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POLLEN FLORA OF PAKISTAN -XLII. BRASSICACEAE

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Abstract

Pollen morphology of 77 species belonging to 36 genera of the family Brassicaceae from Pakistan has been examined by light and scanning electron microscope. Pollen grains are usually radially symmetrical, isopolar sub-prolate to prolate, or prolate-spheroidal rarely oblate-spheroidal, tricolpate rarely 4-8 colpate. Sexine thinner or thicker than nexine. Tectum fine to coarsely reticulate with more or less regular pattern of muri or reticulate – rugulate. On the basis of tectal surface four distinct pollen types are recognized viz., *Arabis bijuga*-type, *Farsetia ramosissima-type, Draba lanceolata* –type and *Erysimum melicentae* – type.

Introduction

Brassicaceae is a cosmopolitan family of about 350 genera and 3000 species, occurring mainly in north temperate zone particularly in Mediterranean region (Mabberely, 1987). In Pakistan it is distributed by 92 genera and 250 species (Jafri, 1973). Cruciferae are annual, biennial and perennial herbs. Corolla is cruciform (4 petals arranged in cross manner. Some common members of Brassicaceae are species of *Brassica oleracea* (Broccoli, Brussels sprout, Cabbage, Cauliflower, Kale etc.). Oil is also extracted from the seed of *Brassica* species. Many Crucifers are cultivated as ornamentals like *Aubrieta deltoidea* (aubrietia), *Erysimum cheire* (wallflower), *Arabis* sp., (rock cress). Chiguriaeva (1973) examined the pollen morphology of the family Brassicaceae in relation to taxonomy. Javied & Naqshi (1975) also utilized pollen data in the classification of family Brassicaceae. Jonsell (1986) during monographic studies of Brassicaceae also examined pollen morphology of this family. Lahham & Al-Essawi (1987) examined the pollen morphology of the family Brassicaceae from Jordan. Pollen morphology of the family Brassicaceae has been examined by Erdtman (1963), Sharma & Nair (1973), Carter *et al*., (1975). Moore & Webb (1978). The most comprehensive studies of Brassicaceae pollen is that of Rollins & Banerjee (1979). However, there are no reports on pollen of the family Brassicaceae from Pakistan. Present investigations are based on the pollen morphology of 77 taxa representing 36 genera of the family Brassicaceae by light and scanning electron microscope.

Materials and Methods

Pollen samples were obtained from Karachi University Herbarium (KUH) or collected from the field. The list of voucher specimens is deposited in KUH. The pollen grains were prepared for light (LM) and scanning microscopy (SEM) by the standard methods described by Erdtman (1952). For light microscopy, the pollen grains were mounted in unstained glycerin 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, pollen grains suspended in a drop of water were directly transferred with a fine pipette to a metallic stub using double sided cello tape and coated with gold in a sputtering chamber (Ion-sputter JFC-1100). Coating was restricted to 150 A. The S.E.M examination was carried out on a Jeol microscope JSM-2. The measurements are based on 15-20 readings from each specimen. Pollen diameter, polar axis (P) and equatorial diameter (E), aperture size, apocolpium, mesocolpium and exine thickness were measured (Tables 1-4).

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

General pollen characters of the family *Brassicaceae*

Pollen grains usually radially symmetrical, isopolar, sub-prolate or prolate to prolate-spheroidal, rarely oblate-spheroidal, tricolpate often 4-8 colpate. Sexine thinner or thicker than nexine. Tectum fine to coarse reticulate or reticulate-rugulate. On the basis of tectum types, four distinct pollen types are recognized viz., *Arabis bijuga*-type, *Farsetia ramosissima-type, Draba lanceolata* – type and *Erysimum melicentae* - type.

Key to the pollen types

1. \+ Tectum reticulate-rugulate ..…….…… *Farsetia ramosissima*-type
   \- Tectum fine-coarse reticulate ……..……... 2

2. \+ Tectum finely reticulate ……... *Arabis bijuga*-type
   \- Tectum not as above ……..…… 3

3. \+ Tectum medium reticulate ……. *Erysimum melicentae* - type
   Tectum coarsely reticulate……...….. *Draba lanceolata* –type

