

## THE SEED ATLAS OF PAKISTAN-XVI. ACANTHACEAE

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### Abstract

Seed macro and micro morphological characters of the 18 taxa belonging to the family Acanthaceae have been examined by using light and scanning electron microscopy. The family Acanthaceae is represented by 2 sub families viz., Acanthoideae and Avicennioideae. A remarkable variation has been observed in seed size, shape, colour and surface at various taxonomic levels. Seed morphological data was also analyzed numerically by clustering to trace out the phylogenetic relationship and the data was found useful as an additional tool to strengthen the recognition of taxa within the family Acanthaceae from Pakistan.

**Key words:** Acanthaceae, Seed morphology, Phenetic relationship, Pakistan.

### Introduction

The family Acanthaceae comprises 229 genera and 3450 species, distributed mostly in tropical regions and extended to Australia, S. America and Mediterranean regions (Mabberley, 2008). In Pakistan the Acanthus family (subfamily Acanthoideae) is represented by 18 genera and 60 species (Malik & Ghafoor, 1988). The other subfamily Avicennioideae is represented by single species *Avicennia marina* (Jafri, 1973, who treated as independent family). Presently 18 taxa distributed in two sub-families viz., Acanthoideae and Avicennioideae of the family Acanthaceae are investigated. Previously the family Avicenniaceae had been treated as a separate family. While, some workers included it within the family Verbenaceae (Cronquist, 1981; Thorne, 1992 a, b; Takhtajan, 1997; APG III, 2009). However, the recent reports on molecular studies strengthen the placement of Avicenniaceae taxa (*Avicennia*) within the family Acanthaceae (Thorne & James, 2007; APG III, 2009). Moreover, Olmstead *et al.*, (2010-2014) proposed a synoptical classification for the order Lamiales, where the members of Avicenniaceae are also merged within the family Acanthaceae. Concerning to the seed morphology of the family Acanthaceae few workers worked on the seed morphology of this family. Simon (1993) published a detailed report on the seed morphology of Indian taxa of the family Acanthaceae. Similarly, the genera *Barleria* L., *Justicia* L. and *Avicennia* L. were also studied for their seeds and data was found very useful as a taxonomic marker (Graham, 1988; Balkwill & Balkwill, 1997; Das & Ghose, 2003; Darbyshire, 2008; Kanokorn *et al.*, 2012). In the present studies seed morphological investigation of the family Acanthaceae from Pakistan is carried out in order to find out additional micro-morphological characters of various taxa and also to strengthen their taxonomic delimitation.

### Material and Methods

Mature and healthy seeds of 18 taxa of the family Acanthaceae were collected from the herbarium specimens.

Mostly 10 plants/species and 10 seeds/plant were studied. The list of voucher specimens is deposited in KUH. Seeds morphological characters were examined under stereomicroscope (Nikon XN Model) and scanning electron microscope (JSM-6380A). For scanning electron microscopy dry seeds were directly mounted on metallic stub using double adhesive tape and coated with gold for a period of 6 minutes in sputtering chamber and observed under SEM. The terminology used is in accordance to Lawrence (1970), Radford *et al.*, (1974) and Stearn (1983) with slight modifications. Numerical analysis was carried out to recognize the relationship and dissimilarities of taxa within the family Acanthaceae. Hierarchical clustering was performed by using Euclidean distance index with the computer package (Anon., 2012). Each taxon was treated as an operational taxonomic unit (OTU). Macro and micro morphological characters of seeds viz., size, shape, colour and surface patterns were examined. Characters were recorded as presence or absence and coded as 1 or 0 respectively and the average values of the quantitative characters viz., seed length and breadth were directly used (Tables 1-3).

### Observations

**General seed characters of the family Acanthaceae:** Seeds 1-20×0.9-15 mm, angular or non-angular, compressed or non-compressed, ovate, broadly ovate, elliptic, broadly elliptic, oblong, broadly oblong, sub-orbicular or broadly cuneate, apex acute, obtuse, rounded, truncate or cirrhose, base cuneate, rounded, reniform, oblique or truncate, light brown, dark brown, dusty brown, yellowish brown, greenish brown, blackish brown, golden brown, golden yellow, off-white or orange brown, surface lineate, rugose, sparsely foveated pusticulate, rosette like verrucation, verrucate with or without fine aculation, glabrous or scaly, hairy, fibrillose, sericeous, appressedly pilose, appressedly strigose, sparsely pubescent or sparsely capitate, hilum basal or sub basal (Table 1; Figs. 1-4).

Presently two sub-families viz., Acanthoideae and Avicennioideae are investigated.

### Key to the sub-families

- 1 + Seeds 1-8 mm long ..... Acanthoideae  
- Seeds 12-20 mm long ..... Avicennioideae

Table 1. Seed morphological characters of the family Acanthaceae.

