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POLLEN FLORA OF PAKISTAN - IV. BORAGINACEAE

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Abstract

Pollen morphology of 49 species representing 20 genera of family Boraginaceae from Pakistan has been examined by light and scanning electron microscope. Boraginaceae is a eurypalynous family and pollen morphology of the family is significantly important at tribal and subfamilial level, such as the tribes Eritrichieae and Cynoglosseae of subfamily Boraginoideae and subfamily Heliotropioideae, respectively, are characterized by heterocolpate pollen which is rare in angiosperm. However, in the other tribes of subfamily Boraginoideae (Trigonotideae and Lithospermeae except *Myosotis*) and subfamily Ehretioideae have homoaperturate pollen (colpate, colporate), ora mostly endocingulate, elliptic-rectangular in equatorial view, with or without constriction at the equator, circular or hexagonal in polar view. Tectum usually psilate or sub-psilate. However, combination of other tectum types i.e., reticulate-rugulate, fossulate or foveolate are also found.

On the basis of size, shape, apertural configuration and exine sculpturing 11 distinct pollen types viz., *Anchusa arvensis - type, Arnebia benthamii - type, Buglossoides arvensis - type, Ehretia obtusifolia - type, Gastrocotyle hispida - type, Heliotropium subulatum - type, Lindelofia longilfora - type, Nonea caspica - type, Onosma hispida - type, Sericostoma pauciflorum - type, Trichodesma indicum - type* are recognized.

Introduction

Boraginaceae is a large cosmopolitan family of about 154 genera and 2,500 species, distributed in temperate especially Mediterranean and tropical regions (Willis, 1973; Mabberley, 1987). The family is represented in Pakistan by 32 genera and 135 species, where *Cordia, Echium* and *Anchusa* are cultivated (Nasir, 1989).

Boraginaceae is readily recognized by the vegetative and floral characters. The family has been divided into various groups since it shows considerable variation in their floral and fruit characters. Hooker (1885) recognized four tribes viz., Cordieae, Ehretieae, Heliotropieae and Borageae, while Cronquist (1981) has accepted 5 subfamilies viz., Cordioideae, Ehretioideae, Heliotropioideae, Boraginoideae and Wellstedioideae.

Boraginaceae is a eurypalynous family (Clarke, 1977; Diez, 1984) in which a large number of species can be recognized by their pollen characters (Diez & Valdes, 1991). One of the first palynological studies in the Boraginaceae was that of Geoffery (see Erdtman, 1952). Later the pollen morphology of the family Boraginaceae has been studied by Erdtman (1952), Avestisian (1956); Bou (1968), Marticorena (1968), Huynh (1971, 1972), Nowicke & Ridgway (1973), Nowicke & Skvarla (1974), Díez (1984) and others. Gupta (1971) studied the pollen morphology of the family Boraginaceae from India. Harmata (1977) while studying the biochemistry of the genera *Symphytum* and *Procopiana* also studied the pollen of these genera. Pollen morphology of the family Boraginaceae from North-West Europe has been examined by Clarke (1977).

Nowicke & Skvarla (1974) described pollen morphology of the genus *Tournefortia* of the family Boraginaceae and divided the family into 4 pollen types, on the basis of shape, apertural type and exine pattern. The pollen of 33 species of family Boraginaceae from Iberian Peninsula belonging tc the tribes Eritrichieae and Cynoglosseae have been studied by Díez & Valdes (1991).

Literature dealing with the Boraginaceae pollen from Pakistan is scarce. However, at generic level, pollen morphology of 3 genera of Boraginaceae from Pakistan viz., *Heliotropium* (Qureshi, 1988), *Onosma* (Qureshi & Qaiser, 1987) and *Arnebia* (Qureshi *et al.*, 1988) have been reported. The present report gives an account of the palynological data based on 49 species representing 20 genera of the family Boraginaceae from Pakistan which should be helpful for interpreting the tribal and subfamilial classification.

Materials and Methods

Pollen samples were obtained from Karachi University Herbarium (KUH) or collected from the field. A list of specimens investigated is given in Appendix 1. 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 (E100,1.25) using 10x eye piece. For SEM studies acetolysed pollen grains suspended in distilled water were transferred with a fine pipette on to the sticky surface of double adhesive cellotape stuck on a metallic stub; then coated with gold, in a sputtering chamber (Ion-sputter JFC-1100). Coating was restricted to 15°A. S.E.M examination was carried out by Jeol microscope. The measurements are based on 15-20 readings from each specimen. Pollen diameter, polar axis (P) and equatorial diameter (E), colpus length, apocolpium, mesocolpium and exine thickness were measured under light microscope.

The terminology used is in accordance with Erdtman (1952), Kremp (1965), Faegri & Iversen (1964) and Walker & Doyle (1975).

General Pollen characters of the Family Boraginaceae

Pollen grains usually radially symmetrical, isopolar, rarely heteropolar, prolate to sub-prolate, rarely oblate - spheroidal to prolate - spheroidal or spheroidal, colporate or colpate mostly heterocolpate, heterocolpate grains are rectangular or dumb - bell shaped, with or without constriction at the equator, more or less circular or hexagonal in polar outline, pseudocolpus generally longer than colporus, endoaperture circular or la-longate, ora mostly forming endocingulum in heterocolpate pollen. Sexine thicker or thinner than nexine or mostly obscure in heterocolpate grains. Tectum commonly psilate to sub-psilate rarely reticulate or striate - rugulate, or scabrate often foveolate - fossulate or fossulate-rugulate.

In the present study on the basis of polarity, size, shape, apertural types and tectal surface, 11 distinct pollen types are recognized viz., *Anchusa arvensis - type, Arnebia benthamii - type, Buglossoides arvensis - type, Ehretia obtusifolia - type, Gastrocotyle*

hispida - type, Heliotropium subulatum - type, Lindelofia longiflora - type, Nonea caspica - type, Onosma hispida - type, Sericostoma pauciflorum - type, Trichodesma indicum - type.

Key to the pollen types

1 + Pollen grains homo-aperturate ---------- 2
- Pollen grains hetero-aperturate ---------- 10

2 + Pollen grains colpate ----------*Sericostoma pauciflorum type*
- Pollen grains colporate ---------- 3

3 + Each colpus with 2 ora ---------- *Arnebia benthamii type*
- Each colpus with single ora ---------- 4

4 + Pollen grains 3-colporate ---------- 5
- Pollen grains 4-6-colporate ---------- 7

5 + Pollen grains prolate, tectum fossulate - foveolate ------- *Anchusa arvensis-type*
- Pollen grains prolate-spheroidal to sub-prolate, often sub-oblate or spheroidal, tectum scabrate, rarely foveolate ---------- 6

6 + Pollen grains heteropolar 14.3-17.8 μm in polar length -- *Onosma hispida-type*
- Pollen grains isopolar, 19.6-26.6μm in polar length-- *Trichodesma indicum-type*

7 + Pollen grains 6 - colporate ---------- 8
- Pollen grains 4-5 colporate ---------- 9

8 + Tectum psilate to subpsilate ---------- *Buglossoides arvensis-type*
- Tectum striate - rugulate or reticulate - rugulate ------ *Ehretia obtusifolia - type*

9 + Tectum reticulate, ora with endocingulum ---------- *Nonea caspica - type*
- Tectum fossulate-foveolate, ora without endocingulum ---------- *Gastrocotyle hispida-type*

10 + Pollen grain not constricted at the equator in equatorial view, ora not forming endocingulum ----------*Heliotropium subulatum -type*
- Pollen grains constricted at the equator in equatorial view, ora forming mostly endocingulum ----------*Lindelofia longiflora - type*

Description of pollen types

Anchusa arvensis - type

Pollen class: 3 - colporate, zonoaperturate.

P/E ratio : Erect

Shape: Prolate

Aperture: Ectoaperture - medium, not sunken, colpi ends acute, Endoaperture-elliptic, la-longate.

Exine: Sexine as thick as nexine or not differentiated.

Ornamentation: Tectum fossulate-foveolate, colpal membrane granulated.

Outlines: Equatorial view - Elliptic - rectangular. Polar view circular, rarely subangular.

Measurements: Polar axis (P) 36 (41) 44 μm, Equatorial diameter (E) 26 (29) 31 μm, colpi length 22 μm. Apocolpium 44 μm. Exine 0.2.2 - 2.5 μm thick.

Comments: A single species, i.e., *Anchusa arvensis* (L.) M. Bieb. is included in *Anchusa arvensis* - type. This species is characterized by having 3-colporate, zonoaperturate pollen, with foveolate - fossulate tectum (Clarke, 1977).

Arnebia benthamii - type (Fig.1 A-C).

Pollen class: 4-6 - colporate rarely 7 - colporate, zonoaperturate 2 ora per colpi.

P/E ratio: Per erect - erect.

Shape: Prolate to perprolate

Apertures: Ectoaperture long, narrow not sunken. Endoaperture 2 ora per colpi.

