BLUMEA 24 (1978) 101-117

EPIDERMAL HAIRS OF ACANTHACEAE

KHWAJA J. AHMAD
Plant Anatomy Laboratory, National Botanic Gardens,
Lucknow-226001, India.

SUMMARY

Structure and distribution of the foliar epidermal hairs of 109 species and two varieties belonging to 39 genera of the family *Acanthaceae* have been studied. Both glandular and non-glandular epidermal hairs have been recorded in the investigated taxa. The glandular hairs may be subsessile or long-stalked. The subsessile glandular hairs are of two types: i) Glandular head panduriform, 2-celled, and ii) Glandular head globular or disc-shaped, 2—8- or more-celled. Subfamilies *Nelsonioideae* and *Thunbergioideae* are characterised by the panduriform hairs, while *Mendoncioideae* and *Acanthoideae* have glandular hairs with a globular head. Long-stalked glandular hairs are present only in nine species. Non-glandular hairs are also widely distributed in the family; they are present in all but ten species. They may be unicellular, or multicellular uniseriate; rarely they are branched. Though the non-glandular hairs are of diagnostic importance at species level only, in some genera like *Barleria*, *Ruttya*, and *Aphelandra*, they are quite characteristic. The present study does not support Bremekamp's (1965) delimitation of the family *Acanthaceae*, involving the transfer of Lindau's (1895) subfamily *Nelsonioideae* to *Scrophulariaceae*, and the raising of his subfamilies *Thunbergioideae* and *Mendoncioideae* to the rank of independent families. Instead, the retention of *Nelsonioideae*, *Thunbergioideae*, *Mendoncioideae*, and *Acanthoideae* within the family *Acanthaceae* is favoured.

INTRODUCTION

The taxonomic and phylogenetic significance of trichomes has long been recognised by a number of workers (Bachmann, 1886; Solereder, 1908; Cooper, 1932; Cowan, 1950; Metcalfe & Chalk, 1950; Goodspeed, 1954; and Sporne, 1956). According to Carlquist (1961), trichomes are, because of their easy accessibility, perhaps the most important anatomical features which could be used for taxonomic purposes. The study of the trichomes of *Rhododendron* by Cowan (1950) and of *Nicotiana* by Goodspeed (1954) showed that they are excellent characters for making out distinctions at subgeneric and generic levels. The epidermal hairs of *Solanum*, according to Roe (1971), provide some of the most important features for diagnostic purposes as many of the hair forms are characteristic for a species or a section. Recent studies in *Jasminum* by Inamdar (1967), in *Compositae* by Ramayya (1972), and in *Loganiaceae* by Bendre (1973) have similarly demonstrated the significance of trichomes in the systematic studies of these taxa of flowering plants.

The *Acanthaceae* are a large family of flowering plants with about 250 genera and over 2500 species spread over the tropics. Though the family has, for many years, been treated as a distinct taxon, its delimitation and subdivision has been the subject of great controversy and divergent and conflicting views have been expressed regarding the systematic position of various taxa. Lindau (1895) divided *Acanthaceae* into four subfamilies: *Nelsonioideae*, *Mendoncioideae*, *Thunbergioideae*, and *Acanthoideae* on the basis of types of fruits, the number of ovules, and the presence or absence of retinacula and their shape. Nees (1847) had earlier recognised two groups in *Acanthaceae*: *Anechmatacantheae* (without retinacula)

and *Echmatacantheae* (with retinacula). While *Anechmatacantheae* has two tribes, *Thunbergieae* and *Nelsonieae*, which together include Lindau's *Thunbergioideae*, *Nelsonioideae*, and *Mendoncioideae*, the second group *Echmatacantheae* has nine tribes comprising Lindau's *Acanthoideae*. Bentham and Hooker (1876) divided *Acanthaceae* into five distinct tribes: *Thunbergieae*, *Nelsonieae*, *Ruellieae*, *Acantheae*, and *Justicieae*. Lindau's subfamilies *Thunbergioideae* and *Mendoncioideae* together constitute Bentham and Hooker's *Thunbergieae* while his *Nelsonieae* is equivalent to the latter's subfamily *Nelsonioideae*. The remaining three tribes of Bentham and Hooker together form Lindau's subfamily *Acanthoideae*. Van Tieghem (1908) constituted the three subfamilies *Nelsonioideae*, *Mendoncioideae*, and *Thunbergioideae* of Lindau into a new family *Thunbergiaceae*, and *Acanthaceae sensu* Van Tieghem comprised Lindau's *Acanthoideae* only. Bremekamp (1953, 1955, 1965) raised *Thunbergioideae* and *Mendoncioideae* to family rank and transferred *Nelsonioideae* to the family *Scrophulariaceae*. Thus, the family *Acanthaceae sensu* Bremekamp consists only of Lindau's subfamily *Acanthoideae*.

In contrast to many reports of palynological, embryological, and cyto-taxonomic studies of *Acanthaceae*, no detailed and systematic investigation has been carried out on the foliar epidermal hairs of this family. Among relatively early reports of the studies of foliar trichomes of *Acanthaceae* may be mentioned the works of Lindau (in Engler & Prantl, 1895), Solereder (1908), and Metcalfe & Chalk (1950). Kumar and Paliwal (1975) investigated the epidermal features, including trichomes of six species of *Thunbergia*, and *Elytraria acaulis* and *Nelsonia campestris*. Singh and Jain (1975) studied the structure and ontogeny of different types of trichomes present on the floral appendages of 41 taxa of *Acanthaceae*. The present investigation, which deals with the structure, distribution, and taxonomic significance of the foliar epidermal hairs of 39 genera (109 species) of *Acanthaceae*, has been carried out with a view to help in a better understanding of the taxonomy of this large and complicated family of flowering plants.

MATERIAL AND METHODS

The material of the species investigated consisted of mature and healthy leaves collected locally, or procured as herbarium specimens from the Botanical Survey of India or from botanical gardens and herbaria of Sri Lanka, Singapore, Malaysia, Indonesia, and Brazil. The names of the species (and varieties) investigated are listed in the Table I at the end of this paper. Epidermal hairs were examined from cuticles separated from leaves by mechanical peeling (scraping with a safety razor blade) or by maceration with 10%—30% nitric acid. The cuticles were washed with water, stained with aqueous safranin, mounted in glycerine and the cover slip was ringed with Canada balsam. While trichome types, their structure, distribution, and range of variation in the family are described under 'Observations', trichome characters of individual species are listed in the Table I.

OBSERVATIONS

Basically two types of hairs are found on the leaf of *Acanthaceae*: (a) Glandular and (b) Non-glandular.

(a) GLANDULAR HAIRS

They have been recorded in all investigated species of the family and can be distinguished into three major categories: (i) subsessile (short-stalked) hairs, with two-celled,

panduriform, glandular head; (ii) subsessile (short-stalked) hairs, with two- or more-celled, globular or disc-shaped head, and (iii) long-stalked hairs with 1- to several-celled stalk and one- or more-celled, globular or hemispherical, glandular head.

(i) Panduriform hairs (Figs. 1—7 and 36). This term was applied to the glandular hairs of *Thunbergioideae* by Hobein (see Solereder, 1908). In this type the two-celled head is roughly dumb-bell shaped or oblong with a slight narrowing in the middle. In side view the hair shows a short one-celled stalk with the foot cell embedded in the epidermal layer (Fig. 36). In the present study, panduriform glandular hairs have been recorded in all the investigated species of the genera *Staurogyne* (Fig. 1), *Elytraria* (Fig. 2), *Nelsonia* (Fig. 3), and *Thunbergia* (Figs. 4—7). The shape of the glandular head while basically remaining panduriform, may often vary in the same species, e.g. *Thunbergia laurifolia* (Figs. 5—7). There is comparatively less variation in the size of the glandular head among different species (Table I).