Name of taxa	Size (mm)		Angular/ Compressed	Shape	Apex	Base	Colour	Surface	Indumentum	Hilum
	Length	Breadth								
<b>Subfamily Acanthoideae, Tribe-Acantheae</b>										
<i>Blepharis ciliaris</i>	5-5.5	3.8-4	Non angular, compressed	Elliptic	Acute	Oblique	Golden brown or yellowish golden	Hairy	Appressedly pilose	Sub basal
<i>B. maderaspatensis</i>	2.8-3	1.4-1.5	Non angular, compressed	Elliptic	Obtuse	Oblique	Dark brown	Hairy	Appressedly pilose	Basal
<i>B. sindica</i>	4-6	3-3.5	Non angular, compressed	Elliptic	Obtuse	Oblique	Yellowish brown	Hairy	Appressedly strigose	Basal
<i>Crossandra infundibuliformis</i>	4-6	3-3.5	Non angular, compressed	Suborbicular	Rounded	Rounded	Golden yellow	Lineated scaly	Fibrillose scaly	Basal
<b>Tribe-Barlerieae</b>										
<i>Barleria acanthoides</i>	4.5	3.8-4	Non angular, compressed	Broadly ovate	Obtuse	Reniform	Golden brown	Hairy-scaly	Fibrillose hairy	Sub basal
<i>B. cristata</i>	4-6	4-6	Non angular, compressed	Broadly ovate	Obtuse	Reniform	Golden brown	Hairy-scaly	Fibrillose hairy	Basal
<i>B. hochstetteri</i>	3.8-4	4-6	Slightly angular, non-compressed	Broadly elliptic	Obtuse	Oblique	Yellowish golden or off-white	Hairy-scaly	Fibrillose hairy	Basal
<i>B. prionitis</i>	7-9	4-6	Slightly angular, non-compressed	Elliptic	Cirrhose	Cuneate	Golden brown, center dark brown	Hairy-scaly	Fibrillose hairy	Basal
<i>Lepidagathis incurva</i>	1-1.2	0.9-1	Non angular, compressed	Broadly elliptic	Cirrhose	Oblique	Orange brown	Hairy-scaly	Fibrillose hairy	Basal
<b>Tribe-Justicieae</b>										
<i>Asystasia gangetica</i>	4-6	4-6	Non angular, compressed	Suborbicular	Rounded	Truncate	Greenish brown	Verrucate along with fine aculeation	Verrucate	Basal
<i>Dicliptera bupleuroides</i> var. <i>bupleuroides</i>	1.4-1.5	0.9-1	Angular, non-compressed	Broadly cuneate	Truncate	Truncate	Dusty brown	Rosette like verrucation	Sparsely pubescent	Basal
<i>D. bupleuroides</i> var. <i>nazimii</i>	1.4-1.5	0.9-1	Angular, non-compressed	Broadly oblong	Rounded	Truncate	Dark brown	Rosette like verrucation	Sparsely pubescent	Basal
<i>D. paniculata</i>	2.8-3	2.8-3.2	Non angular, compressed	Sub orbicular	Rounded	Reniform	Blackish brown	Rugose	Sparsely capitate hairs	Basal
<b>Tribe-Ruellieae, Subtribe-Ruellinae</b>										
<i>Ruellia patula</i>	3.2-3.5	2.5	Non angular, compressed	Ovate	Acute	Truncate	Dark brown or golden yellow	Rugose	Margin hairy sericeous	Basal
<i>R. sindica</i>	2.8-3	1.8-2	Non angular, compressed	Broadly elliptic	Acute	Oblique	Dark brown	Hairy arising from center	Sericeous	Basal
<i>R. tuberosa</i>	2.4-2.5	1.4-1.5	Non angular, compressed	Elliptic	Acute	Oblique	Light brown	Hairy	Sericeous	Sub basal
<b>Subtribe-Strobilantinae</b>										
<i>Strobilanthes glutinosus</i>	3.2-3.5	2.2-2.5	Non angular, compressed	Oblong	Obtuse	Slightly reniform	Yellowish golden	Hairy	Sericeous	Basal
<b>Subfamily Avicennioideae</b>										
<i>Avicennia marina</i>	18-20	12-15	Non angular, non-compressed	Broadly elliptic	Obtuse	Oblique	Blackish brown	Sparsely foveated pustulate	Glabrous	Basal

**Table 2. List of characters, scored for the cluster analysis for the taxa of the family Acanthaceae listed in table 3.**

S. No.	Characters description
1.	Seed length (mm)
2.	Seed breadth (mm)
<b>Shape</b>	
3.	Angular/Non-angular: Non-angular (0), Slightly angular-non-angular (1)
4.	Compressed/Non-compressed: Non compressed (0), Compressed (1)
5.	Ovate: Absent (0), Present (1)
6.	Broadly ovate: Absent (0), Present (1)
7.	Elliptic: Absent (0), Present (1)
8.	Broadly elliptic: Absent (0), Present (1)
9.	Oblong: Absent (0), Present (1)
10.	Broadly oblong: Absent (0), Present (1)
11.	Sub-orbicular: Absent (0), Present (1)
12.	Broadly cuneate: Absent (0), Present (1)
<b>Apex</b>	
13.	Acute: Absent (0), Present (1)
14.	Obtuse: Absent (0), Present (1)
15.	Rounded: Absent (0), Present (1)
16.	Truncate: Absent (0), Present (1)
17.	Cirrhose: Absent (0), Present (1)
<b>Base</b>	
18.	Cuneate: Absent (0), Present (1)
19.	Rounded: Absent (0), Present (1)
20.	Reniform: Absent (0), Present (1)
21.	Oblique: Absent (0), Present (1)
22.	Truncate: Absent (0), Present (1)