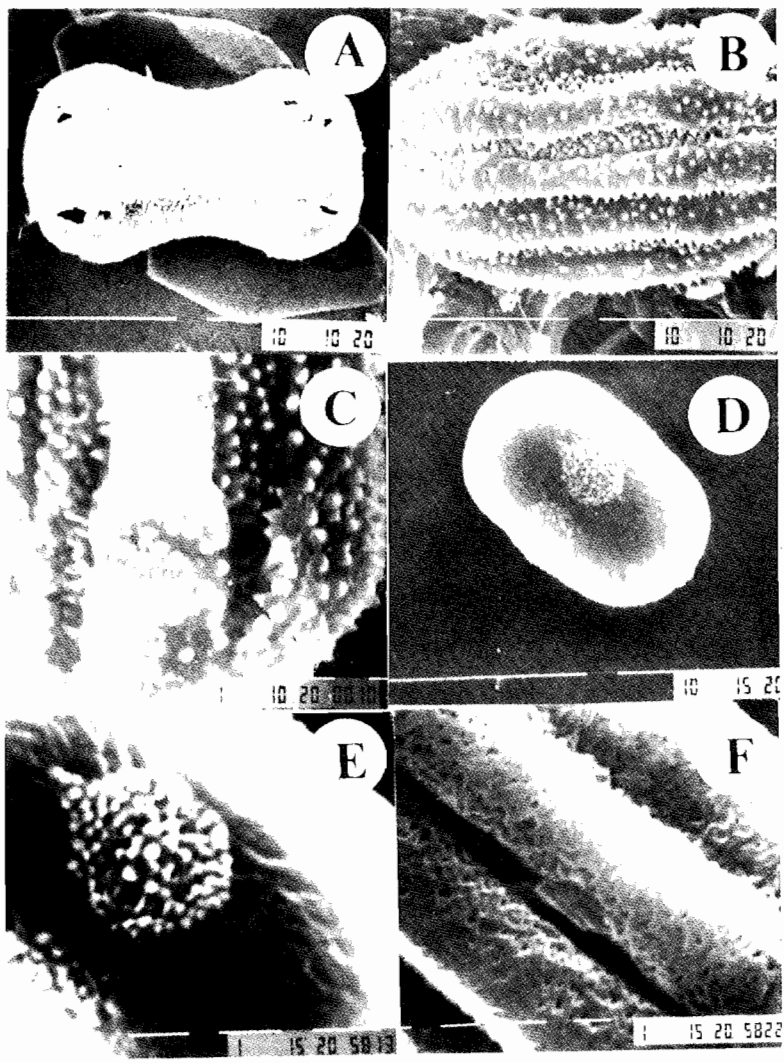

Fig. 1. Scanning electron micrographs (S.E.M.) of the pollen grains. *Arnebia euchorma*: A, Equatorial view. *A. hispidissima*: B, Equatorial view; C, Exine pattern. *Buglossoides arvensis*: D, Equatorial view; E, Exine pattern. *Ehretia laevis*: F, Exine pattern.

Scale bar (A, B & D) = 10 μm; (C, E, F) = 1 μm.

Exine: Sexine and nexine not differentiated.
Ornamentation: Tectum areolate or echinate, colpal membrane verrucate or echinate.
Outlines: Equatorial view - equatorial outline constricted oval, and constricted rectangular. Polar view - 4 - 7 lobed, circular.
Measurements: Length (L) 21.1 (36.40) 55.0 μm, breadth (B) 10.0 (-21) 28.6 μm, colpus length (C) 19.8 - 49.5 μm. Mesocolpium 4.4 - 12.6 μm. Apocolpium 1.6 - 5.5 μm. Exine 1.7 - 3.3 μm thick. P/E ratio 1.46 - 2.20 μm.

Key to the species

1	+	Tectum echinate	2
	-	Tectum psilate	3
2	+	Colpi lenght 24.2 μm	*A. hispidissima*
	-	Colpi lenght 69.8 μm	*A. guttata*
3	+	Mesocolpium 11 - 12.1 μm	4
	-	Mesocolpium 4.4 - 7.7.	6
4	+	Colpi C. 49.5 μm long	*A. inconspicua*
	-	Colpi 26.4 - 33.8 μm long	5
5	+	Polen grains prolats	*A. decumbens*
	-	Polar view 4 - 10 lobed, oval-rectangular in equatorial view Pollen grain Reoprolate	*A. fimbriopetala*
6	+	Polar length 28.6 - 34.1	*A. euchroma*
	-	Polar length 35 - 44.0	7
7	+	Apocolpium 1.8 μm	*A. griffithii*
	-	Apocolpium c. 5.5 μm	*A. linearifolia*

Comments: *Arnebia benthamii* - type is easily recognized by its distinct apertural type i.e., two ora per colpi. Similar type of grains in the genus *Arnebia* have also been reported by Huynh (1971); Ben Saad-Liman & Nabli (1982) and Qureshi *et al.*, (1989). Only a single genus *Arnebia* is included in this pollen type. However, species of this genus show little variation in their tectum type such as, in *Arnebia guttata* Bunge and *Arnebia hisipdissima* (Lehm.) A. DC., tectum is echinate, while in *Arnebia benthamii* (Wall. ex G.Don) I.M.Johnston,*A. decumbens* (Vent.) Coss. & Kark., *A. euchroma* (Royle ex Benth.) I. M. Johnston, *A. fimbriopetala* Stock, *A. griffithii* Boiss., *A. inconspicua* (Hemsl. & Lace) I. M. Johnston, *A. linearifolia* A.DC., psilate to sub-psilate tectum is observed. However, these species are further classified on the basis of polar length, colpi length, apocolpium and mesocolpium (See Key to the species, (Table 1).

The presence of two endoapertures per ectoapertures has also been reported in other families, for instance in Didymelaceae and Euphorbiaceae (Erdtman, 1952); Myoporaceae, Primulaceae, Scrophulariaceae and Grossulariaceae (Verbeek-Reuvers, 1976).

Buglossoides arvensis - type (Fig.1D & F).
Pollen class: 6-colporate, zonoaperturate.
P\E ratio: Erect.
Shape: Prolate.
Apertures: Ectoaperture - small, not sunken, end acute. Endoaperture - la-longate, ora

Table 1. Pollen characters in the species included in *Arnebia benthamii*-type.

Name of taxa	Shape	P/ Eratio	Length in μm	Breadth in μm	Colpus length in μm	Apertures in μm	Mesocolpium in μm	Apocolpium in μm	Exine thichness	Tectum
Arnebia benthamii (Wall. ex. G. Don) I.M.Johnston	prolate	1.57	21.0(22.0) 24.0	11.0(14.0) 15.0	21.0	5	7.7	1.7	1.7	psilate
A. euchroma (Royle ex. Benth.) I.M.Johnston	perprolate	2.03	28.6(31.3) 34.1	12.1(15.4) 17.6	25.3	5	5.5	4.4	2.2	psilate
A. hispidissma (Lehm.) A. DC.	prolate peprolate	1.55	21.0(28.0) 30.0	10.0(18.0) 23.0	24.2	6	5.5	4.4	1.9	Echinate
A. guttata Bunge	prolate	1.58	24.0(27.0) 30.0	14.0(17.0) 19.0	19.8	6	4.4	2.8	2.2	Echinate
A. decumbens (Vent.) Coss & Krak	prolate	1.81	33.0(35.2) 4.8	18.7(19.4) 22.0	26.4	5	11.0	1.6	3.3	psilate scabrate
A. fimbriopetala Stocks	perprolate	1.61	27.0(34.0) 46.0	17.0(21.0) 25.0	33.0	4	11.0	1.6	3.3	psilate
A. griffithii Boiss	perprolate	2.20	35.0(41.0) 43.0	14.0(18.0) 21.0	3.0	4	6.6	1.8	1.1	psilate
A. linearifolia A.DC.	prolate	1.46	37.0(41.0) 44.0	27.0(28.0) 29.	27.5	5	6.6	5.5	2.2	psilate
A. inconspicua (Hemsl. & Lace) I.M.Johnston	prolate	1.89	40.7(50.9) 55.0	24.2(28.0) 28.6	49.5	5	12.1	2.2	3.3	psilate

operculate, scabrate operculum, with granules around the colpi.
Exine: Sexine as thick as nexine.
Ornamentation: Psilate, colpal membrane granulated.
Outlines: Equatorial view - rectangular with slightly constricted at the equator. Polar view - more or less circular or hexagonal.
Measurements: Polar axis (P) 14.3 (15.4) 16.5 μm, and equatorial diameter (E) 8.8 (9.7) 11 μm, colpus length 8.8-9.9 μm, ora 2.2-5.5 x 1.1-5.5 μm in size. Mesocolpium 4.4-5.5 μm, P/E ratio: 1.51-1.61, P.A.I. 1.70-2.12.

Key to the species

1 + Ora 2.2x1.1 μm in size ---------- ***B. arvensis***
\- Ora 5.5x5.5 μm in size ----------***B. tenuiflora***

Comments: ***Buglossoides arvensis*** - type is characterized by having 6-colporate (Homoaperturate) pollen with psilate tectum. Pollen of ***Buglossoides arvensis*** - type is more or less similar to that of the *Lindelofia longiflora* - type in several characteristic features, such as la-longate ora, granules around the colpi and pollen grains constricted at the equator in equatorial view. However, the latter type differs in having heteroaperturate (heterocolpate) pollen grains.
Ehretia obtusifolia - type (Fig.1 F; Fig.2 A & B).
Pollen class: 6-colporate, zonoaperturate, rarely 8-colporate.
P/E ratio: Suberect to semierect
Shape: Sub-prolate to prolate-spheroidal
Apertures: Ectoaperture-long not sunken, ends acute. Endoaperture ± elliptic, ora la - longate.
Exine: Sexine thicker than or as thick as nexine.
Ornamentation: striate - rugulate or reticulate - rugulate, colpal mambrane granulated.
Outlines: Equatorial view-Elliptic pole side slightly obtuse, isopolar. Polar view-triangular 6-8 - lobed.
Measurements: Polar axis (P) 25.25 (27.95) 29.7 μm, and equatori al diameter (E) 17.75 (22.7) 26.4 μm. P/E ratio 1.23-1.28, colpus length 20-22 μm. Mesocolpium 10-11 μm. Apocolpium 0.5 μm often obscure. Exine 2.2 μm thick. P.A.I. 2.16-2.18.

