

## POLLEN FLORA OF PAKISTAN - 1. MALVACEAE

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### Abstract

Pollen morphology of 42 species belonging to 12 genera of the family Malvaceae from Pakistan were examined by light and scanning electron microscope. Pollen morphology of the family is fairly uniform. Pollen grains are generally radially symmetrical apolar, rarely isopolar (*Abutilon*), mostly spheroidal to oblate - spheroidal rarely sub-oblate, pantoporate or triporate zonaaperturate. Tectum uniformly echinate, medium to finely perforated, or punctate with granules or scabrae in between spines. On the basis of various pollen characters viz., polarity, diameter of grains, exine thickness and spines size, 6 distinct pollen types recognized are *Abelmoschus crinitus* - type, *Abutilon indicum* - type, *Hibiscus aristi-valvis* - type, *Malva parviflora* - type, *Senra incana* - type and *Sida ovata* - type.

### Introduction

The family Malvaceae comprising of c. 88 genera and c. 2,3000 species are distributed in tropical, subtropical and temperate regions (Willis, 1973; Mabberley, 1987). In Pakistan it is represented by 19 genera with 94 specific and intraspecific taxa (Abedin, 1979).

Palynologically, Malvaceae is a stenopalynous family and pollen characters in the family are more or less uniform Culhane & Blackmore (1988) divided the family into 6 pollen types, based on number of apertures, grains diameter and spinular morphology. This is also supported by Christensen (1986) that the generic delimitation based on pollen morphology is difficult in the family. However, Saad (1960) considered that the pollen morphology in the family Malvaceae are quite distinctive which could apparently distinguish between the genera.

Whereas pollen morphology of the family Malvaceae has been studied by Master, (1874), Lang (1937), Sayeeduddin *et al.*, (1942), Erdtman (1952), Nair (1958, 1960, 1962), Saad (1960), Chadhuri (1965), Fryxell & Hashmi (1971) but the most comprehensive study of the Malvaceae pollen is that of Christensen, (1986). In Pakistan, pollen morphology of only few genera of this family has been studied by Siddiqui *et al.*, (1982, 1984), using light microscope. In the present studies an attempt has been made to provide a complete information of pollen morphology of Malvaceae from Pakistan. Present pollen data is based on pollen morphology of 42 species representing 12 genera.

## Material and Methods

Pollen samples were obtained from Karachi University Herbarium (KUH) or from plant collected from the field. The pollen grains were prepared for light and scanning microscopy by the standard methods described by Erdtman (1952). For light microscope the pollen grains were mounted in unstained glycerine jelly and observations were made with a Nikon Type-2 microscope, under (E40,0.65) and oil immersion (E10,1.25) using 10x eye piece. For SEM studies pollen grains suspended in a drop of water and indirectly transferred with a fine pipette to a metallic stub using double sided cellotape and coated with gold, in a sputtering chamber (Ion-sputter JFC-1100) with coating restricted to 150A<sup>0</sup>. S.E.M examination was carried out on a Jeol microscope JSM-T200. The measurements were based on 15-20 readings from each specimen. Pollen diameter, polar axis (P) and equatorial diameter (E) for isopolar grain, pore diameter, apoporium, mesoporium and exine thickness were measured. List of specimens investigated is given in Appendix 1.

### General pollen characters of the family Malvaceae

Malvaceae is fairly uniform in their pollen characters. Pollen grains generally radially symmetrical apolar, rarely isopolar (*Abutilon*), mostly spheroidal to oblate - spheroidal rarely sub-oblate, pantoporate or triporate, zonoaperturate. Tectum uniformly echinate, medium to finely perforated, sparsely to densely granulated in between spines.

In the present study 6 different pollen types are recognized on the basis of polarity, grains diameter, exine thickness, and spines size viz., 1) *Abelmoschus crinitus* - type, 2) *Abutilon indicum* - type, 3) *Hibiscus aristivalvis* - type, 4) *Malva parviflora* - type, 5) *Senra incana* - type, 6) *Sida ovata* - type.

### Key to the pollen types

- |    |  |                                   |
|----|--|-----------------------------------|
| 1- | Pollen grains isopolar, 3-zonoporate -----     | <i>Abutilon indicum</i> type      |
|    | Pollen grains apolar, pantoporate -----        | 2                                 |
| 2- | Spine with distinct spine base -----           | <i>Sida ovata</i> type            |
|    | Spine base absent, indistinct -----            | 3                                 |
| 3- | Pore diameter more than 10 $\mu\text{m}$ ----- | <i>Abelmoschus crinitus</i> type  |
|    | Pore diameter less than 10 $\mu\text{m}$ ----- | 4                                 |
| 4- | Exine 7.28-8.91 $\mu\text{m}$ thick -----      | <i>Senra incana</i> type          |
|    | Exine less than 7.18 $\mu\text{m}$ thick ----- | 5                                 |
| 5- | Spines 2.2-6.6 $\mu\text{m}$ long -----        | <i>Malva parviflora</i> type      |
|    | Spines 7.7-24.2 $\mu\text{m}$ long -----       | <i>Hibiscus aristivalvis</i> type |

### Description of the pollen types

1) *Abelmoschus crinitus* - type (Fig.1 A & B).

Pollen class: Pantoporate

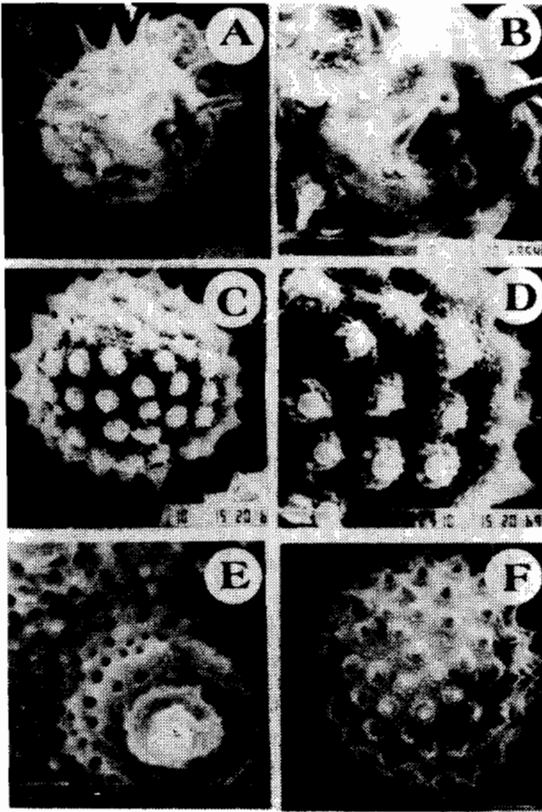


Fig.1. Scanning electron micrographs of pollen grains:

*Abelmoschus crinitus*: A, pollen grains; B, Exine patern. *Abutilon theophrasti*: C, pollen grains; D, Exine pattern. *A. indicum*: E, Exine pattern; F, Pollen grain.