Pollen type: *Arabis bijuga - type* (Fig. 1 A-C)
Pollen class: Tricolpate
P/E ratio: 108-140
Shape: Prolate-spheroidal to sub-prolate rarely prolate.
Apertures: Colpus long sunken with acute ends.
Exine: Sexine thicker than nexine.
Ornamentation: Finely reticulate more or less regular pattern of muri.
Measurements: Size: Polar axis P=16 (25.5) 32.5 μm and equatorial diameter E=15 (21.5) 28 μm, trilobed, with apertures on the angles of the outline of the grain in polar view, colpi 10 (15.5) 20 μm long. Exine 1.0 (1.5) 2.5 μm thick, sexine as thick as nexine. Tectum finely reticulate.
Species included: *Arabidopsis mollissima* (C.A. Mey) Busch, *A. traxacifolia* (T.And.) Jafri, *Arabidopsis wallichii* (Hook.f. Thoms.) Busch, *A. stricta* (Camb.) Busch., *Arabis amlpexicaule* Edgew., *A. bijuga* Watt., *A. pterosperma* Edgew, *Bassica juncea* (L.) Czern., *B. napus* L.*ssp. napus, B. nigra* (L.) Koch., *B. oleracea* var. *botrytis* L., *B. oleracea* var. *capitata*, *B. rapa ssp. rapa, B. rapa ssp. campestris, Cardamine impatiens* L., *Chorispora sibirica* (L.) DC., *Douepia tortuosa* Camb., *Drabopsis verna* Koch., *Euclidium syriacum* (L.) R.Br., *Malcolmia scorpioides* (Bunge) Boiss.

Table 1. Pollen characters of the species included in pollen type - *Arabis bijuga*.

Name of taxa	P/E Ratio	Polar length in µm (P)	Equatorial diameter µm (E)	Colpus length (L)	Exine thickness in µm
Arabis pterosperma	113	23.0 (24.5±0.71) 26.25	15.0 (17.5±0.02) 20.5	12.5 (14.77±0.43) 17.5	1.5 (1.87±0.16) 2.25
Doupia tortuosa	108	16.25 (18.33±0.21) 20.5	15.0 (16.67±0.17) 17.5	11.25 (12.93±0.18) 20.5	1.75 (2.23±0.03) 2.5
Euclidium syriacum	131	19.0 (21.52±0.5) 23.7	15.9 (16.34±0.34) 17.5	15.0 (16.02±0.36) 17.5	1.25 (1.45±0.08) 1.75
Chorisphora sibirica	104	23.0 (27±0.58) 28.7	17.5 (20.04±0.27) 21.5	17.5 (21.04±0.51) 12.5	2.0 (2.06±0.03) 2.25
Malcolmia scorpioides	127	18.5 (19.64±0.32) 20.5	14.5 (15.35±0.24) 16.5	10.0 (11.87±0.33) 12.5	1.75 (1.77±0.02) 2.5
Arabidopsis mollissima	123	17.5 (19±0.33) 20.5	12.5 (15.34±0.53) 17.5	12.5 (14.2±0.42) 16.27	1.25 (1.54±0.06) 1.75
A. wallichii	133	20.0 (21.61±0.27) 23.5	14.0 (16.23±0.31) 17.5	15.0 (16.65±0.42) 20.5	1.5 (1.8±6.03) 2.5
A. taraxacifolia	117	15.0 (17.08±1.0) 20.5	13.0 (14.58±0.26) 15.5	10.0 (10.83±0.52)	1.25 (1.58±0.08) 1.75
A. stricta	140	16.25 (19.38±6.54) 22.5	11.25 (13.83±0.29) 15.0	10(14.12±0.52)17.5	1.75 (1.96±0.06) 2.25
Cardamine impatiens	123	20.0 (22.64±0.33) 25.75	16.25 (18.38±0.27) 22.5	15.0 (16.55±0.24) 17.5	1.0 (1.46±0.04) 1.75

Table 1. (Cont'd.)

Arabis amplexcaule	124	23.0 (25.48±0.41) 75.5	17.5 (23.5±0.38) 23.5	16.25 (18.41±0.49) 22.5	1.75 (1.88±0.03) 2.5
A. bijuga	126	21.75 (22.45±0.08) 23.5	15.0 (17.8±0.47) 20.75	16.25 (17.8±0.33) 20.5	1.25 (1.81±0.05) 2.5
Drabopsis verna	124	22.5 (24.38±0.4) 25.5	17.25 (18.6±0.39) 20.5	16.25 (17.75±0.81) 20.5	1.5 (1.84±0.07) 2.5
Brassica napus ssp. *napus*	105	19.5 (20.1) 22.0	20.0 (20.0) 22.0	13.2 x 11	4.4
B. nigra	107	23.0 (28.4) 34.0	23.0 (26.4) 33.0	16.3	2.2-3.3
B. oleracea var. *botrytis*	123	31.0 (37.0) 38.0	27.0 (30.0) 33.0	33 x 1.1	1.1-3.3
B. oleracea var. *capitata*	117	22.0 (27.0) 31.0	22.0 (23.0) 24.0	23.1 x 2.2	4.4
B. rapa spp. *rapa*	104	19.0 (22.0) 24.0	20.0 (21.0) 22.0	13.2 x 1.1	3.3
B. rapa ssp. *campestris*	1.17	24.0 (27.0) .030	18.0 (23.0) 26.0	24.1 x 1.1	4.4
B. juncea	1.10	29.0 (33.0) 35.0	24.0 (30.0) 33.0	25.3	4.4

Table 2. Pollen characters of the species included in pollen type - *Erysmum melicentae*.