Key to the species

1 + Tectum striate-rugulate ---------- ***E. obtusifolia***
\- Tectum reticulate-rugulate ---------- ***E. laevis***

Comments: *Ehretia obtusifolia* - type is characterized by its 6-colporate rarely 8-colporate grains with striate-rugulate or reticulate-rugulate tectum. A single genus *Ehretia* is included in this type. *Ehretia obtusifolia* - type has some resemblance to the *Buglossoides arvensis* - type (both the types have 6-colporate, zono-aperturate grains). However, latter type differs in number of features, like la - longate ora, with granules around the colpi and psilate tectum, and grains are constricted at the equator in equatorial view, while *Ehretia obtusifolia* - type has la-longate ora with colpal margins non-granulated and grains are unconstricted at the equator in equatorial view. The two

species of this pollen type are easily delimited by their tectal surface (see key to the species). Gupta (1971) reported 3-colporate grains in the genus *Ehretia*.

Gastrocotyle hispida - type (Fig.2C).

Pollen class: 5-colporate, zonoaperturate

P/E ratio: Erect

Shape: Prolate.

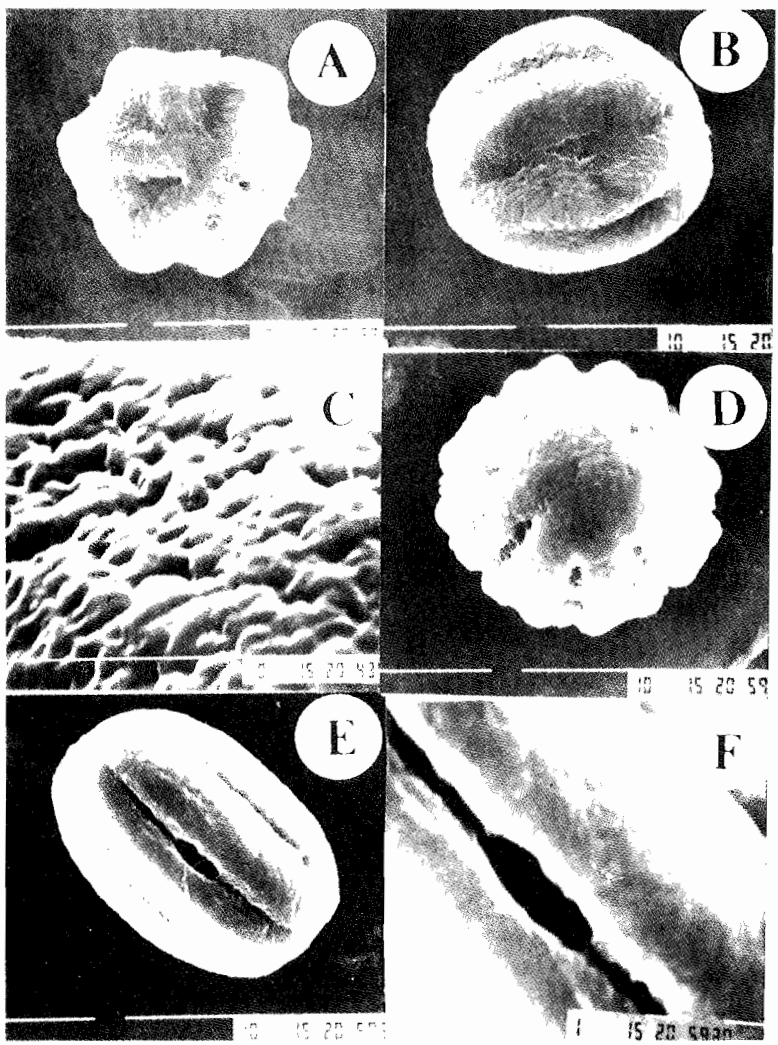

Fig. 2. Scanning electron micrographs (S.E.M.) of the pollen grains. *Ehretia obtusifolia*: A, Polar view; B, Equatorial view. *Gastrocotyle hispida*: C, Exine pattern. *Heliotropium bacciferum*: D, polar view. *H. alii*: E, Equatorial view; F, Exine pattern.

Scale bar (A-E) = 10 μm; F = 1 μm.

Apertures: Ectoapertures - long, narrow acute ends. Endoaperture, la-longate, elliptic.
Exine: Sexine as thick as nexine.
Ornamentation: Tectum fossulate-foveolate.
Outlines: Equatorial view - Elliptic rectangular. Polar view 5 lobed ± circular.
Measurements: Polar axis (P) 31.9 (34.1) 36.3 μm and, Equatorial diameter (E) 24.2 (25.3) 28.6 μm, colpi length 27.5 μm, ora 6.6x3.3 μm in size. Mesocolpium c 12.1μm. Apocolpium c. 6.6 μm. Exine c. 3.3 μm thick. P.A.I. 2.09.
Comments: *Gastrocotyle hispida* - type is easily delimited by having 5 - colporate, zonoaperturate pollen. The only species belonging to this type is *Gastrocotyle hispida* (Forssk.) C.B. Clarke. Pollen grains of *Gastrocotyle hispida* - type are ± similar to the grains of *Nonea caspica* - type (Both the types have 4-5 - colporate pollen). However, *Nonea caspica* - type has reticulate tectum.

Heliotropium subulatum - type (Fig.2 D - F; Fig.3 A-C; Fig.6 A-E).
Pollen class: 6-8 heterocolpate, zonoaperturate.
P/E ratio: Erect to suberect or semierect.
Shape: Prolate to sub-prolate or prolate-spheroidal.
Apertures: Ectoapertures pseudocolpus in general longer than colporus. Endoaperture circular, la - longate rarely la-longate.
Exine: Sexine as thick as or thicker or thinner than nexine.
Ornamentation: Tectum mostly subpsilate-psilate or rarely striate-rugulate or fossulate-rugulose or foveolate-fossulate.
Outlines: Equatorial view - Elliptic-rectangular, pole sides mostly obtuse. Polar view 6-8 lobed rarely 10-lobed ± circular.
Measurements: Polar axis (P) 16.8 (32.1) 48.8 μm, and equatorial diameter (E) 12.5 (22.4) 41.42 μm, colpus length (L) 14.3 (18.35) 23.81 μm, ora 2.2x7.7 μm in size. Mesocolpium 3.75 (11.7) 14.3 μm. Apocolpium 2.8 (10.75) 12.25 μm. Exine thickness 0.35 (2.87) 3.61 μm. P.A.I. 0.87-3.1.

Key to the Species

1	+	Pollen grains prolate to sub-prolate	2
	-	Pollen grains prolate-spheroidal	9
2	+	Tectum psilate to sub-psilate	5
	-	Tectum foveolate-fossulate or striate-rugulose	3
3	+	Tectum striate-rugulose	*H. ophioglossum*
	-	Tectum not as above	4
4	+	P/E ratio per erect, 1.17	*H. dasycarpum*
	-	P/E ratio erect 1.43	*H. rariflorum*
5	+	Polar length 39.6 ---- 48.4 μm	*H. supinum*
	-	Polar length 19.8 ---- 31.9	6
6	+	Mesocolpium 2.2 μm	*H. biannulatum*
	-	Mesocolpium 3.76 ----- 13.1 μm	7
7	+	Pollen grains sub-prolate	8
	-	Pollen grains prolate --*H. alii-group --(H. alii,H. remotiflorum,H. bacciferum)*	

8	+	Polar length 19.8 - 22 μm	*H. calcareum*
	-	Polar length 25.3 - 27.5 μm	*H. crispum*
9	+	Polar length 35 - 48.4	*H. strigosum*
	-	Polar length 18.2 - 34.8	10
10	+	Mesocolpium 5.8 - 7.2	11
	-	Mesocolpium 14.3 - 23.32	*H. subulatum*
11	+	Tectum sub-psilate, apocolpium 3.61 - 4.32 μm	*H. europaeum*
	-	Tectum sub-psilate, scabrate, apocolpium 7 μm	*H. curassavicum*

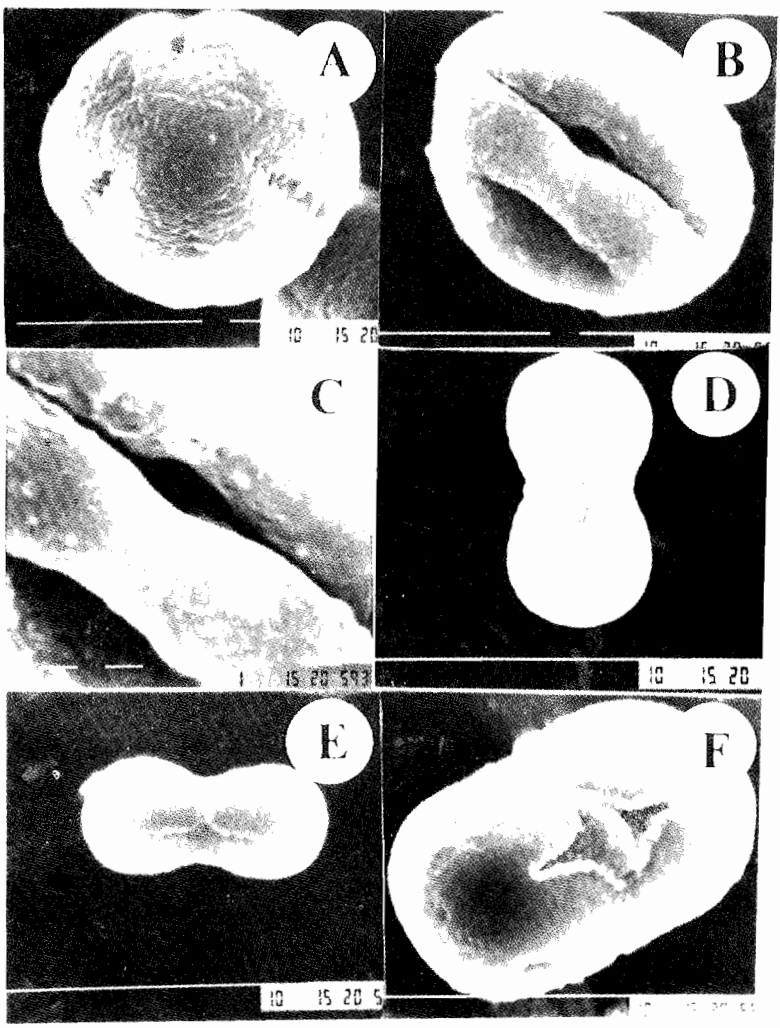

Fig. 3. Scanning electron micrographs (S.E.M.) of the pollen grains. *Heliotropium biannulatum*: A, Polar view; B, Equatorial view; C, Exine pattern. *Asperugo procumbens*: D, Equatorial view. *Paracaryum rugulosum*: E, Equatorial view. *Pseudomertensia neumorsa*: F, Equatorial view.
Scale bar (A & B, D-F) = 10 μm; C = 1 μm.