Scale bar A = 100; B & F = 10  $\mu\text{m}$ .

**Shape:** Spheroidal

**Aperture:** Circular

**Exine:** Exine thick, sexine thinner than exine.

**Ornamentation:** Echinata, spines long, tapering, without spine base, tectum finely scabrate-punctate in between spines.

**Outline:** Circular

**Measurements:** Pollen diameter 110 (137.11) 148.5  $\mu\text{m}$ , pore diameter 12.1  $\mu\text{m}$ , spine length 27.5  $\mu\text{m}$ , exine 3.3  $\mu\text{m}$  thick.

**Comments:** *Abelmoschus crinitus*- type is easily distinguished by its large diameter of pore (more than 10  $\mu\text{m}$ ). Pollen grains of *Abelmoschus crinitus* - type are  $\pm$  similar to grains of *Senra incana* - type, because both types have large conical spines, but latter type differs by having less than 100  $\mu\text{m}$  diameter of grains.

2) *Abutilon indicum* - type (Fig.1 C-F; Fig.7 A & B).

**Pollen class:** 3-zonoporate

**Shape:** Sub-oblate to oblate -spheroidal rarely prolate spheroidal or spheroidal.

**Aperture:** Pore circular, small, medium.

**Exine:** Very thick, sexine thinner than or as thick as nexine, rarely thicker than nexine.

**Ornamentation:** Echinata, spines sharp with acute or acuminate tips, mostly with distinct spine base, tectum perforated with scabrae or granules often reticulate or reticulate-rugulate in between spines.

**Outline:** In polar view rounded trilobed, in equatorial view somewhat oblate.

**Measurements:** Polar axis (P) 43.08 (79.5  $\pm$  0.21) 89.75  $\mu$ m, equatorial diameter (E) 48.4 (80.17  $\pm$  1.19) 82.57  $\mu$ m; pore diameter 2.2 (7.31  $\pm$  0.06) 7.18  $\mu$ m; Mesopodium 24.4 (45.03  $\pm$  1.60) 71.8  $\mu$ m, Apopodium 19.7 (26.9  $\pm$  0.65) 53.85; Exine 1.79 (5.06  $\pm$  0.03) 7.81  $\mu$ m thick.

**Comments:** This pollen type is easily delimited by having 3-4 zonoporate isopolar pollen. Only a single genus *Abutilon* is included in this pollen type. However, the species of this genus show little variation in their shape, such as in *Abutilon fruticosum* Guill. and Pers; *A.hirtum* (Lamk.) Sweet, *A.alii* S.Abedin, *A.pakistanicum* Jafri and Ali and *A.theophrasti* Medic., have oblate-spheroidal pollen, while in *A.figarianum* Webb., *A.indicum* (L.) Sweet, *A.muticum* (Del. ex DC.) Sweet, *A.pannosum* (Forst. f.) Schl., sub-oblate and in *A.bidentatum* Rich., spheroidal pollen are found. However, these species are further classified on the basis of spines size, pore diameter, mesopodium and tectal surface in between the spines (Table 1).

### Key to the pollen types

- |    |   |                        |
|----|---|------------------------|
| 1  | + Pollen grains sub-oblate rarely spheroidal -----            | 2                      |
|    | - Pollen grains oblate-spheroidal to prolate-spheroidal ----- | 6                      |
| 2  | + Polar length of pollen grains 43.08-61.03 -----             | 3                      |
|    | - Polar length of pollen grains 71.8 - 89.7 -----             | 5                      |
| 3  | + Pollen grains spheroidal -----                              | <i>A. bidentatum</i>   |
|    | - Pollen grains sub-oblate -----                              | 4                      |
| 4  | + Spines with distinct perforate base -----                   | <i>A. muticum</i>      |
|    | - Spines with distinct perforated base -----                  | <i>A. pannosum</i>     |
| 5  | + Spines 5.38-8.97 $\mu$ m long -----                         | <i>A. figarianum</i>   |
|    | - Spines 3.59-4.62 $\mu$ m long -----                         | <i>A. indicum</i>      |
| 6  | + Pollen grains prolate-spheroidal -----                      | <i>A. karachianum</i>  |
|    | - Pollen grains oblate-spheroidal -----                       | 7                      |
| 7  | + Tectum reticulate inbetween spines -----                    | <i>A. hirtum</i>       |
|    | - Tectum perforated or punctate in between spines -----       | 8                      |
| 8  | + Mesopodium c 24.4 $\mu$ m -----                             | <i>A. theophrasti</i>  |
|    | - Mesopodium 35.9-53.8 $\mu$ m -----                          | 9                      |
| 9  | + Spines 7.18-7.53 $\mu$ m long -----                         | <i>A. alii</i>         |
|    | - Spines 3.3-3.6 $\mu$ m long -----                           | 10                     |
| 10 | + Pore diameter 2.2 $\mu$ m -----                             | <i>A. pakistanicum</i> |
|    | - Pore diameter 6.8-7.18 $\mu$ m -----                        | <i>A. fruticosum</i>   |

