

POLLEN FLORA OF PAKISTAN–LXXI. ROSACEAE

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Abstract

Pollen morphology of 50 species representing 17 genera of the family Rosaceae i.e., *Alchemilla*, *Argemone*, *Cotoneaster*, *Crataegus*, *Duchesnea*, *Fragaria*, *Eriybotyra*, *Filipandula*, *Geum*, *Malus*, *Prunus*, *Potentilla*, *Pyrus*, *Rosa*, *Sibbaldia*, *Sorbaria* and *Sorbus* has been studied from Pakistan by light and scanning electron microscope. Pollen grains are usually free, radially symmetrical, isopolar, prolate-spheroidal to subprolate or oblate-spheroidal rarely perprolate, tricolporate rarely tricolpate. Tectum mostly coarsely-finely striate, rarely striate-rugulate, scabrate or spinulose often reticulate. Rosaceae is more or less eurypalynous family. Significant variation is found in P/E ratio, shape and exine ornamentation and on the basis of these characters family has been divided into seven pollen types viz., *Agrimonia eupatoria*-type, *Alchemilla ypsilotoma*-type, *Cotoneaster affinis*-type, *Fragaria nubicola*-type, *Geum roylei*-type, *Malus pumila*-type, *Potentilla pamirica*-type. Pollen data is useful at specific and generic level.

Introduction

The family Rosaceae consisting of 85 genera and about 3000 species, including many apomictic lines (Mabberley, 2008). In Pakistan, it is represented by 27 genera and about 160 species Landrein *et al.*, (2009). Rosaceae is a heterogenous family and usually divided into four well marked subfamilies: (1) Spiraeoideae (fruit follicle or capsule, *Spiraea*); (2) Maloideae (fruit a fleshy pome, ovary inferior, *Pyrus*, *Malus*, *Sorbus*); (3) Rosoideae (gynoecium of usually 10 or more pistils, fruit often dry, *Rubus*, *Fragaria*, *Potentilla*, *Geum*, *Rosa*); and (4) Prunoideae (gynoecium of a single pistil, rarely 2 to 5; fruit drupe, *Prunus*), sometimes these subfamilies are treated as independent families.

The family Rosaceae is important in temperate regions for fruits and ornamentals. Some important genera are *Spiraea*; *Rosa* (Rose); *Rubus* (Blackberry, Dewberry, Raspberry); *Potentilla* (Five finger, cinquefoil); *Fragaria* (Strawberry); *Pyrus* (pear); *Malus* (apple); *Sorbus* (mountain-ash, chokeberry), *Amelanchier* (Serviceberry, shadbush); *Pyracantha* (Fire thorn); *Crataegus* (hawthorn); *Prunus* (Plum, peach, cherry, apricot, almond); *Cotoneaster* and *Cydonia* (quince). Number of workers has examined pollen morphology of the family Rosaceae such as Faegri & Iversen. (1964), Reitsma (1966); Eide (1979, 1981), Moore & Webb (1987), Hebda *et al.*, (1988, 1990); Moore *et al.*, (1991), Hebda & Chinnappa (1990); Ueda (1992), Garcia and Sánchez (2004), Khan (2004), Wrońska-Pilarek & Lira (2006), Richerd *et al.*, (2009) Dobes & Paule (2010), Kolodziejek & Gabara (2008) examined the pollen morphology of the Polish taxa of the genus *Potentilla* sub sect. *Collinae* (Rosaceae). Dönmez (2008) studied the pollen morphology of Turkish genus *Crataegus* of the family Rosaceae. Pollen morphology of the genus *Potentilla* from Iran has been examined by Fagher *et al.*, (2012). Fatemi *et al.*, (2011) examined pollen morphology of the genus *Rosa* from Iran. Wroriska-Pilarek and Jagodzinski (2013) studied the pollen morphology of *Rosa* species from Poland.

There are no reports on the pollen morphology of the family Rosaceae from Pakistan and Kashmir. However, Tahir (2005) examined the pollen morphology of seven species of the genus *Sibbaldia* from Pakistan. The present study is the first attempt on pollen morphology of the family Rosaceae from Pakistan and Kashmir by scanning and light microscope.

Material and Methods

Polleniferous material was obtained from the specimens of Karachi University Herbarium (KUH). In few cases fresh material collected from the field. The list of voucher specimens is deposited in KUH (Centre for Plant Conservation). 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). The coating was restricted to 150 Å. T.S.E.M examination was carried out on a Jeol microscope JSM-6820. The measurements are based on 15-20 readings from each specimen. Pollen diameter, polar axis (P), equatorial diameter (E), aperture size and exine thickness were measured (Tables 1-2).

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

Result and Observations

General pollen morphology of the family Rosaceae: Pollen grains usually radially symmetrical, isopolar, prolate-spheroidal to sub-prolate or oblate-spheroidal, prolate, tricolporate, amb trilobed or triangular, with apertures on the angles of the outline of the grain in polar view, colpal membrane generally scabrate or granulated, ora circular to transversely elliptic, sexine thicker or thinner than nexine, or as thick as nexine. Tectum generally striate, rarely striate-rugulate, often scabrate-spinulose or reticulate. On the basis of apertural types, shape class and exine surface family has been divided into seven pollen types viz., *Agrimonia eupatoria*-type, *Alchemilla ypsilotoma*-type, *Cotoneaster affinis*-type, *Fragaria nubicola*-type, *Geum roylei*-type, *Malus pumila*-type, *Potentilla pamirica*-type.

Table 1. General pollen characters found in the *Fragaria nubicola* - pollen type.