Name of Taxa	P/E Ratio	Polar length in µm (P)	Equatorial diameter µm (E)	Colpus length (L) µm	Exine thickness in µm
Goldbachia laevigata	110	20.5 (23.02±0.58) 25.0	20 (20.87±0.18) 22.5	15 (17.37±0.47) 20.5	1.75 (2.12±0.07) 2.5
Cordaria draba	1.51	23.0 (26.55±0.43) 32.5	15 (17.47±0.62) 20.5	1.75 (21.5±0.85) 27.5	17.5 (21.5±0.85) 27.5
Coronocarpus didynamous	127	21.0 (23.84±0.54) 27.5	16.2 (18.75±0.37) 20.5	15.0 (19.75±0.7) 22.5	2.0 (2.2±0.03) 2.5
Alyssum desertoruim	147	27.5 (32±1.22) 35.5	20.0 (21.75±0.5) 23.3	20.0 (25.75±0.45) 27.5	1.75 (1.86±0.0) 2.5
Diceratella canescens	122	22.5 (25.17±0.59) 28.5	20.0 (21.10±0.33) 23.77	12.5 (14.8±0.35) 17.5	2.5 (2.5±0.02) 2.75
Leptaleum filifolium	119	17.0 (21.4±1) 25.5	14.0 (17.9±0.72) 2.5	15.0 (16.13±0.75) 20.5	1.75 (1.93±0.03) 2.5
Malcolmia strigosa	127	16.25 (18.6±0.48) 20.5	12.2 (14.5±0.43) 17.5	12.5 (13.95±0.45) 16.2	1.25 (1.75±0.06) 2.50
Eremobium aegyptium	134	17.5 (20.5±0.33) 22.5	14.5 (15.16±0.36) 17.5	10.0 (13.38±0.42) 16.2	2.0 (20.0±0.04) 2.5
Citharelum lehmannii	117	17.5 (20.9±0.03) 22.5	16.5 (17.7±0.24) 19.5	12.5 (14.6±0.26) 15.5	1.5 (1.92±0.01) 0.25
Arabidopsis pumila	137	22.0 (23±0.46) 25.5	16.25 (17.23±0.32) 18.75	17.5 (18.75±0.48) 20.5	1.75 (1.96±0.06) 2.25
Alliaria petiolata	116	20.0 (21.01±0.23) 22.5	17.5 (18±0.18) 19.5	12.5 (14.48±0.26) 17.5	1.75 (2.0±0.03) 2.25
Arabis saxicola	139	22.5 (26.5±0.9) 26.7	16.25 (18.38±0.27) 22.5	15.0 (16.55±0.24) 17.5	1.0 (1.46±0.044) 1.75

Table 3. Pollen characters of the species included in pollen type – *Draba lanceolata*.