<b>Colour</b>	
23.	Light brown: Absent (0), Present (1)
24.	Dark brown: Absent (0), Present (1)
25.	Dusty brown: Absent (0), Present (1)
26.	Yellowish brown : Absent (0), Present (1)
27.	Greenish brown: Absent (0), Present (1)
28.	Blackish brown: Absent (0), Present (1)
29.	Golden brown: Absent (0), Present (1)
30.	Golden yellow: Absent (0), Present (1)
31.	Orange brown: Absent (0), Present (1)
32.	Off-white: Absent (0), Present (1)
<b>Surface</b>	
33.	Lineate: Absent (0), Present (1)
34.	Rugose: Absent (0), Present (1)
35.	Foveate: Absent (0), Present (1)
36.	Pusticulate: Absent (0), Present (1)
37.	Aciliate: Absent (0), Present (1)
38.	Verrucate: Absent (0), Present (1)
39.	Rosette: Absent (0), Present (1)
40.	Scaly: Absent (0), Present (1)
41.	Fibrillose: Absent (0), Present (1)
42.	Sericeous: Absent (0), Present (1)
43.	Appressedly pilose: Absent (0), Present (1)
44.	Appressedly strigose: Absent (0), Present (1)
45.	Capitate hairy: Absent (0), Present (1)
<b>Indumentum</b>	
46.	Pubescent: Absent (0), Present (1)
47.	Glabrous: Absent (0), Present (1)
<b>Hilum</b>	
48.	Basal: Absent (0), Present (1)
49.	Sub basal: Absent (0), Present (1)

**General seed characters of the subfamily Acanthoideae:** Seeds 1-9×0.9-6 mm, angular or non-angular, compressed or non-compressed, ovate, broadly ovate, elliptic, broadly elliptic, oblong, broadly oblong, sub-orbicular or broadly cuneate, apex acute, obtuse, rounded, truncate or cirrhose, base cuneate, rounded, reniform, oblique or truncate, light brown, dark brown, dusty brown, yellowish brown, greenish brown, golden

brown, golden yellow, off-white, orange brown, surface lineate, rugose, rosette like verrucation, verrucate along with or without fine aculation, scaly or hairy, fibrillose, sericeous, appressedly pilose, appressedly strigose, sparsely pubescent or capitate hairy, hilum basal or sub basal.

Presently 4 tribes viz., Acantheae, Barlerieae, Justicieae and Ruellieae are investigated.

#### Key to the tribes

- 1 + Seeds appressedly pilose, appressedly strigose, scaly, capitate hairy, verrucate or sparsely pubescent ..... 2  
 - Seeds sericeous or fibrillose hairy ..... 3  
 2 + Seeds appressedly pilose, appressedly strigose or scaly ..... Acantheae  
 - Seeds verrucate, capitate hairy or sparsely pubescent ..... Justicieae  
 3 + Seeds sericeous ..... Ruellieae  
 - Seeds fibrillose hairy ..... Barlerieae

**General seed characters of the tribe Acantheae:** Seeds 2.8-6×1.4-4 mm, slightly angular or non-angular, compressed, elliptic or sub-orbicular, apex acute or obtuse, base rounded, oblique or truncate, dark brown, yellowish brown, golden yellow, golden brown or

yellowish golden, surface lineated scaly, fibrillose, appressedly pilose or appressedly strigose, hilum basal or sub basal.

Presently 2 genera viz., *Blepharis* Juss. and *Crossandra* Salisb. are investigated.

#### Key to the genera

- 1 + Seeds elliptic, appressedly pilose or appressedly strigose ..... *Blepharis*  
 - Seeds sub-orbicular, scaly ..... *Crossandra*

***Blepharis* Juss:** Seeds 2.8-6×1.4-3.5 mm, slightly angular, compressed or non-compressed, elliptic, apex obtuse or acute, base oblique, dark brown, yellowish brown, golden yellow, golden brown or yellowish golden, surface hairy, appressedly pilose or appressedly

strigose, hilum basal or sub basal.

Represented by 3 species viz., *Blepharis ciliaris* (L.) B. L. Burtt, *B. maderaspatensis* (L.) Roth. and *B. sindica* Stocks ex T. Anders.

Table 3. Data matrix of the family Acanthaceae scored for 49 characters present in table 2.

Name of taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Subfamily Acanthoideae, Tribe-Acantheae																									
<i>Blepharis ciliaris</i>	5.2	4	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
<i>B. maderaspatensis</i>	2.9	1.46	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1
<i>B. sindica</i>	5	3.28	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
<i>Crossandra infundibuliformis</i>	5	3.5	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Tribe-Barlerieae																									
<i>Barleria acanthoides</i>	4.46	4	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>B. cristata</i>	5	5	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>B. hochstetteri</i>	4	5	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
<i>B. prionitis</i>	8	5	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
<i>Lepidagathis incurva</i>	1.2	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Tribe-Justicieae																									
<i>Asystasia gangetica</i>	5	5	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0
<i>Dicliptera bupleuroides</i> var. <i>bupleuroides</i>	1.4	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0
<i>D. bupleuroides</i> var. <i>nazimii</i>	1.46	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1
<i>D. paniculata</i>	2.9	3	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Tribe-Ruellieae, Subtribe-Ruellinae																									
<i>Ruellia patula</i>	3.46	2.47	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
<i>R. sindica</i>	3	1.96	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
<i>R. tuberosa</i>	2.47	1.46	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
Subtribe-Strobilanthinae																									
<i>Strobilanthes glutinosus</i>	3.4	2.4	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Subfamily Avicennioideae																									
<i>Avicennia marina</i>	19	14	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1