Name of species	Shape	Polar length (P) in μm	Equatorial diameter (E) in μm	Colpus length in μm	Mesocolpium in μm	Apocolpium in μm	Exine thickness in μm
<i>Fragaria nubicola</i> (Hook.) Lindl. ex Lacaita	Ob-Sp	15.78(18.41)21.04	11.5(19.30)23.67	10.52(11.62)11.50	5.62(5.62)7.89	7.89(9.52)10.52	2.63
<i>Potentilla supina</i> L.	Pr-Sp	18.2(18.35)18.76	13.0(14.01)14.4	15.35(16.90 \pm)	10.6(12.4 \pm 0.80)	10.40(12.4 \pm 0.49)	1.30(1.30 \pm 0.05)
<i>Rosa banksiae</i> W.T. Aiton	Sub-Pr	11.5(27.35)34	11.5(21.45)34.9	10.52(13.93)18.41	7.8(13.43)15.8	5.2(8.75)10.52	2.63
<i>Rosa brunonii</i> Lindl.	Sub-Pr	18.4(28.4)36.8	10.52(18.6)23.67	10.52(18.6)23.6	5.26(6.83)7.89	10.52(14.4)18.41	2.6(3.15)5.26
<i>Rosa multiflora</i> Thunb.	Pr	26	11.5(15.25)21.04	11.5(17.38)21.0	5.25(7.36)7.89	11.5	2.63
<i>Sorbus transhianica</i> Rupr.	Sub-pr	22.1(22.45)22.8	15.61(16.25)	18.01(18.2 \pm)	17.6(17.9)18.2	10.40(10.80)11.7	1.30(1.31)1.32

Ob-Sp = Oblate-Spheroidal, Pr-Sp = Prolate-Spheroidal, Sub-Pr = Sub-Prolate, Pr = Prolate

Alchemilla ypsilotoma*-type*Pollen class:** 3-colporate, 3-zonocolporate**P/E ratio:** 0.97**Shape:** Oblate-spheroidal**Aperture:** Ectoaperture-colpus long, sunken, narrow, end acute**Endoaperture:** Circular**Exine:** Sexine thicker than or than nexine**Ornamentation:** Scabrate**Outline:** Equatorial view elliptic, polar view triangular**Measurements:** Polar axis (15.81-) 21.20 (-26.26) μm , and Equatorial diameter E(15.5-) 19.45 (-23.4) μm ; colpi (15.35-) 15.5 (-15.8) μm in length. Mesocolpium (17.6-) 17.9 (-18.2) μm . Apocolpium (10.40-) 11.05 (-11.7) μm . Exine (1.30-) 1.31 (-1.32) μm **Species included:** *Alchemilla ypsilotoma* Rothm.**Pollen type: *Agrimonia eupatoria* -type** (Fig. 1A &B)**Pollen class:** Tricolporate 3-zonocolporate**P/E ratio:** 0.99**Shape:** Oblate-spheroidal**Aperture:** Ectoaperture-colpus long, narrow, end acute. Endoaperture circular**Exine:** Sexine thinner than sexine**Ornamentation:** Spinulose**Outline:** Equatorial view elliptic, polar view triangular**Measurements:** Polar axis (20.81-) 23.70 (-26.26) μm and Equatorial diameter E(20.5-) 21.95 (-23.4) μm ; colpi (15.35-) 15.57 (-15.8) μm in length, tapering at both the ends, colpal membrane subsilate. Mesocolpium (17.6-) 17.90 (-18.2) μm . Apocolpium (10.40-) 11.05 (-11.7) μm . Exine (1.30-) 1.31 (-1.32) μm .**Species included:** *Agrimonia eupatoria* L.**Pollen type: *Cotoneaster affinis*-type** (Fig. 1C)**Pollen class:** 3-colporate 3-zonocolporate.**P/E ratio:** 1.14-1-25**Shape:** Prolate-spheroidal to Sub-prolate**Aperture:** Ectoaperture-colpus not sunken long margin irregular, end acute**Exine:** Sexine thinner than nexine**Ornamentation:** Tectum sub-psilate**Outline:** Equatorial view elliptic, polar view tri lobed, 3-lobed**Measurements:** Polar axis P(23.2-) 28.61 (-34.00) μm , and Equatorial diameter E(20.0-) 27.11 (-34.4) μm ; colpi (15.35-) 16.70 \pm 0.65 (-18.21) μm in length, tapering at both the ends, colpal membrane subsilate. Mesocolpium (10.6-) 12.41 (-14.2) μm . Apocolpium (10.40-) 10.85 (-11.7) μm . Exine (1.30-) 1.31 (-1.32) μm **Species included:** *Cotoneaster acutifolia*, *Cotoneaster affinis* var. *bacillaris* Lindl.**Pollen type: *Geum roylei*** (Fig. 1D)**Pollen class:** 3-colporate, 3-zonocolporate**P/E ratio:** 1.33**Shape:** Sub-prolate**Aperture:** Ectoaperture-colpus not sunken long margin irregular, end acute**Endoaperture:** Circular**Exine:** Sexine thicker or thinner than nexine

Ornamentation: Tectum reticulate
Outline: Equatorial view elliptic, polar view tri lobed
Measurements: Polar axis (P) (20.5-) 21.05 (-21.6) μm , and equatorial diameter E(14.0-) 15.613 (-16.26) μm , colpi (13.01-) 15.60 (-18.2) μm in length, tapering at both the ends, colp membrane subsilate. Mesocolpium (15.6-) 16.91 (-18.2) μm . Apocolpium (10.11-) 10.90 (-11.8) μm . Exine (2.65-) 2.72 (-2.79) μm .
Species included: *Geum roylei* Bolle

Pollen type: *Fragaria nubicola* (Fig. 1E & F; Fig. 2A & B)
Pollen class: 3-colporate, 3-zonocolporate
P/E ratio: 1.25-1.48

Shape: Oblate-spheroidal, Sub-prolate to prolate.
Apertures: Ectoapertures-colpus long, sunken, narrow, margins, Endoaperture circular

Exine: Sexine thicker or thinner than nexine.
Ornamentation: Tectum striate-rugulate
Outline: Equatorial view elliptic, Polar view tri - lobed with aperture on the angles of the outline of the grains in polar view
Measurements: Polar axis (P) (14.3) 20.11(27.7) μm . Equatorial diameter (13.4) 20.76 (28.12) μm . Colpus length (14.5) 20.10 (25.50) μm . Mesocolpium (10.00) 15.75 (21.50) μm . Apocolpium 0.75-5.55 μm . Exine (0.25) 1.75 (3.25) μm thick
Species included: *Fragaria nubicola* (Hook. f.) Lindl. ex Lacaita., *Potentilla supina* L., *Rosa banksiae* W.T Aiton., *Rosa brunonii* Lindle., *Rosa multiflora* Thunb. and *Sorbus tianshanica* Rupr.

