and Subramanian, 1983; Inamdar, 1970, etc.).
Any information about plant or group of plants is potentially useful parameter determining and understanding systemic relationships. This gathered information may be available in small or large quantities, and it may conform only one or from many parts of the plant. From whatever source, all the different kinds of data can be employed to arrive at better conclusions. The present investigator, apart from his discipline of study (vegetative anatomy), gathered data from different disciplines like embryology, palynology, floral anatomy, cytology (karyology) and phytochemistry, etc. The workers in these fields although revealed information, many times it is not assessed from standpoint of taxonomy and phylogeny. Data from such disciplines is being projected in the following from this point of view.

Mohan Ram and Wadhi (1965) evaluated embryological features of the Acanthaceae on the basis of information them available. The family Acanthaceae, in most taxonomic accounts, is divided into different subfamilies *viz.*, Nelsonioideae, Mendoncioideae, Thunbergioideae and Acanthoideae. Some authors regard the subfamily Acanthoideae as true Acanthaceae, while some others raised the subfamily Thunbergioideae and Mendoncioideae to the level of independent families, separate from the Acanthaceae (*sensu stricto*). The subfamily Nelsonioideae is referred by some outside the family Acanthaceae and has advocated the view that it should be merged with the family Scrophulariaceae. Lindau (1895) segregated the Nelsonioideae from remaining Acanthaceae on the basis of larger number of ovules and rudimentary jaculators. In the Acanthaceae (*Acanthaceae sensu stricto*), the number of ovules is usually limited and jaculators are well developed. The tribes Acantheae and Aphelandrae of the Acanthaceae show similar features as those of members of Nelsonioideae, especially rudimentary jaculators identical, initial stages of endosperm and embryo development, elastically dehiscing capsules and inarticulate branches. Mohan Ram and Wadhi (*loc.cit.*), did not fever the transference of Nelsonioideae from the Acanthaceae to the Scrophulariaceae. They conceived the gross resemblance of the Nelsonioideae
(Acanthaceae) with the Rhinantheae (Scrophulariaceae) as a parallel development. In their opinion, this does not necessarily warrant their inclusion in the same taxonomic entity. Earlier Maheshawari (1964) also opined similarly.

The embryology of the subfamily Thunbergioideae has been investigated by Mohan Ram and Wadhi (1964), Pathak and Ambegaokar (1963) and Mauritzon (1934). The members of Thunbergioideae exhibit some distinctive exomorphic features such as winding habits, beaked capsular fruits, four rounded ovules and absence of jaculators. They also show unique embryological features, for example, absence of chalazal haustorium, occurrence of coenocytic secondary haustorium and hat-shaped endosperm (cf. Mohan Ram Wadhi, 1964). Mauritzon (1934) proposed to raise Thunbergioideae (sensu Lindau, 1895) to the family level, Bremekamp (1953) also opined similarly. Mohan Ram and Wadhi (1965) also lend support to such a conclusion. Khaleel and Boraiah (1972) studied cytoembryology of Thunbergia mysorensis. They advocated a separation of Thunbergia from the Acanthaceae into a separate family Thunbergiaceae based on features such as characteristic anther connective, horse shoe-shaped microsporangium, nature of pollen grain, prominent hypostase-tissue present below the embryosac, polysporous megaspore tetrads and absence of a linear 3-celled stage of endosperm. Patil (1986) made an all-pervasive examination of characters and endeavored to accrue evidence from different disciplines about the genus Thunbergia. He assessed endomorphic as well as exomorphic features of the genus and rest other Acanthaceae. He then appraised a subfamilial rank (Thunbergioideae) for this genus under the Acanthaceae, along with others. The present investigator is also inclined to subscribe such a view.