Comments: *Heliotropium subulatum* - type is easily delimited by having 6-10-heterocolpate pollen, without constriction at the equator in equatorial view (Qureshi, 1985). Similar type of heterocolpate pollen grains are also found in *Lindelofia longiflora* - type but in latter type ora forming, endocingulum and pollen with constriction at the equator. The heterocolpate pollen grains are rather rare in angiosperms. Pseudocolpi or colpi are generally longer than compound aperture (colporus). According to Díez & Valdes (1991) the heterocolpate pollen grains occur only in tribes Eritricheae and Cynoglosseae of the subfamily Boraginoideae and in the subfamily Heliotropioideae. Present finding also confirms the above idea because the genus *Heliotropium* and many genera of *Lindelofia longiflora* - type belong to the subfamilies Boraginoideae and Heliotropioideae. A single genus *Heliotropium* representing 14 species is included in this pollen type. Although these species are similar in apertural type but the variation in shape, size mesocolpium and tectum surface is significantly enough for differentiating the species from each other. However, one group i.e., *Heliotropium alii* - group is recognized which contains three species (see key to the species, Table-2).

Lindelofia longiflora-type (Fig.3 D-F).

Pollen class: 6-8 heterocolpate, zonoaperturate.

P/E ratio: Mostly erect rarely semi - erect or sub-erect often adequate.

Shape: Prolate to sub-prolate or per-prolate rarely prolate-spheroidal or spheroidal.

Apertures: Ectoaperture, simple ectocolpi are generally long and narrow than compound ectocopli (colpi without ora). Endoaperture, small, la-longate, operculate mostly forming endocingulum.

Exine: Sexine as thick as nexine or thicker than nexine.

Ornamentation: Psilate to sub-psilate or scabrate mostly granules around the colpi.

Outlines: Equatorial view - Elliptic or rectangular, mostly constricted at the equator in equatorial view. Polar view - circular or rectangular.

Measurements: Polar axis (P) 6.6 (26.8) 44 μm, and equatorial diameter (E) 4.4 (18.25) 30.8 μm, colpus length (L) 4.4-33.5 μm, ora 1.1-5.5x1.1-3.3 μm in size. Mesocolpium 2.2 (14) 24.2 μm. Apocolpium 1.1 (2.6) 3.3 μm or obscure. Exine 0.55 (2.75) 3.3 μm thick. P/E ratio: 1.00-1.90.

Key to species and species groups

1	+	Polar length 38.5-44 μm ---------- *Rochelia stylaris*
	-	Polar length 6.6-20.9 μm ---------- 2
2	+	Tectum scabrate ---------- 3
	-	Tectum psilate sub-psilate ---------- 4
3	+	Colpus length 9.9 μm, mesocolpium 6.6 μm -------- *Pseudomertensia echioides*
	-	Colpus length 11 μm, mesocolpium 4 μm ---------- *P. torllii*
4	+	Pollen grains spheroidal ---------- *Lindelofia anchusoides*
	-	Pollen grains prolate, per prolate or prolate-spheroidal ---------- 5
5	+	Polar length 6.6-8.8 μm ---------- 6
	-	Polar length 9.9-20.9 μm ---------- 7
6	+	Colpi length 4.4 μm ---------- *Myosotis arvensis*
	-	Colpi length 6.6 μm ---------- *Cynoglossum glochidiatum-group* (*Mattiastrum bungei, M. asperum, Paracaryum intermedia, Cynoglossum glochidiatum*)

Table 2. Pollen characters in the species included in *Heliotropium subulatum*-type.

Name of taxa	Shape	P/E ratio	Polar length (P) in μm	Equatorial diameter (E) in μm	Aperture	Colpus length in μm
H. alii Y. Nasir	prolate	1.53	27.6(28.1)32.9	12.5(16.7)28.7	6-heterocolpate	17.5(20.6)25.
H. bacciferum Forssk.	prolate	1.48	28.6(29.9)31.9	17.6(20.1)23.1	8-heterocolpate	c.19.8
H. biannulatum Bunge	prolate	1.47	24.2(28.3)31.9	15.4(19.27)23.1	6-heterocolpate	-
H. calcareum Stocks	sub-prolate	1.24	19.8(20.6)22	13.2(16.5)18.8	6-heterocolpate	c.16.5
H. crispum Desf.	sub-prolate	1.21	25.3(26.7)27.5	19.6(22)23	6-heterocolpate	c.19.8
H. dasycarpum Lede.	sub-prolate	1.17	28.1(25.8)28.5	20.4(21.8)24.2	6-heterocolpate	c.20.9
H. europaeum L.	prolate spheroidal	1.04	28.7(30.9)34.1	25.11(29.5)32.2	6-heterocolpate	c.21.5(23.3)30.72
H. curassaviaum L.	prolate	1.08	18.2(21.63)23.68	17.7(20.02)21.11	6-heterocolpate	16.8(19.04)21.23
H. ophioglossum Stocks. ex. Boiss.	prolate spheroidul	1.47	16.8(22.71)26.61	12.6(15.40)18.21	6-heterocolpate	18.21(20.70)23.81
H. subulatum (DC.) Valke.	prolate	1.09	19.7(24.6)28.72	19.7(22.5)25.12	6-heterocolpate	14.3(20.61)23.32
H. rariflorum Stocks	prolate	1.43	26.4(27.6)28.6	17.6(19.2)22	8-heterocolpate	c.25
H. remotiflorum Rech. & Riedl	prolate	1.36	19.8(23.8)26.4	13.2(17.3)19.8	6-heterocolpate	c.17.6
H. strigosum Willd.	prolate-	1.47	35.9(41.28)48.46	32.3(36.13)41.42	6-10-heterocolpate	25.21(29.01)35.9
H. supinum L.	prolate spheroidul	1.70	39.6(43.6)48.4	22(25.5)28.6	6-heterocolpate	-

Table 2 (Cont'd)

Name of taxa	Ora in μm	Mesocolpium in μm	Apocolpium in μm	Exine thickness in μm	Tectum
H. alii Y. Nasir	---	3.75(4.58)5.5	3.87	c.1.25	subpsilate
H. bacciferum Forssk.	4.4x7.7	c13.1	c.5.5	2.2-4.4	subpsilate
H. biannulatum Bunge	3.3x3.3	c.22	c.11	c2.2	sub-psilate
H. calcareum Stocks	3.3x3.3	5.5	c.3.3	c1.1	subpsilate
H. crispum Desf.	2.2x4.4	c.7.7	obscure	c.2.2	subpsilate
H. dasycarpum Lede.	2.2x3.3	c.9.9	obscure	2.2	fossulate-rugulose
H. europaeum L.	5.74(6.55)6.82	7.18(8.43)10.42	3.94	2.07	sub-psilate
H. curassaviaum L.	c.2.11	5.61(6.11)7.11)	c.7	0.70(1.19)1.41	sub-psilate
H. ophioglossum Stocks. ex. Boiss.	c.2.81	7.70(10.81)15.4	2.8	1.126(1.38)1.41	Striate-rugulose
H. subulatum (DC.) Valke.	3.61	14.3(17.90)21.5	16.1(21.01)25.11	0.35(2.28)2.59	sub-psilate
H. rariflorum Stocks	4.4x3.3	c.11	obscure	c.2.2	
H. remotiflorum Rech. & Riedl	3.3x3.3	14.3	c.3.3	c.1.7	sub-psilate
H. strigosum Willd.	3.21(3.55)5.5	4.71	3.91(7.74)10.7	3.8	sub-psilate
H. supinum L.	3.3x7.7	c.25.3	c.7.7	c2.2	sub-psilate fossulate

7 + Colpi length 10-13.2 μm -***Pseudomertensia moltkioides-group*** (*Pseudomertensia moltkioides, P. nemorosa, Rochelia bungei, Lappula spinocarpos, L. heterantha*).
- Colpi length 4.4-8.8 ---------- 8
8 + Mesocolpium 2.8-3.3 μm ---------- 9
- Mesocolpium 4.4-5.5 μm ---------- 10
9 + P/E ratio per erect ---------- ***Lindelofia longiflora***
- P/E ratio erect ---------- ***Mattiastrum howardii-group*** (*Mattiastrum howardii, Paracaryum rugulosum, Pseudomertensia parvifolia*).
10 + Polar length 9.9 μm ---------- ***Hackelia macrophylla***
- Polar length 9.9-12.1 μm ---------- ***Asperugo procumbens-group*** (*Asperugo procumbens, Eritrichium nanum, Lepechiniella microcarpa, Lindelofia stylosa, Lappula barbata*)

Comments: This pollen type is readily recognized by its heterocolpate, constricted grains at the equator in equatorial view, ora forming endocingulum. *Lindelofia longiflora* - type shows their resemblance to the *Heliotropium subulatum* - type because both have heterocolpate pollen. However, the *Heliotropium subulatum* - type has unconstricted grains at the equator and ora without endocingulum. Species of 12 genera are included in this pollen type, namely *Asperugo, Cynoglossum, Lindelofia, Hackelia, Lappula, Lepechiniella, Myosotis, Mattiastrum, Eritrichium, Paracaryum, Pseudomertensia* and *Rochelia*. The various species belonging to *Lindelofia longiflora* - type are difficult to differentiate, because the margins between species are too small to attempt an accurate separation. However, little variation is found in polar length, colpi length, size, shape and mesocolpium. On the basis of above pollen characters all the 24 species are divided into 4 groups i.e., *Cynoglossum glochidiatum* - group, *Pseudomertensia moltkioides* - group, *Mattiastrum howardii* - group, *Asperugo procumbens* - group and 7 species namely *Rochelia stylaris* Boiss., *Pseudomertensia echioides* (Benth.) Baill, *P. trollii* (Melch.) Stewart & Kazmi, *Lindelofia anchusoides* (Lindl.) Lehm, *Myosotis arvensis* (L.) Hill, *Lindelofia longiflora* (Benth.) Baill, *Hackelia macrophylla* (Brand) I.M. Johnston (see key to the species and species - groups, Table-3).