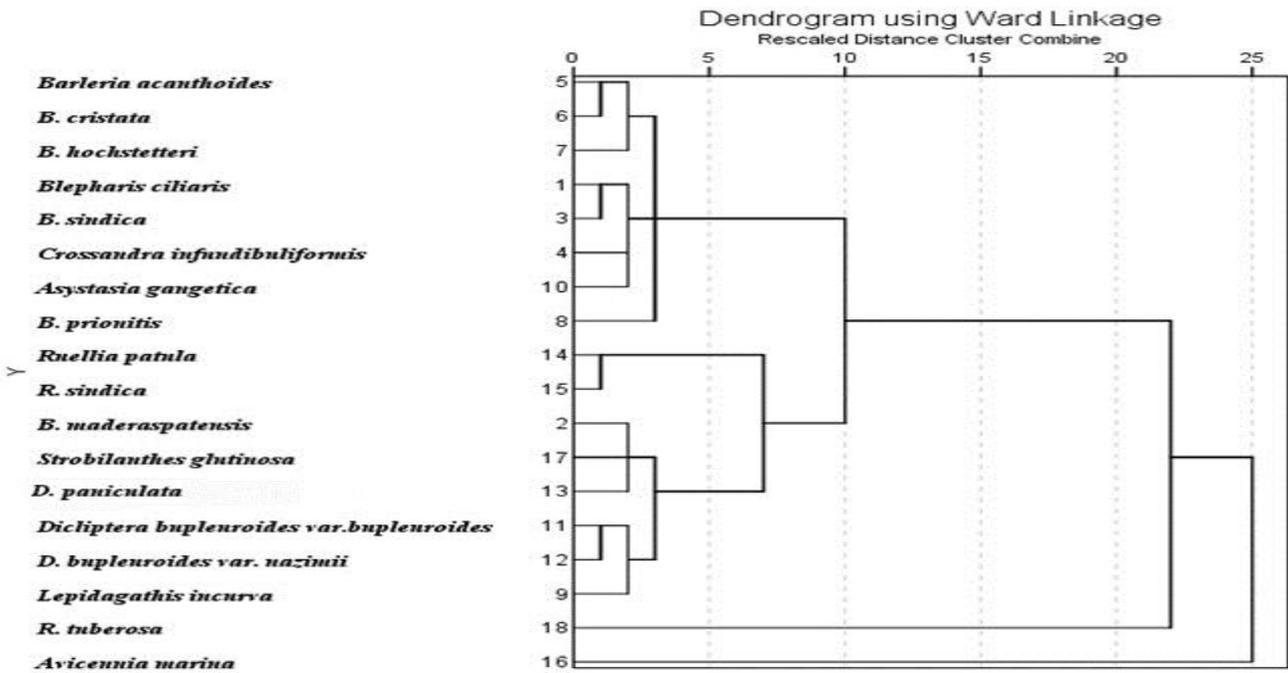


Fig. 1. Dendrogram showing the relationship of the taxa within the family Acanthaceae.

**Key to the species**

- 1 + Seeds apically acute ..... *B. ciliaris*
- Seeds apically obtuse ..... 2
- 2 + Seeds dark brown, appressedly pilose ..... *B. maderaspatensis*
- Seeds yellowish brown, appressedly strigose ..... *B. sindica*

**Crossandra Salisb:** Seeds 4-6×3.4-3.6 mm, non-angular, compressed, sub-orbicular, apex and base rounded, golden yellow, surface lineated scaly, fibrillose, hilum basal in position.

Represented by only one species viz., *Crossandra infundibuliformis* (L.) Nees.

**General seed characters of the tribe Barlerieae:** Seeds 1-9×0.9-6 mm, slightly angular or non-angular,

compressed or non compressed, broadly ovate, elliptic, broadly elliptic or sub globose, apex obtuse, cirrhose or rounded, base reniform, oblique or cuneate, golden brown, yellowish golden, off-white, orange brown or golden brown, centrally dark brown or not, surface fibrillose, hilum basal.

Presently 2 genera viz., *Barleria* L. and *Lepidagathis* Willd. are investigated.

**Key to the genera**

- 1 + Seeds 4-8 mm long, golden brown, yellowish golden or off white ..... *Barleria*
- Seeds 1-1.2 mm long, orange brown ..... *Lepidagathis*

**Barleria L.** Seeds 3.9-9×3.9-6 mm, slightly angular or non-angular, compressed or non compressed, broadly ovate, elliptic, broadly elliptic or broadly elliptic, apex obtuse or cirrhose, base reniform, oblique or cuneate, golden brown, yellowish golden, off-white, orange brown

or golden brown, sometimes centrally dark brown, surface hairy fibrillose, hilum basal.

Represented by 4 species viz., *Barleria acanthoides* Vahl, *B. cristata* L., *B. hochstetterii* Nees and *B. prionitis* L.