Mohan Ram and Masand (1963) compared to features of habit, inflorescence, placentation, pollen grains, ovules, endothelium, jaculator, embryo sac, endosperm, embryo, seed and fruit in case of subfamily Nelsonioideae and Acanthoideae belonging to the Acanthaceae and subfamily
Rhinanthoideae of the Scrophulariaceae. They reached to a conclusion that Acanthaceae and Rhinanthoideae have a close similarity in many features. They further stated that a asymmetrical growth of the endosperm in the Nelsonioideae is in contrast to the symmetrical type in Rhinanthoideae, an exclusively acanthaceous feature. They also opined that the presence of rudimentary and nonfunctional jaculator in *Nelsonia* and *Elytraria* and its absence in Rhinanthoideae mark a strong point of difference.

Cosa (1978) revealed embryological features in *Dischoriste humilis* such as glandular tapetum, simultaneous microsporogenesis, tenuinellate ovules, Polygonum type of embryo sac and porogamous fertilization, cellular endosperm and solanoid type of embryo development. The author justified segregation of *Dischoristae* from the genus *Ruellia*.

Pollen gains have been emphasized so far their comparative features, especially those of apertures, wall structure and exine ornamentations. Presently, the usefulness of palynology has become part of routine studies. Their features are being incorporated into most taxonomic, phylogenetic and evolutionary studies. The family Acanthaceae is classic palynologically. The earlier palynological revelations have been summarized aptly by Erdtman (1952). Considerable diversity of pollen grains with respect to shape, size, aperture, exine stratifications and ornamentations is revealed. The apertures vary greatly from taxon to taxon with respect to type, number and distribution. A large number of contributions are on record (cf. Bischoff, 1833; Mohl, 1835; Edgeworth, 1879; Strasburger, 1882; Radlkofev, 1883, 1884; Fischer, 1890; Lindau, 1893, 1895, 1905; Urban, 1924; Armbruster and Oenike, 1929; Griebel, 1931; Fritzsche, 1932, 1937; Zander, 1935-1941; Drahowzal, 1936; Lillo, 1937; Bremekamp, 1938, 1940, 1942, 1944, 1945, 1949, 1951, 1952, 1957, 1960; Benoist, 1943; Bhaduri, 1944; Rizzini, 1947, 1950; Erdtman, 1952; Deodikar and Thakur, 1954; Narayanan, 1956; Natarajan, 1957; Deodikar, Thakur and Shah, 1958; Chaubal, 1961; Raj, Bhoj, 1961, 1973; Sharma and Vishnu, 1963; Huard, 1965; Mittre-Vishnu and Gupta, 1966; De,
Anima, 1967, 1968; Marticornea, 1968; Gilli, Alexander, 1970; Medus and Sanokho, 1974; Van Campo, 1978; Brummitt, Ferguson and Medeline, 1980; Bir and Sagoo, 1981; Terao, 1982; Mcdade, 1982, 1984; Hansen, 1985, 1992; Immelman, 1989; Scotland, Susan, Stephen, 1989; Hilsenbeck, 1989 a, b; Furness, 1989, 1990, 1991, 1992, 1993, 1994 a, b; 1995 a, b; 1996; 1998; Furness and Matthew, 1996; Scotland, 1992 a, b; 1993; Kelbessa, 1990, 1999 a, b; Brack-Hanes and Marilou, 1990; Daniel, 1991, 1999; Evrard and Demille Camps, 1992; Ensermu, Brummitt and Furness, 1992; Trigo, 1993; Palacio, Rodolfo and Devid, 1994; Figueiredo, Estrela and Michael, 1996; Wasshausen, Dieter and Cecilia, 1997; Carine, Mark and Scotland, 1998; Lippi and Rossi, 1999; Scotland and Vollesen, 2000, etc.). Chaubal (1961) also investigated 42 genera of the Indian Acanthaceae palynologically. She recorded palynological differences and similarities at and above generic ranks. The tribe Hygrophileae, according to her, resembles the tribe Petalidieae, Strobilantheae, Ruellieae, Pseuderanthemeae, etc., but differs from all of them in having 4-colporate grains. The tribe Patalidieae with its *Phaulopsis* on one hand shows resemblances to the tribe Strobilantheae and with its *Petalidium* on the other hand shows some resemblance to the tribe Pseuderanthemeae. Therefore it stands in between these two tribes, and forms a connecting link between the two. In the tribe Strobilantheae except *Dyschoriste*. on account of its shape and *Thelepaepalae* and *Strobilanthes* on account of their shape and spinous exine, and the genera show significant deviations in palynological characters. The tribe Ruellieae appears to form, so to say, a connecting link between the tribes Barlerieae and Pseuderanthemeae, having both the types of pollen grains common to the two tribes. The tribe Barlerieae shows some resemblance to the tribe Ruellieae genus *Eranthemum* with its spheroidal, 3-zonicolporate, large, bigger brochate pollen grains. The tribe Acantheae shows a distinct affinity to the tribe Andrographideae, the major difference being the absence of germpore in Acanthaceae and its more or less faintly defined presence in Andrographideae.
Excepting the genus *Rungia*, all other genera seem to be fairly well fitted into Odontonemeae tribe, on the basis of their broad palynological homologies. Considering all the similarities and dissimilarities the tribe Justicieae does not seem to be palynologically a homogenous group. It should be possible to split this tribe into a number of groups, at least four groups, based on 2-zoniporate- pororate, 2-3-zonicolporate condition, and presence or absence of pseudocolpi. It is quite clear that the family Acanthaceae is eurypalynous. It, therefore, afforded fair number of palynological characters to be used in delineations within the Acanthaceae. (*cf*. Erdtman, 1952, Chaubal, *loc.cit.*).