Nonea caspica - type (Fig.4 A & B).

Pollen class: 4-6-colporate, zonoaperturate.

P/E ratio: erect

Shape: Prolate.

Apertures: Ectoaperture - narrow, with acute ends. Endoapertures la-longate forming an endocingulum (reticulate).

Exine: Sexine as thick as nexine or not differentiated.

Ornamentation: Tectum finely-medium reticulate, with ± regular pattern of muri, lumina ± circular in shape, 0.016-0.166 μm in diameter.

Outlines: Equatorial view - rectangular, polar side obtuse. Polar view round-square 4-6 lobed.

Measurements: Polar axis (P) 36.3 (38.7) 40.7 μm, and equatorial diameter (E) 24.2 (27.2) 30.8 μm, colpus 16.8-18.7 μm long, endocingulum 5.5-7.7x4.4-5.5 μm in size. Mesocolpium 12.1-14.3 μm. Apocolpium c. 11 μm. Exine thickness 2.2-3.3 μm. P.A.I. 1.90-2.23.

Table 3. Pollen characters in the species included in *Lindelofia longiflora*-type.

Name of taxa	Shape	P/E ratio	Polar length (P) in μm	Equatorial diameter (E) in μm	Aperture	Colpus length in μm
Asperugo procumbens L.	prolate	1.83	11(11.33)12.1	5(6)7	6-heterocolpate	c.7.7
Eritrichium nanum (L.) Schrad.	prolate	1.59	9.9(10.5)11	6.6	6-heterocolpate	c.7.7
Lappula barbata (M. Bieb.) Gurke	per-prolate	2	11	4.4	6-heterocolpate	11
L. heterantha (Ledeb.) Gurke	prolate	2	11	5.5	6-heterocolpate	c.10
Lappula spinocarpos (Forssk.) Aschers & Kuntze	Perprolate	1.90	13.2(14.7)15.4)	7.7	6-heterocolpate	c.11
Cynoglossum glochidiatum Wall. ex Benth.	prolate	1.6	7.7	8.8	6-heterocolpate	c.6
Paracaryum rugulosum (DC.) Boiss.	sub-prolate	1.27	12.1(13.0)	9.9(10.2)11	6-heterocolpate	---
P. intermedium (Fresen) Lipsky	prolate	1.69	7.7(8.3)8.8	4.4(4.9)5.5	6-heterocolpate	---
Lepechiniella microcarpa (Boiss.) Riedl	prolate	1.22	11(11.7)12.1	8.8(9.5)9.9	6-heterocolpate	6.6
Lindelofia anchusoides (Lindl.) Lehm.	spheroi dal	1.00	11	11	6-heterocolpate	8.5
L. stylosa (Kar. & Kir.) Brand	sub-prolate	1.21	12.1	10	6-heterocolpate	8.8

Table 3 (Cont'd)

Name of taxa	Ora in μm	Mesocolpium in μm	Apocolpium thickness	Exine in μm	Tectum
Asperugo procumbens L.	5.6	c. 4.4	c. 2.2	c 1.1	psilate
Eritrichium nanum (L.) Schrad.		5.5	c. 1.1	---	psilate
Lappula barbata (M. Bieb.) Gurke	1.1x1.1	c. 4.4	c. 1.7	c. 1.1	sub-psilate
L. heterantha (Ledeb.) Gurke	1.1x1.1	c.5.5	c.1.7	c.1.1	psilate
Lappula spinocarpos (Forssk.) Aschers & Kuntze	2.2x2.2	c.4.4	3.3	c.1.1	sub-psilate
Cynoglossum glochidiatum Wall. ex Benth.	c.2.2x1.1	c-3.3	c-1.7	c-0.7	psilate
Paracaryum rugulosum (DC.) Boiss.	3.3x2.2	---	obscure	---	Psilate
P. intermedium (Fresen) Lipsky	2.2x.11	----	c.1.7	---	Subpsilate
Lepechiniella microcarpa (Boiss.) Riedl	---	5.5	c.2.2	c.1.7	Psilate
Lindelofia anchusoides (Lindl.) Lehm.	3.3x2.2	c.4.4	obscure	---	psilate
L. stylosa (Kar. & Kir.) Brand	3.3x2.2	c.4.4	obscure	---	psilate

Table 3 (Cont'd)

Name of taxa	Shape	P/E ratio	Polar length (P) in pm	Equatorial diameter (E) in μm	Aperture	Colpus length in μm
L. longiflora (Benth) Baill.	per-prolate	2.15	11	4.4(5.1)5.5	6-het-colpate	7.7
Mattiastrum asperum (Stocks) Brand	prolate	1.74	11(11.5)12.1	5.5(6.0)6.8	6-het-colpate	c.8.8
M. howardii Kazmi	prolate	1.73	9.9(10.4)11	5.5(6.6)6.6	6-het-colpate	c.8.8
M. bungei (Boiss.) Rech. S. & Ried	prolate	1.68	7.7(8.4)8.8	4.4(5.0)5.5	6-het-colpate	c.6.6
Myosotis arvensis (L.) Hill.	prolate-spheroidal	2.0	6.6	3.3	6-het-colpate	c.4.4
Hackelia macrophylla (Brand) I.M. Johnston	prolate	1.73	9.9	5.5(5.7)6.6	6-het-colpate	---
Pseudomertensia parvifolia (Decne.) Riedl	prolate	1.77	15.4(16.3)17.6	8.8(9.2)9.9	6-het-colpate	c.8.8
P. trollii (Melch.) Stewart & Kazmi	prolate	1.36	15.4(15.6)16.5	11(11.4) 12.1	6-het-colpate	c.11
P. echioides (Benth.) Riedl	prolate	1.55	14.3(14.8)17.8	8.3(9.5)9.9	6-het-colpate	9.9
P. moltkioides (Royle. ex Benth.) Kazmi	prolate	1.67	17.7(19.9)20.9	9.9(11.9)12.1	6-het-colpate	13.2
P. nemorosa (DC.) Stewart & Kazmi	prolate	1.65	16.5(17.4)18.7	11(10.5)12.1	6-het-colpate	c.11
Rochelia stylaris Boiss.	Prolate	1.42	38.5(40.2)44.026	4(28.3)30.8	6-het-colpate	c.38.5
R. bungei Trautv.	prolate	1.68	13.4(13.6)14.3	7.7(8.2)8.	6-het-colpate	11

Table 3 (Cont'd)

Name of taxa	Ora in in μm	Mesocolpium in μm	Apocolpium in μm	Exine thickness in μm	Tectum
L. longiflora (Benth) Baill.	c.4.4	---	---	—	psilate
Mattiastrum asperum (Stocks) Brand	c.2.8	c.2.2	---	—	psilate
M. howardii Kazmi	---	c.3.3	---	---	psilate
M. bungei (Boiss.) Rech. S. & Ried	c.3.3	c.1.7	—	---	psilate
Myosotis arvensis (L.) Hill.	2.2x1.5	c.2.2	—	---	subpsilate
Hackelia macrophylla (Brand) I.M. Johnston	---	c.3.3	obscure	c. 0.55	subpsilate
Pseudomertensia parvifolia (Decne.) Riedl	3.3x1.1	0.6	---	---	subpsilate
P. trollii (Melch.) Stewart & Kazmi	3.3x2.2	4	1.7	---	sub-psilate
P. echioides (Benth.) Riedl	4.4x2.2	6.6	obsure	c 1.1	scabrate
P. moltkioides (Royle. ex Benth.) Kazmi	5.5x3.3	8.8	c1.1	----	sub-psilate
P. nemorosa (DC.) Stewart & Kazmi	5.5x2.2	8.8	c.1.1	---	sub-psilate
Rochelia stylaris Boiss.	c.24.2	c.23.1	c.3.3	---	psilate
R. bungei Trautv.	2.2x1.1	5.5	2.2	c.1.1	psilate

Key to the species

1 + Mesocolpium 12.1 μm ---------- *N. caspica*
- Mesocolpium 14.3 μm ---------- *N. pulla*

Comments: The pollen grains of *Nonea caspica* - type is easily recognized by its reticulate endocingulum, and reticulate tectum This pollen type has some resemblance to