**Key to the species**

- 1 + Seeds broadly ovate ..... 2
- Seeds elliptic, broadly elliptic ..... 3
- 2 + Seeds with sub-basal hilum ..... *B. acanthoides*
- Seeds with basal hilum ..... *B. cristata*
- 3 + Seeds broadly elliptic, apically obtuse with oblique base ..... *B. hochstetterii*
- Seeds elliptic, apically cirrhose with cuneate base ..... *B. prionitis*

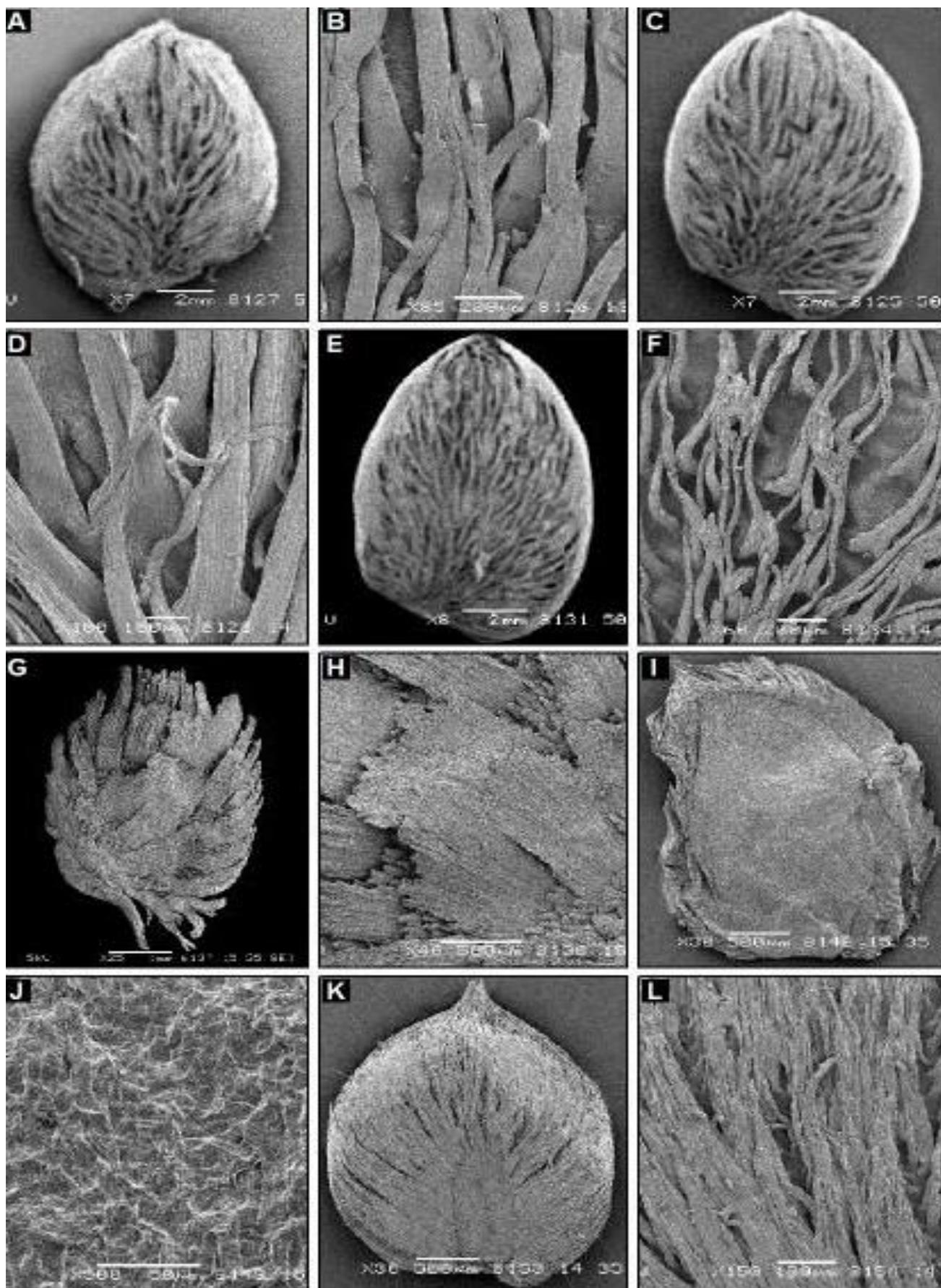


Fig. 2. Scanning electron micrographs. *Blepharis ciliaris*: A, seed; B, surface. *B. maderaspatensis*: C, seed; D, surface. *B. sindica*: E, seed; F, surface. *Crossandra infundibuliformis*: G, seed; H, surface. *Barleria acanthoides*: I, seed; J, surface. *B. cristata*: K, seed; L, surface (Scale bars: A, C, E= 2 mm; G= 1 mm; H, I, K= 500  $\mu$ m; B, F= 200  $\mu$ m; D, L= 100  $\mu$ m; J= 50  $\mu$ m).