Key to the pollen types

- 1. + Pollen grains colpate *Malus pumila*-type
 - Pollen grains tricolporate 2
- 2. + Tectum scabrate or spinulose or punctuate 3
 - Tectum not as above 6
- 3. + Tectum reticulate *Geum roylei*-type
 - Tectum scabrate or spinulose often subsilate 4
- 4. + Tectum sub-psilate *Cotoneaster affinis*-type
 - Tectum not as above 5
- 5. + Tectum scabrate *Alchemilla ypsilotoma*-type
 - Tectum spinulose *Agrimonia eupatoria* -type
- 6. + Tectum striate-rugulate *Fragaria nubicola*-type
 - Tectum simplly striate *Potentilla pamirica*-type

Key to the species

- 1. + Polar length of pollen 40-42 μm *Cotoneaster acutifolia*
 - Polar length of pollen less than 42 μm *Cotoneaster affinis* var. *bacillaris*

Key to the species and species groups

- 1. + Pollen oblate-spheroidal *Fragaria nubicola*
 - Pollen not as above 2
- 2. + Pollen prolate *Rosa multiflora*
 - Pollen sub-prolate or prolate-spheroidal group-I
 (*Potentilla supine* L., *Rosa banksiae* W.T Aiton. and *Rosa brunonii* Lindle. *Sorbus tianshanica* Rupr.)

Pollen type: *Malus pumila*
Pollen class: 3-colpate 3-zonocolpate
P/E ratio: 1.30
Shape: Sub-prolate
Aperture: Ectoapertue-colpus not sunken long margin irregular, end acute
Exine: Sexine thinner than nexine
Ornamentation: Tectum striate
Outline: Equatorial view elliptic, polar view trilobed, 3-lobed
Measurements: Polar axis P (23.2-) 28.61 (-34.00) μm , and Equatorial diameter E(20.0-) 27.21 (-34.4) μm . colpi (15.35-) 16.78 (-18.21) μm in length, tapering at both the ends, colp membrane subsilate. Mesocolpium (10.6-) 12.41 (-14.2) μm . Apocolpium (10.40-) 11.05 (-11.7) μm . Exine (1.30-) 1.31 (-1.32) μm
Species included: *Malus pumila* L.

Pollen type: *Potentilla pamirica* (Fig. 2C-F; Fig. 3 A-F)
Pollen class: Tricolporate, trizonocolporate
P/E ratio: 0.88-1.71
Shape: Prolate spheroidal or oblate-spheroidal, sub-prolate
Aperture: Ectoapertue-colpus not sunken long margin irregular, end acute
Endoaperture: Circular
Exine: Sexine thicker or thinner than nexine
Ornamentation: Tectum coarse to fine striate
Outline: Equatorial view elliptic, polar view oblate, 6-lobed
Measurements: Polar axis (P) (15.5) 18.12 (56.25) μm , equatorial diameter (11.52) 18.12 (34.25) μm and colpus length (16.5) 11.87 (49.50) μm long. Colpal membrane granulated. Mesocolpium (10.6-) 12.41 (-54.2) μm . Apocolpium (10.40-) 11.05 (-13.7) μm . Exine (1.20-) 1.31 (-1.32) μm .

Table 2. General pollen Characters of the species found in the *Potentilla pamirica* - pollen type.