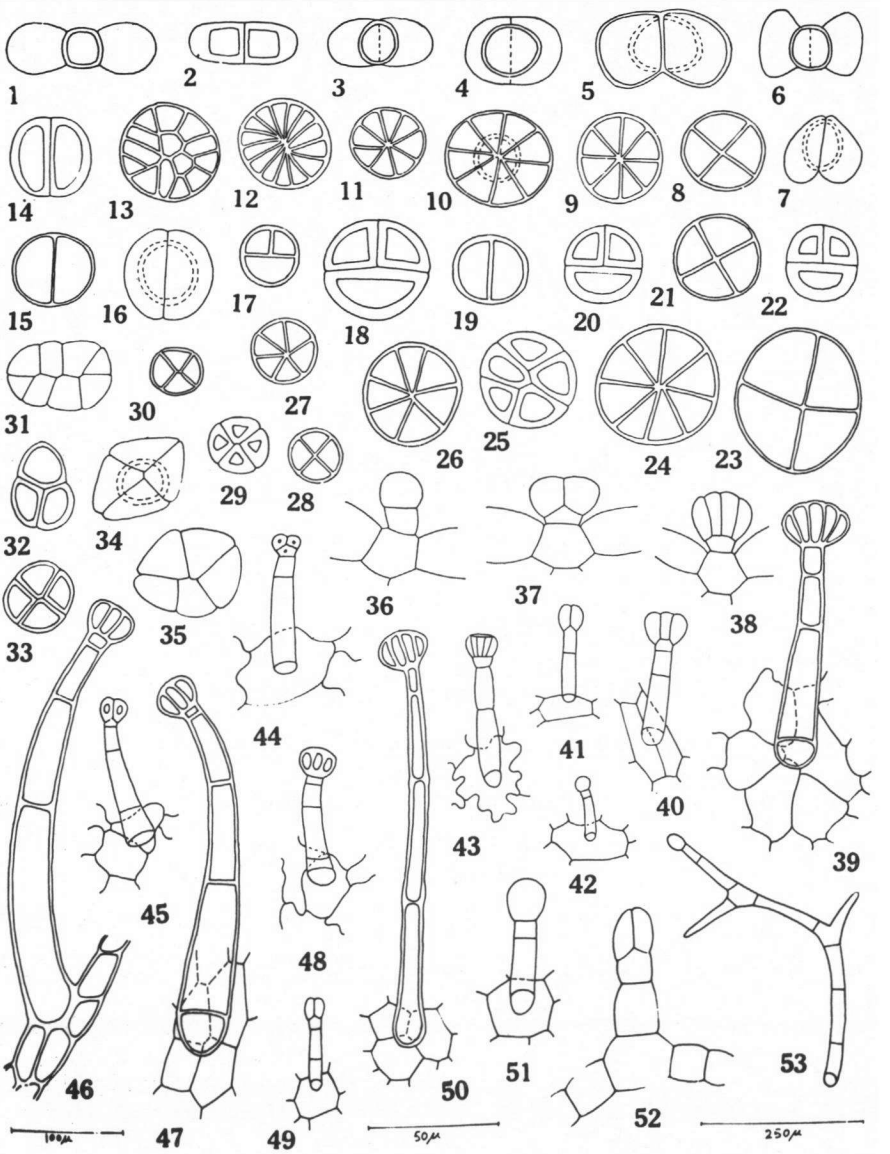
(ii) Subsessile (short-stalked) hairs with globular or disc-shaped head (Figs. 8—35 and 37, 38). These hairs are recorded in all the investigated genera except *Staurogyne*, *Elytraria*, *Nelsonia*, *Thunbergia*, and in *Hygrophila* except the species *H. serpyllum*. The glandular head is globular or disc-shaped and is formed of 2—8 cells. The 4-celled condition is the most common (Figs. 8, 21). In genera like *Strobilanthes*, *Pseuderanthemum*, and *Ruellia* glandular hairs with 8-celled head are more common (Figs. 9—11). In *Ruellia tweediana*, *R. lorentziana* (Fig. 12), and *Ruttya speciosa* (Fig. 13) glandular hairs with a more than 8-celled head are also common. Glandular hairs with 2-celled head are present in *Blepharis maderaspatensis* (Fig. 14), *Crossandra nilotica* (Fig. 15), and *C. infundibuliformis*. Glandular hairs with 2—4-celled head are common in *Aphelandra tetragona* (Fig. 16), *Gymnostachyum latifolium* (Fig. 17), *Peristrophe tinctoria* (Fig. 18), *Lepidagathis purpuricaulis* (Figs. 19, 20), *Justicia vahlii* (Fig. 22), and *Beloperone guttata*. In some species, e.g. *Asystasia dalzelliana* (Fig. 25), *Fittonia verschaffeltii* var. *argyroneura* (Fig. 26), *Hemigraphis colorata* (Figs. 27, 28), and *Dianthera nodosa* (Fig. 31), glandular hairs have a variable number of cells.

In surface view, the outline of the glandular head is circular but *Mendoncia coccinea* and *M. velloziana* often have glandular heads which are triangular, quadrangular, or rhomboid in shape (Figs. 32—35).

Like the panduriform hairs, these hairs also have a short unicellular stalk with the foot cell embedded in the epidermal layer (Figs. 37, 38).

The diameter of the globular head varies only slightly in a species. Among species of the same genus the diameter does not vary more than 1 to 1.5. Thus the variation is 23—34 μm in seven species of *Ruellia* and 22—34 μm in nine species of *Strobilanthes*. Species with typically small glandular heads are: *Petalidium barlerioides* (19 μm, Fig. 30), *Hygrophila polysperma* (21 μm, Fig. 29), *Hemigraphis colorata* (22 μm, Figs. 27, 28), and *Lepidagathis cuspidata* and *Strobilanthes scaber* (both 22 μm). Species with conspicuously large glandular heads are *Graptophyllum pictum* (38 μm), *Justicia procumbens* (35 μm, Fig. 23), and *Barleria courtallica* (35 μm, Fig. 24).

(iii) Long-stalked glandular hairs (Figs. 39—53). These hairs consist of a 1—5-celled uniseriate stalk terminated by a 1—several-celled globular or hemispherical head. The foot cell may arise from the middle of an epidermal cell (Figs. 41—44, 48, 49, and 51) or may be surrounded by 2 to several epidermal cells (Figs. 39—40, 45—47, 50). Such hairs occur intermixed with the short-stalked glandular hairs in several species. In *Hygrophila serpyl-*



Glandular hairs (Figs. 1—53). — Figs. 1—7. Sub-sessile glandular hairs with panduriform head. 1. *Staurogyne longifolia*; 2. *Elytraria acaulis* var. *lyrata*; 3. *Nelsonia campestris*; 4. *Thunbergia erecta*; 5—7. *T. laurifolia*. — Figs. 8—35. Sub-sessile glandular hairs with globular head. 8. *Sanchezia nobilis*; 9. *Strobilanthes ixiocephalus*; 10. *Pseuderanthemum malaccense*; 11—12. *Ruellia lorentziana*; 13. *Ruttya speciosa*; 14. *Blepharis maderaspatensis*; 15. *Crossandra nilotica*; 16. *Aphelandra tetragona*; 17. *Gymnostachyum latifolium*; 18. *Peristrophe tinctoria*; 19—20. *Lepidagathis purpuricaulis*; 21. *L. trinervis*; 22. *Justicia vahlii*; 23. *J. procumbens*; 24. *Barleria courtallica*; 25. *Asystasia dalzelliana*; 26. *Fittonia verschaffeltii* var. *argyroneura*; 27—28. *Hemigraphis colorata*; 29. *Hygrophila polysperma*; 30. *Petalidium barlerioides*; 31. *Dianthera nodosa*; 32—33. *Mendoncia velloziana* var. *sparatteria*; 34—35. *M. coccinea*. — Figs. 36—38. Glandular hairs in sectional view. 36. *Thunberg'a grandiflora*; 37. *Hemigraphis hirta*; 38. *Petalidium barlerioides*. — Figs. 39—51. Long-stalked glandular hairs. 39—43. *Hygrophila serpyllum*; 44. *Dyschoriste erecta*; 45—48. *Dyschoriste vagans*; 49—51. *Lepidagathis cuspidata*. — Fig. 52. Sectional view of long-stalked glandular hair of *Dicliptera roxburghiana*. — Fig. 53. A branched trichome of *Dyschoriste vagans* with glandular head on one branch. — Scale 100 μm for Figs. 39—51; scale 50 μm for Figs. 1—38, 52; scale 250 μm for Fig. 53.

lum, however, short-stalked glandular hairs are absent. The long-stalked glandular hairs occur densely in *Hygrophila serpyllum* (Figs. 39—43) and *Dyschoriste vagans* (Figs. 45—48); they are quite common in *Lepidagathis cuspidata* (Figs. 49—51), *Dicliptera roxburghiana* (Fig. 52), and *Dipteracanthus patulus*. In *Dyschoriste erecta* (Fig. 44), *Justicia tranquebariensis*, *Ruellia rosea*, and *Strobilanthes heyneanus* they are sparse and generally restricted to the veins and the margin.

The length of the long-stalked glandular hairs varies from 25 μm to more than a millimeter. They are the longest in *Dyschoriste vagans* (Figs. 45—48) where they measure up to 1062 μm in length. In *Hygrophila serpyllum* (Figs. 41—43) and *Lepidagathis cuspidata* (Figs. 49, 51), these hairs commonly arise from a single epidermal cell each, instead of having a multi-celled hair-base. Branched hairs with one branch glandular and the others without the glandular head are rarely found in *Dyschoriste vagans* (Fig. 53).

