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REVIEW ARTICLE

Occurrence and significance of cystoliths in Acanthaceae

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ABSTRACT

The present authors studied foliar anatomical features of 43 species belonging to 22 genera of the family Acanthaceae. Cystoliths are characteristic of the family. However, they are totally absent in *Acanthus spinosus* L., *Adhatoda beddomei* C.B.Clarke and *Staurogyne zeylanica* (Nees) O. Ktze. Generally, they are present in laminar epidermis, petiolar epidermis and ground tissue. They exhibit different shapes, sizes and even colors. In some taxa, both ends of cystoliths are obtuse or acute, whereas in others one of the ends of cystolith are either obtuse or acute. They observed either single or double. This communication reviewed their occurrence in the family and highlighted their taxonomic significance.

Introduction

It is doubtless that most of the taxonomic evidence is usually drawn from exomorphology of plants. This is so because of easily visible and convenient nature. Moreover, there is high degree of coincidence between the expressed phenotypic characters and the genotype of the taxon. Generally, mircromorphological features are overlooked during routine taxonomic investigations. It is only when the exomorphic characters are felt inadequate, the micromorphological ones are employed for the said purpose. Use of microscopic features in plant classification has a long history. Directly visible chemical criteria are used in taxonomy. For example starch grains (Reichert, 1913; Takeoka, 1962), raphides (Gulliver, 1866; Gibbs, 1963; Tomlinsom, 1962; Jaccard and Frey, 1928 ; Kharchenko, 1928), silica (Tomlinson, 1961), gypsum (Brunswick, 1920), etc. have been conveniently employed in taxonomy. Crystals of calcium oxalate, so called cystoliths or lithocysts, have also similar significance. The present authors investigated foliar anatomical features of some Acanthaceae, of which cystoliths form a slender segment. Their observation along with a general review is being communicated in this contribution.

Materials and Methods

The plants were collected from various places like Tropical Botanic Garden and Research Institute, Palode, Thiruvanthapuram District (Kerala) ; Malbar Botanical Garden, Kozhikode (Kerala); Munnar, Idukki District (Kerala); Forest Research Institute, Peechi, Trichur (Kerala); Calicut University, Botanical Garden, Kozhikode (Kerala); Lal Bag Garden, Bangalore (Karnataka); Government Batanic Garden, Ootacamund (Tamilnadu) and Charanmal, District Dhule (Maharashtra). They were preserved in F.A.A. solution. The chemical method was followed for the separation of peels. Diluted nitric acid and chromic acid (5-10%) were used in different proportions. In some cases, Three Acid Treatment (TAT Method) was followed (Ramayya and Vanaja, 1979). Epidermal peels were stained in safranin (1%). They were and mounted in glycerin and made semi-permanent slides by ringing with nail paints. The cellular sketches were drawn using prism type of camera lucida. They were inked by using Camligraph or Rotring isographs technical pens with 0.1, 0.2, 0.3 points.

Results and Discussion

Cystoliths are silicified bodies with cellulose skeleton or occasionally not encrusted. They are generally found in vegetative parts in several acanthaceous species (Metcalfe and Chalk, 1950). They vary in nature, shape, size, color and occurrence throughout the family. The present authors investigated 43 species belonging to 22 genera of the Acanthaceae. They are generally present in the leaf lamina and petiole studied for the present contribution. Out of these, they occudr in the epidermal layers of 40 species, except *Acanthus spinosus, Adhatoda beddomei* and *Staurogyne zeylanica*. While studying transverse section of the laminar part of the leaves, they have been recorded in 30 species out of 43 species presently studied. They are wanting in the taxa such as *Acanthus spinosus, Adhatoda beddomei, Andrographis alata, A. wightiana, Fittonia gigantea, Goldfussia anysophylla, Hygrophila schulli, Justicia carnea, J. trinervia, Micranthes oppositifolius, Nilgirianthes asper, Pseuderanthemum malabaricum, Rungia parviflora, Staurogyne zeylanica, Stenosiphonium cordifolium, Strobilanthes asperrimus, S. ciliates* and *S. kunthianus*. The present authors also studied anatomy of leaves (in T.S.) of these taxa. Cystoliths are observed in the petioles of 28 species, whereas the petioles of other species are devoid of them e.g. *Andrographis elongata, Beloperone comosa, Fittonia gigantea, Hygrophila schulli, Justicia trinervia, J. wynaddensis, Pseuderanthemum malabaricum, Rungia parviflora, Staurogyne zeylanica, Strobilanthes asperrimus, S. kunthianus* and *S. lupulinus*.