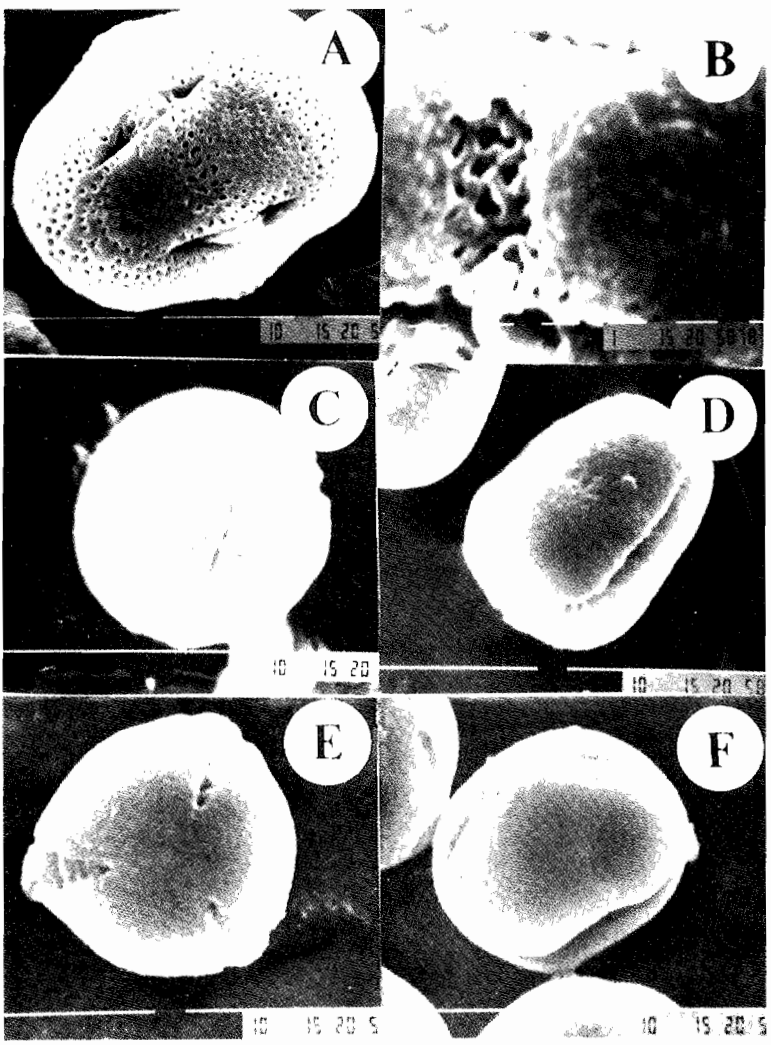

Fig. 4. Scanning electron micrographs (S.E.M.) of the pollen grains. *Nonea caspica*: A, Equatorial view; B, Exine pattern. *Onosma dichraontha*: C, polar view. *O. griffithii*: D, Equatorial view. *O. thomsonii*: E, polar view; F, Equatorial view.
Scale bar (A-E) = 10 μm; F = 1 μm.

Table 4. Pollen Characters in the species included in *Onosma hispida* - type

Name of Taxa	Shape	P/E ratio	Length in μm	Breadth in μm	Colpus in μm	Ora in μm	Mes-oco-colpium	Apoco lpium in μm	Exine Thickness	Tectum
Onosma dichro-antha Boiss.	Sub-Prolate	1.22	16.5 (16.95) 17.6	12.1(13.8) 14.8	c.10	c.0.55	c.11	------	1.65-3.3	Sub-psilate
O. limitaneum I.M. Johnston	spheroida	1.0	15.46 (16.7) 17.8	15.4 (16.5) 17.6	c.11	2.2	14.3-15.5	syn-colpate	2.2-2.45	Scabrate
O. hispida Wall. ex G.Don	Sub-Prolate	1.26	15.4	12.2	c.10.2	---	c.8.8	obs-cure	c.1.1	Foveolate
O. thomsonii C.B.Clarke	Sub-oblate	0.86	14.3	16.5	c.11	1.1x3.3	12.1	1.85	c.1.65	Scabrate-punctate scabrate
O. griffithii Vatke	Sub-prolate	1.25	14.3(14.5) 15.4	12.3(12.6) 13.3	11	4x4	9.9	---	1.1	Punctate-scabrate

Gastrocotyle hispida - type (both the types have 4-5 colporate pollen). However, pollen grains of *Gastrocotyle hispida* -type are characterized by fossulate-foveolate tectum, and ora without endocingulum. Two included species of this pollen type can be separated on the basis of mesocolpium (see key to the species).

Onosma hispida - type (Fig.4 C-F; Fig.5 A).

Pollen class: 3-colporate.

P/E ratio: Semierect to semi-transverse rarely adequate.

Apertures: Ectoaperture - colpi long narrow. Endoaperture - small circular.

Exine: Sexine as thick as nexine or thicker than nexine.

Ornamentation: Scabrate or scabrate-punctate, rarely foveolate.

Outlines: Equatorial view heteropolar, slightly constricted at the equator. Polar view - circular or trilobed, ora situated near the broader poles.

Measurements: Length (L) 14.3 (15.6) 17.18 μm. Breadth (B) 12.1 (14.3) 17.6 μm, colpus 10-11 μm, ora 0.55-4 μm in diameter. Mesocolpium 8.8-15.5 μm. Apocolpium 1.85 or syncolpate. Exine 1.1- 2.45 μm thick. P.A.I. 1.07-3.4.

Key to the Species

1	+	Pollen grains sub-prolate	2
	-	Pollen grains sub-oblate to spheroidal	4
2	+	Tectum foveolate	***Onosma hispida***
	-	Tectum scabrate punctate	3
3	+	Mesocolpium 11 μm, ora 0.55 μm in diameter	***O. dichroantha***
	-	Mesocolpium 9.9 μm, ora 4 μm in diameter	***O. griffithii***
4	+	Pollen grains sub-oblate, colpi non anastomosing	***O. thomsonii***
	-	Pollen grain spheroidal, colpi anastomosing	***O. limitaneum***

Comments: This type is very easily distinguished from other types in the family by its heteropolar, tricolporate pollen grains, mostly syncolpate. Qureshi & Qaiser (1987) and Huynh (1972) also reported similar pollen in the genus ***Onosma***. A single genus *Onosma* is included in this pollen type. Species of this genus show considerable variation in their general pollen characters such as shape, size, colpi length, mesocolpium, ora size and tectal surface, which are significantly helpful for characterizing the species (see key to the species, Table-4).

Sericostoma pauciflorum - type (Fig.5 B & C; Fig.6 F).

Pollen class: 2-colpate

P/E ratio: Subtransverse.

Shape: Oblate-spheroidal

Apertures: Colpate, narrow, long with acute ends.

Exine: Sexine thicker at the polar region than at the corners.

Ornamentation: Tectum sparsely scabrate to punctate colpal membrane granulated.

Outlines: Equatorial view - rectangular. Polar view - dumbel shaped.

Measurements: Polar axis (P) 19.70 (21.18) 25.13 μm, and equatorial diameter (E) 17.91 (21.2) 23.12 μm, colpi 14.3 (15.0) 17.9 μm long. Mesocolpium 14.3 (20.3) 21.5 μm. Apocolpium 4.30 (5.18) 7.18 μm. Exine 0.71 (1.50) 1.79 μm thick. P.A.I. 0.95. P/E ratio: 0.99.

Comments: *Sericostoma pauciflorum* - type is readily recognized by its, dumb - bell shape, bi-colpate pollen. *Sericostoma pauciflorum* Stocks ex Wight is the only species included in this type. Similar type of pollen in this species have also been reported by Erdtman (1952) and Gupta (1971).

Trichodesma indicum - type (Fig.5 D-F).

Pollen class: 3-colporate, zonoaperturate.

P/E ratio: Sub erect

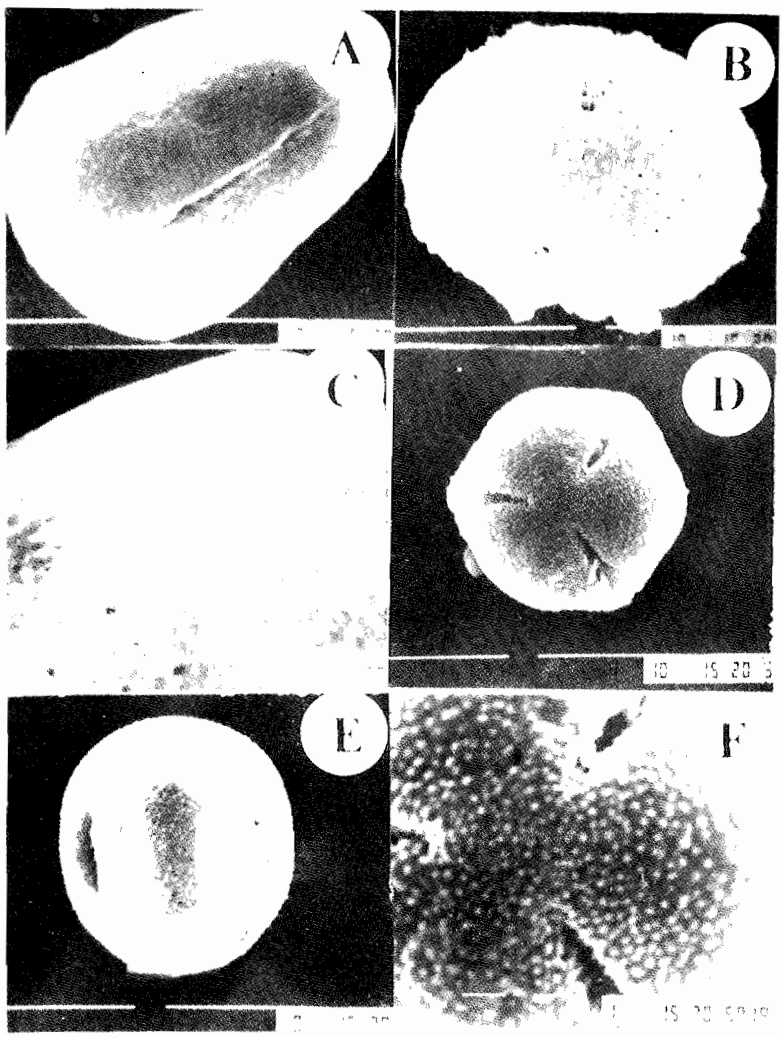

Fig. 5. Scanning electron micrographs (S.E.M.) of the pollen grains. *Onosma hispida*: A, Equatorial view. *Sericostoma pauciflorum*: B, Polar view; C, Exine pattern. *Trichodesma indica*: D, Polar view; E, Equatorial view; F, Exine pattern. Scale bar (A, D; E & F) = 10 μm; C = 1 μm.