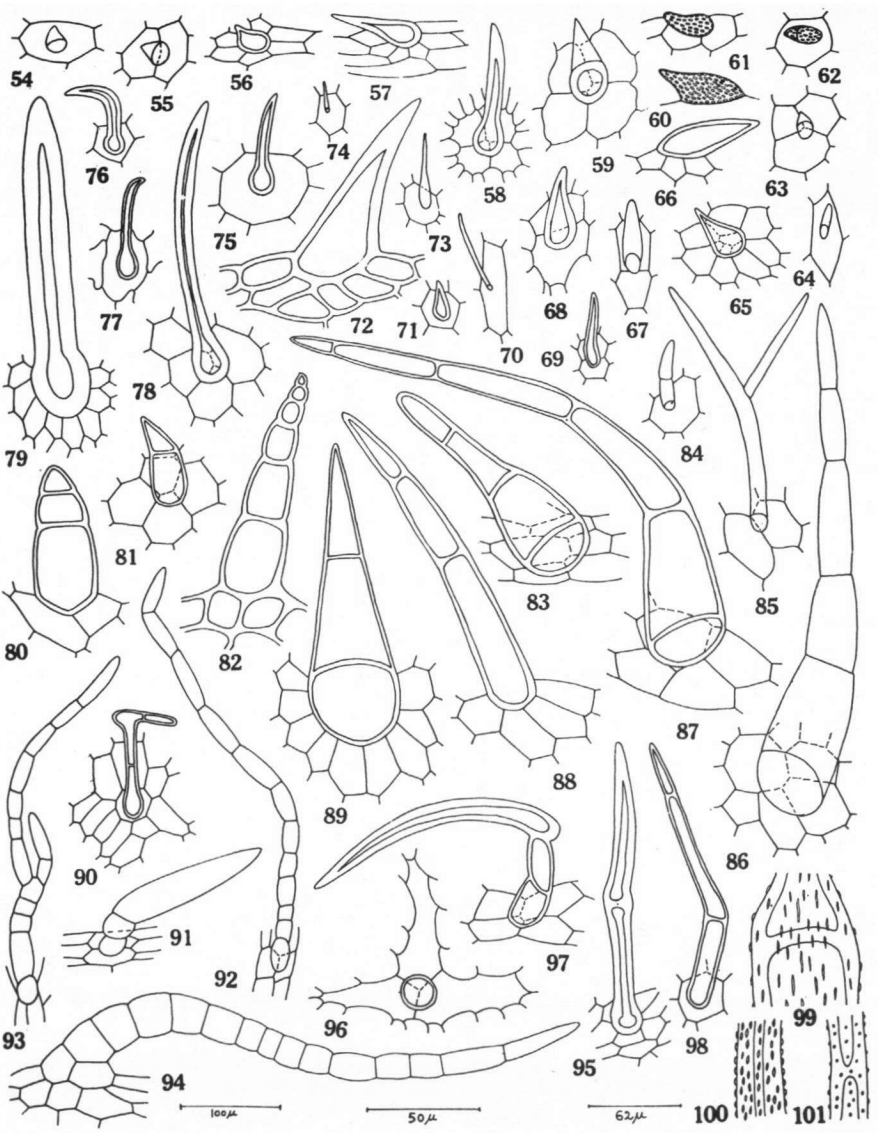
(b) NON-GLANDULAR HAIRS

Distribution and frequency. Non-glandular hairs are of wide occurrence in *Acanthaceae*. In a majority of species, they are common (++, Table I), in thirteen species they are found to be dense (+++, Table I), and in 21 species sparse (+, Table I). Non-glandular hairs are generally more numerous on the veins and the margin than in the intercostal areas, and in some species they are confined to the veins and the margin. In many species, especially those of the genera *Strobilanthes*, *Eranthemum*, and *Hygrophila*, the non-glandular hairs on the lower epidermis are confined to margin and veins but on the upper epidermis they are also common in the intercostal areas. Non-glandular hairs are absent in *Thunbergia affinis*, *T. mysorensis*, *Ruellia tweediana*, *Eranthemum albo-marginata*, *Barleria courtallica*, *Pseuderanthemum atropurpureum*, *P. kewense*, *P. variabile*, *Odontonema nitidum*, and *O. strictum*.

Shape and size. The non-glandular hairs vary in shape, size, number of cells, thickness and ornamentation of the wall, and in the structure of the hair-base. The size variation within a species may be considerable, *e.g. Dyschoriste erecta* (12—800 μm), *Barleria lawii* (106—1416 μm), and *Asystasia chelonoides* (81—1203 μm). But some species have, on an average, longer hairs than the others. Conspicuously elongated hairs are found in *Strobilanthes heyneanus* (average length 932 μm), *Justicia procumbens* (Fig. 87, 893 μm), *Peristrophe bicalyculata* (822 μm), *Hygrophila salicifolia* (720 μm), *H. quadrivalvis* (654 μm), *H. auriculata* (637 μm), *Barleria lawii* (590 μm), and *Mendoncia velloziana* var. *sparatteria* (590 μm). Short hairs occur in *Pseuderanthemum malaccense* (64 μm), *P. grandiflorum* (Fig. 65, 62 μm), *Thunbergia grandiflora* (Fig. 56, 73 μm), *Eranthemum wattii* (Fig. 63, 57 μm), and *Hygrophila polysperma* (55 μm).

The hairs are uniseriate in all the investigated species except *Elytraria acaulis* var. *lyrata* in which they are sometimes biseriate near the base (Fig. 94). Branched hairs are rarely found in *Dyschoriste vagans* (Fig. 85) and *Pseuderanthemum bicolor* (Fig. 93).

Generally, both unicellular and multicellular hairs occur in a species. Unicellular hairs are, however, predominant in *Staurogyne longifolia* (Figs. 54—55), *Thunbergia grandiflora* (Fig. 56), *T. laurifolia* (Fig. 57), *T. kirkii*, *Mendoncia coccinea* (Fig. 58), *Dyschoriste dalzellii* (Fig. 59), *D. erecta* (Figs. 60—62), *Eranthemum wattii* (Fig. 63), *E. capense* (Fig. 64), *Pseuderanthemum grandiflorum* (Fig. 65), *Hygrophila serpyllum* (Fig. 70), *Lepidagathis trinervis* (Fig. 72), *L. cuspidata* (Figs. 73—74), *L. purpuricaulis* (Figs. 75—76), *L. incurva* (Figs. 77—78), *Barleria cuspidata* (Fig. 79), *B. lupulina*, *B. prionitis*, and *Gymnostachyum latifolium*. Unicellular hairs are also quite common in *Asystasia dalzelliana* (Fig. 66), *Justicia betonica* (Fig. 67), *J. vahlii* (Fig. 68), *Dianthera nodosa* (Fig. 69), and *Rhinacanthus nasuta* (Fig. 71).



Non-glandular hairs (Figs. 54—101). — Figs. 54—79. Unicellular non-glandular hairs. 54—55. *Staurogyne longifolia*; 56. *Thunbergia grandiflora*; 57. *T. laurifolia*; 58. *Mendoncia coccinea*; 59. *Dyschoriste dalzellii*; 60—62. *D. erecta*; 63. *Eranthemum wattii*; 64. *E. capense*; 65. *Pseuderanthemum grandiflorum*; 66. *Asystasia dalzelliana*; 67. *Justicia betonica*; 68. *J. vahlii*; 69. *Dianthera nodosa*; 70. *Hygrophila serpyllum*; 71. *Rhinacanthus nasuta*; 72. *Lepidagathis trinervis*; 73—74. *L. cuspidata*; 75—76. *L. purpuricaulis*; 77—78. *L. incurva*; 79. *Barleria cuspidata*. — Figs. 80—98. Multicellular non-glandular hairs. 80. *Fittonia verschaffeltii* var. *argyroneura*; 81. *F. verschaffeltii* var. *pearcei*; 82. *Gymnostachym febrifugum*; 83. *Andrographis echioides*; 84. *Hemigraphis hirta*; 85. *Dyschoriste vagans* (branched hair); 86. *Ruellia formosa*; 87. *Justicia procumbens*; 88. *Hygrophila serpyllum*; 89. *Asystasia chelonoides*; 90. *Adhatoda vasica*; 91. *Aphelandra tetragona*; 92—93. *Pseuderanthemum bicolor*; 94. *Elytraria acaulis* var. *lyrata*; 95. *Mendoncia velloziana* var. *sparatteria*; 96. *M. velloziana* var. *sparatteria* (stellate hair-base); 97. *Ruttya speciosa*; 98. *Lepidagathis cuspidata*. — Figs. 99—101. Portions of non-glandular hairs magnified, to show wall ornamentation. 99. *Eranthemum purpurascens*; 100. *Ruttya speciosa*; 101. *Dyschoriste vagans*. — Scale 100 μm for Figs. 54—84, 86—98; scale 62 μm for Fig. 85; scale 50 μm for Figs. 99—101.