Cystoliths (sometimes also called lithocysts) occur singly, double or triple. They exhibit, in general, various shapes and sizes. The present authors noted them either singly or double. They are mostly singly elongated bodies. However, they are double in case of *Barleria prattensis* (Fig. 7-8), *Peristrophe montana* (Fig.39) and *Stenosiphonium russellianum* (Fig. 48). Variations in respect of their both ends have been observed. Both ends are tapering in *Strobilanthes anamallaica* (Fig.51), *Stenosiphonium russellianum* (Fig.48) and *Pachystachys lutea* (Fig.38). Both ends are rounded or obtuse in *Andrographis alata* (Fig.1), *A. elongata* (Fig.2), *A. macrobotrys* (Fig.3), *A. stellulata* (Fig.4-5), *A. wightiana* (Fig.6), *Barleria prattensis* (Fig. 7-8), *Beloperone comosa* (Fig. 10), *B. nemorosa* (Fig. 12), *B. plumbaginifolia* (Fig. 14), *Dicliptera foetida* (Fig. 15-16), *Fittonia gigantea* (Fig. 17), *Goldfussia anysophylla* (Fig.18-19), *Hygrophila schulli* (Fig. 21-22), *Justicia carnea* (Fig. 24), *J. trinervia* (Fig. 25-26), *Mackenzia intergrifolia* (Fig. 32), *Pseuderanthemum malabaricum* (Fig. 41), *Rungia parviflora* (Fig. 44), *Stenosiphonium cordifolium* (Fig. 45), *S.parviflorum* (Fig. 47), *Strobilanthes ciliates* (Fig. 58), *S. hamintoniana* (Fig. 61), *S.kunthianus*(Fig. 62) and *S. lupulinus* (Fig. 64). In some cases, one of the ends is either obtuse or tapering e.g. *Beloperone comosa* (Fig.9), *B. nemorosa* (Fig. 11), *B. plumbaginifolia* (Fig. 13), *Graptophylum pictum* (Fig. 20), *Hypoestes sanguinolenta* (Fig. 23), *Justicia wynaddensis* (Fig. 27-28), *Libonia floribunda* (Fig. 29-30), *Mackenzia intergrifolia* (Fig. 31), *Micranthes oppositifolius* (Fig. 33), *Neuracanthus sphaerostaschys* (Fig. 34-35), *Nilgirianthes asper* (Fig. 36-37), *Pachystachys lutea* (Fig.38), *Pseuderanthemum malabaricum* (Fig. 40), *P. reticulatum* (Fig. 42-43), *Stenosiphonium parviflorum* (Fig. 46), *S. russellianum* (Fig. 49), *Strobilanthes anamallaica* (Fig.50), *S. asperrimus* (Fig.52), *S. barbatus* (Fig.53-54), *S.bonaccordensis* (Fig.55-56), *S. ciliates* (Fig.57), *S. glandulosus* (Fig. 59) and *S.lupulinus* (Fig. 63). However, in some cases like *Barleria prattensis* (Fig. 7-8), *Beloperone comosa* (Fig. 9-10), *B. nemorosa* (Fig. 11-12), *B. plumbaginifolia* (Fig. 13-14), *Mackenzia intergrifolia* (Fig. 31-32), *Pseuderanthemum malabaricum* (Fig. 40-41), *Stenosiphonium parviflorum* (Fig. 46-47), *Strobilanthes ciliates* (Fig.57-58), and *S. lupulinus* (Fig. 63-64), adaxially cystoliths show one end tapering and other end obtuse but abaxially cystoliths show both ends rounded or obtuse. In *Stenosiphonium russellianum* (Fig. 48-49) adaxially cystoliths show both ends tapering, while abaxially one end is obtuse. However, in *Strobilanthes anamallaica* (Fig. 50-51) abaxially cystoliths show both ends tapering, while adaxially one end is obtuse. In *Pachystachys lutea* adaxially cystoliths are tapering at both ends.