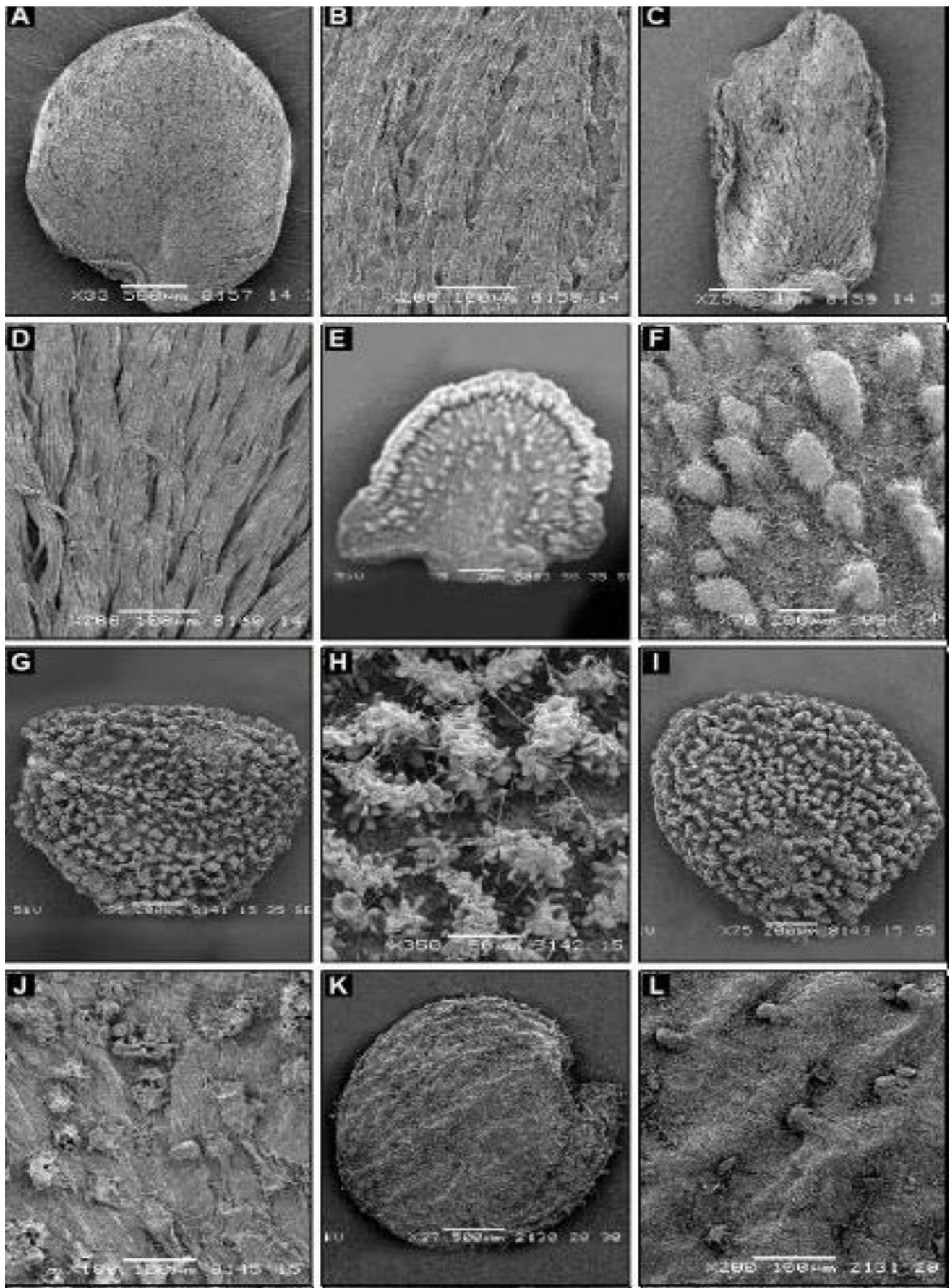


Fig. 3. Scanning electron micrographs. *Barleria hochstetterii*: A, seed; B, surface. *B. prionitis*: C, seed; D, surface. *Asystasia gangetia*: E, seed; F, surface. *Dicliptera bupleuroides*: G, seed; H, surface. *D. bupleuroides* var. *nazimii*: I, seed; J, surface. *D. paniculata*: K, seed; L, surface (Scale bars: E= 2 mm; C= 1 mm; A, K= 500  $\mu$ m; F, G, I= 200  $\mu$ m; B, D, J, K= 100  $\mu$ m; H= 50  $\mu$ m).