The unicellular hairs vary a great deal in shape and size. They may be small conical or papillose (Figs. 54—56, 59—63, 65, 66, 68, 71), small and stout, or slender needle-shaped (Figs. 70, 73, 74), or comparatively large, stout, and erect (Figs. 72, 78, 79). They are typically thick-walled lanceolate in *Barleria cuspidata* (Fig. 79), *B. lupulina*, and *B. prionitis*. Generally, the hairs have a several-celled hair-base but in some cases they arise from the middle of an epidermal cell (Figs. 54, 62, 64, 70—71, 73—77).

The multicellular hairs (Figs. 80—95, 97—98) are generally 2—6-celled. They may be up to 12-celled in *Pseuderanthemum bicolor* (Figs. 92, 93) and up to 15-celled in *Elytraria acaulis* var. *lyrata* (Fig. 94). As in the case of unicellular hairs, the shape of the multicellular hairs varies greatly. They may be short and conical (Figs. 80—81), long and slender (Fig. 92), or long and stout (Figs. 82—83, 86—89, 95).

The non-glandular hairs of some species are characteristic. In *Aphelandra tetragona* (Fig. 91) the hair is built of two or more small basal cells surmounted by a much elongated apical cell. The hairs of *Ruttya speciosa* (Fig. 97) are similar but the apical cell here lies at right angles to the basal part and has a thicker wall than the basal cells. In *Adhatoda vasica* (Fig. 90) the hairs are sometimes T-shaped. Lanceolate thick-walled hairs occur in several species of *Barleria* (Fig. 79). Thick-walled uniseriate hairs with bulgings at the nodes are recorded in *Mendoncia velloziana* var. *sparatteria* (Fig. 95).

The hair-base is generally multicelled, with polygonal, isodiametric, straight-walled cells. However, small and slender, or more rarely long and stout non-glandular hairs often spring from the middle of an epidermal cell (Figs. 84, 90, 98). *Hygrophila serpyllum* has both these types: 1—2-celled, small, slender hairs emerging from a single epidermal cell (Fig. 70) and 2—4-celled, longer, and stouter hairs with a multicelled hair-base (Fig. 88). In species with sinuous-walled epidermal cells, the hair-base cells are less sinuous or straight-walled. In *Mendoncia coccinea* and *M. velloziana* var. *sparatteria*, non-glandular hairs of the upper epidermis have a typically stellate hair-base with 2—several arms (Fig. 96).

The non-glandular hairs are moderately thick-walled. In species of *Barleria* the thickness of the wall is considerable and the hairs consequently have narrow lumina. The wall ornamentation generally consists of round, oval, elliptic, or linear tubercles (Figs. 60—62, 99—101). Sometimes, the wall ornamentation can be used for diagnostic purposes.

DISCUSSION

The study of the foliar epidermal hairs of 39 genera (109 species) of *Acanthaceae* reveals that various features of the epidermal hairs, like their shape, size, the number of cells comprising them, thickening and ornamentation of the wall, type of hair-base, *etc.* play a very useful role in the systematic consideration of various taxa. The glandular hairs of the three types mentioned earlier occur intermixed with the non-glandular ones. While the glandular hairs are more important at the higher level (subfamily, tribe *etc.*), the non-glandular hairs are of diagnostic value at lower levels such as genus, species, and variety.

Hobein (see Solereder, 1908) observes that the panduriform glands are characteristic of the *Thunbergioideae*, whilst the disc-shaped glands occur in the rest of the *Acanthaceae*. The present investigation, however, shows that the panduriform glandular hairs are uniformly present in *Nelsonioideae* as well, and they are characteristic of these two sub-families of the *Acanthaceae*. Kumar and Paliwal (1975), who studied the foliar trichomes of six species of *Thunbergia* (subfamily *Thunbergioideae*) and *Elytraria acaulis* and *Nelsonia campestris* (subfamily *Nelsonioideae*) have recorded long-stalked glandular hairs in *Nelsonia campestris*. However, they have not reported the presence of subsessile panduriform glandular hairs in the species investigated by them.

In the genera of the subfamily *Acanthoideae* and *Mendoncioideae* (of Lindau, 1895) presently investigated, the glandular hairs have only a globular or disc-shaped head. This is in conformity with the observations of Solereder (1908). In *Mendoncia* (sub-family *Mendoncioideae*), while the heads of glandular hairs are basically globular or disc-shaped, they may frequently be modified and appear quadrangular or triangular in surface view.

While the diameter of the head of glandular hairs does not vary appreciably, it can sometimes be used for distinguishing one species of a genus from the other, *e.g. Thunbergia erecta* (42 μm) and *T. kirkii* (31 μm); *Strobilanthes scaber* (22 μm) and *S. scrobiculatus* (34 μm); *Justicia diffusa* (26 μm) and *J. procumbens* (35 μm). The number of cells comprising the glandular head is quite important and can be used as a taxonomic character. In some cases it is constant for a sub-family or a genus. All the investigated genera of the sub-families *Thunbergioideae* and *Nelsonioideae* have only 2-celled glandular heads. The nine species of *Strobilanthes* presently studied uniformly show 4—8-celled glandular heads. Similarly, the seven species of *Barleria* have 4—8 (mostly 4)-celled glandular heads. All the six species of *Pseuderanthemum* have 4—8 (mostly 8)-celled glandular heads. On the other hand, within a genus, some species can easily be distinguished from the others by the difference in the number of cells comprising their glandular heads. According to Santapau (1951), the differences between *Dyschoriste dalzellii* and *D. vagans* are minute and relate only to the size of the anther spurs. However, the present investigation shows that they can easily be distinguished from each other by their epidermal hairs. *D. dalzellii* has subsessile glandular hairs with a 4-celled head, but in *D. vagans* the head is 8-celled; *D. vagans* also has a dense covering of long-stalked glandular hairs which are lacking in *D. dalzellii*.

The long-stalked glandular hairs have been recorded only in nine species of subfamily *Acanthoideae* and not in the other subfamilies. However, according to Kumar and Paliwal (1975), they are present in *Nelsonia campestris* (subfamily *Nelsonioideae*) also. While their taxonomic significance at higher level appears to be limited, as they are present in widely different taxa, they are nevertheless important from diagnostic point of view at species level. For example, such hairs occur in *Hygrophila serpyllum*, *Dyschoriste erecta*, *D. vagans*, *Strobilanthes heyneanus*, *Dipteracanthus patulus*, *Lepidagathis cuspidata*, and *Justicia tranquebariensis*, but are absent in the other investigated species of the genera.

Non-glandular hairs play a very significant role in the taxonomic consideration of various taxa as they show considerable range of variation in their shape, size, wall thickening, and hair-base structure. However, as pointed out earlier, unlike glandular hairs, the non-glandular hairs are more useful at species level; rarely they are also useful in distinguishing some genera from the others.

The species of *Barleria* have very characteristic non-glandular hairs which are uniceliular (rarely 1- to several-celled) with thick walls and a narrow canal-like lumen having a spherical enlargement at the base of the hair (Fig. 79). According to Hobein (see Solereder, 1908) these hairs are present in most genera of the tribe *Barlerieae* investigated by him. Metcalfe and Chalk (1950) have also characterised various tribes of *Acanthaceae* by various types of non-glandular hairs. However, the present investigation shows that in *Lepidagathis*, which belongs to the same tribe, uniseriate hairs with unthickened walls occur. The same view is expressed by Solereder (1908).

The genus *Strobilanthes* is quite uniform in its non-glandular hairs which are 1- to several-celled, stout, with a several-celled hair-base of polygonal cells forming a rosette around the foot or basal cell. Their distribution pattern is also quite characteristic as they are generally confined to costal and marginal areas.

A number of species are characterised by their typical non-glandular hairs. These

include: conical unicellular hairs on the upper epidermis of *Dyschoriste dalzellii* (Fig. 59), branched hairs of *D. vagans* (Fig. 85) and *Pseuderanthemum bicolor* (Fig. 93), conical unicellular hairs of *Lepidagathis trinervis* (Fig. 72), and typical hairs of *Adhatoda vasica* (Fig. 90), *Aphelandra tetragona* (Fig. 91), and *Ruttya speciosa* (Fig. 97). These have been described under 'Observations'.

The hair-base is also an important diagnostic character. The two species of *Mendoncia* are characterised by typically stellate hair-bases on the upper epidermis (Fig. 97). Rizzini (1948) divided *Mendoncia* into four subgenera on the basis of the characters of the hair-base. The two species investigated here have non-glandular hairs with a conspicuously stellate hair-base on the upper epidermis; on the lower epidermis the hair-base cells, though basically indistinguishable from the other epidermal cells, frequently form rosette or stellate pattern.

In many species, *e.g. Hygrophila serpyllum* (Fig. 70), *Dipteracanthus patulus*, *Lepidagathis cuspidata* (Figs. 73—74), *L. purpuricaulis* (Fig. 75—76), non-glandular hairs frequently arise from the middle of an epidermal cell and this feature is very characteristic for those species.

The density of the non-glandular hairs often varies considerably within a genus and is not an absolutely reliable character for diagnostic purposes. However, the size of the hair and the number of cells comprising it, are important features and several species of a genus can be distinguished from each other on the basis of these characters (Table I).