Name of species	Shape	Polar axis (P) in μm	Equatorial diameter in μm	Colpus in μm	Mesocolpium in μm	Apocolpium in μm	Exine thickness
<i>Cotoneaster rosea</i> Edgew	Ob-sp	23.41(24.31±0.96)	23.4(26.10) 26.4	16.9(17.7±0.65) 18.50	24.9(24.3±0.87) 24.9	11.4(12.4) 13.5	1.25(2.34±0.05) 2.60
<i>Crataegus songarica</i> C. Koch	Ob-sp	22...5(24.31±23.6)	26.0(18.21±0.96) 26.26	13.1(26.10±0.65) 18.21	15.6(10.4±0.87) 18.21	10.11(11.6±6.44) 11.81	1.15(1.51±0.05) 2.75
<i>Duchesnea indica</i> (Andrews) Focke	Sub-sp	26.49(31.44±0.96) 36.40	20.80(26.00) 31.2	18.2(19.01±0.65) 20.8	18.2(19.5±0.87) 20.8	10.4(11.7±0.49) 13.8	2.65(2.60±0.05) 2.79
<i>Eriobotrya japonica</i> (Thunb.) Lindley	Pro-sp	20.41(20.8±0.96) 20.6	18.0(18.20) 18.4	29.91(39.70±0.65) 39.8	24.9(24.3±0.87) 324.9	11.4(12.34±0.10) 13.5	1.25(2.34±0.05) 2.60
<i>Fillipandula vestata</i> Wallich ex G. Don	Pro-sp	(20.41)20.8±0.94	18.0(18.20) 18.4	39.91(39.7±0.65) 39.8	24.9(24.3±0.81) 24.9	11.4(12.4±0.49) 13.5	1.25(2.34±0.03) 2.60
<i>Potentilla anserine</i> L.	Ob-sp	20.5(20.85) 23.4	20.81(23.41±0.46) 26.26	13.01(14.61±0.45) 15.2	15.6(16.9±0.67) 18.2	10.40(10.05±0.40) 11.7	2.65(2.60±0.05) 2.79
<i>Potentilla bamehalensis</i> Cambess.	Pro-sp	20.41(23.70±0.96) 28.6	18.2(20.8±(23.4)	10.4(21.90±0.45) 23.44	15.6(16.90±0.87) 18.21	11.7(12.35±1.9) 13.0	2.25(2.60±0.05) 2.67
<i>Potentilla chrysantha</i> Trevir.	Sub-pr	20.8(20.70±0.86) 26.26	15.1(15.65) 16.1	15.35(15.01±0.110) 10.35(10.01±0.6)	17.6(17.9±0.87) 18.21	10.40(10.05±49) 11.7	1.30(1.31±0.05) 1.32
<i>Potentilla desertorum</i> Bunge	Sub-pr	15.01(15.50±0.96) 16.2	13.0(13.01) 13.4	10.35(10.01±0.6) 10.81	13.6(13.9±0.8) 15.61	9.14(10.4±0.4) 11.61	1.35(1.30±0.05) 1.4
<i>Potentilla donjouncana</i> Cambess.	Sub-pr	25.11(25.5±0.9) 26.6	18.00(19.5) 21.4	18.41(18.5±0.6) 18.7	11.6(13.3) 15.6	9.14(10.4) 11.6	1.35(1.30) 1.40
<i>Potentilla dryadanthoides</i> (Juz.) Viroshilov	Sub-pr	20.5(20.85) 23.4	15.81(16.90±0.96) 16.96	17.6(17.9±0.87) 18.2	18.01(18.2) 18.51	10.40(7.80±0.49) 11.71	1.30(1.31) 1.32
<i>Potentilla gefida</i> C.A. Mey	Pr - sp	23.41(26.01±0.96) 28.6	23.4(24.90) 26.4	15.61(19.31±0.65) 23.21	19.5(20.15±0.8) 20.81	12.4(13.0) 13.7	1.25(1.30) 1.35
<i>Potentilla Gerardiana</i> Lindl. ex Lehn.	Ob-sp	28.41(24.1±0.96) 26.6	23.4(24.90) 26.4	15.61(17.7±0.65) 18.5	15.9(16.9±0.87) 17.9	11.4(12.4±0.49) 13.51	1.25(1.90±0.05) 2.61
<i>Potentilla grisea</i> Juz.	Ob-sp	20.5(20.85) 23.4	20.8(23.41±0.4) 26.26	13.01(13.61±0.6) 18.2	15.6(16.9±0.87) 18.2	10.11(10.5±0.49) 11.00	2.65(2.60) 2.79
<i>Potentilla monanthus</i> Lindl.	Pr-sp	23.11(24.8±0.96) 26.6	20.8(21.9) 23.4	16.91(20.8±0.65) 18.5	11.6(13.3±0.87) 15.6	9.14(10.4±0.49) 11.6	1.35(1.30±0.45) 1.30
<i>Potentilla multifida</i> L.	Ob-sp	18.46(18.41) 19.5	19.5(19.30) 20.67	10.52(15.61) 15.8	15.12(15.62) 16.89	7.89(9.52) 10.52	1.3 1.3
<i>Potentilla oebrecta</i> Lindl.	Ob-sp	20.81(20.70±0.96) 26.26	20.5(20.85) 23.4	15.35(15.61±0.85) 15.8	17.6(17.9±0.87) 18.21	10.40(10.05±0.49) 11.7	1.30(1.31±0.5) 1.32
<i>Potentilla pamirica</i> Th. Wolf	Pr - sp	26.49(26.81±0.96) 27.26	20.5(21.95) 23.4	15.35(15.61±0.85) 15.8	17.6(17.9±0.87) 20.8	10.4(11.7±0.49) 13.0	2.65(2.60±0.05) 2.79
<i>Potentilla pamirica</i> Th. Wolf var. <i>pamiroaltaica</i> (Juz.) M. Shah & Wilcock	Pr-sp	20.81(23.41±0.96) 26.26	20.5(20.85) 23.4	13.01(15.61±0.65) 18.2	15.6(10.9±0.81) 18.2	10.4(10.7±0.49) 11.0	2.65(2.66) 2.79

Table 2. (Cont'd.).