Occurrence of cystoliths in the Acanthaceae have been repeatedly reported by various workers. Solereder (1908) mentioned double cystoliths in *Glossochilus durechellii* (Barlerieae). The genus *Lasiocladus* has also double cystoliths. They are fusiform in shape e.g. *Petalidium barleriodes* and *Sautieria decesnei* (Ruellieae). They are elongated with either ends pointed or rounded in case of *Tetramurium nervosum* (Justicieae). Various colors like greenish, violet, blue green, etc. have been also on record (*cf.* Solereder, 1908). Metcalfe and Chalk (1950) also summarized the various features then revealed. They reported their absence in the species of *Acanthus, Aphelandra, Blepharis, Crossandra, Ebermatiera, Elytraria, Geissomeria, Mendoncia, Meynia, Nelsonia, Pseudocalyx, Stenandrium and Thunbergia*. They also noticed double cystoliths, solitary rounded cystoliths, solitary elongated cystoliths with blunt ends, solitary elongated cystoliths with one end pointed, solitary elongated but pointed at both ends, apart from cystoliths of variable shapes. They also mentioned non-calcified elongated and slightly lignified cystoliths in *Ruellia* and *Strobilanthes*. Ahmad (1979) recorded cystoliths in 82 species of the subfamily Acanthoideae. In his opinion, they are absent in the subfamilies Nelsonioideae, Mendoncioideae and Thunbergioideae. They are also absent in some genera of the Acanthoideae. Solereder (1908) did mention absence of cystoliths in *Adhatoda vasica*. However, Ahmad (*loc.cit.*) reported its presence in the subepidermal region. In his opinion, cystoliths are present only in the epidermal layers of both sides. He also mentioned various shapes of cystoliths like round, oval, oblong, conical, arc-shaped, bean-shaped, T, Y, or V-shaped. Elongated cystoliths are either spindle or cigar-shaped either with blunt or pointed ends. They are also double. He further opined that the species can be distinguished by the presence or absence of cystoliths. Kumar and Paliwal (1975) investigated the tribes Thunbergieae and Nelsonieae. Cystoliths are completely absent in case of the former, except *Thunbergia laevis*. This is in contrast to the statement made by Solereder (1908) and Metcalfe and Chalk (1950). Kumar and Paliwal (1982) surveyed the members of Acanthaceae and reported characteristics of cystoliths and considered them of systematic value. Kumar and Paliwal (1978) studied Acanthaceae and hold a similar view. Ahmad (1975) also added to the knowledge of cystoliths in the family and confirmed the earlier reports. Ahmad (1976) investigated epidermal features of two genera *viz.*, *Hygrophila* and *Dyschoriste*. He reported them as simple, spindle, sickle or cigar-shaped. Ahmad (1975) again reported cystoliths in some species of *Lepidagathis* and *Barleria*. In his opinion, the various features of cystoliths can help in making distinctions at the species level. He justified the removal of *Lepidagathis* from the Barlerieae. (*sensu* Lindau 1895). Selvaraj and Subramanian (1983) revealed conical, cylindrical, globular, bilanceolate and bilobed types. This resume clearly suggests that the various characteristics of cystoliths can be conveniently employed in taxonomy and phylogenetic considerations. Similar such reports are on record (*cf.* Inamdar, Chaudhari and Rao, 1990; Tavares and Neves, 1993; Ahmad a,b,c,d 1974; Kumar and Paliwal, 1975; Karlstrom, 1979, 1980; De, Anima, 1968a, b).

Taxonomic and Significance

Occurrence of cystoliths in the 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, Chaudhari and Rao, 1990; Tavares and Nerves, 1993; Karlstrom, 1979; 1980; De Anima, 1968a, b). The earlier and present accounts revealed different features of cystoliths. They have different shapes and sizes. They occur as 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, bean-shaped or bent sharply like T-, Y-, or V-shaped. The elongated cystoliths may be spindle or cigar-shaped with both ends blunt / 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 C but supported other group partially. However, this has possible to him on the basis of information then available. 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 the 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.

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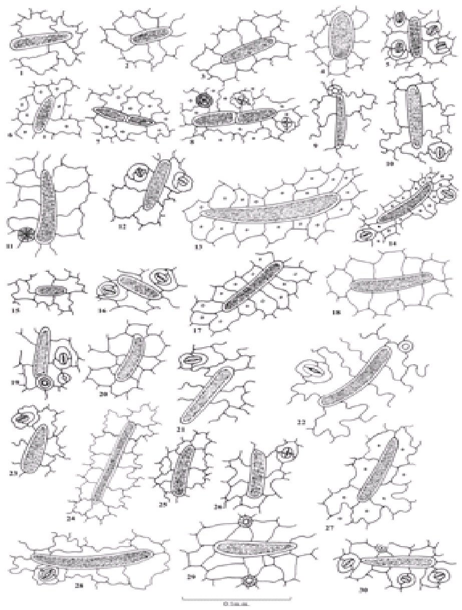