Table 1. Pollen characters in the species included in *Abutilon indicum* type

Name of Species	Shape $\mu\text{m}$	Polar axis $\mu\text{m}$	Equatorial diameter (E) $\mu\text{m}$	Pore diameter $\mu\text{m}$
<i>Abutilon alii</i>	Oblate-spheroidal	68.21(70.6 $\pm$ 1.19)71.8	78.9(80.17 $\pm$ 1.19)82.57	7.18
S. Abedin.				
<i>A. bidentatum</i>	Spheroidal	49.5	49.5	3.3
A. Rich.				
<i>A. figarianum</i>	Sub-oblate	71.8(79.5 $\pm$ 2.9)89.75	57.44(65.33 $\pm$ 2.8)71.8	5.39
Webb.				
<i>A. fruticosum</i>	Oblate-spheroidal	46.67(50.4 $\pm$ 0.58)53.8	52.0(55.9 $\pm$ 0.63)57.4	6.8(7.0 $\pm$ 0.17)7.18
Guill & Perr.				
<i>A. hirtum</i> (Jamk.) Sweet	Oblate-spheroidal	64.6(68.38 $\pm$ 0.77)71.8	71.8(75.0 $\pm$ 0.8)78.9	Obscure
var. <i>hirtum</i>				
<i>A. indicum</i> (L.)	Sub-oblate	71.8(75.9 $\pm$ 1.10)78.9	51.4(61.03 $\pm$ 0.78)64.62	Indistinct
Sweet.				
<i>A. karachianum</i>	Porate-spheroidal	49.15(50.1)51.7	48.11(49.5)50.6	2.2
S. A. Hus. & S. R. Baq.				
<i>A. pakistanicum</i>	Oblate-spheroidal	55(56)66	53.9(66)72.1	2.2
Jafri & Ali				
<i>A. pannosum</i>	Sub-oblate	53.8(57.4 $\pm$ 3.4)61.03	68.2(70.0 $\pm$ 1.8)7.18	
(Forst. f) Schlect.				
<i>A. muticum</i> (Del. ex. DC)	Sub-oblate	43.08(53.85 $\pm$ 2.3)61.03	61.03(65.46 $\pm$ 0.85)68.2	3.59(3.69 $\pm$ 0.06)3.94
Sweet.				
<i>A. theophrastii</i>	Oblate-spheroidal	49.5(53.5)55	51.7(53.6)51.2	2.2
Medic.				

Table 1 (Cont'd)

Name of Species	Apophorium $\mu\text{m}$	Mesopodium $\mu\text{m}$	Spine length $\mu\text{m}$	Tectum
<i>Abutilon alii</i> S. Abedin.	28.7	52.85	7.18(7.31 $\pm$ 0.05)7.53	Echinate/finely perforated, densely granulated.
<i>A. bidentatum</i> A. Rich.	23.6	33	2.2	Echinate/densely punctate, sparsely scabrate.
<i>A. figarianum</i> Webb.	28.72(35.9 $\pm$ 3.63)53.85	46.67(57.8 $\pm$ 2.7)71.8	5.3(7.11 $\pm$ 0.26)8.97	Echinate/finely perforated with sparse granules.
<i>A. fruticosum</i> Guill & Perr.	19.7(21.09 $\pm$ 0.44)23.4	35.9(39.4 $\pm$ 0.65)41.28	3.6(3.66 $\pm$ 0.017)3.94	Echinate/finely punctate, sparsely granulated.
<i>A. hirtum</i> (lamk.) Sweet var. <i>hirtum</i>	21.5(28.7 $\pm$ 1.07)32.3	46.6(51.4 $\pm$ 1.03)55.85	3.59(5.06 $\pm$ 0.74)8.9	Echinate/finely reticulate, densely granulated.
<i>A. indicum</i> (L.). Sweet.	25.1(27.3 $\pm$ 0.65)28.7	46.67(52.5 $\pm$ 1.50)57.4	3.29(3.59 $\pm$ 0.74)4.62	Echinate/finely reticulate, sparsely granulated.
<i>A. karachianum</i> S.A. Hus. & S.R. Baq.	22	38.5	4.4	Echinate/punctate-scabrate.
<i>A. pakistanicum</i> Jafri & Ali	22	52.8	3.3	Echinate/punctate-scabrate.
<i>A. pannosum</i> (Forst. f.) Schlect.	25.1(28.71 $\pm$ 0.92)32.3	50.2(52.8 $\pm$ 0.66)53.8	3.6	Echinate/densely perforate to scabrate.
<i>A. muticum</i> (Del. ex DC) Sweet.	21.54(26.92 $\pm$ 0.96)	39.49(45.03 $\pm$ 1.60)53.85	3.23(4.18 $\pm$ 0.31)5.38	Echinate/finely perforated to granulated.
<i>A. theophrastii</i> Medic.	22	24.4	5.5	Echinate/scabrate-punctate.

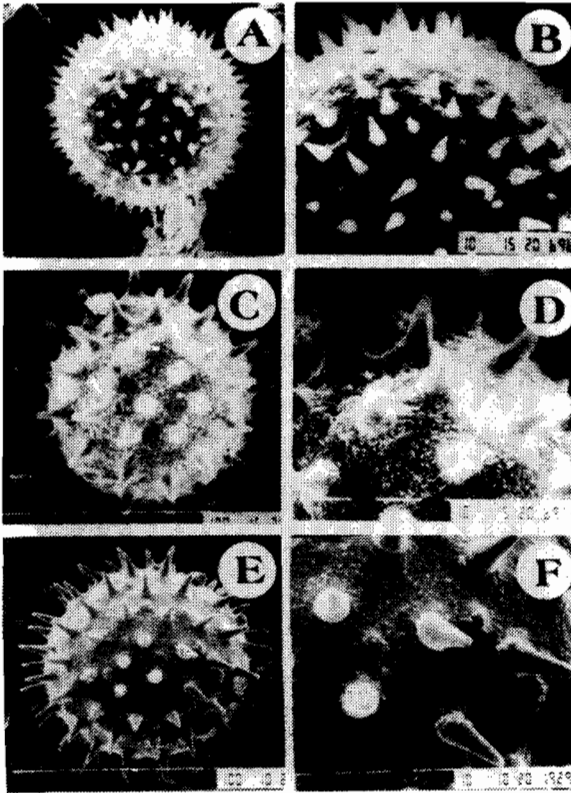


Fig.2. Scanning electron micrographs of pollen grains:

*Althaea ludwigii*: A, pollen grains; B, Exine pattern. *Hibiscus lobatus*: C, pollen grains; D, Exine pattern.

*Pavonia procumbens*: E, pollen grains; F, Exine pattern.

Scale bar = A, D & F = 10  $\mu\text{m}$ ; C & F = 100  $\mu\text{m}$ .

### 3) *Hibiscus aristivalvis* - type (Fig.2 A-F; Fig. 7 D).

**Pollen class:** Pantoporate

**Shape:** Spheroidal

**Aperture:** Pore circular

**Exine:** Exine thick, sexine thinner than nexine or rarely thicker or as thick as nexine.

**Ornamentation:** Echinate, spines dimorphic, longer spine sharp and point and shorter ones blunt or round ends, or all these spines are variable in size, tectum punctate or densely granulated often scabrate in between spines.