Name of species	Shape	Polar axis (P) in μm	Equatorial diameter in μm	Colpus in μm	Mesocolpium in μm	Apocolpium in μm	Exine thickness
<i>Potentilla plurijuga</i> Hand -Mazz	Ob-sp	22.5(23.05) 13.6	26.0(26.01 \pm 0.96) 26.2	18.01(18.2 \pm 0.65) 18.2	15.6(11.7 \pm 0.8) 18.2	10.11(11.6 \pm 0.49) 11.8	2.65(2.0 \pm 0.05) 1.30(1.31 \pm 0.5)
<i>Potentilla reptans</i> L.	Ob-sp	20.5(20.85) 23.11	20.8(20.70 \pm 0.96) 26.26	18.01(18.21 \pm 0.65) 18.5	17.6(17.9 \pm 0.87) 18.21	10.41(10.05 \pm 0.49) 11.7	1.30(1.31 \pm 0.5) 1.32
<i>Potentilla sundaica</i> (Blume) O. Kunt	Ob-sp	23.11(23.41 \pm 0.96) 24.6	23.4(24.7) 26.4	16.9(18.2 \pm) 18.5	15.9(16.9 \pm 0.87) 17.9	9.14(10.4 \pm 0.40) 11.6	2.35(2.60) 29.0
<i>Potentilla sino-nivea</i> Hulten	Pr-sp	20.81(23.40) 26.25	20.5(2.85) 2.14	15.35(15.61) 15.8	19.6(19.5) 20.2	10.40(10.05) 11.7	1.30(1.31) 1.32
<i>Prunus amygdalatus</i> Batsch	Pr-sp	32.6(45.30 \pm 0.96) 47.8	30.60(40.01) 42.4	30(30.8 \pm 0.65) 31.21	30.6(32.4 \pm) 40.2	10.40(12.4) 11.7	1.30(1.30) 1.32
<i>Prunus domestica</i> L.	Sub-pr	49.30(52.30 \pm 0.91) 57.8	34(14.01) 54.40	35.35(36.90 \pm 0.65) 49.21	34.6(42.4 \pm 0.87) 54.21	10.40(12.4) 11.7	1.30(1.30) 1.32
<i>Persica vulgaris</i> Mill.	Pr-sp	30.60(46.30 \pm 0.96) 57.81	30.60(41.10) 52.4	15.35(16.90 \pm 0.65) 18.21	30.6(40.4 \pm 0.87) 51.21	10.40(12.4) 11.7	1.30(1.30 \pm 0.05) 1.32
<i>Prunus armeniaca</i>	Pr-sp	40.8(48.80) 56.10	34.0(43.01) 49.4	15.35(16.90 \pm 0.65) 18.21	10.6(12.4 \pm 0.8) 14.2	10.40(12.4 \pm 0.40) 11.7	1.30(1.30 \pm 0.05) 1.32
<i>Pyrus cuminis</i> L.	Sub-p	17.2(26.20 \pm 0.96) 34.4	13.60(23.20) 34.4	15.35(16.9 \pm 0.65) 18.2	11.6(22.4 \pm 0.87) 14.3	10.40(12.4 \pm 0.40) 11.7	1.30(1.30 \pm 0.05) 1.32
<i>Rosa beggeriana</i> Schrenk	Pr	36.68	18.4(18.93) 21.04	18.4(19.62) 21.0	18.4	7.89(9.62) 10.52	2.63 2.63(2.98)
<i>Rosa canina</i> L.	Sub-Pr	31.56(34.19) 36.38	15.78(27.7) 36.82	15.7(17.43) 21.04	5.2(6.68)7.87	10.52(16.25) 18.41	2.63(2.98) 3.94
<i>Rosa chinensis</i> Jacq.	Sub-Pr	26.3(31.03) 31.56	15.7(21.30) 23.67	15.78(21.30) 23.67	11.5(14.4) 15.7	5.26(7.10) 7.89	2.63 2.6
<i>Rosa foetida</i> J. Herm.	Sub-Pr	21.02(25.51) 28.9	11.5(19.19) 21.04	15.78(18.6) 26.3	15.78(18.6) 26.3	5.26(6.41) 4.89	2.6 2.63(3.15)
<i>Rosa ecae</i> Aitch.	Sub-Pr	23.67(34.4) 52.6	23.67(29.56) 52.61	10.52(11.3) 11.5	10.52(18.6) 42.6	7.89(9.90) 1.5	2.63(3.15) 52.0
<i>Rosa kokanica</i> (Regel) Juz.	Pr	23.6(27.1) 31.56	21.04(23.67) 26.3	10.52(11.3) 11.5	11.5(14.4) 15.78	5.26(6.70) 7.89	2.63 2.63(3.15)
<i>Rosa laevigata</i> Rich.	Pr	26.3(28.03) 31.5	15.78(18.69) 34.19	15.78(16.51) 18.41	11.5(17.38) 21.04	11.5(13.91) 15.7	2.63(3.15) 52.26
<i>Rosa webbiana</i> Wall. ex Royle	pr	26.6(28.99) 31.56	10.52(20.5) 31.56	10.52(14.7) 15.78	13.51(14.7) 15.78	10.52(14.7) 15.78	2.63(3.14) 5.26
<i>Sorbaria atichisonii</i> (Nemsi) zrehder	Sub-pr	10.4(11.05) 11.7	16(16.90) 13.6	10.4(11.2) 12.7	12.7(17.9) 14.3	10.40(10.50) 11.7	1.80(1.82 \pm 0.05) 1.92
<i>Sibbaldia purpurea</i> Royle	Sub-pr	22.1(22.45) 22.8	15.61(16.25) 16.96	17.6(1.29) 18.2	17.6(17.9) 18.2	10.40(10.80) 11.7	1.30(1.31 \pm 0.05) 1.32