Fig: 1-30 Cystoliths in surface view

1. Andrographis alata (Vahl) Nees*,* 2. *A. elongata* (Vahl) T. And. , 3. *A. macrobotrys* Nees, 4-5. *A. stellulata* C. B. Clarke, 6. *A. wightiana* Arn.ex Nees, 7-8. *Barleria prattensis* Santapau, 9-10. *Beloperone comosa* Nees, 11-12. *B. nemorosa* Nees, 13-14. *B. plumbaginifolia* (N. Jacquin) Nees, 15-16. *Dicliptera foetida* (Forsskal) Blatter, 17. *Fittonia gigantean* Linden ex Andre., 18- 19. *Goldfussia anysophylla* (G. Lodd) Nees*,* 20. *Graptophylum pictum* (L.) Griffith, 21-22. *Hygrophila schulli* (Buch - Ham) M.R. Almeida and S.M. Almeida, 23. *Hypoestes sanguinolenta* Hook., 24. *Justicia carnea* Edward F. Gilman, 25 – 26. *J. trinervia* Vahl, 27-28. *J. wynaddensis* (Nees) Heyne ex T. Ander., 29-30. *Libonia floribunda* K. Koch

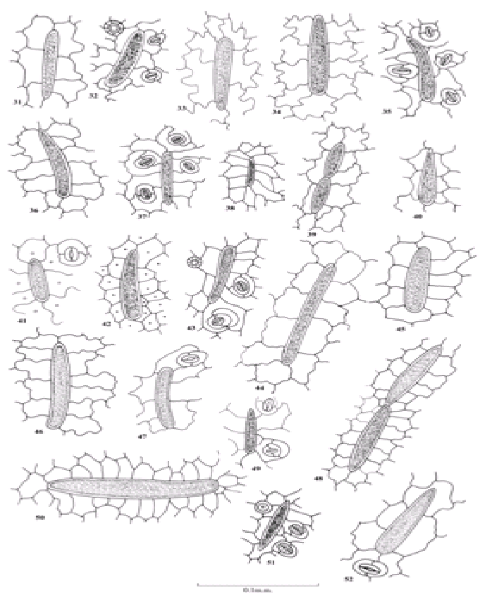

Fig: 31-52 Cystoliths in surface view

31-32. *Mackenzia intergrifolia* (Dalz.) Bremek., 33. *Micranthes oppositifolius* Wendl., 34-35. *Neuracanthus sphaerostaschys* (Nees) Dalz., 36-37. *Nilgirianthes asper* (Wight) Sant., 38. *Pachystachys lutea* Nees, 39. *Peristrophe montana* Nees, 40-41. *Pseuderanthemum malabaricum* (C. B. Clarke) Gamble, 42-43 *P. reticulatum* Radlkf., 44. *Rungia parviflora* (Retz.) Nees, 45. *Stenosiphonium cordifolium* (Vahl) Alston., 46-47. *S. parviflorum* T. Anders., 48-49. *S. russellianum* Nees, 50–51. *Strobilanthes anamallaica* J. R. I. Wood., 52. *S. asperrimus* Nees,

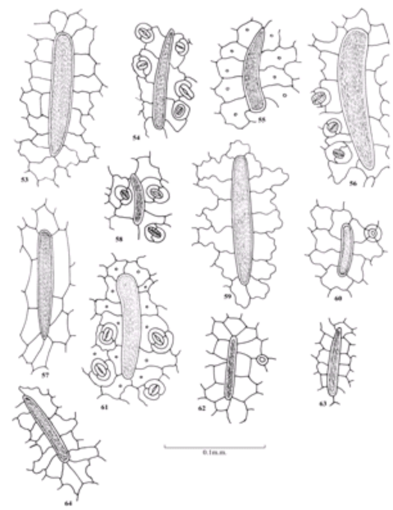

Fig: 53-64 Cystoliths in surface view
53-54. *S. barbatus* Nees, 55-56. *S. bonaccordensis* Santhosh and Raj., 57-58. *S. ciliates* Nees, 59. *S. glandulosus* Kuntze, 60-61 *S. hamintoniana* (Steud.) Bosser and Heine, 62. *S. kunthianus* (Nees) Anders. ex Benth., 63-64. *S. lupulinus* Nees.

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