**Outline:** Circular.

**Measurements:** Pollen diameter 64.9 (96.41) 123.2  $\mu\text{m}$ , pore diameter 2.2 (5.57) 7.7  $\mu\text{m}$ , spine length 7.7 (10.7) 24.2  $\mu\text{m}$ . Exine 4.3 (6.6) 8.9  $\mu\text{m}$  thick.

**Table 2. Pollen characters in the species included in *Hibiscus aristivalis*-type.**

Name of the species	Pollen diameter	Pore diameter	Spine length
<i>Althaea ludwigii</i> L.	64.9 (68.2) 77	2.2	7.7
<i>Hibiscus aristivalvis</i> Garcke	78.98 (92.19 + 1.73) 106.9	3.59 (4.42 + 0.25) 5.38	10.77 (11.84 + 0.54) 14.36
<i>H.caesius</i> Garcke	87.3	7.7	12
<i>H.lobatus</i> (J.A. Murray) O.Ktze.	115 (116.6) 117.7	5.5	19.8
<i>H.obtusilobus</i> Gercke	73.8 (93.9 + 2.36) 107.7	5.38 (6.28 + 0.51) 7.18	7.18 (13.6 + 7.26) 19.7
<i>H.micranthus</i> L.f.	78.9 (88.13) 100.52	3.6 (5.74 + 1.11) 6.49	7.53 (12.1 + 0.72) 14.36
<i>H.trionum</i> L.	110 (116.6) 123.2	6.6	18.7
<i>Malva mohileviensis</i> Cowrar	72.6 (83.2) 93.5	1.65	7.7
<i>Pavonia arabica</i> Hochst & Steud.	111.1 (120.4) 126.5	4.4	16.3
<i>P.glechomaefolia</i> (A.Rich).Garcke.	93.5 (96.4) 99	5.5	17.6
<i>P.grewioides</i> Hochst. ex Boiss.	75 (77.75) 80.5	5.5	12.1
<i>P.procumbens</i> (W. & A.) Walp	100.5 (105.9 + 1.23) 107.7	3.4 (4.0 + 0.34) 5.4	10.7 (15.8 + 1.05) 18.3
<i>P.zeylanica</i> (L.) Cav.	114.4	5.5	24.1

### Key to the Groups

- + Diameter of grain 110  $\mu\text{m}$  or more *Hibiscus trionum* group (Species: *Hibiscus lobatus*, *H. trionum*, *Pavonia arabica*, *P.zeylanica*).
- Diameter of grain less than 110  $\mu\text{m}$  *Hibiscus caesius* - group (Species: *Althaea ludwigii*, *Hibiscus aristivalvis*, *H.caesius*, *H.obtusilobus*, *H. micranthus*, *Malva mohileviensis*, *Pavonia glechomaefolia*, *P.grewioides* and *P. procumbens*).

**Comments:** *Hibiscus aristivalvis* - type is largest among all the 6 pollen types. Majority of the species are included in this pollen type (13 species representing 4 genera i.e., *Malva* (p.p), *Althaea*, *Hibiscus* and *Pavonia*). This pollen type is characterized by its long tapering spines, ranges from 7.2-24.7  $\mu\text{m}$  long. Pollen grains of *Hibiscus aristivalvis* - type closely resemble that of *Malva parviflora* - type, but latter type has relatively small spines (< than 7  $\mu\text{m}$  long). Similar to *Malva parviflora* type few species of this pollen type have also dimorphic spines such as *Hibiscus micranthus* L.f., *H. caesius* Garcke, *Pavonia arabica* Hochst & steud. ex Boiss., *P.zeylanica* (L.) Cav., and *Malva mohileviensis* Downar. Whereas, the remaining species have monomorphic spines as in *Hibiscus obtusilobus* Garcke, *H.aristivalvis* Garcke, *Althaea ludwigii* L. and *Pavonia grewioides* Hochst. ex Boiss., long, conical spines with slightly recurved apices



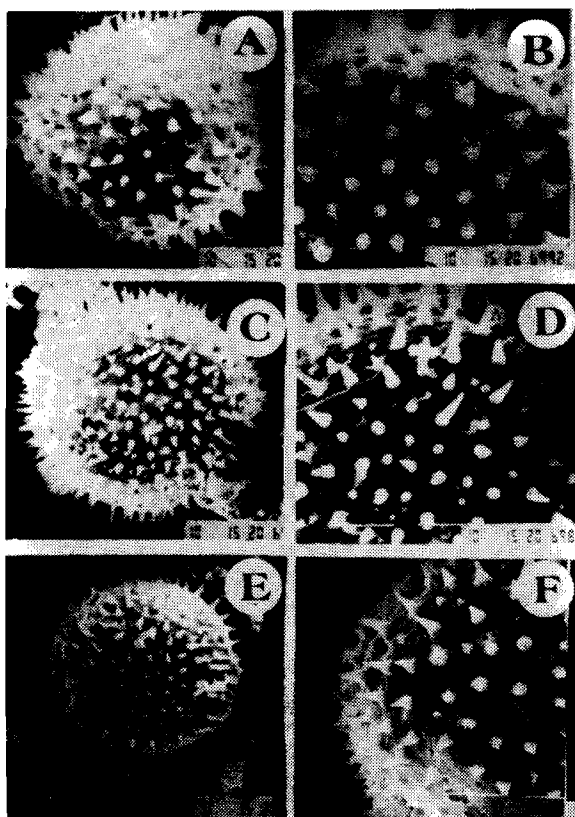


Fig.3. Scanning electron micrographs of pollen grains:

*Malva verticillata* var. *rafiqii*: A, pollen grains; B, Exine pattern. *Malva neglecta*: C, pollen grain; D, Exine pattern. *M. parviflora*: E, pollen grains; F, Exine pattern.

Scale bar = 10  $\mu$ m.

and in *H. lobatus* (J.A. Murray) O.Kt., *Pavonia procumbens* (W. & A.) Walp., *P. glechomaefolia* (A.Rich) Garcke, *H. trionum* L. bluntly rounded ends spines are found. However, this pollen type can be divided into 2 subgroups based on grains diameter viz., *Hibiscus trionum* group and *Hibiscus caesius* group. The I<sup>st</sup> subgroup has more than 110  $\mu$ m diameter of grain, whereas in II subgroup species have less than 110  $\mu$ m diameter of pollen. (Table 2).

#### 4. *Malva parviflora* - type (Fig. 3A - F).

**Pollen class:** Pantoporate

**Shape:** Spheroidal

**Aperture:** Small, + circular.

**Exine:** Exine thick, sexine thicker or thinner than nexine. **Ornamentation:** Echinate, spines dimorphic, pointed or blunt apices, without spine base, tectum finely punctate often subspsilate in between spines.