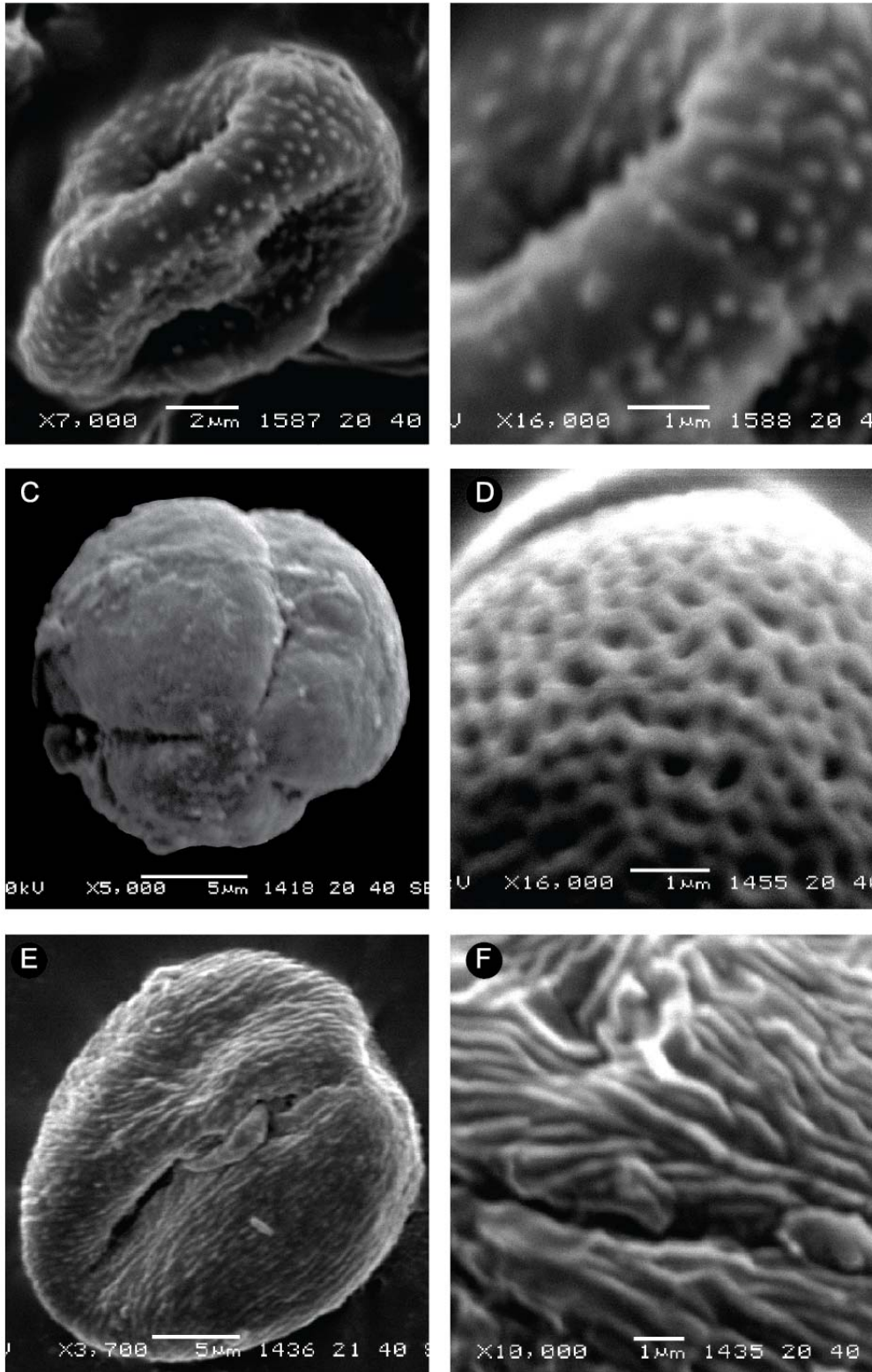


Fig. 1. Scanning electron micrographs. *Agrimonia eupatoria*: A, equatorial view; B, exine pattern. *Cotoneaster affinis*: C, polar view. *Geum roylei*: D, exine pattern. *Rosa multiflora*: E, equatorial view; F, exine pattern.

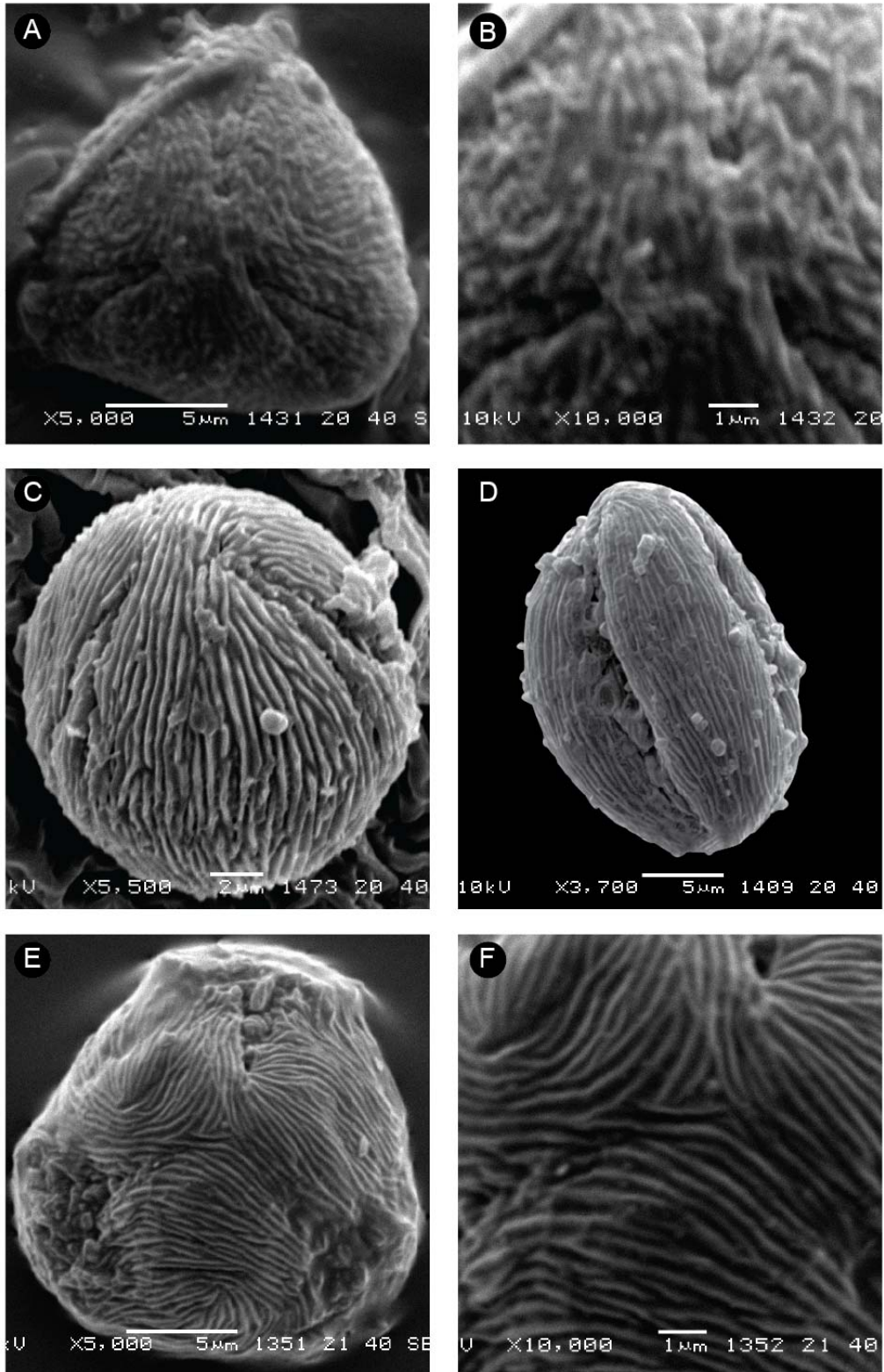


Fig. 2. Scanning electron micrographs. *Fragaria nubicola*: A, equatorial view; B, exine pattern. *Sibbaldia purpurea*: C, equatorial view. *Potentilla chrysantha*: D, equatorial view. *Potentilla grisea*: E, equatorial view; F, exine pattern.