Name of taxa	P/E Ratio	Polar length in µm (P)	Equatorial diameter µm (E)	Colpus length (L)	Exine thickness in µm
Farsetia heliophila	111	17.5 (19.8±0.42) 22.5	15.2 (17.62±0.38) 20.5	12.5 (13.92±0.34) 16.25	1.75 (2.05±0.65) 2.0
Micro sisymbrium flaccidum	111	23.0 (24.5±0.26) 25.54	21.25 (22.06±0.12) 22.75	15.0 (17.5±0.33) 20.5	2.0 (2.3±0.06) 2.5
Istatus stocksii	106	22.0 (23.4±0.1) 25.5	20.0 (22.5±0.4) 24.5	15.0 (18.12±0.5) 20.5	2.25 (2.57±0.08) 3.5
I. minima	108	25.0 (26.45±0.44) 27.5	20.0 (22.3±0.68) 25.5	20.0 (20.8±0.52) 22.5	2.0 (2.37±0.75) 2.75
Lepidium virginicum	122	20.0 (21±1) 23.5	16.75 (17.13±0.32) 17.5	12.5 (13.75±1.24) 15.0	1.25 (1.75±0.07) 2.5
Capsella bursa-pastoris	135	22.5 (26.15±0.31) 26.25	16.0 (17.5±0.27) 20.5	15.0 (17.75±0.4) 20.5	1.5 (1.87±0.05) 2.35
Boreava orientalis	143	23.75 (26.72±0.36) 27.5	16.5 (18.5±0.39) 20.5	17.5 (18.85±0.35) 20.5	1.25 (1.89±1.25) 2.2
Euclidium tenuissimum	128	27.5 (30.06±0.5) 32.5	22.5 (23.43±0.3) 25.5	17.5 (21.36±0.86) 25.5	2.25(2.45±0.03) 2.5
Farsetia hamiltonii	119	16.25 (20.8±0.63) 25.5	14.5 (17.4±0.39) 20.5	10.0 (14.8±0.77) 17.5	1.75 (1.95±0.04) 2.25
Alyssum dasycarpum	168	30.0 (35±0.45) 40.5	20.0 (21.03±0.43) 22.5	25.0 (29.37±0.91) 32.5	1.5 (1.87±0.06) 2.5
Christolen himalayensis	139	22.5 (26.47±0.42) 27.5	17.5 (19.01±0.27) 20.5	18.75 (20.28±0.31) 22.5	2.0 (2.28±0.04) 2.5
Barbaraea intermedia	127	20.75 (23.27±0.39) 26.75	17.5 (18.06±0.23) 20.5	15.0 (17.5±0.4) 20.5	1.75 (1.97±0.03) 2.25
Chorispora tanella	139	20.75 (22.7±0.25) 24.5	14.25 (16.31±0.03) 17.5	17.5 (18.5±0.33) 20.5	1.25 (1.6±0.07) 2.5
Malcolmia africana	128	18.75 (21.36±0.4) 23.2	15.0 (16.65±0.45) 19.5	15.0 (16.34±0.45) 20.5	1.5(1.64±0.03) 2.5

Table 3. (Cont'd.)

Name of taxa	P/E Ratio	Polar length in µm (P)	Equatorial diameter µm (E)	Colpus length (L)	Exine thickness in µm
M. cabulica	135	16.5 (19.09±0.85) 25.5	11.25 (14.07±0.65) 17.5	10.0 (14.07±0.81) 20.5	1.25 (1.32±0.02) 2.5
Erysimum hieraciifolium	120	32.5 (33.66±0.12) 35.5	27.5 (28±0.24) 28.25	22.5 (23.38±0.8) 20.5	2.25 (2.33±0.08) 2.5
E. melicentae	127	28.75 (31.15±0.45) 33.3	22.5 (24.43±0.2) 27.5	21.5 (23.52±0.12) 27.5	2.25 (2.4±0.03) 2.5
E. grifithianum	148	27.5 (34.77±1.23) 39.5	20.0 (23.45±0.75) 27.5	20.0 (27.02±1.01) 22.5	2.25(2.41±0.03) 2.5
Barbaraea vulgaris	134	22.5 (24.55±0.47) 28.5	16.5 (18.28±10.31) 21.75	15.0 (18.08±0.48) 22.5	1.5 (1.78±0.06) 2.55
Nasturtium officinale	132	205 (23.95±0.47) 25.5	17.0 (19.04±0.27) 20.5	15.0 (18.18±0.51) 20.5	1.75 (2±0.03) 2.25
Diceratella folccosa	120	20 (22.40±0.39) 25.5	17.5 (19.59±0.9) 20.75	12.5 (14.88±0.35) 17.5	2.5 (2.52±0.02) 2.75
Matthiola macranica	115	30 (31.85±0.33) 32.75	25.0 (27.57±0.55) 30.5	21.25(23±0.37) 25.5	2.75 (3.1±0.09) 3.5
M. flavida	117	20.0 (23.25±0.71) 28.5	17.5 (19.8±0.5) 22.5	21.25 (23±0.37) 25.5	2.75 (3.1±0.09) 3.5
Chorispora bungeana	121	23.75 (25.65±0.27) 27.0	18.75 (21.16±0.4) 22.5	17.5 (20.16±0.36) 22.5	2.0 (2.25±0.03) 2.5
A. turkestanicum	149	36.26 (37.5±0.39) 38.75	22.5(25.1±0.79) 27.5	27.5 (29.5±0.93) 32.5	1.75 (1.85±0.28) 2.5
Draba altaica	129	23.25 (24.89±0.35) 26.25	17.5 (19.21±0.52) 20.5	15(17.85±0.59) 20.5	2.0 (2.2±0.07) 2.5
Draba lanceolata	122	25.0 (26.35±0.36) 27.5	20.0 (21.5±0.43) 23.5	17.5 (19.5±0.9) 22.5	2.25 (2.45±0.03) 2.5
Draba melanopus	116	20.5 (22.28±0.59) 24.5	17.0 (19.16±0.57) 21.25	15.0 (16.78±0.65) 20.5	2.0 (2.21±0.0) 2.5
Draba stenocarpa	120	22.5 (24.57±0.58) 26.25	18.75 (20.37±0.5) 22.5	17.5 (18.75±0.4) 20.5	1.5 (1.92±0.1) 2.25

Table 4. Pollen characters of the species included in pollen type - *Farsetia ramosissima*.