Shape: Prolate-spheroidal to prolate.
Apertures: Ectoaperture- Colpi long, narrow, colpi ends acute, ora la-longate or lo-longate.
Exine: Sexine as thick as or thicker than nexine.

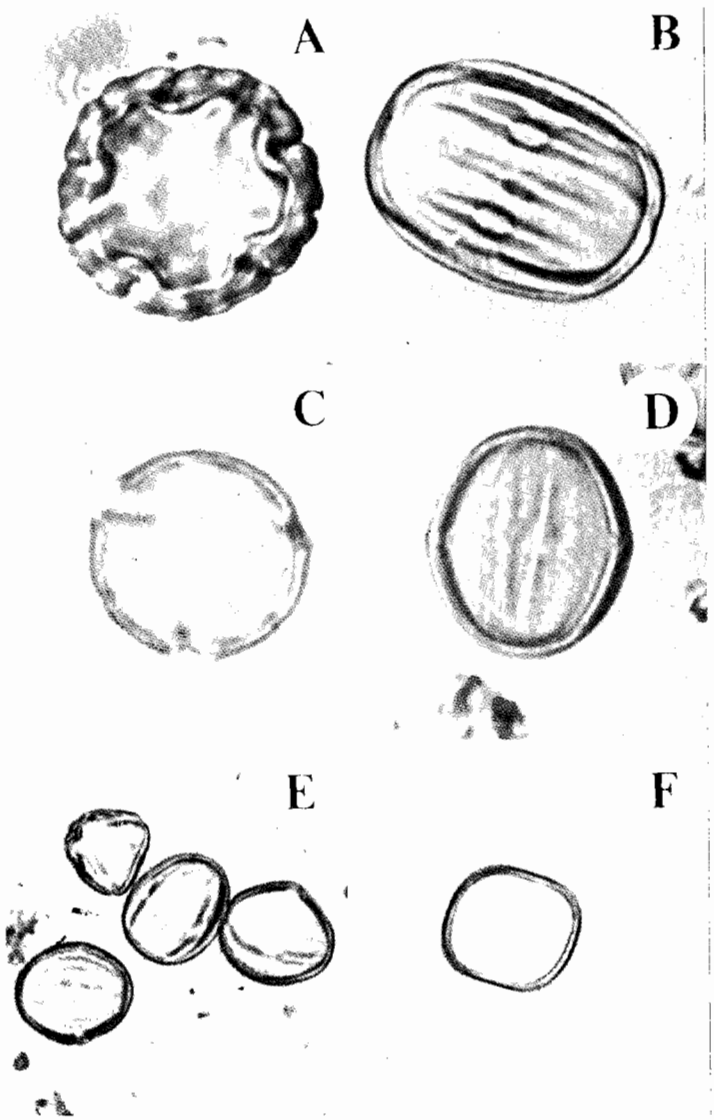

Fig. 6. Light micrographs (LM) of the pollen grains. *Heliotropium strigosum*: A, Polar view; B, Equatorial view; *H. europaeum*: C, Polar view; D, Equatorial view; *H. ophioglossum*: E, Equatorial view. *Sericostoma pauciflorum*: F, Equatorial view (All Figures X 400).

Table 5. Pollen characters in the species included in *Trichodesma indicum* - type

Name of Taxa	Shape	P/E ratio	Polar length (P) in μm	Equatorial (E) in μm	Colpus length (C) in μm	Mesopium in μm	Apocolpium in μm	Exine thickness in μm	Tectum
Trichodesma indicum (L.) R. Br.	Prolate Spheroidal	1.03	20.9 (21.4) 22.0	19.8 (20.7) 22.0	c. 19.8	c.16.5	2.16	1.1-2.2	Scabrate
T. incanum (Bunge) A. Dc.	Sub-Prolate	1.28	24.5 (24.8) 26.65	14.5 (17.75) 20	20 (21.55) 23.75	12.5 (15.75)	1.25 (5.41)	---	Scabrate
T. africanum (L.) R.Br.	Prolate Spheroidal	1.06	19.6 (21.3) 22	16.5 (20.0) 22.0	c.18.5	c.16.5	2.3	11-2.2	Scabrate

Ornamentation: Tectum scabrate, colpal membrane granulated.
Outlines: Equatorial view - elliptic. Polar view trilobed with aperture at the angles.
Measurements: Polar axis (P) 19.6 (22.5) 24.5 μm, and equatorial diameter (E) 16.5 (20.9) 23.15 μm. Colpus length 18.5 (21.55) 23.2 μm. Mesocolpium 12.5 (14.6) 16.5 μm. Apocolpium 1.26 (2.95) 2.3 μm. Exine 1.1-2.2 μm thick. P.A.I. 1.03-1.219.

Key to the Species

1 + Polar length 24.5-26.65 μm ---------- ***Trichodesma incanum***
- Polar length 19.6-22 μm -***Trichodesma indicum-type*** *(T.indicum, T.africanum)*

Comments: Pollen grains of this type are very characteristic and easily recognized by having scabrate or scabrate-punctate tectum. A single genus *Trichodesma*, representing 3 species are included in this pollen type. Pollen morphology of these species is fairly uniform. However, pollen of these species show little variation in their polar length which is helpful for characterizing the species into one group i.e., *Trichodesma indicum* - group and a single species *T. incanum* (Bunge) A. DC. (see key to the species, Table-5).

Appendix-I.

Taxa	Locality	Collector
Anchusa arvensis (L.) M. Bieb.	Mona near Zandra, (Ziarat)	Jafri & Akbar 2189 (KUH)
Arnebia benthamii (Wall ex G Don) I.M.Johnston	Mingora, Swat	S.I. Ali 26098 (KUH)
A. decumbens (Vent.) Coss. & Kark	Kashmir,Bedori Balochistan, Kalat, Panjugur to Surat, Basima	Kapoor S. (KUH) Jennifer Lamond 662 (KUH)
A.euchorma (Royle ex Benth.) I.M.Johnston	Battal, Kashmir	R.R.Stewart S.n. (KUH)
	Kashmir, Mitsahoi, Ladak	R.R. Stewart 10004 (KUH).
A. fimbriopetala Stocks	13 miles from Sunster on to Gawader	M. Qaiser, Azad Raza & Abrar 1019 (KUH).
A. griffithii Boiss.	Peshawar	Mohindar Nath S.n. (KUH).
A. guttata Bunge	Tikse, after Leh.Indus valley	Billiet et I. Leonard 6845 (KUH).
	Skardu, Baltistan	Saood Omer 390 (KUH).
A.hispidissima(Lehm.) A.DC.	Marine base, Jiwani	M. Qaiser & Dr. Khan 7144 (KUH)
	28 miles from Karachi	Sultan-ul-Abedin 5210 (KUH).
A.inconspicua (Hemsl. & Lace) I.M. Johnston	Balochistan: Maslaki	R.R. Stewart 28293 (KUH).
A. linearifolia A.DC.	Makran: Hoshab to Panjgur	Jennifer Lamond 56 (KUH).
Asperugo procumbens L.	Meterological Deptt., Quetta	S. Abedin 4833 (KUH)
Buglossoides arvensis (L.) Johnston	Kahuta	R.R. Stewart, Mohindor Nath 19358 (KUH)
Buglossoides tenuiflora (L.f.) Johnston	Kurram Valley	M.A.H.Afindi 1014 (KUH)

Appendix-I (Cont'd)

Taxa	Locality	Collector
	c. 4 miles from Haripur on way to Garhi Habibullah	Saood Omer, S.Nazimuddin & A.Wahid 489 (KUH).
Cynoglossum glochidiatum Wall. ex Benth.	Quetta	Madassir Asrar s.n. (KUH)
	Passu Hunza	Saood Omer 429 (KUH)
	Kalam	S.M.H.Kazmi 432 (KUH)
	Darra Sher Khan	Abdul Rashid s.n. (KUH)
Ehretia laevis Roxb.	Kala Chita Hills, Campellpur Dist.	R.R.Stewart 13608 (KUH)
	Lawrence Garden	Saida Qureshi s.n. (KUH).
Ehretia obtusifolia Hochst ex DC.	Between Dina & Sohawa on way to Islamabad	M. Qaiser & A. Ghafoor 7328 (KUH)
	Kallar Kahar	R.R. Stewart 337 (KUH)
Eritrichium nanum (L.) Schrad.	1.5 miles from Shigar on way to Trichmir	Kamal A. Malik & S. Nazimuddin s.n. (KUH)
Gastrocotyle hispida (Forssk.) C.B.Clarke	Shreen, Balochistan	Rasool Baksh 95 (KUH)
	Hushab, Awaran Road, Murree	S.Omer, M. Qaiser & Y. Nasir 2156 (KUH)
	32 miles from Nag on way to Basima	S.Abedin Abrar Hussain 6916 (KUH).
Hackelia macrophylla (Brands) I.M.Johnston	Changla gali	R.R.& I.D. Stewart 7646 (KUH).
	Sonamarg, Kashmir	R.R.Stewart s.n. (KUH)
Heliotropium alii Y. Nasir	8 miles from Sunstar-Turbat Rd.	S.I.Ali, S.A.Farooqi &S.Abedin 1101(KUH)