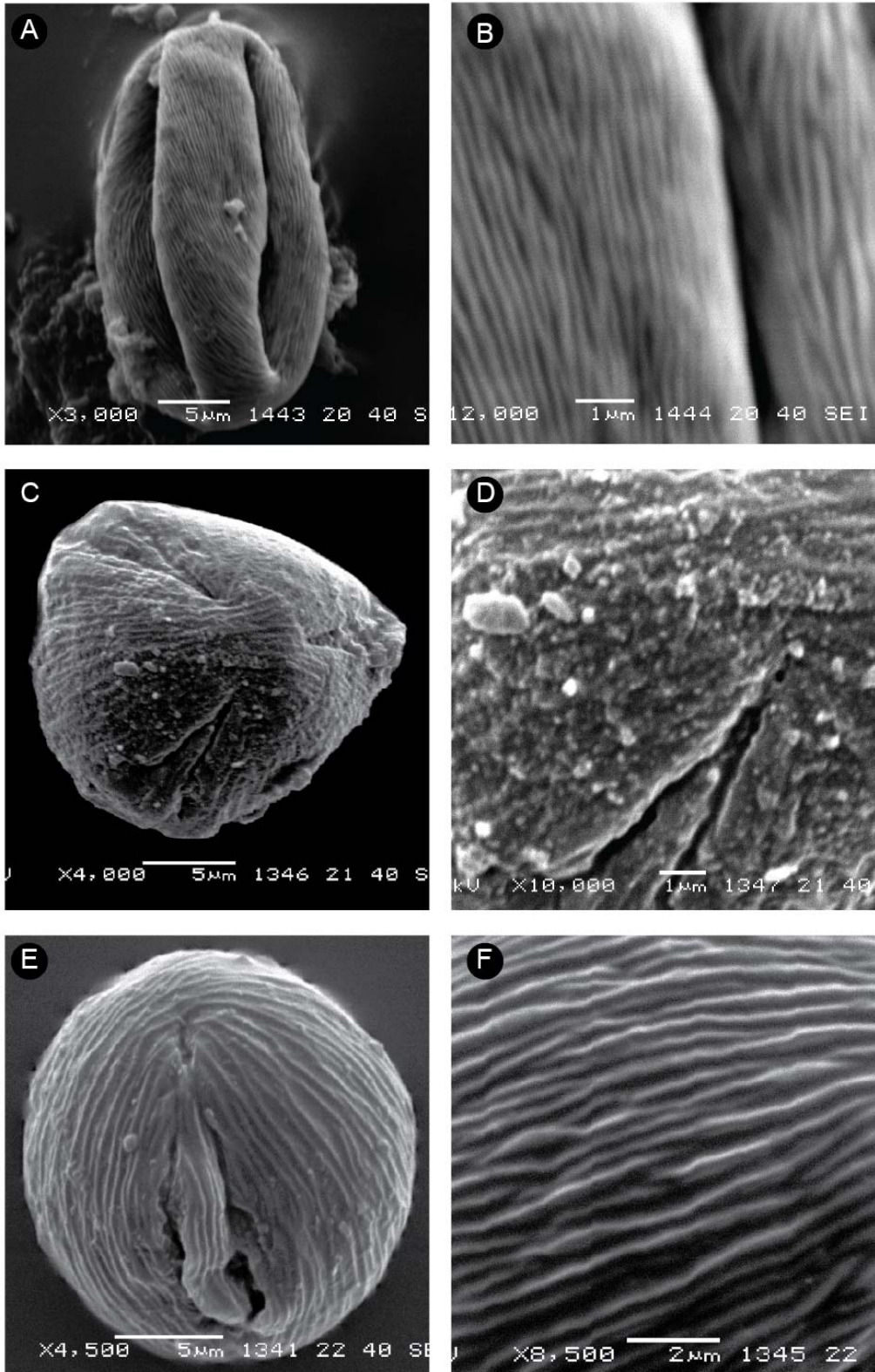


Fig. 3. Scanning electron micrographs. *Potentilla cuminis*: A, equatorial view; B, exine pattern. *Potentilla bannehalensis*: C, equatorial view; D, exine pattern. *Potentilla gerardiana*: E, equatorial view; F, exine pattern.