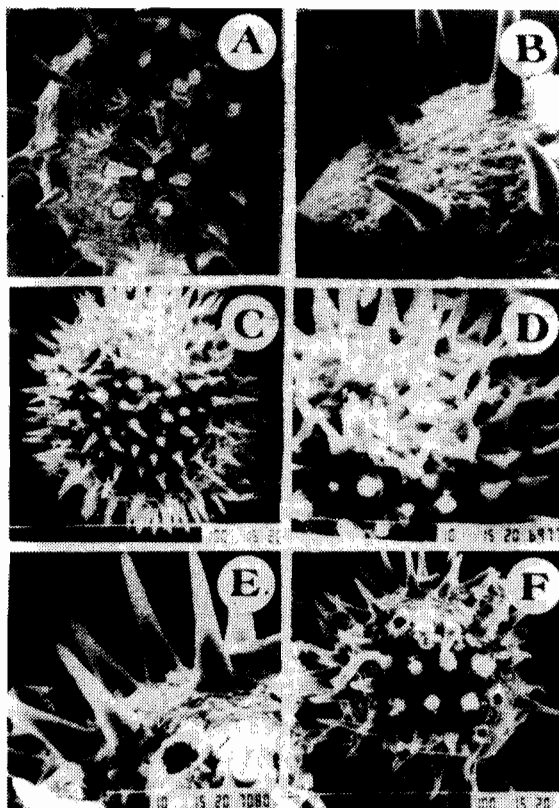


Fig.4. Scanning electron micrographs of pollen grain:

*Senra incana*: A, pollen grains; B, Exine pattern. *Lavatera cashemiriana*: C, pollen grain; D, Exine pattern. *Urena lobata*: E, Exine pattern; F, Pollen grain.

Scale bar = A, B, D & E = 10  $\mu\text{m}$ ; C & F = 100  $\mu\text{m}$ .

**Outline:** Circular

**Measurements:** Pollen diameter 64.1 (78.2) 148.5  $\mu\text{m}$ , pore diameter 1.42-2.2  $\mu\text{m}$ , spine length 2.2-6.6  $\mu\text{m}$ , exine 4.46-6.6  $\mu\text{m}$  thick.

**Comments:** Pollen of *Malva parviflora* - type closely resembles that of *Hibiscus aristivalvis* - type. The distinguishing features of this pollen type is spine length which is smaller than 7  $\mu\text{m}$ , only a single genus *Malva* belongs to this pollen type. The spines in this genus are distinctly dimorphic i.e, within a single grain large pointed and bluntly rounded ends spines are found, these spines are variable in size. Similar dimorphic spines in the genus *Malva* have also been reported by Nair (1958); Erdtman *et al.*, (1961) and Culhane & Blackmore (1988). Saad (1960) distinguished between *Malva* and *Lavatera* pollen on the basis of spine length (Table 3).

**5) *Senra incana* - type** (Fig.4 A - F; Fig. 7 F).

**Pollen class:** Pantoporate

**Table 3. Pollen characters in the species included Malva Parviflora-type**

Name of species	Diameter of grains $\mu\text{m}$	Pore diameter $\mu\text{m}$	Spine length $\mu\text{m}$	Exine thickness $\mu\text{m}$
<i>Malva nicaeensis</i> All	70.4 (78.2) 88	2.2	4.4	4.4
<i>M. neglecta</i> Wallr.	90.2 (97.6) 103	2	6.6	4.4
<i>M. microcarpa</i> Pers.	55.5 (57.2) 64.4	1.4	2.2	5.5
<i>M. parviflora</i> L.	64.9 67.2) 71.5	2.2	4.4	4.4
<i>M. verticillata</i> L. var rafiqii S.abedin	77(83.4) 91.3	2.2	5.5	6.6

**Shape:** Spheroidal

**Aperture:** Small and circular

**Exine:** Exine thick, sexine thicker or thinner than nexine rarely as thick as nexine.

**Ornamentation:** Echinate, spine long, conical, pointed, few spines slightly recurved at the apex, monomorphic or dimorphic, tectum punctate or sub-psilate with scabrae in between spines, basal cushion absent or  $\pm$  indistinct.

**Outline:** Circular

**Measurements:** Pollen diameter 69.10 (91.4  $\pm$  0.75) 111.3  $\mu\text{m}$ , pore diameter 3.31 (4.05  $\pm$  0.05) 6.6  $\mu\text{m}$ ; spine length 8.8 (17.9  $\pm$  7.1) 25.12  $\mu\text{m}$ , Exine 7.28 (7.99  $\pm$  0.98) 8.97  $\mu\text{m}$  thick.

**Comments:** *Senra incana* - type is characterized by its thick exine, 3 genera (*Lavatera*, *Senra* and *Urena*) each representing a single species are included in this pollen type. Although, these species are similar in exine thickness, but they differ in pollen grains diameter and spines morphology, as in *Senra incana* Cav., more than 100  $\mu\text{m}$  diameter of grains with monomorphic spines are found. While, *Lavatera cashemiriana* Lamb., and *Urena lobata* L. have dimorphic spines and pollen grains dimension is also less than 100 (60-97  $\mu\text{m}$ ). However, Culhane & Blackmore (1988) reported more than 100 (98-125) diameter of grains in other species of the genus *Lavatera* (Table 4).

**6) *Sida ovata* - type** (Fig. 5 & 6 A-F; Fig 7 E).

**Pollen class:** Pantoporate

**Table 4. Pollen characters in the species included in senra incana-type**

Name of species	Diameter of grains $\mu\text{m}$	Spines length $\mu\text{m}$	Exine thickness $\mu\text{m}$
<i>Lavatera cashemiriana</i> Lamb.	60(78.5)97	8.8(9.9)11	8.8
<i>Senra incana</i> Cav.	100.23 (106 $\pm$ 0.85) 111.3	25.13 7.18(7.99 $\pm$ 0.28)	8.37
<i>Urena lobata</i> L.	85.5(89.2)96.8	16.5	8.8