Non-glandular hairs often show a wide range of variation within a species, but where they are of a characteristic form they can serve as a means of distinction among the species. Stace (1965, p. 52) remarks: 'The most usual division, between glandular and non-glandular types (of trichomes), suffers from the same disadvantages as other systems in that there is no sharp distinction between the two groups, and in any case the division separates obvioulsy very closely related types'. *Dyschoriste vagans* illustrates strikingly the transition between glandular and non-glandular hairs. Except for the terminal gland, there is little difference between the long-stalked glandular hairs and the non-glandular hairs of this species. Where the hairs are branched, one branch may be non-glandular and the other terminated by a gland (Fig. 53).

The delimitation of *Acanthaceae* by Nees (1847), Bentham & Hooker (1876), Lindau (1895), Van Tieghem (1908) and Bremekamp (1953, 1955, 1965) has been explained earlier (see 'Introduction'). The present study shows that Lindau's (1895) four subfamilies namely: *Nelsonioideae*, *Mendoncioideae*, *Thunbergioideae*, and *Acanthoideae*, have broadly similar non-glandular hairs. While *Nelsonioideae* and *Thunbergioideae* have glandular hairs with panduriform head, those of the *Acanthoideae* and *Mendoncioideae* have globular or disc-shaped heads. This character, however, does not justify Bremekamp's (1965) transfer of *Nelsonioideae* to *Scrophulariaceae* as the glandular hairs in the latter are not panduriform (Metcalfe & Chalk, 1950). In this respect *Nelsonioideae* is more close to *Thunbergioideae*. Also, members of the *Mendoncioideae* have glandular and non-glandular hairs basically similar to those of the *Acanthoideae*.

In the light of the present investigation, therefore, the transfer of Lindau's subfamily *Nelsonioideae* to *Scrophulariaceae* and raising of his subfamilies *Mendoncioideae* and *Thunbergioideae* to family rank as suggested by Bremekamp (1953, 1955, 1965) in his delimitation of *Acanthaceae* is not justified. This view is also supported by evidence from the stomata (Ahmad, 1974, 1974a; Paliwal, 1966, 1967; Kumar & Paliwal, 1975) and embryology (Johri & Singh, 1951). The present study, therefore, lends support to the treatment of *Nelsonioideae*, *Mendoncioideae*, *Thunbergioideae*, and *Acanthoideae*, either as subfamilies, or as tribes under the family *Acanthaceae*.

ACKNOWLEDGEMENTS

I owe my deep gratitude to Dr. R. V. Sitholey for his valuable guidance in this work and to my colleague Mr. D. B. Shukla for helping me in the local collection and laboratory assistance. I wish also to thank the following individuals and organisations for supplying me the bulk of the material required for this study: Dr. A. N. Rao, University of Singapore; the Curator, Lembaga Biologi Nasional, Bogor (Indonesia); Dr. K. C. Cheang, Waterfalls Garden, Penang (Malaysia); the Superintendent, Royal Botanic Gardens, Peradeniya (Sri Lanka); Dr. Margaret Emmerich, Curator of the Herbarium Museu Nacional, Rio De Janeiro (Brazil); and the Director, Botanical Survey of India, Calcutta, India.

I wish especially to record my grateful thanks to Dr. T. N. Khoshoo, Director, National Botanic Gardens, Lucknow, for the facilities provided to me and for taking keen interest in this work.

REFERENCES

AHMAD, K. J. 1974. Cuticular studies in some Nelsonioideae (Acanthaceae). Bot. J. Linn. Soc. 68: 73—80

—— 1974a. Cuticular studies in some species of Mendoncia and Thunbergia (Acanthaceae). Bot. J. Linn. Soc. 69: 53—63.

BACHMANN, O. 1886. Untersuchungen über die systematische Bedeutung der Schildhaare. Flora 69: 387—400; 403—415; 428—448.

BENDRE, A. M. 1973. Studies in the family Loganiaceae. I. Trichomes. Jour. Indian bot. Soc. 52: 225—234.

BENTHAM, G., & J. D. HOOKER, 1876. Genera Plantarum. 1862—1883; Acanthaceae in 2: 1060—1122.

BREMEKAMP, C. E. B. 1953. The delimitation of the Acanthaceae. Proc. Koninkl. Nederl. Akad. Wet. Amst. Ser. C, 56: 533—546.

—— 1955. The Acanthaceae of the Malesian area. I. General considerations. Proc. Koninkl. Nederl. Akad. Wet. Amst. Ser. C, 58: 162—171.

—— 1965. Delimitation and subdivision of the Acanthaceae. Bull. Bot. Surv. India 7 (1—4): 21—30.

CARLQUIST, S. 1961. Comparative Plant Anatomy. Holt, Rinehart & Winston.

COOPER, D. C. 1932. The development of the peltate hairs of Shepherdia canadensis. Amer. J. Bot. 19: 423—428.

COWAN, J. M. 1950. The Rhododendron leaf: A study of the epidermal appendages. Oxford & Boyd, London.

GOODSPEED, T. H. 1954. The genus Nicotiana. The Chronica Botanica Co.,Waltham.

INAMDAR, J. A. 1967. Studies on the trichomes of some Oleaceae, structure and ontogeny. Proc. Indian Acad. Sci. Sect. B, 66 (4): 164—167.

JOHRI, B. M., & H. SINGH, 1959. The morphology, embryology and systematic position of Elytraria acaulis (Linn. f.) Lindau. Botanisk. Notiser. 112: 227—251.

KUMAR, S., & G. S. PALIWAL, 1975. Foliar anatomy of the family Acanthaceae. Acta Bot. Indica 3: 121—131.

LINDAU, G. 1895. Acanthaceae. In A. Engler & K. Prantl, Die natürlichen Pflanzenfamilien 4 (3B): 274—354. Leipzig.

METCALFE, C. R., & L. CHALK, 1950. Anatomy of the Dicotyledons. Oxford, Clarendon Press.

NEES VON ESENBECK, C. G. 1847. Acanthaceae. In A. P. De Candolle, Prodromus Systematis Naturalis Regni Vegetabilis 11: 46—519. Paris.

PALIWAL, G. S. 1966. Structure and ontogeny of stomata in some Acanthaceae. Phytomorphology 16 (4): 527—532.

—— 1967. Stomatal ontogeny in the family Acanthaceae and the systematic position of the genus Elytraria. Proc. Indian Sci. Congr. 54, Part III, Abst., Sect. VI. Botany: 306—307.

RAMAYYA, N. 1972. Classification and phylogeny of the trichomes of angiosperms. In Research Trends in Plant Anatomy. Ed. Ghouse & Yunus, Aligarh, India.

RIZZINI, C. T. 1948. Disquisito Circa Acanthacearum aliquot genera Brasiliensia. Arquivos do Jardim Botanico, Rio de Janeiro 8: 295—372.

ROE, K. F. 1971. The terminology of hairs in the genus Solanum. Taxon 20: 501—508.

SANTAPAU, H. 1951. The Acanthaceae of Bombay. Bot. Memoirs 2. Bombay Univ., Bombay.

SINGH, V., & D. K. JAIN, 1975. Trichomes in Acanthaceae. I. General structure. J. Indian bot. Soc. 54: 116—127.

SOLEREDER, H. 1908. Systematic anatomy of the dicotyledons. Transl. L. A. Boodle & F. E. Fritsch; Revis. D. H. Scott, Oxford.

SPORNE, K. R. 1956. The phylogenetic classification of the angiosperms. Biol. Rev. 31: 1—29.

STACE, C. A. 1965. Cuticular studies as an aid to plant taxonomy. Bull. Br. Mus. nat. Hist. 4 (1): 1—78.

VAN TIEGHEM, PH. 1908. Structure du pistil et de l'ovule, du fruit et de la graine des Acanthacées. Dédoublement de cette famille. Ann. Sci. nat. Ser. 9, Bot. 7: 1—24.

TABLE I. EPIDERMAL HAIRS OF ACANTHACEAE

Explanation of abbreviations. — D: average diameter of glandular head; Glob: globular head of subsessile glandular hair; L: length of long-stalked glandular and non-glandular hairs (minimum, average, and maximum in that order); Low: trichomes on lower epidermis; Ls: long-stalked glandular hairs; Pand: panduriform head of sub-sessile glandular hairs; Rhomb: rhomboid or quadrangular head of glandular hairs; Ss: subsessile glandular hairs; St: stalk of the long-stalked glandular hairs; U: trichomes on upper epidermis. +: sparse; ++: common; +++: dense.