The Nelsonioideae with its prolate spheriodal, 3-zonicolpate or 3-zonicolparate, reticulate pollen grains show a closer homology to the Scrophulariaceae, in addition to the other systematic features discussed earlier. It exhibits closer similarity with the Scrophulariaceae than to any other adjacent families (*cf*. Chaubal, *loc.cit.*). Although so, the synthetic assessment of the Nelsonioideae does not permit such a transfer to another family as stated earlier. The present investigator is inclined to support such a standpoint.

Palynological tool has been conveniently used as an aid in taxonomy particularly of the acanthaceous plexus by large number of workers as stated above. The pollen morphological data has been helpful for splitting or lumping of different genera, sub-genera, tribes, subtribes and subfamilies.

Cytological or karyological study is relatively younger evidence than the other traditional ones. The chromosome morphology, size, shape and even extra-chromosomal materials have been used in taxonomy (*cf*. Speta, 1977, 1979; Hassall, 1976; Jones, 1985, etc.). A very helpful perspective on use of cytology in dealing with certain genera comes from Love (1963). The family Acanthaceae has also received attention of cytologists. A brief resume of the same is provided herewith. Govindarajan and Subramanian (1983) carried out karyomorphological study in some South Indian Acanthaceae. They
investigated 30 species belonging to 16 genera. Chromosome numbers are noted ranging from 2n = 16 to 60. Their study revealed presence of a continuous series of a basic number between X = 08 and X = 34. However, the commonest basic number in the family is X = 16. They presumed X = 16 to have been derived from the lower X = 08 by doubling. They concluded that number 08 is the ancestral basic number of the family. They further opined that aneuploidy changed chromosome numbers and produced the basic numbers X = 11, 13, 14, 15, and 16 in the early evolution of the family. They further added that polyploidy and dibasic amphidiploidy gave rise to the higher basic number (X = 17 to 34) encountered in the family. Saggo and Bir (1982) extended cytological observation on 19 species of Acanthaceae from Central India. They concluded the basic number in the family ranging from X = 08 to 25. They considered the numbers X = 09, 14, 16, and 17 as the commonest ones. They noted number of genera which showing polybasic nature as: Barleria (X = 15, 16, 19, 20), Blepharis (X = 12, 13, 15, 17), Thunbergia (X = 9, 10, 14, 16), Rungia (X = 8, 10, 13, 15, 25), Justicia (X = 9, 13, 14, 15, 16, 17) and Strobilanthes (X = 8, 9, 10, 11, 13, 14, 15). They further penned that the variability in the basic number and polybasic nature of several genera clearly suggest that cytologically family Acanthaceae is a highly evolved one and this could be possibly be the result of aneuploidy operative at generic level. This has culminated into the evolution of morphological variations. They also thought that polyploidy has not been as potent a factor of cytological evolution in the family as aneuploidy. Sareen and Sanjogata (1976) investigated chromosome numbers in 12 species of the Acanthaceae from Chandigarh and its neighborhood. They investigated various genera such as Hemigraphis, Lepidogathis, Peristrophe, Justicia, Blepharis, Thunbergia, Rungia and Dicliptera. They also pointed out the occurrence of aneuploidy of cytoploidy in the family.