Name of Taxa	P/E Ratio	Polar length in µm (P)	Equatorial diameter µm (E)	Colpus length (L)	Exine thickness in µm
Mulcolmia behboundiona	111	14.5 (15.87±0.2) 17.75	12.5 (14.2±0.22) 15.5	8.75 (9.75±0.16) 10.5	1.75 (1.77±0.02) 2.5
Diplotaxis harra	102	20.52 (28.95±0.85) 35.0	17.5 (20.5±0.8) 27.5	17.5 (20.5±0.89) 27.5	2.5 (2.8±0.0) 8.25
Crambe cordifolia	104	20.5 (22.5±0.7) 25.5	20.0 (21+35±0.39) 22.5	13.75 (11.25±0.81) 20.5	2.5 (2.8±0.0) 8.25
Farsetia ramosissima	103	17.85 (18.43± 0.18) 20.5	16.25 (18.3±0.2) 20.5	12.6 (17.6±0.18) 15.5	1.5 (1.87±0.16) 2.75
Conringa planisiliqua	104	21.25 (22.8±0.21) 25.5	21.25 (22.88±0.2) 24.5	17.5 (19.0±0.3) 20.5	2.25 (2.34±0.03) 2.5
Isatis costata	93.45	17.5 (19±0.76) 20.5	20.0 (20.33±0.16) 20.5	12.5 (14.16±0.86) 15.5	2.0 (2.25±0.14) 2.5
Diplolaxis griffithii	116	23.5 (26.5±0.36) 27.5	20.0 (22.47±0.5) 25.5	15.0 (17.5±0.55) 20.5	2.5 (2.53±6.67) 2.27
Cordaria chalepense	153	21.25 (24.0±1.28) 30.5	16.75 (15.75±0.53) 17.3	16.25 (18.25±0.98) 22.5	1.75 (1.89±0.06) 2.5
Diptychocapus stricta	126	25.5 (28.5±1.15) 32.5	22.5 (22.6±0.08) 23.5	17.5 (20.0±0.2) 25.5	2.25 (2.45±0.4) 2.5
Erysimum crassicaule	121	18.5 (22.12±0.88) 27.5	15.0 (18.15±0.29) 21.5	13.75 (17.4±0.04) 20.5	2.25 (2.3±0.81) 2.5
E. repandum	136	27.5 (30.47±0.6) 20.5	20.0 (22.3±0.23) 25.5	20.0 (21.42±0.5) 22.5	2.0 (2.39±0.07) 2.5
Descurainia sophia	125	17.5 (20.42±0.47) 25.5	15.0 (16.20±0.22) 17.5	11.25 (15.5±0.59) 20.5	1.25 (1.7±0.04) 2.5

Key to the species and group

1. + Pollen grains prolate-spheroidal ……..…… *Douepia tortuosa* - subtype (*Arabis pterosperma, Doupia tortuosa, Bassica juncea, Brassica napus* ssp. *napus, B. nigra, B. rapa ssp. rapa*)
   - Pollen grains sub-prolate to prolate …….. 2

2. + Pollen grains subprolate ……. *Arabidopsis mollissima*- subtype (*Arabidopsis mollissima, A. traxacifolia, Arabis amlpexicaule, A. bijuga, Brassica oleracea* var. *capitata, B. rapa* ssp. *campestris, Cardamine impatiens, Chorispora sibirica, Drabopsis verna, Euclidium syriacum Malcolmia scorpioides*)
   - Pollen grains prolate …..…….…… *Arabidopsis wallichii*-subtype (*Arabidopsis wallichii, A. stricta, Brassica oleracea* var. *botrytis* L.)

Pollen type: *Erysimum melicentae* (Fig. 1D-F. Fig. 2 A & B).
Pollen class: Tricolpate
P/E ratio: 110-151
Shape: Sub-prolate to prolate rarely prolate-spheroidal
Apertures: Colpus long sunken with acute ends.
Exine: Sexine thicker or thinner than nexine.
Ornamentation: Medium reticulate with more or less regular pattern of muri.
Measurements: Size: Polar axis P=16 (24.5) 32.5 μm and equatorial diameter E=15 (21.5) 32 μm, (trilobed, with apertures on the angles of the outline of the grain in polar view, colpi 10 (15.5) 17.5 μm long. Exine 1.0 (1.96) 2.5 μm thick, sexine as thick as nexine. Tectum medium reticulate.
Species included: *Alliaria petiolata* (M.Bieb.) Cav. Grande, *Arabis saxicola* Edgew, *Alyssum desertorum* Staph, *Arabidopsis pumila* (Steph) Busch, *Cardaria drapa* (L.) Desv,. *Cithareloma lehmannii* Bunge, *Coronocarpus didymus* (L.) Smith, *Diceratella canescens* (Boiss.) Boiss., *Goldbachia laevigata* (M.Bieb.) DC. *Eremobium aegypticum* (Spreng) Boiss., *Leptaleum filifolium* (Willd.) DC., *Malcolima strigosa* Boiss.