The source of the material from which the voucher specimens are taken is indicated in abbreviated form and is given within brackets. The following internationally accepted abbreviations have been used: BLAT, Blatter Herbarium, St. Xavier's College, Bombay (India); BOG, Lembaga Biologi Nasional, Bogor (Indonesia); BSI-North, Botanical Survey of India, Northern Circle, Dehra Dun (India); BSI-South, Botanical Survey of India, Southern Circle, Coimbatore (India); BSI-West, Botanical Survey of India, Western Circle, Poona (India); CHAMOL, Parsari Farm, Chamoli, U.P. (India); CNH, Central National Herbarium, Botanical Survey of India, Calcutta (India); DE, Dr. Anima De, Bose Research Institute, Calcutta (India); DUN, Dehra Dun, U.P. (India); LUCK, Lucknow, U.P. (India); LWG, National Botanical Gardens, Lucknow (India); MALAY, Waterfalls Garden, Penang (Malaysia); POND, Medical College, Pondicherry (India); PDA, Royal Botanical Gardens, Peradeniya (Ceylon); RIO, Herbarium Museu Nacional, Rio De Janeiro (Brazil); SING, Department of Botany, University of Singapore, Singapore.

Species	Voucher specimen	Glandular hairs	Non-glandular hairs
1. *Staurogyne longifolia* (Nees) O. Ktze.	LWG 64561 (ex SING)	Ss., Pand., 2-celled. (D. 39 μm)	++, 1—2(up to 7)-celled. (L: 17—59—190 μm)
2. *Elytraria acaulis* (L.*f.*) Lindau	LWG 64614 (ex LUCK)	Ss., Pand., 2-celled. (D. 32 μm)	++, 1—3-celled. (L: 70—349—944 μm)
3. *E. acaulis* var. *lyrata* (Nees) Bremek.	LWG 64546 (ex SING)	Ss., Pand., 2-celled. (D. 32 μm)	++, up to 15-celled, often biseriate. (L: 59—204—519 μm)
4. *Nelsonia campestris* R. Br.	LWG 64593 (ex LUCK)	Ss., Pand., 2-celled. (D. 34 μm)	++, 2—9-celled. (L: 106—476—1014 μm)
5. *Mendoncia coccinea* Vell.	R 114.908 (ex RIO)	Ss., Glob., Rhomb., 3—5-celled. (D. 33 μm)	++, 1—6-celled; hair-base on upper, stellate. (L: 47—330—826 μm)
6. *M. velloziana* (Mart.) Nees var. *sparatteria* (Mart.) Nees	R 38.323 (ex RIO)	Ss., Glob., Rhomb., 3—5-celled. (D. 30 μm)	++, 1—6-celled. (L: 82—590—1334 μm)
7. *Thunbergia affinis* S. Moore	LWG 64606 (ex LUCK)	Ss., Pand., 2-celled. (D. 38 μm)	
8. *T. alata* Bojer *ex* Sims	LWG 64607 (ex LUCK)	Ss., Pand., 2-celled. (D. 40 μm)	++, 1—3(mostly 1)-celled. (L: 80—191—427 μm)
9. *T. erecta* T. Anders.	LWG 64609 (ex LUCK)	Ss., Pand., 2-celled. (D. 42 μm)	+, 1—3(mostly 1)-celled. (very rare)
10. *T. fragrans* Roxb.	LWG 64589 (ex LUCK)	Ss., Pand., 2-celled. (D. 38 μm)	++, 1—3(mostly 1)-celled. (L: 212—424—944 μm)
11. *T. grandiflora* Roxb.	LWG 64595 (ex LUCK)	Ss., Pand., 2-celled. (D. 35 μm)	++, 1—3(mostly 1)-celled. (L: 40—73—115 μm)
12. *T. kirkii* Hook. *f.*	LWG 64590 (ex LUCK)	Ss., Pand., 2-celled. (D. 31 μm)	+, 1—3-(mostly 1)-celled. (L: 165—554—743)
13. *T. laurifolia* Lindl.	LWG 64563 (ex MALAY)	Ss., Pand., 2-celled. (D. 38 μm)	++, 1—3(mostly 1)-celled. (L: 42—89—187 μm)
14. *T. mysorensis* T. Anders.	LWG 64562 (ex MALAY)	Ss., Pand., 2-celled. (D. 36 μm)	
15. *Sanchezia nobilis* Hook. *f.*	LWG 64615 (ex LUCK)	Ss., Glob., 2—8(mostly 4)-celled. (D. 27 μm)	+, 1—3-celled. (L: 45—155—335 μm)
16. *Hygrophila auriculata* (Schumach.) Heine	LWG 64617 (ex LUCK)	Ss., Glob., 4—8(mostly 8)-celled. (D. 25 μm)	++, 2—6-celled. (L: 176—637—1570 μm)
17. *H. polysperma* (Roxb.) T. Anders.	(ex BSI-South)	Ss., Glob., 4—8(mostly 4)-celled. (D. 21 μm)	Of two types; i) ++, short, unicellular (rarely 2-celled), conical, confined to margin, Low. only. (L: 20—55—137 μm); ii) +++, 1—3-celled, U. only. (L: 20—270—825 μm)
18. *H. quadrivalvis* (Buch.-Ham.) Nees	(ex BSI-South)	Ss., Glob., 4—8(mostly 8)-celled. (D. 27 μm)	+++, 2—6-celled. (L: 236—654—1038 μm)
19. *H. salicifolia* (Vahl) Nees	BSD 42757 (ex BSI-North)	Ss., Glob., 4—8-celled. (D. 26 μm)	++, 2—6-celled. (L: 106—720—1486 μm)
20. *H. serpyllum* T. Anders.	BSI 76626 (ex BSI-West)	+++, Ls., St. 1—3-celled. (L: 25—102—240 μm)	Of two types: i) +++, short, slender, 1—2-celled, Low. & U. (L: 30—79—140 μm); ii) +++, long, stout, 2—4-celled, Low. & U. (L: 224—578—1298 μm)

Species	Voucher specimen	Glandular hairs	Non-glandular hairs
21. *Petalidium barlerioides* Nees	LWG 64613 (ex LUCK)	Ss., Glob., 2—8(mostly 4—8)-celled. (D. 19 μm)	++, 1—5-celled. (L: 42—106—212 μm)
22. *Dyschoriste dalzellii* O. Ktze.	BSI 66489 (ex BSI-West)	Ss., Glob., 4-celled. (D. 27 μm)	Of two types: i) ++, 1—4-celled, Low. only. (L: 141—531—920 μm); ii) ++, short, unicellular, conical, U. only. (L: 62—85—100 μm)
23. *D. erecta* O Ktze.	BSI 66604 (ex BSI-West)	Of two types: i) ++, Ss., Glob., 4-celled, Low. & U. (D. 23 μm); ii) +, Ls., St. 1—2-celled, Low. only. (L: 77—106—117 μm)	++, 1—4-celled. (L: 12—192—800 μm)
24. *D. vagans* O. Ktze.	BSI 3857 (ex BSI-West)	Of two types: i) ++, Ss., Glob., 8-celled, Low. & U. (D. 26 μm); ii) +++, Ls., St. 2—5-celled, Low. & U. (L: 106—384—1062 μm)	+++, up to 9(mostly 2—4)-celled, rarely branched. (L: 94—291—849 μm)
25. *Hemigraphis alternata* T. Anders.	LWG 64548 (ex SING)	Ss., Glob., 4—8-celled. (D. 25 μm)	+, 2—5-celled. (L: 110—167—205 μm)
26. *H. colorata* Hall. *f.*	LWG 64549 (ex MALAY)	Ss., Glob., 4—8-celled. (D. 22 μm)	++, 2—5-celled. (L: 94—276—601 μm)
27. *H. hirta* T. Anders.	LWG 64583 (ex LUCK)	Ss., Glob., 4—8-celled. (D. 24 μm)	++, 2—5(often 1)-celled. (L: 50—204—490 μm)
28. *Strobilanthes alatus* Wall. *ex* Nees	(ex CHAMOL)	Ss., Glob., 4—8-celled. (D. 25 μm)	++, 1- to several-celled. (L: 118—283—637 μm)
29. *S. barbatus* Nees	BSI 79955 (ex BSI-West)	Ss., Glob., 4—8-celled. (D. 27 μm)	++, 1- to several-celled. (L: 94—168—295 μm)
30. *S. callosus* Nees	BSI 9685 (ex BSI-West)	Ss., Glob., 4—8-celled. (D. 26 μm)	+++, 1- to several-celled. (L: 94—200—354 μm)
31. *S. crispus* (L.) Blume	LWG 64588 (ex BOG)	Ss., Glob., 4—8-celled. (D. 25 μm)	++, 1- to several-celled. (L: 55—195—460 μm)
32. *S. heyneanus* Nees	LWG 64586 (ex LUCK)	Of two types: i) Ss., Glob., 4—8-celled. (D. 27 μm); ii) +, Ls., St. 3—4-celled. (L: 750 μm)	++, 1- to several-celled. (L: 635—932—1191 μm)
33. *S. ixiocephalus* Benth.	BLAT 490 (ex BLAT)	Ss., Glob., 4—8-celled. (D. 27 μm)	+, 1- to several-celled. (L: 155—272—400 μm)
34. *S. pulneyensis* Clarke	BSI 74982 (ex BSI-West)	Ss., Glob., 4—8-celled. (D. 25 μm)	++, 1- to several-celled. (L: 236—613—1298 μm)
35. *S. scaber* Nees	LWG 64567 (ex LUCK)	Ss., Glob., 4—8-celled. (D. 22 μm)	++, 1- to several-celled. (L: 90—227—357 μm)
36. *S. scrobiculatus* Dalz.	BLAT 354 (ex BLAT)	Ss., Glob., 4—8-celled. (D. 34 μm)	+, 1- to several-celled. (L: 175—340—550 μm)
37. *Ruellia formosa* Andr.	LWG 64559 (ex DE)	Ss., Glob., 4—8-celled. (D. 27 μm)	++, 1—8(mostly 2—4)-celled. (L: 224—495—684 μm)
38. *R. lorentziana* Griseb.	LWG 64580 (ex LUCK)	Ss., Glob., 4—8(often more than 8)-celled. (D. 26 μm)	++, 1—8(mostly 2—4)-celled. (L: 153—365—1121 μm)
39. *R. malacosperma* Greenman	LWG 64558 (ex DE)	Ss., Glob., 4—8-celled. (D. 32 μm)	+, 1—8(mostly 2—4)-celled. (L: 147—205—262 μm)