Datta and Maiti (1970) made cytological observation on subtribes viz., Barlerieae, Andrographideae, Eujusticieae and Diclipterieae of the tribe
Justicieae (*sensu* Bentham and Hooker, 1873). In their opinion, the subtribe Barlerieae is the most primitive amongst the tribe Justicieae. They suggested separation of subtribe Barlerieae from the tribe Justicieae thereby supporting the treatment by Engler and Diels (1936). However, they do not justify separation of *Ecbolium* and *Rungia* from it.

Grant (1955) made cytogenetic studies in the Acanthaceae based on information then available in his opinion the subfamily Thunbergioideae and Mendocioideae do not deserve independent familial status outside the Acanthaceae. There are also other reports on cytological information for the family Acanthaceae stating use of cytological data at different taxonomic levels and for determining their phylogeny (*cf.* Daniel and Tson, 1993; Krishnaswami and Menon, 1974; Fedorov, 1974; Datta and Maiti, 1967; etc.).

Gibbs (1974) summarized an array of chemicals revealed by the phytochemists. At the outset, he remarked that ‘this is a big family with 250 to 252 genera and 2700 species which has not been studied at all thoroughly by the chemists. He recorded acanthaceous taxa containing carbohydrates, raphides, saponins, tannins, HCN, phenolic acid, seed fats, mucilage, quinines, leucoenthocyanins, coumarins, alkaloids, etc. Gibbs (*loc.cit.*), however, is silent on taxonomic / phylogenetic aspects of the family and made no categorical statements. This information does not lead one to each certain conclusions. Sarma and Narayana (1983) studied chemistry of 14 taxa representing four subtribes of the tribe Ruellieae (*sensu* Bentham and Hooker, 1862-1883). These authors commented that the tribe Ruellieae is a homogenous taxon. The subtribe Petallidae differs from other subtribes in positive reaction for cyanogenesis and tricanthereae in the presence of tannin. According them, the revival of the genus *Asteracantha* is not justifiable. Narayana and Sarma (1984) investigated chemistry of seven species of *Thunbergia*. They showed resemblance and differences in some chemical contents between the species of *Thunbergia*. However, they suggested retention of the tribe Thunbergiae within the Acanthaceae.
Daniel and Sabnis (1987) screened Acanthaceae for leaf flavonoids, phenolic acids and aucubins. They supported independent status for *Thunbergia* into a family Thunbergiaceae. They further suggested that the subfamily Nelsonioideae as an intermediate link between Thunbergiaceae and Acanthaceae but remarked for its inclusion within the Acanthaceae. Thunbergiaceae, in their opinion, is relatively more primitive than Acanthaceae.

Gensen *et al.* (1988) investigated 40 species of Acanthaceae. They reported 20 different iridoids from the family of which seven of them are so far unique for the Acanthaceae. Notably, amounts of betaine are also detected from subfamilies Acanthoideae and Ruellioideae. They recorded trigonelline in all five subfamilies of Acanthaceae. They also detected quaternary methyl ammonium compounds in all five subfamilies of the Acanthaceae. They, therefore, supported their position within the Acanthaceae. Regarding *Thunbergia*, they have different opinions. They found iridoid glucoside and stilbricoside in the genus *Thunbergia*, family Stilbaceae and Retziaceae. They, therefore, lend support to Dalhlgren’s placing of two latter families in the Scrophulariales. Sarma (1998) investigated 42 taxa from six subtribes of the tribe Justiceae (*sensu* Bentham and Hooker, 1862-1883). They opined that the overall chemical characteristics speak of homogeneity of the tribe.