Appendix-I (Cont'd)

Taxa	Locality	Collector
Heliotropium bacciferum Forssk.	Sonmiani	S.A. Farooqi & S. Abedin 1208 (KUH)
	P.E.C.H.S.	Ruqayya Islam s.n. (KUH).
	17 miles from Sunstar on way to Gwadar	S. Abedin & A. Hussain 6327 (KUH)
	At Sunstar,	Tahir Ali 900 (KUH)
Heliotropium biannulatum Bunge	Near Landi Kotal, Khyber Agency	M. Qaiser & S. Abedin 6130 (KUH).
	Between Jamrud & Torkhum Pass	Coll.Ignot.2008
Heliotropium europaeum L.	University Campus Karachi Botany Dept.	Anjum Perveen s.n. (KUH)
Heliotropium calcareum Stocks	c. 1 mile from Rahnjoato on way to Thana Kuther Range	Kamal A. Malik S.Omer & A. Wahid 2506 (KUH).
Heliotropium crispum Desf.	32 miles from Khuzdar on way to Wad Josiji Camp	S. Abedin & A. Hussain 7237 (KUH). M. Qaiser 372 (KUH).
Heliotropium curassavicum L.	Karachi University Campus	Anjum Perveen 66 (KUH)
	Defence Housing Society Karachi	Anjum Perveen 33 (KUH).
Heliotropium dasycarpum Ledeb. var.*dasycarpum*	Roadside near Guest House, Balochistan Univ.,Quetta	S. Khatoon, Atta Mohd., Ejaz Ahmed 445 (KUH).
	Near Kash on way to Ziarat	M. Qaiser & A.Ghafoor 1404 (KUH).
Heliotropium ophioglossum Stocks ex Boiss.	Karachi University Campus	Anjum Perveen 8 (KUH)
	Malir	Shamshad M. Naqvi s.n. (KUH)

Appendix-I (Cont'd)

Taxa	Locality	Collector
Heliotropium rariflorum Stocks	Near HEJ Res. Instt., Karachi	S. Khatoon & Aisha Begum 322 (KUH)
	18.5 miles from Karachi on way to Bela along road side.	S. Abedin 9905 (KUH).
	Karachi Univ. Campus, A Type Quarter	S. Omer & A. Husain s.n. (KUH)
Heliotropium remotiflorum Rech. f. & Riedl	Balochistan, Pasni to Makran: Kappar road to Gwadar	Jennifer Lamond 462 (KUH)
Heliotropium strigosum Stocks ex Boiss.	Karachi University Campus, Botany Dept.	Anjum Perveen 72 (KUH)
Heliotropium subulatum (DC.) Vatke	Karachi University Campus	Anjum Perveen 336 (KUH)
	Karachi University Campus	Anjum Pervem 45 (KUH)
Heliotropium supinum L.	Nagar Parker	S.I.Ali,S.A.Farooqi & S. Abedin 4416 (KUH).
	Sehwan near Lake	Coll. Ignot 3860 (KUH).
Lappula barbata (M. Bieb.) Gurke	About 20 miles from Panjgur on way to Hshab	A. Ghafoor & M.Qaiser 371 (KUH)
Lappula heterantha (Ledeb.) Gurke	c. 67 Km from Sost on way to Khunjerab Pass (Top), ± 3900 m.	S.I.Ali, W.Sugong, T. Ali & G.ke 3356 (KUH)
Lappula spinocarpos (Forssk.) Aschers & Kuntze	Kakar Goth, c. 40 miles Suta Goth	Kamal A. Malik, S. Omer & A. Wahid 2481 (KUH).
Lindelofia anchusoides (Lindl.) Lehm.	Gilgit Rd. Deosai Plains, Baltistan & Ladakh, Khandala College Gujrat	R.R. Stewart 19715 (KUH,RAW) Shmroadar N2012 (KUH)
Lindelofia longiflora (Benth.) Baill.	Pahlgam Kashmir	R.R.Stewart & I.D. Stewart s.n. (KUH,RAW)

Appendix-I (Cont'd)

Taxa	Locality	Collector
	Rajdhiangar Rd.	R.R.Stewart & I.D. Stewart 19307 (KUH)
Lindelofia stylosa (Kar. & Kir.) Brand	Thake, Baltistan	S.Omer, S.Nazi muddin A.Wahid 924 (KUH,RAW).
Mattiastrum bungei (Boiss.) Rech.f. & Riedl)	c. 40 miles from Seeta Goth on way to Kuti-ki-Qabar	Kamal A. Malik, S. Omer & A. Wahid
	Kerther Range	2397 (KUH)
	Hazara gangi forest, Quetta	A.Ghafoor& Rizwan Yusuf 1231 (KUH)
Mattiastrum howardii Kazmi	Nasbar nullah Yasin, Gilgit	S. Omer 241 (KUH)
Myosotis arvensis (L.) Hill	Kaghan	S.Omer,S.Nazimud din & A. Wahid 676 (KUH)
Nonea caspica (Willd.) G.Don	Between Mingora & Swat Dist. NWFP	M. Qaiser & A.Ghafoor 7407 (KUH)
	Ziarat,Sibi Dist	S.Omer, & A.Ghafoor 1535 (KUH)
Nonea pulla (L.) D.C.	Mingora	S.I.Ali 2601 (KUH)
Onosma dichroantha Boiss.	Parachinar & Kurram	R.R.Stewart 28939 (KUH)
	Beyond Satpura Village on way to Deosai Plains, ± 3700 meters	M.Qaiser, S.Omer & S.Z. Hussain 8618 (KUH)
Onosma griffithii Vatke	5 miles from Pazrak on way to Miranshah,N. Waziristan	M.Qaiser & S.Abedin 6240 (KUH)
	Sor Range	M.G.Konieczuy s.n. (KUH)
Onosma hispida Wall. ex G. Don	Hazara	J.F.Duthie s.n. (KUH)
Onosma limitaneum I. M. Johnston	Harboi hills, Boh-khel area c. 36 km from Kalat on way to Jahan	A.Ghafoor & Steve M. Goodman 5197 (KUH)

Appendix-I (Cont'd)

Taxa	Locality	Collector
Onosma limitaneum I.M. Johnston	Hazargangi forest Quetta	A.Ghafoor & R. Yusuf 1275 (KUH)
Onosma thomsonii C. B. Clarke	Bagh	R.R. Stewart & E. Nasir 23704 (KUH)
	Between Sunny Bank & Nathiagali	M. Qaiser & S.Abedin 5623 (KUH)
Paracaryum intermedium (Fresen) Lipsky	c. 46 miles from Seeta Goth on way A. Wahid to Kuti-ji-Kabar	Kamal A. Malik, S. Omer & 2447 (KUH)
	Between Hirok & Dozan	S.M.H. Jafri 2936 (KUH)
Paracaryum rugulosum (DC.) Boiss.	22 miles from Panjgur on way Nag	S. Abedin & A.Hussain 6794 (KUH).
	Jall Pass var.	S.M.A.Kazmi 1286 (KUH).
	Sandaman Tangior 2 miles from Ziarat.	S.M.A.Kazmi 1660 (KUH).
Pseudomertensia echioides (Benth.) Riedl	Upper Satpura Nullah	M.A.Siddiqi, Y.Nasir & Zafar Ali 4231 (KUH,RAW).
Pseudomertensia moltkioides (Royle ex Benth.) Kazmi	Hazara	Inayat s.n. (KUH)
	Vakh, Tangai, ± 6800 ft. Naran, N.W.F.P.	Steve M. Goodman s.n. (KUH).
		S.M.H Jafri & S.I Ali 3389 (KUH).
Pseudomertensia nemorosa (DC.) Stewart & Kazmi	Azad Kashmir	R.R. Stewart & E. Nasir 25540 (KUH)
Pseudomertensia parvifolia (Decne.) Riedl	Changla Gali, Murree hills 9000 ft.	R.R.Stewart s.n. (KUH,RAW)
	Shangla Pass, 34 54' N.72 30'E	Steve M. Goodman s.n. (KUH)

Appendix-I (Cont'd)

Taxa	Locality	Collector
Pseudomertensia trolli (Melch.) Stewart & Kazmi	Beyond Satpur village towards Deosai	M. Qaiser, S. Omer & S. Husain s.n. (KUH).
Rochelia bungei Trautv.	Shiga Nullah, Baltistan	S. Nazimuddin & A.Wahid 881 (KUH)
	Quetta Dist.	M.A.Kazmi 163 (KUH)
Rochelia stylaris Boiss.	1 mile from Khwar to Choa Saidan	S.A.Farooqi & M.Qaiser 2848 (KUH)
	45 miles from Ziarat on way to Quetta	Sultan-ul-Abedin 4784 (KUH)
Sericostoma pauciflorum Stocks ex Boiss.	Karachi University Campus	Anjum Perveen 102 (KUH).
	Near Hub river	Anjum Perveen 183 (KUH)
Trichodesma africanum (L.) R.Br.	c. 4 Km from Seetan Goth on way to Kuti-ji-Kabar, Kerther Range, Larkana	Kamal A. Malik, S. Omer & A. Wahid 2366 (KUH)
	c. 4 miles from Khomele on way to Sehwan	Kamal A. Malik, M.Qaiser, S. Omer & Gohar Khan 2108 (KUH)
Trichodesma incanum (Bunge) A.DC.	Mansehra, ± 1000 meters	M. Qaiser & S. Omer & S. Nazimuddin (KUH)
Trichodesma indicum (L.) R.Br.	Behind Dean's of Faculty Science Karachi University	S.Khatoon 559 (KUH)
	Koti-ki-Kabar, Sulhad Nullah on way Mansehra	S.I.Ali, S.Sugong, Tahir Ali & G-Ke 3072 (KUH).

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