Species	Voucher specimen	Glandular hairs	Non-glandular hairs
40 *R. repens* Linn.	LWG 64560 (ex SING)	Ss., Glob., 4—8-celled. (D. 23 μm)	++, 1—8(mostly 2—4)-celled. (L: 137—245—425 μm)
41. *R. rosea* Hemsl.	LWG 64596 (ex LUCK)	Ss., Glob., 4—8-celled; +, Ls. (D. 26 μm)	+, 1—8(mostly 2—4)-celled. (L: 142—337—650 μm)
42. *R. tuberosa* Linn.	LWG 64604 (ex LUCK)	Ss., Glob., 4—8-celled. (D. 24 μm)	+, 1—8(mostly 2—4)-celled. (L:148—166—225 μm)
43. *R. tweediana* Griseb.	LWG 64605 (ex LUCK)	Ss., Glob., 4—8(often more than 8)-celled. (D. 34 μm)	
44. *Dipteracanthus patulus* (Jacq.) Nees	LWG 64602 (ex POND)	Of two types: i) Ss., Glob., 4—8-celled. (D. 27 μm); ii) ++, Ls., St. 2—3-celled. (L: 220 μm)	+++, 1—4-celled. (L: 82—164—260 μm)
45. *D. prostratus* (Poir.) Nees	LWG 64603 (ex CNH)	Ss., Glob., 4—8-celled. (D. 27 μm)	++, 1—4-celled. (L: 212—440—1003 μm)
46. *Eranthemum albomarginata* Mart.	(ex POND)	Ss., Glob., 8- or more-celled. (D. 30 μm)	
47. *E. capense* Linn.	MH 13801 (ex BSI-South)	Ss., Glob., 4-celled. (D. 25 μm)	++, 1—4-celled. (L: 27—70—170 μm)
48. *E. nervosum* (Vahl) R. Br.	LWG 64608 (ex LUCK)	Ss., Glob., 4-celled. (D. 26 μm)	++, 1—4-celled. (L: 22—100—235 μm)
49. *E. purpurascens* Nees	LWG 64610 (ex LUCK)	Ss., Glob., 4-celled. (D. 34 μm)	++, 1—4-celled. (L: 53—87—162 μm)
50. *E. roseum* (Vahl) R. Br.	(ex POND)	Ss., Glob., 4-celled. (D. 26 μm)	++, 1—4-celled. (L: 57—102—195 μm)
51. *E. wattii* Stapf.	LWG 64547 (ex SING)	Ss., Glob., 4-celled. (D. 25 μm)	++, 1—4-celled. (L: 22—57—127 μm)
52. *Lepidagathis cristata* Willd.	BSI 72973 (ex BSI-West)	Ss., Glob., 4-celled. (D. 24 μm)	++, 1-celled. (L: 117—272—400 μm)
53. *L. cuspidata* Wall. *ex* Nees	LWG 64612 (ex DUN)	Of two types: i) Ss., Glob., 4—8-celled. (D. 22 μm); ii) ++, Ls., St. 2—5-celled. (L: 27—135—330 μm)	++, 1—4-celled. (L: 15—167—450 μm)
54. *L. incurva* D. Don.	BSI 79530 (ex BSI-West)	Ss., Glob., 4-celled. (D. 23 μm)	++, 1-celled. (L: 22—142—512 μm)
55. *L. purpuricaulis* Nees	BSD 40247 (ex BSI-Dun)	Ss., Glob., 2—4-celled. (D. 27 μm)	+++, 1-celled. (L: 50—205—735 μm)
56. *L. trinervis* Wall. *ex* Nees	BSI 71408 (ex BSI-West)	Ss., Glob., 4-celled (D. 26 μm)	++, 1-celled. (L: 58—119—175 μm)
57. *Barleria courtallica* Nees	BSI 86000 (ex BSI-West)	Ss., Glob., 4—8-(mostly 4)-celled. (D. 35 μm)	
58. *B. cristata* Linn.	LWG 64598 (ex LUCK)	Ss., Glob., 4—8(mostly 4)-celled. (D. 26 μm)	++, 1- to several-celled. (L: 188—410—743 μm)
59. *B. cuspidata* Heyne *ex* Nees	MH 12502 (ex BSI-South)	Ss., Glob., 4—8(mostly 4)-celled. (D. 34 μm)	+, 1-celled, thick-walled. (L: 247—483—731 μm)

Species	Voucher specimen	Glandular hairs	Non-glandular hairs
60. *B. lawii* T. Anders.	BSI 76416 (ex BSI-West)	Ss., Glob., 4—8(mostly 4)-celled. (D. 27 μm)	++, 1- to several-celled, thick-walled. (L: 106—590—1416 μm)
61. *B. lupulina* Lindl.	LWG 64601 (ex LUCK)	Ss., Glob., 4—8(mostly 4)-celled. (D. 32 μm).	+, 1-celled, thick-walled. (L: 177—389—731 μm)
62. *B. prionitis* Linn.	LWG 64599 (ex LUCK)	Ss., Glob., 4—8(mostly 4)-celled. (D. 35 μm)	+, 1-celled, thick-walled. (L: 448—531—625 μm)
63. *B. strigosa* Willd. var. *terminalis* (Nees) Clarke	LWG 64600 (ex LUCK)	Ss., Glob., 4—8(mostly 4)-celled. (D. 31 μm)	++, 1- to several-celled, thick-walled. (L: 61—280—660 μm)
64. *Blepharis maderaspatensis* (Linn.) Roth	LWG 64591 (ex LUCK)	Ss., Glob., 2-celled. (D. 31 μm)	++, 1—4-celled. (L: 82—369—755 μm)
65. *Acanthus montanus* T. Anders.	LWG 64611 (ex LUCK)	Ss., Glob., 4-celled. (D. 25 μm)	++, 1—8(mostly 3—4)-celled. (L: 52—142—287 μm)
66. *Crossandra infundibuliformis* (Linn.) Nees	LWG 64544 (ex DE)	Ss., Glob., 2-celled. (D. 24 μm)	++, 1—3-celled. (L: 27—74—125 μm)
67. *C. nilotica* Oliver	LWG 64570 (ex LUCK)	Ss., Glob., 2-celled. (D. 32 μm)	++, 1—6(mostly 3—4)-celled. (L: 70—377—778 μm)
68. *Aphelandra tetragona* Nees	LWG 64572 (ex LUCK)	Ss., Glob., 2—4-celled. (D. 27 μm)	++, 1- to several-celled. (L: 212—362—590 μm)
69. *Andrographis echioides* Nees	LWG 64576 (ex POND)	Ss., Glob., 4—8(mostly 8)-celled. (D. 30 μm)	++, 1—6-celled. (L: 118—267—401 μm)
70. *A. paniculata* (Burm.) Wall. *ex* Nees	LWG 64569 (ex LUCK)	Ss., Glob., 4—8(mostly 8)-celled. (D. 27 μm)	++, 2—3(up to 9)-celled on upper. (L: 75—111—155 μm)
71. *Gymnostachyum febrifugum* Benth.	BSI 74776 (ex BSI-West)	Ss., Glob., 4—6(mostly 4)-celled. (D. 24 μm)	++, 1—6-celled. (L: 37—98—250 μm)
72. *G. latifolium* (Dalz.) T. Anders.	BSI 97409 (ex BSI-West)	Ss., Glob., 2—4(mostly 4)-celled. (D. 23 μm)	++, short, conical, unicellular (rarely 2-celled). (L: 12—26—50 μm)
73. *Asystasia chelonoides* Nees var. *quadrangularis* Clarke	MH 12735 (ex BSI-South)	Ss., Glob., 4—8(mostly 4)-celled. (D. 31 μm)	++, confined to upper, 1—7 (mostly 2—4)-celled. (L: 81—424—1203 μm)
74. *A. dalzelliana* Santapau	MH 20313 (ex BSI-South)	Ss., Glob., 4—8(mostly 4)-celled. (D. 33 μm)	++, 1—7(mostly 2—4)-celled. (L: 94—224—436 μm)
75. *A. gangetica* (Linn.) T. Anders.	MH 19317 (ex BSI-South)	Ss., Glob., 4—8(mostly 4)-celled. (D. 25 μm)	+++, 1—7 (mostly 2—4)-celled. (L: 47—224—507 μm)
76. *A. intrusa* Blume	LWG 64542 (ex MALAY)	Ss., Glob., 4—8(mostly 4)-celled. (D. 24 μm).	+++, 1—7(mostly 2—4)-celled. (L: 118—330—483 μm)
77. *Graptophyllum pictum* Griff.	(ex LUCK)	Ss., Glob., 8-celled. (D. 38 μm)	+, 2—3-celled. (L: 55—116—150 μm)
78. *Pachystachys coccinea* Nees	LWG 64571 (ex LUCK)	Ss., Glob., 4-celled. (D. 29 μm)	++, 3—6-celled. (L: 236—413—531 μm)
79. *Pseuderanthemum atropurpureum* (Bull.) Bailey	LWG 64564 (ex POND)	Ss., Glob., 4—8(mostly 8)-celled. (D. 29 μm)	