Even in bird’s eyeview, it is notable that the various systems of plant classification have included the family Acanthaceae always alongwith the Scrophulariaceae. Both of these families have been referred either to the order Scrophulariales, Personales or Tubiflorae. Botanists from different disciplines have always discussed their interrelationships in past. Some authors / investigators and plant morphologists transferred some acanthaceous taxa to the family Scrophulariaceae, while others thought some taxa intermediate between Acanthaceae and Scrophulariaceae. Hutchinson (1969) thought the order Personals derived from the Solanales. Takhajan (1969) placed Scrophulariales very near to the Polemoniales and thought a common origin
from them. His order Scrophulariales includes Acanthaceae, Scrophulariaceae, Solanaceae and few other families.

Cronquist (1981) placed Scrophulariaceae and Acanthaceae in his order Scrophulariales. He considered the Scrophulariales related to the order Solanales. He further stated that the family Scrophulariaceae is connected to the Acanthaceae by transitional genera. He further opined that the Acanthaceae diverge from the Scrophulariaceae primarily in their exclusively dehiscent fruit and especially secondary funicles. (i.e. jaculator). In his opinion, the ecological significance of the concurrent law of endosperm and development of cystoliths is obscure. He further remarked that perhaps the cystoliths served a defensive function. In the preceding synthetic discussion an attempt has been made by present investigator to put on record all the evidence from different disciplines to indicate systematic affinity between Acanthaceae and Scrophulariaceae. There are few features which show affinity with each other. All the same, there are others which warrant little relatedness *inter se*.

The genus *Pentstemonacanthus* of the Acanthaceae is characterized by its five fertile stamens. Thus theoretically, the androecium is comprised of basic five members. The posterior stamens usually show reduction first in other members of the Acanthaceae with 4 – stamened condition. This trend has further progressed culminated in to a 2 – stamened condition in still few other genera of the family. The corolla is a typically 5 – lobed, usually bilabiate, upper lip is usually erect and bifid. The upper lip is sometime absent in the genus *Acanthus* and others (Lawrance 1951). This clearly suggests that corolla also suffer some reduction. The trend of reduction in the members of androecium is also observed in the family Scrophulariaceae (Lawrance 1951; Ratnalikar, 1972). The forces reduction in case of corolla in the Scrophulariaceae however appear more pronounced (Lawrance 1951; Ratnalikar, 1972; Rao V. S. 1953). In both of these families oligomerous condition of the androecium is derived through isomery (Cronquist, 1968; Eames, 1961; Puri, 1951; Varghese, 1971; Wernham, 1911; etc.).
The family Acanthaceae can be characterized by diacytic type of stomata both, glandular and eglandular trichomes characteristic, cystoliths, unilacunar node, pinnate and semi-crespedodromous venation pattern. Jaculated seeds are usually few but fairly larger is size. This set of characters disbands the family Acanthaceae from most of its related families, including the Scrophulariaceae. It appears pertinent to throw light on the resemblances between the families Acanthaceae and Scrophulariaceae. Both of these families exhibit the common features such as: (i) attainment of zygomorphy, (ii) reduction in number of stamens from basic five-stamened condition, (iii) reduction in number of carpels to two basically from pentacarpellary condition, (iv) attainment of predominantly herbaceous habit, (v) unilacunar, one-traced node, (vi) unitegmic ovules and (vii) cellular endosperm. This set of resembling characters also leads one to thought of close relationship. Nevertheless, this is not the case. These are the features which appear to have been developed in most of the sympetalous taxa parallel. This may not help us with certainty to conclude for affinities between the Acanthaceae and Scrophulariaceae. Thus, the family Acanthaceae stands distinctive within the alliance.