Key to the species and group

1. + Pollen grains prolate-spheroidal ……. *Goldbachia laevigata*
   - Pollen grains sub-prolate to prolate ……...……. 2
2. + Pollen grains prolate ……...… *Alyssum desertorum*-sub-type *(Alyssum desertorum, Arabis saxicola, Arbidopsis pumila, Cardaria drapa*)
   - Pollen grains sub-prolate …… *Alliaria petiolata* –subtype (*Alliaria petiolata, Cithareloma lehmannii, Coronocarpus didymus, Diceratella canescens, Goldbachia laevigata, Eremobium aegypticum, Leptaleum filifolium, Malcolima strigosa*)

Pollen type: *Draba lanceolata*- type (Fig. 2 C-F; Fig. 3A-F; Fig. 4A-F)
Pollen class: Tricolpate
P/E ratio: 106-168
Shape: Prolate to subprolate rarely prolate-spheroidal

Fig. 1. Scanning Electron micrographs of pollen grains. *Arabis bijuga*: A, Equatroial view, B, Exine pattern. *A. pterosperma*: C, Polar view. *Leptaleum filifolium*: D, Equatorial view. *Cithareloma lehmannii*: E, polar view, F, Exine pattern. Scale bar = A, C, D & E = 10; B, F = 1 μm

Fig. 2. Scanning Electron micrographs of pollen grains. *Leptaleum filifolium*: A, Exine pattern. *Eremobium aegypticum*: B, pollen grains. *Isatis minima*: C, Equatroial view, D, Exine pattern. *Capsella burspastoris*: E., Polar view, F, Exine pattern. Scale bar =B, C & E = 10; A, D & F = 1 μm

Fig. 3. Scanning Electron micrographs of pollen grain. *Boreava orientalis*: A, Equatorial view. *Euclidium tenuissimum*: B, Equatorial view, C, Exine pattern. *Farsetia hamiltonii*: D, Exine pattern, E, Equatorial view. *Alyssum desertorum*: F, Exine pattern. Scale bar = A , B & E = 10; C, D & F = 1 μm

Fig. 4. Scanning Electron micrographs of pollen grains. *Draba stenocarpa:* A, Exine pattern, B, Equatorial view. *Draba trinervia*: C, Polar view. *Christolea himalayensis*: D, Equatorial view, E, Exine pattern. *Barbrea intermidia*: F, Equatorial view. Scale bar = B –D & F= 10; A & E = 1 μm

Apertures: Colpus long sunken with acute ends.
Exine: Sexine thicker than nexine.
Ornamentation: Coarsely reticulate.
Measurements: Size: Polar axis P=16 (27.5) 39.5 μm and equatorial diameter E=16 (18.5) 22.1 μm, (trilobed, with apertures on the angles of the outline of the grain in polar view, colpi 10 (21.5) 32.5 μm long. Exine 1.5 (2) 2.5 μm thick, sexine as thick as nexine. Tectum coarsely reticulate.
Species included: *Alyssum desertorum* Staph, *Boreava orientalis* Jaub. & Spach, *Capsella bursa-pastoris* (L.) Medik., *Chorispora bungeana* Fish & Mey, *Christolea himalayensis* (Camb.) Jafri, *Chorispor*a *tenella* (Pallas) DC., *Draba trinervis* Schultz, *D. altaica* (C.A. Mey) Bunge, *D. lanceolata* Royle, *D. melanopus* Kom., *D. stenocarpa* Hook. F. & Thoms. *Euclidium tenuissimum* (Pallas) B. Fedtsch., *Erysimum meilicentae* Dunn., *E. griffithianum* Boiss, *Farsetia hamiltonii* Royle, *Diceratella floccose* (Boiss.) Boiss., *Farsetia heliophila* Bunge ex Coss., *Isatis stocksii* Rech.f Boiss, *I. minima* Bunge, *Lepidium virginicum* L, *Matthiola macranica* Rech f., *Mathiola flavida* Boiss., *Malcolmia cabulica* (Boiss.) Hook. F. Thoms, *Malcolmia africana* (L.) R.Br., *Nasturtium officinale* R. Br., *Microsisymbrium flaccidum* Schulz.