Species	Voucher specimen	Glandular hairs	Non-glandular hairs
80. *P. bicolor* (Schrank) Radlk.	LWG 64553 (ex DE)	Ss., Glob., 4—8(mostly 8)-celled. (D. 28 μm)	+, 1- to several(up to 12)-celled, slender, rarely branched. (L: 118—228—354 μm)
81. *P. grandiflorum* Domin	LWG 64554 (ex SING)	Ss., Glob., 4—8(mostly 8)-celled. (D. 32 μm)	++, 1- to several(mostly 1)-celled. (L: 27—62—130 μm)
82. *P. kewense* Bailey	(ex LUCK)	Ss., Glob., 4—8(mostly 8)-celled. (D. 28 μm)	
83. *P. malaccense* Linden	LWG 64555 (ex MALAY)	Ss., Glob., 4—8(mostly 8)-celled. (D. 32 μm)	++, 1- to several(mostly 1)-celled. (L: 37—64—115 μm)
84. *P. variabile* (R. Br.) Radlk.	LWG 64585 (ex LUCK)	Ss., Glob., 4—8(mostly 8)-celled. (D. 27 μm)	
85. *Peristrophe acuminata* Nees	LWG 64556 (ex SING)	Ss., Glob., 4-celled. (D. 35 μm)	+, 1—3-celled. (L: 67—152—280 μm)
86. *P. bicalyculata* (Retz.) Nees	LWG 64584 (ex LUCK)	Ss., Glob., 4-celled. (D. 25 μm)	++, 1—7-celled. (L: 424—822—1073 μm)
87. *P. tinctoria* Nees	LWG 64557 (ex MALAY)	Ss., Glob., 2—4-celled. (D. 33 μm)	++, 1—3-celled. (L: 59—174—332 μm)
88. *Rungia pectinata* Nees	LWG 64565 (ex LUCK)	Ss., Glob., 4-celled. (D. 28 μm)	++, 1—4-celled. (L: 42—119—235 μm)
89. *Dicliptera roxburghiana* Nees	LWG 64577 (ex DUN)	Of two types: i) Ss., Glob., 4-celled. (D. 26 μm); ii) ++, Ls., St. 2-celled. (L: 42—51—65 μm)	++, 1—5-celled. (L: 32—130—357 μm)
90. *Odontonema nitidum* O. Ktze.	LWG 64551 (ex DE)	Ss., Glob., 4—8-celled. (D. 27 μm)	
91. *O. strictum* O. Ktze.	LWG 64552 (ex DE)	Ss., Glob., 4—8-celled. (D. 27 μm)	
92. *Ecbolium viride* (Forsk.) Alston	LWG 64594 (ex CNH)	Ss., Glob., 8-celled. (D. 35 μm)	+, 1—3-celled. (L: 75—142—260 μm)
93. *Rhinacanthus nasuta* (Linn.) Kurz.	LWG 64578 (ex PDA)	Ss., Glob., 4-celled. (D. 25 μm)	++, 1—5(mostly 2—3)-celled. (L: 35—155—354 μm)
94. *Ruttya speciosa* (Hochst.) Engl.	LWG 64579 (ex LUCK)	Ss., Glob., 8- or more-celled. (D. 30 μm)	++, 3—7-celled, 1—several small basal cells, surmounted by an elongated thick-walled apical cell. (L: 389—578—802 μm)
95. *Fittonia gigantea* Linden *ex* Andre	LWG 64592 (ex LUCK)	Ss., Glob., 4—8(mostly 4)-celled. (D. 31 μm)	++, 1—10(mostly 2—4)-celled. (L: 75—150—475 μm)
96. *F. verschaffeltii* Coemans var. *argyroneura* Regel	LWG 64575 (ex LUCK)	Ss., Glob., 4—8(mostly 4)-celled. (D. 26 μm)	++, 1—10(mostly 2—4)-celled; upper hairs conical. (L: 50—200—442 μm)
97. *F. verschaffeltii* Coemans var. *pearcei* Regel	LWG 64574 (ex LUCK)	Ss., Glob., 4—8(mostly 4)-celled. (D. 29 μm)	++, 1—10(mostly 2—4)-celled, upper hairs typically conical. (L: 42—162—377 μm)
98. *Justicia betonica* Linn.	LWG 64587 (ex PDA)	Ss., Glob., 4-celled. (D. 32 μm)	+, 1—5-celled. (L: 59—236—826 μm)
99. *J. calycotricha* Hort.	LWG 64566 (ex LUCK)	Ss., Glob., 4-celled. (D. 31 μm)	+, 1—5(mostly 1)-celled, conical. (L: 55—82—142 μm)

Species	Voucher specimen	Glandular hairs	Non-glandular hairs
100. *J. diffusa* Willd.	MH 20431 (ex BSI-South)	Ss., Glob., 4-celled. (D. 26 μm)	+++, 1—5-celled. (L: 57—189—362 μm)
101. *J. gendarussa* Burm. *f.*	LWG 64597 (ex LUCK)	Ss., Glob., 4—8-celled. (D. 34 μm)	+, 1—5-celled. (L: 129—247—342 μm)
102. *J. procumbens* Linn.	MH 17319 (ex BSI-South)	Ss., Glob., 4-celled. (D. 35 μm)	+++, 1—5-celled. (L: 306—893—2006 μm)
103. *J. tranquebariensis* Linn.	MH 12639 (ex BSI-South)	Of two types: i) Ss., Glob., 4-celled. (D. 26 μm); ii) +, Ls. (L: 123 μm)	+++, 1—5-celled. (L: 45—161—287 μm)
104 *J. vahlii* Roth	MH 16622 (ex BSI-South)	Ss., Glob., 2—4-celled. (D. 29 μm)	+++, 1—5 celled (mostly 1-celled), conical. (L: 42—92—290 μm)
105. *Adhatoda vasica* Nees	LWG 64568 (ex LUCK)	Ss., Glob., 4-celled. (D. 25 μm)	++, 1—4-celled. (L: 52—142—287 μm)
106. *Dianthera candicans* Benth. & Hook. *f.*	LWG 64545 (ex DE)	Ss., Glob., 4-celled. (D. 27 μm)	++, 3—6-celled. (L: 157—267—300 μm)
107. *D. nodosa* Benth. & Hook. *f.*	LWG 64573 (ex LUCK)	Ss., Glob., 4—8-celled. (D. 31 μm)	++, 1—2-celled. (L: 50—91—152 μm)
108. *Beloperone amherstiae* Nees	LWG 64581 (ex LUCK)	Ss., Glob., 4-celled. (D. 29 μm)	+, 1—4-celled. (L: 155—197—250 μm)
109. *B. guttata* Brandegee	LWG 64543 (ex MALAY)	Ss., Glob., 2—4-celled. (D. 27 μm)	+++, 1—4-celled. (L: 35—239—483 μm)
110. *B. oblongata* Lindley	LWG 64582 (ex LUCK)	Ss., Glob., 4—8-celled. (D. 30 μm)	+++, 1—4-celled. (L: 35—266—554 μm)
111. *Jacobinia carnea* Nichols.	LWG 64550 (ex MALAY)	Ss., Glob., 4-celled. (D. 26 μm)	++, 2—4-celled. (L: 42—105—200 μm)