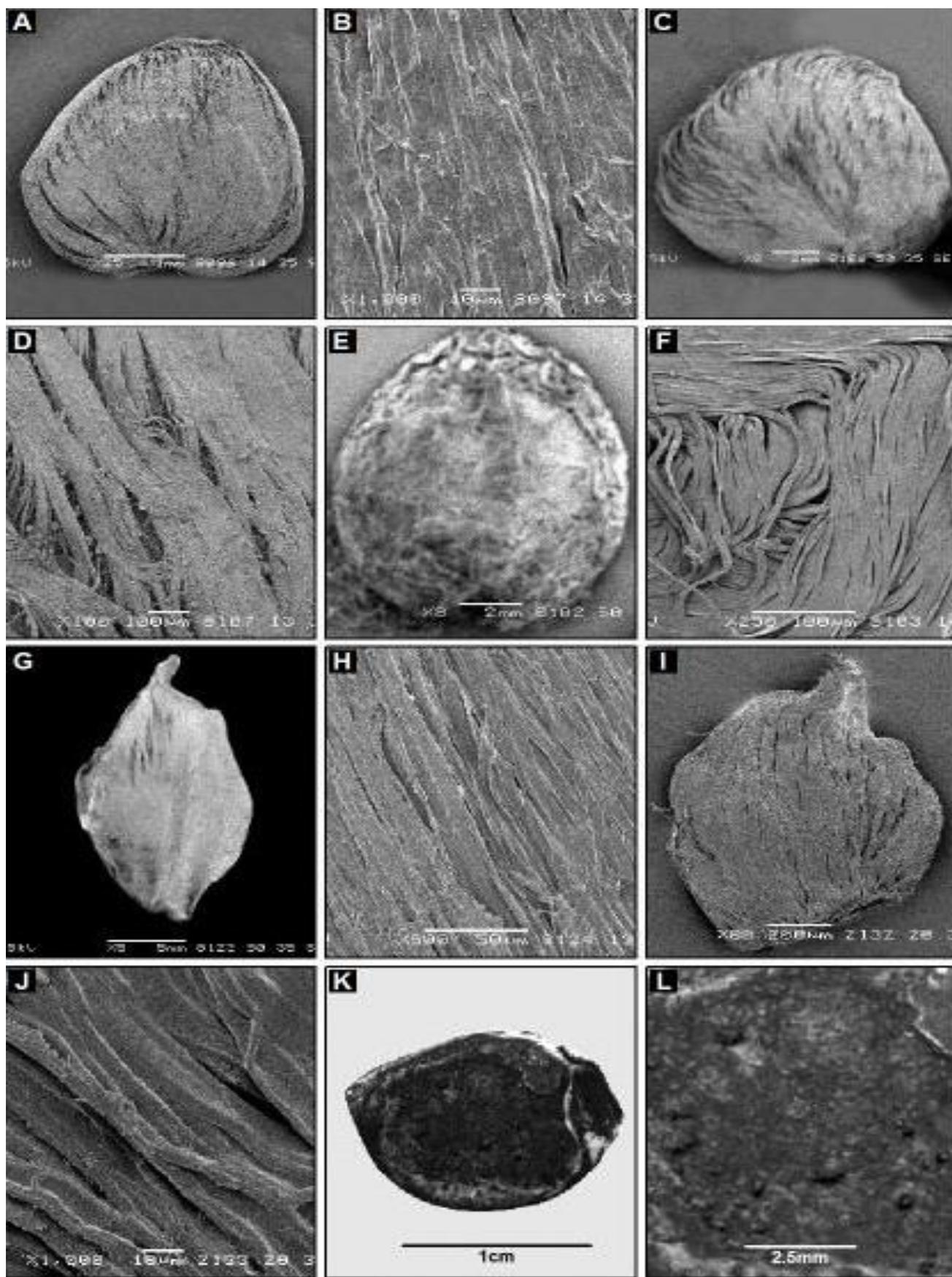


Fig. 4. Scanning electron micrographs. *Ruellia patula*: A, seed; B, surface. *R. indica*: C, seed; D, surface. *R. tuberosa*: E, seed; F, surface. *Strobilanthes glutinosus*: G, seed; H, surface. *Lepidagathis incurva*: I, seed; J, surface (Scale bars: G= 5 mm; C, E= 2 mm; A= 1 mm; I= 200 µm; D, F= 100 µm; H= 50 µm; B, J= 10 µm).  
Light micrographs. *Avicennia marina*: K, seed; L, surface (Scale bars: K, L= 100X).

**Lepidagathis** Willd: Seeds 1-1.3×0.9-1 mm, non-angular, compressed, broadly elliptic, apex cirrhose, base oblique, orange brown, surface fibrillose hairy, hilum basal in position.

Presently a single species viz., *Lepidagathis incurva* Buch.-Ham.ex D. Don is investigated.

**General seed characters of the tribe Justiceae:** Seeds 1.4-6×0.9-6 mm, angular or non-angular, compressed or

non compressed, broadly cuneate or sub-orbicular, apex rounded, base reniform or truncate, dark brown, dusty brown, blackish brown or greenish brown, surface rugose, rosette like verrucation or verrucate along with or without fine aculation, sparsely pubescent or capitate hairy, hilum basal.

Represented by 3 genera viz., *Asystasia* Blume and *Dicliptera* Juss.

#### Key to the genera

- 1 + Seeds surface verrucate ..... *Asystasia*  
 - Seeds surface sparsely pubescent or capitate hairy ..... *Dicliptera*

**Asystasia** Blume: Seeds 4-6×4-6 mm, non-angular, compressed, sub-orbicular, apex rounded, base truncate, greenish brown, surface verrucate along with or without fine aculation, hilum basal in position.

Represented by a single species viz., *Asystasia gangetica* (L.)T. Anders.

**Dicliptera** Juss: Seeds 1.4-3×0.9-3.2 mm, angular or non-angular, compressed or non-compressed, sub orbicular,

broadly oblong or broadly cuneate, apex rounded or truncate, base reniform or truncate, blackish brown, dark brown or dusty brown, surface rosette like verrucate, rugose, sparsely pubescent or sparsely capitate hairy, hilum basal in position.