Key to the species and group

1. \+ Pollen grains prolate-spheroidal ..……..……*Isatis stocksii*-subtype (*Isatis stocksii*, *Isatis minima*)
   \- Pollen grains not as above ……. 2

2. \+ Pollen grains prolate ……. *Capsella bursa-pastoris*. -subtype (*Capsella bursa-pastoris*, *Boreava orientalis*, *Chorispora tenella*, *Malcolmia cabulica*)
   \- Pollen grains sub-prolate …… *Matthiola macranica*-subtype *(Chorispora bungeana, Christolea himalayensis, Draba trinervis, D. altaica, D. lanceolata, D. melanopus, D. stenocarpa, Euclidium tenuissimum, Erysimum meilicentae, E. griffithianum, Farsetia hamiltonii, Diceratella floccose, Farsetia heliophila, Lepidium virginicum, Matthiola macranica, Matthiola flavida, Malcolmia africana, Nasturtium officinale, Microsisymbrium flaccidum)*

Pollen type: *Farsetia ramosissima* - type (Fig. 5 A-G)
Pollen class: Tricolpate
P/E ratio: 102-113
Shape: Sub-prolate to prolate-spheroidal rarely prolate.
Apertures: Colpus long sunken with acute ends.
Exine: Sexine thicker than nexine.
Ornamentation: Reticulate – rugulate.
Measurements: Size: Polar axis P = 14 (23.5) 32.5 μm and equatorial diameter E=12 (18) 24 um, trilobed, with apertures on the angles of the outline of the grain in polar view, colpi 8.75 (16.5) 25.5 μm long. Exine 1.5 (2) 2.5 μm thick, sexine as thick as nexine. Tectum reticulate-rugulate.
Species included: *Barbaraea vulgaris*, *Conringia planisiliqua* Fisch & Mey., *Crambe cardifolia* Steven, *Descurainia sophia* (L.) Webb. & Berth., *Diplotaxis griffithii* (Hook. f.

Fig. 5. Scanning Electron micrographs of pollen grains. *Diplotaxis harra*: A, Polar view, *D. grifithii*: B, Equatorial view, C, Exine pattern. *Crambe cordifolia*: D, Polar view. *Conringia planisliqua*: E, Equatorial view, F, Exine pattern, G, Polar view. Scale bar = A, B, D, E & G = 10; C & F = 1 μm

& Thoms.) Boiss., *Diptychocarpus strictus* (Fish.M.Beib.) Trautv, *Diplotaxis harra* (Forssk.) Boiss, *Erysimum crassicaule* (Boiss.) Boiss., *Erysimum melicentae* Dunn., *E. repandum* L., *Farsetia ramosissima* Hochst. ex Boiss., *Malcolmia behboudiana* Rech.f., *Moricandia sinaica* (Boiss.) Boiss. *Lepidium aucheri* Boiss., *Isatis costata* C.A.Mey

Key to the species and group

1. + Pollen grains oblate-spheroidal……..……..*Isatis costata*
   - Pollen grains prolate-spheroidal or prolate to sub-prolate …… 2
2. + Pollen grains prolate …….. *Erysimum crassicaule*-subtype *(Erysimum crassicaule,E. repandum, Barbaraea vulgaris)*
   - Pollen grains sub-prolate …..……..…… *Diplotaxis griffithii*-subtype (*Conringia planisiliqua, Crambe cardifolia*, *Descurainia sophia, Diplotaxis griffthii*, *Diptychocarpus strictus*, *Diplotaxis harra*, *Erysimum crassicaule, Erysimum melicentae, E. repandum, Farsetia ramosissima, Malcolmia behboudiana, Moricandia sinaica, Lepidium aucheri*)