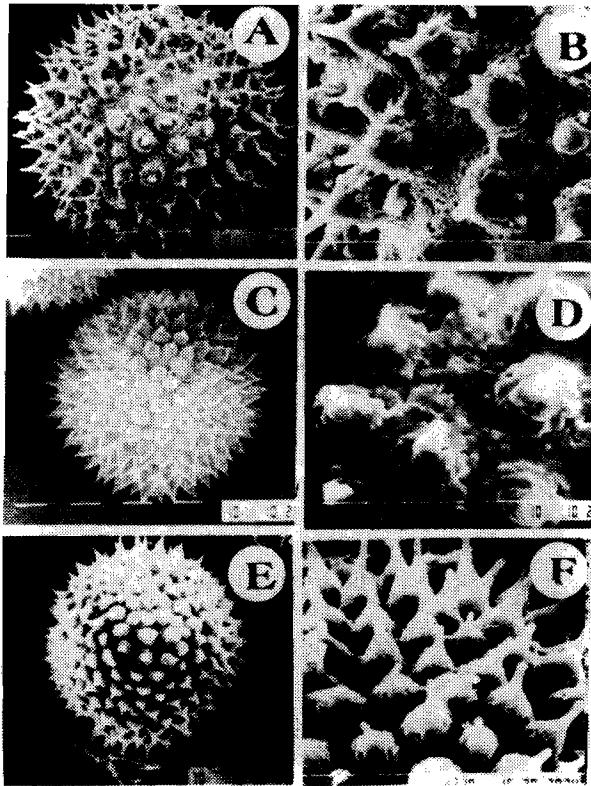


Fig.5. Scanning electron micrographs of pollen grains:

*Gossypium stocksii*: A, pollen grains; B, Exine pattern. *Malvastrum coromandelianuns*: C, pollen grains; D, Exine pattern, *Sida spinosa*: E, pollen grains; F, Exine pattern.

Scale bar = 10  $\mu$ m.

**Shape:** Spheroidal

**Aperture:** pores circular or elliptic often obscure.

**Exine:** Exine thick, sexine as thick as nexine or thinner than nexine.

**Ornamentation:** Echinate long, tapering ends, few spines with recurved apices, spines monomorphic or dimorphic with distinct spine base, tectum medium-finely perforated or punctate; rarely reticulate-rugulate with granules or scabrae in between spines.

**Outline:** Circular

**Measurements:** Pollen diameter  $49.5 (80.5 \pm 1.44) 100.5 \mu\text{m}$ , pore diameter  $2.2 (6.73 \pm 0.33) 7.18 \mu\text{m}$ , spine length  $2.3 (7.2 \pm 0.03) 7.53 \mu\text{m}$ , Exine  $2.2 (4.74 \pm 0.44) 7.18 \mu\text{m}$  thick.

**Comments:** This pollen type is readily recognized by its large distinct perforated often gamete spine base. Three genera viz., *Gossypium*, *Malvastrum* and *Sida* are included in this pollen type. *Sida ovata* - type shows their resemblance to the *Abutilon*

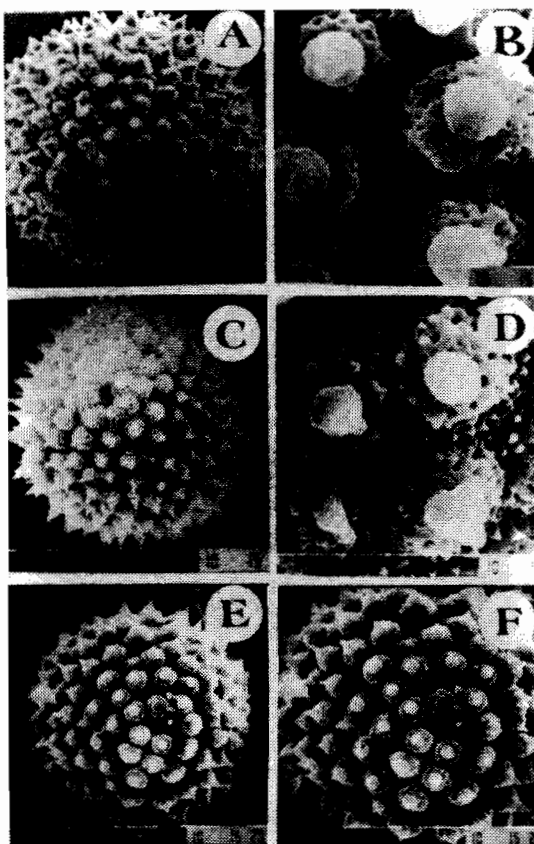


Fig.6. Scanning electron micrographs of pollen grains:

*Sida ovata*: A, pollen grains; B, Exine pattern, *Sida tiagii*: C, pollen grains; D, Exine pattern, *S. cordata*: E, pollen grains; F, Exine pattern.

Scale bar = 10  $\mu\text{m}$ .

*indicum* - type (both have distinct spine base). However, the latter type differs by having isopolar, 3-4 zonoporate pollen; while in the *Sida ovata* - type apolar, pantoporate grains are commonly found.

On the basis of spine length two distinct subgroups are recognized viz., *Sida cordata* subgroup and *S. alii* subgroup. In *Sida alii* subgroup spines are less than 5  $\mu\text{m}$  in length, which includes the taxa like, *Sida ovata* Forsk, *S. tiagii* Bhandari, *S.cordifolia* L., *S.yunnanensis* Hu, and *Gossypium stocksii* Mast. However, in this subgroup *Gossypium stocksii* Mast., is easily separated by its reticulate - rugulate interspinal surface while, in the remaining species perforated - punctate often subpsilate interspinal tectum is observed. In *Sida cordata* subgroup pollen grains have more than 5  $\mu\text{m}$  long spines. This subgroup comprises species of two genera i.e., *Malvastrum* {*M.coromendelianum* (L.) Garcke and *Sida* {*S.cordifolia* L. and *S.cordata*

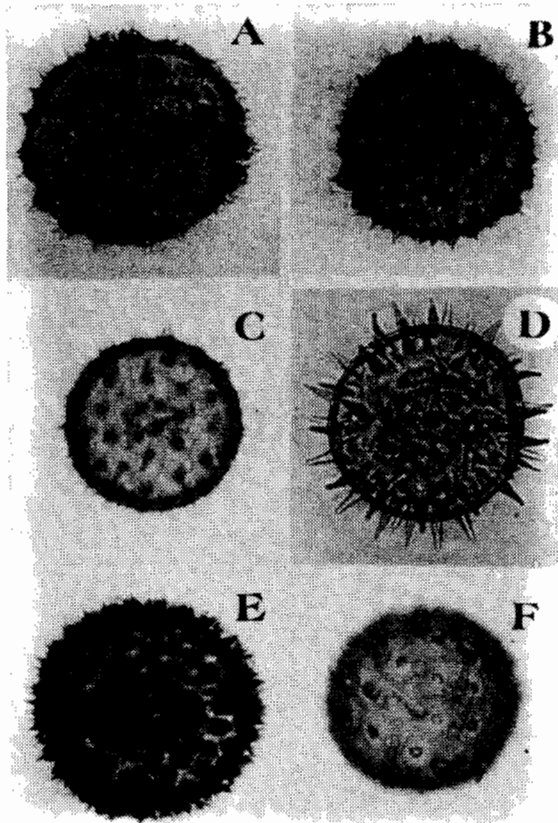


Fig.7. Light micrographs (L.M) of pollen grains:

*Abutilon fruticosum*: A, Pollen grains. *A. hirtum*: B, pollen grains. *Hibiscus aristivalvis*: C, pollen grains. *Hibiscus micranthus* D, pollen grains. *Malvastrum coromendelianum*: E, pollen grains. *Senra incana*: F, pollen grains, All figures = 400x.

(Burm.f.) Bors. Similarly, *Grossypium stocksii* subgroup species of the genus *Sida* are easily separated by their gammate spine base, while in the genus *Malvastrum* (*M.coromendelianum* (L.) Garcke) pollen grains have perforated spines base (Table 5).

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**Table 5. Pollen characters in the species included in *Sida ovata* type**

Name of Species	Pollen diameter $\mu\text{m}$	Pore diameter $\mu\text{m}$	Spine length $\mu\text{m}$
<i>Gossypium stocksii</i> Mast.	71.8(78.9 $\pm$ 1.45)89.7	+ obscure	3.6(3.69 $\pm$ 0.05)3.94
<i>Sida alii</i> S.Abedin	55(60.5)67.9	5.5	4.4
<i>S.cordata</i> (Burm.f.)Bors	49.5(63.25)77	3.3(3.85)4.4	5.51
<i>S.cordifolia</i> L.	71.8 (76.4 $\pm$ 1.88)89.9	3.61	7.18(7.21 $\pm$ 0.03)7.53
<i>S.ovata</i> Forssk.	75.39(80.55 $\pm$ 1.71)86.61	7.18	3.23(3.44 $\pm$ 0.09)3.94
<i>S.spinosa</i> L.	59.4(69.39)79.2	3.3 (3.85) 4.4	3.31
<i>S.tiagii</i> Bhandari	78.98(82.74 $\pm$ 1.14)100.5	3.23(4.72 $\pm$ 0.77)7.4	3.23(3.48 $\pm$ 0.005)3.59
<i>S.yunnanensis</i> Hu	51.7(57.2)62.7	2.21	4.41
<i>Mabustrum coromendelianum</i> (L.) Garcke	68.12(77.7 $\pm$ 1.48)82.57	5.7(6.73 $\pm$ 0.33)7.18	6.89(7.14 $\pm$ 0.11)7.18

## Appendix

TAXA	LOCALITY	COLLECTOR
<b>MALVACEAE</b>		
<i>Abelmoschus crinitus</i> Wall.	Near Bejnath Distt. Kangra	H.K.Rawal Chand s.n. (KUH)
<i>Abutilon alii</i> S. Abedin	Near C.D.R.I., University Campus, Karachi.	Sultan-ul Abedin 5372 (KUH) Sultan-ul Abedin 5376 (KUH)
	-do-	
<i>A. bidentatum</i> A.Rich.	Between Islamkot & Nagar Parkar	M.Qaiser, A.Ghafoor & Abrar Hussain s.n. (KUH)
	Marghi Band, S.Waziristan Agency	S.Ayub Shah Gailani s.n. (KUH)
	Karachi Distt.: Mangopir	S.Abedin & M.Qaiser 5685 (KUH)
<i>A. fruticosum</i> Guill. & Pers.	Yaseen Abad Graveyard, Dastgir, Karachi.	Rizwan Yusuf 43 (KUH)
<i>A. figarianum</i> Webb.	Sonmiani	Sultan-ul Abedin 3694 (KUH)
	-do-	S.A.Farooqi & S. Abedin 1223 (KUH)
<i>A. hirtum</i> (Lamk.) Sweet	Memmon Goth	Anjum Perveen 162 (KUH)
	-do-	Anjum Perveen 163 (KUH)
<i>A. indicum</i> (L.) Sweet	Darsano-Chano	Anjum Perveen 161 (KUH)
	Near Biological Research Centre	Anjum Perveen 325 (KUH)
<i>A. muticum</i> (Del. ex DC.) Sweet	Botany Dept., University Campus, Karachi	Anjum Perveen 67 (KUH)
	Darsano-Chano	S. Abedin & A. Ghafoor 1341 (KUH)
<i>A. karachianum</i> S.A.Hus. & S.R.Baq.	Dathana Malir, 3 miles from Malir on way to Darsano Chano Memon Goth, Karachi	S.Abedin 5414 (KUH) S.Abedin 5486 (KUH)
	Bela Distt. Sonmiani	S. Abedin 5517 (KUH)
<i>A. pakistanicum</i> Jafri & Ali	Sonmiani	S.I.Ali & S.Abedin 697 (KUH)
	1 mile from Sonmiani on way to Karachi	S.Abedin 3695 (KUH)
<i>A.theophrastii</i> Medic	Rest House, Booni Chitral Dist. near Rest House, Booni	S.Abedin 8045 (KUH) S.Abedin 8039 (KUH)
<i>Althaea ludwigii</i> L.	C.8 miles before Nag, Panjgur - Nag Rd. Khuzdar Distt.: 3 miles from Basima on way to Surab.	S.Abedin & Abrar Hussain 6830 (KUH) S.Abedin & Abrar Hussain 6951 (KUH)
<i>Gossypium stocksii</i> Mast.	University Campus, Karachi.	Abrar Hussain s.n. (KUH)
<i>Hibiscus aristivalvis</i> Garcke	University Campus, Karachi.	Anjum Perveen 131 (KUH)