Presently only one species viz., *Dicliptera bupleuroides* Nees, with 2 varieties namely, *Dicliptera bupleuroides* Nees var. *bupleuroides* and *D. bupleuroides* Nees var. *nazimii* Malik & A. Ghafoor are investigated.

#### Key to the varieties

- 1 + Seeds broadly cuneate, dusty brown ..... *D. bupleuroides* var. *bupleuroides*  
 - Seeds broadly oblong, dark brown ..... *D. bupleuroides* var. *nazimii*

**General seed characters of the tribe Ruellieae:** Seeds 2.4-3.5×1.4-2.5 mm, non-angular, compressed, ovate, oblong, elliptic, broadly elliptic, apex acute or obtuse, base reniform, truncate or oblique, dark brown, golden

yellow, light brown with white wings, surface rugose, sericeous, hilum basal or sub basal in position.

Presently 2 subtribes viz., Ruelliinae and Strobilanthiniae are investigated.

#### Key to the subtribes

- 1 + Seeds ovate, broadly elliptic or elliptic ..... Ruelliinae  
 - Seeds oblong ..... Strobilanthiniae

**General seed characters of the subtribe Ruelliinae:** Seeds 2.4-3×1.4-2.5 mm, non-angular, compressed, ovate, elliptic, broadly elliptic, apex acute, base truncate or oblique, dark brown, golden yellow, light brown with white wings, surface

rugose, sericeous, hilum basal or sub basal in position.

Presently the genus *Ruellia* L. with 3 species viz., *Ruellia patula* Jacq., *R. indica* A. Ghafoor & Heine and *R. tuberosa* L. is investigated.

#### Key to the species

- 1 + Seeds ovate, base truncate ..... *R. patula*  
 - Seeds elliptic, broadly elliptic, base oblique ..... 2  
 2 + Seeds broadly elliptic, hilum basal ..... *R. indica*  
 - Seeds elliptic, hilum sub-basal ..... *R. tuberosa*

**General seed characters of the subtribe Strobilanthiniae:** Seeds 3.2-3.5×2.2-2.5 mm, non-angular, compressed, oblong, apex obtuse, base slightly reniform, yellowish golden, surface sericeous, hilum basal in position.

Presently the genus *Strobilanthes* Blume with only one species viz., *S. glutinosus* Nees is investigated.

**General seed characters of the subfamily Avicennioideae:** Seeds 18-20×12-15 mm, non-angular, non-compressed, broadly elliptic, apex, obtuse, base oblique, dark brown or blackish brown, sparsely pusticulate, glabrous, hilum basal.

Represented by the genus *Avicennia* L. with only one species *Avicennia marina* (Forssk.) Vierh.

## Results and Discussion

The dendrogram of the family Acanthaceae (Fig. 1) shows 2 distinct groups. The first group is represented by a single species, *Avicennia marina* of the subfamily Avicennioideae. It falls separately from rest of the taxa of the subfamily Acanthoideae due to the presence of larger seeds and tree habit which also points out its primitive nature (Sporne, 1972; Corner, 1976). While the taxa of the subfamily Acanthoideae are characterized by smaller seeds and usually herbaceous plants rarely under-shrubs or shrubs. Furthermore, *Ruellia tuberosa* gets apart from rest of the taxa of the second group by having light brown seeds. While, the remaining taxa are characterized by dark brown, dusty brown, yellowish brown, greenish brown, blackish brown, golden brown, golden yellow, off-white or orange brown seeds. The second group could be further splitted into two subgroups on the basis of the seed size. Among the taxa of the first subgroup, *Barleria prionitis* falls separately from rest of the taxa by having usually 7-9 mm long seeds with cirrhose apex. While in the remaining taxa 2.8-6 mm long seeds with acute, obtuse or rounded apex are present. Moreover, *B. acanthoides*, *B. cristata* and *B. hochstetteri* share the common cluster, due to the presence of seeds with fibrillose hairs but still remain distinct due to different seed shapes and hilum position. Another cluster of the first subgroup occupied by *Blepharis ciliaris*, *B. sindica*, *Crossandra infundibuliformis* and *Asystasia gangetica* due to the presence of elliptic or sub-orbicular seeds and could be easily discriminated from each other by having specific indumentum. Similarly, the taxa of the second subgroup could be separated into 2 clusters. Within the first cluster the two species of the genus *Ruellia* viz., *R. patula* and *R. sindica* are coupled by having the seeds with sericeous indumentum and spheroidal pollen grains (Perveen & Qaiser, 2010), while the taxa of second cluster having seeds with verrucate, pubescent, appressedly pilose, capitate or fibrillose hairy indumentum and prolate pollen grains (Perveen & Qaiser, 2010). Among the taxa of the another cluster 3 taxa viz., *Blepharis maderaspatensis*, *Strobilanthes glutinosus* and *D. paniculata* are further grouped by having 3-3.5 mm long seeds. While, the remaining three taxa viz., *Dicliptera bupleuroides* var. *bupleuroides*, *D. bupleuroides* var. *nazimii* and *Lepidagathis incurva* further forming another group due to the presence of 1-1.5 mm long seeds, but all these species could be easily separated by having different seed shapes and indumentum.

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