Discussion and Conclusions

Brassicaceae is a stenopalynous family (Erdtman, 1952). Pollen grains are generally prolate to sub-prolate or prolate – spheroidal rarely oblate – spheroidal, 3 - colpate often 4-8 –colpate as in *Erysimum stocksiana.* Tectum reticulate, reticulum varies from fine – coarse. Appel & Al-Shehbaz (2003) also reported tricolpate reticulate pollen in the family Brassicaceae. However, they reported sparsely spinulose and punctate tectum in the genus *Heliophila* and 10-colpate pollen in few genera of Brassicaceae. Erdtman (1963) divided the species of Brassicaceae into two pollen types on the bases of exine thickness. Moore & Webb (1987) classified the family in tricolpate with reticulate pollen. Khalik (2002) divided the family into three pollen types on the basis of lumina size. The generic delimitation based on pollen morphology is difficult. However, on the basis of tectal surface four distinct pollen types are recognized viz., *Arabis bijuga* – type, *Erysimum melicentae* - *type*, *Farsetia ramosissima* - type, *Draba lanceolate* - type. The *Arabis bijuga* – type is easily recognized by having finely reticulate pollen, 20 species are included in this pollen type viz., *Arabidopsis mollissima* (C.A. Mey) Busch, *A. traxacifolia* (T.And.) Jafri, *Arabidopsis wallichii* (Hook. f. Thoms.) Busch, *A. stricta* (Camb.) Busch., *Arabis amlpexicaule* Edgew., *A. bijuga* Watt., *Arabis pterosperma* Edgew, *Brassica juncea* (L.) Czern., *B. napus* L., ssp., *napus*, *B. nigra* (L.) Koch., *B. oleracea* var. *botrytis* L., *B. oleracea* var. *capitata*, *B. rapa* ssp. *rapa*, *B. rapa* ssp., *campestris*. *Cardamine impatiens* L., *Chorispora. sibirica* (L.) DC., *Douepia tortuosa* Camb., *Drabopsis verna*, *Euclidium syriacum* (L.) R.Br., *Malcolmia. scorpioides* (Bunge) Boiss. This pollen type is further divided into three subtypes on the basis of pollen shape classes (see key to the species or species group). *Erysimum melicentae* – type is delimited by its medium reticulate tectum, 12 species have medium reticulate tectum such as *Alyssum desertorum* Staph, *Alliaria petiolata* (M.Bieb.) Cav. Grande, *Arabis saxicola* Edgew, *Arbidopsis pumila* (Steph) Busch, *Cardaria drapa*, *Cithareloma lehminniii*, *Coronocarpus didymus* (L.) Smith, *Diceratella canescens* (Boiss.) Boiss., *Goldbachia laevigata* (M.Bieb.) DC., *Eremobium aegypticum* (Spreng) Boiss., *Erysimum melicentae* Dunn., *E. repandum* L., *E. griffithianum* Boiss., *Leptaleum filifolium* (Willd.)

DC., *Malcolima. strigosa* Boiss. This type also divided into two subtype based on pollen shape class (see key to the species and species group). *Draba lanceolata*- type is the largest among all the four pollen types (28 species). This pollen type is characterized by its coarsely reticulate tectum. viz., *Alyssum desertorum* Staph, *Boreava orientalis* Jaub. & Spach, *Capsella bursa-pastoris* (L.) Medik., *Chorispora bungeana* Fish & Mey, *Christolea himalayensis* (Camb.) Jafri, *Chorispor*a *tenella* (Pallas) DC., *Draba trinervis* Schultz, *D. altaica* (C.A. Mey) Bunge, *D. lanceolata* Royle, *D. melanopus* Kom., *D. stenocarpa* Hook. F. & Thoms., *Euclidium tenuissimum* (Pallas) B. Fedtsch, *Erysimum melicentae* Dunn., *E. griffithianum* Boiss., *Farsetia hamiltonii* Royle, *Diceratella floccose* (Boiss.) Boiss., *Farsetia heliophila* Bunge ex Coss., *Isatis stocksii* Rech.f Boiss, *I. minima* Bunge, *Lepidium virginicum* L, *Matthiola macranica* Rech f., *Matthiola flavida* Boiss., *Malcolmia africana* (L.) R.Br., *Nasturtium officinale* R. Br., *Microsisymbrium flaccidum* Schulz,**.** It is also divided into three subtype (see key to the species). *Farsetia ramosissima* - type is easily distinguished by its reticulate – rugulate tectum. Jonsell (1987) reported similar pollen in the genus *Farsetia* 13 species are included in this pollen type like, *Conringia planisiliqua* Fisch & Mey., *Crambe cardifolia* Steven, *Descurainia sophia* (L.) Webb. & Berth., *Diplotaxis grifftihii* (Hook.) & Thoms. Boiss., *Diptychocarpus strictus* (Fish. M. Beib.) Trautv, *Diplotaxis harra* (Forssk.) Boiss, *Erysimum crassicaule* (Boiss.) Boiss. *Erysimum melicentae* Dunn., *E. repandum* L., *Farsetia ramosissima* Hochst. ex Boiss, *Malcolmia behboudiana*, Rech.f., *Moricandia sinaica* (Boiss.) Boiss. *Lepidium aucheri* Boiss. Like other three types this pollen type is also classified into two subtypes

Pollen morphologically the family is more closely related to Tamricaceae where both families have tricolpate pollen with reticulate tectum (Qaiser & Perveen, 2004). Ertdman (1952) reported that the family is more close to family Capparaceae. However, Capparaceae is eurypalynous family, in this family tricolporate pollen are common (Perveen & Qaiser, 2001). Pollen morphology confirms the homogeneous nature of the family.

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