## Cont'd (Appendix)

TAXA	LOCALITY	COLLECTOR
<i>H. caesius</i> Garcke	15 miles from Nowshera on way to Talagang	M.Qaiser 2706 (KUH)
	7 miles from Pail on way to Khushab	M.Qaiser & S.A.Farooqi 2747 (KUH)
<i>H. lobatus</i> (J.A.Murray) O.Ktze.	Sakesar	Iftikhar Ahmed D (KUH)
	Rawalpindi Distt.Topi Park	R.R.Stewart 21379 (KUH)
<i>H. micranthus</i> L.f.	Applied Physics Dept., University Campus, Karachi	Abrar Hussain s.n. (KUH)
<i>H. obtusilobus</i> Garcke	Between Malir Halt & Kala Board Qasim Garden, Bela	Abrar Hussain s.n. (KUH)
		Sultanul Abedin
<i>H. trionum</i> L.	Kharawallas between Zhob & Shighar	Tahir Ali & Tufail Ahmed 1104 (KUH)
	Hazara Distt., Shogran near Forest Rest House	S.Abedin & M.Qaiser 8803 (KUH)
<i>Lavatera cashmiriana</i> Camb.	Pashmal, 52 miles from Mingora on way to Kalam, Kala Bagh, 2 miles from Nathiagali on way to Abbottabad	S.Abedin 8372 (KUH)
		S.Abedin 7656, 7660 (KUH)
<i>Malva microcarpa</i> Pers.	Lawrence garden, on hill, Lahore Punjab, Gujranwala dist. 65 miles from Lahore, on way to Rawalpindi	S.A.Farooqi 2280 (KUH)
		S.Abedin 7951 (KUH)
<i>M. mohileviensis</i> Downar	University Orchard Quetta	S.Khattoon & Mola Baksh 507 (KUH)
	Quetta dist. 5700 ft.	R.R.Stewart 28187 (KUH)
<i>M. neglecta</i> Wallr.	Herboi hills: Bundkhi c.9 Km. east, N.E. of Kalat on way to Johan 15-20 miles from Chilas on way to Babusar ± 6500-7000'	A.Ghafoor & S.M.Goodman 5175 (KUH)
		S. Omer & M. Qaiser 2608 (KUH)
	Sibi dist. near Governor's House Ziarat	M.Qaiser & S.Abedin 3325 (KUH)
<i>M. nicaeensis</i> All.	Abbotabad	M.Qaiser & S.Abedin 5655 (KUH)
	Hazara dist., Abbotabad	S.Abedin 2893 (KUH)
<i>M. parviflora</i> L.	Near Locust Station Panjgur	S.Abedin & Abrar Hussain 6627, 6629 (KUH)
	18 miles from Wad on way to Bella	S.Abedin & Abrar Hussain 7272 & 7273 (KUH)
<i>M. verticillata</i> var. <i>rafiqii</i> S.Abedin	Utror (Swat)	S.Abedin 8454 & 8466 (KUH)

## Cont'd (Appendix)

TAXA	LOCALITY	COLLECTOR
<i>Malvastrum coromandelianum</i> (L.) Garcke	University Campus, Karachi.	Inside Plant Protection Dept. Anjum Perveen 82 (KUH) Bashir Ahmed s.n. (KUH)
<i>Pavonia arabica</i> Hochst.	Near Dean Science office, Karachi University Campus. Karachi - Mangopir	Jafri 1515 (KUH) Abrar Hussain s.n. (KUH)
<i>P. glechomaefolia</i> (A.Rich.) Gracke	Memon Goth, Malir, Karachi Tharparker dist. Nagar Parker hill	M.Qaiser & A.Ghafoor 4039 (KUH)
<i>P. grevioides</i> Hochst. ex Boiss.	Karachi dist.: University Campus	S.Abedin & Abrar Hussain 3802 5772-3 (KUH)
<i>P. procumbens</i> (W. & A.) Walf.	On way to Darsano-Chano 2,1/2 miles from Karachi on way to Bela	Anjum Perveen 165 (KUH)
<i>P. zeylanica</i> (L.) Cav.	Lasbela	Sultabul Abedin 37110 (KUH) S.F.Hassan 19 (KUH)
<i>Sida alii</i> S.Abedin	Topi Park Jhelum dist. 3 miles from Choa Saidan Shah on way to Kalar.	R.R.Stewart 11058 (KUH) M.Qaiser 2812 (KUH)
<i>Sida cordata</i> (Burm.f.) Borss	Changa Manga Forest Changa Manga Lahore Muzaffarabad Dist.: 2 miles from Muzaffarabad on way to Abottabad Tharparker Dist., Chandon Bund, Nagar Parker	Saeed-ul Haq 1691 (KUH) S.Abedin 2618 (KUH) S.A.Farooqi & M.Qaiser 3156 (KUH)
<i>S. cordifolia</i> L.	Manghopir Near Cotton Committee Centre Building, Moulvi Tameezuddin Road, Karachi.	S.I.Ali, S.A.Farooqi & S.Abedin 4461 (KUH) Sultan-ul Abedin 5701 (KUH)
<i>S. ovata</i> Forssk.	Botany Deptt., University Campus, Karachi.	Abrar Hussain s.n. (KUH)
<i>S. spinosa</i> L.	Near Microbiology Deptt. K.Univ. Campus. miles from Hyderabad on way to Lahore near Miani Forest Thatta Dist.: 3 miles from Gharo on way to Keti Bunder. Karachi Dist.: Darsano Chano, Guava Garden	Anjum Perveen 89 (KUH) Abrar Hussain s.n. (KUH) S.Abedin 3915 (KUH)
<i>S. tiagii</i> Bhandari	Botany Deptt., University Campus, Karachi.	S.I.Ali, S.Abedin & A.Ghafoor 4148 (KUH) S.Abedin 12 (KUH) Anjum Perveen 92 (KUH)

## Cont'd (Appendix)

TAXA	LOCALITY	COLLECTOR
<i>S. yunnanensis</i> Hu	Vill.Kangar between Berar Kot and Muzaffarabad ± 3500'	M.Qaiser & A.Ghafoor 4880 (KUH)
	Vill.Sarwar, near Dulai dist. Muzaffarabad	M.Qaiser & A.Ghafoor 4964 (KUH)
	Hazara dist.: 12 miles from Nathiagali on way to Abbottabad	S.A.Farooqi & M.Qaiser 3429 (KUH)
<i>Senra incana</i> Cav.	Karachi University Campus	Anjum Perveen 56 (KUH)
<i>Urena lobata</i> L.	Near Chowk between Sarai Muhajir & Piplan. Muzaffarabad - Mianwali Rd.	A.Ghafoor & Tahir Ali 3755 (KUH)
	Punjab: Multan Distt. 4 miles from Pattoki on way to Multan.	M.Qaiser 3571 (KUH)

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