Species included: *Cotoneaster rosea* Edgew., *Crataegus songarica* C. Koch., *Duchesnea indica* (Andrews) Focke, *Eriobotrya japonica* (Thunb.) Lindley, *Filipandula vestita* (Wall. ex G. Don.) Maxim., *Potentilla anserina* L., *Potentilla bannehalensis* Cambess., *Potentilla chrysantha* Treir, *Potentilla desertorum* Bunge, *Potentilla doubjouniana* Cambess., *Potentilla dryadanthoides* (Juz.) Viroschilov, *Potentilla gelida* C.A. Mey, *Potentilla gerardiana* Lindl. ex Lehm., *Potentilla grisea* Juz., *Potentilla monanthes* Lindl., *Potentilla multifida* L., *Potentilla ochreatea* Lindl., *Potentilla pamirica* Th. Wolf,

Potentilla pamirica var. *pamiroalaica* (Juz.) M. Shah & Wilcock, *Potentilla plurijuga* Hand.-Mazz., *Potentilla reptans* L., *Potentilla sundaica* (Blume) O. Kuntz, *Potentilla sino-nivea* Hulten, *Prunus amygdalus* Batsch, *Prunus armeniaca* L., *Prunus domestica* L., *Persica vulgaris* Mill, *Pyrus cuminis* L., *Rosa beggeriana* Schrenk, *Rosa canina* L., *Rosa chinensis* Jacq., *Rosa ecae* Aitch., *R. foetida* J. Herm, *Rosa indica* L., *Rosa kokanica* (Regel) Juz., *Rosa laevigata* Rich., and *Rosa webbiana* Wall. ex Royle., *Sorbaria aitchisonii* (Hemsl.) Rehder and *Sibbaldia purpurea* Royle

Key to the species groups

1. + Pollen finely striate group-I
(*Potentilla bannehalensis* Cambess., *Potentilla chrysantha* Treir, *Potentilla monanthes* Lindl., *Rosa beggeriana* Schrenk, *Rosa canina* L., *Rosa chinensis* Jacq. and *Rosa webbiana* Wall. ex Royle)
- Pollen coarsely-medium striate 2
2. + Tectum coarsely striate group-II
(*Cotoneaster rosea* Edgew., *Duchesnea indica* (Andrews) Focke, *Potentilla doubjouniana* Cambess., *Potentilla dryadanthoides* (Juz.) Viroschilov, *Potentilla plurijuga* Hand.-Mazz., *Potentilla reptans* L., *Potentilla sundaica* (Blume) O. Kuntz, *Potentilla sino-nivea* Hulten, *Rosa foetida* J. Herm, *Rosa kokanica* (Regel) Juz., and *Sibbaldia purpurea* Royle)
- Tectum medium striate group-III
(*Crataegus songarica* C. Koch., *Eriobotrya japonica* (Thunb.) Lindley, *Filipandula vestita* (Wall. ex G. Don.) Maxim., *Potentilla anserina* L., *Potentilla desertorum* Bunge, *Potentilla gerardiana* Lindl. ex Lehm., *Potentilla grisea* Juz., *Potentilla multifida* L., *Potentilla ochreatea* Lindl., *Potentilla pamirica* Th. Wolf, *Potentilla pamirica* var. *pamiroalaica* (Juz.) M. Shah & Wilcock, *Potentilla reptans* L., *Prunus amygdalus* Batsch, *Prunus armeniaca* L., *Prunus domestica* L., *Persica vulgaris* Mill, *Pyrus cuminis* L., *Rosa ecae* Aitch., *Rosa laevigata* Rich., and *Sorbaria aitchisonii* (Hemsl.) Rehder.

Discussion

Schulze-Menz (1964) divided the Rosaceae into four subfamilies viz., Rosoideae, Spiraeoideae, Maloideae (Pomoideae), and Prunoideae (or Amygdaloideae), based on fruit types and structure. However, Hutchinson (1964) divided the family into some tribes but did not distinguish subfamilies. Such as, tribes Exochordeae, tribe Spiraeaceae, tribe Neillieae, tribe Gillenieceae (*Sorbaria*), tribe Kerrieae, tribe Dryadeae, tribe Ulmarieae (*Filipendula*), tribe Sanguisorbeae (*Agrimonia*), tribe Potentilleae (*Potentilla*, *Fragaria*), tribe Rubeae, tribe Roseae (*Rosa*), tribe Pruneae (*Prunus*), tribe Maleae, (*Eriobotrya*, *Sorbus*, *Malus*, *Pyrus*), tribe Crataegeae. Kalkman (1988) designated three informal groups around the genera and 11 tribes viz., Tribe Spiraeaceae, Tribe Gillenieceae, Tribe Kerrieae, Tribe Ulmarieae, Tribe Sanguisorbeae, Tribe Potentilleae, Genus Group, Tribe Rubeae, Tribe Roseae, Alchemilla Group, Tribe Pruneae, Cydonia group, Tribe Maleae, Tribe Crataegeae.

Rosaceae is more or less euryalynous family. Pollen grains are usually radially symmetrical, isopolar, tricolporate rarely tricolpate, tectum generally coarse to fine striate, rarely striate-rugulate often spinulose-scabrate or subsulate. Shape class also varies from prolate-spheroidal to oblate-spheroidal or sub-prolate to prolate. On the basis exine ornamentation and apertural types family has been divided into seven pollen types viz., *Agrimonia eupatoria*-type, *Alchemilla ypsilotoma*-type, *Cotoneaster affinis*-type, *Fragaria nubicola*-type, *Geum roylei*-type,

Malus pumila-type, *Potentilla pamirica*. Hebda and Chinnappa (1994) recognized six pollen types within the family Rosaceae: 1: striate and macroperforate, 2: striate and microperforate, 3: tuberculate and perforate, 4: microverrucate, 5: verrucate, and 6: perforate, without supratectal features. Thakur & Thakur (1970) suggested that the exine was genetically stable for various species of Rosaceae and could be used for identification of species. Hebda *et al.*, (1990) reported that the pollen surface sculpturing, aperture and aperture structure, pollen shape, size were all useful characters to differentiate the various genera and even species of the family Rosaceae. Differences in size and surface ornamentation of grains are useful character for delimiting the species of the genus *Malus* (Joneghani, 2008).

Present pollen data is based on 50 species and 18 genera viz., *Alchemilla*, *Agrimonia*, *Cotoneaster*, *Crataegus*, *Duchesnea*, *Fragaria*, *Eriobotrya*, *Filipandula*, *Geum*, *Malus*, *Persicaria*, *Prunus*, *Potentilla*, *Pyrus*, *Rosa*, *Sorbaria*, *Sibbaldia* and *Sorbus*. Pollen characters are significantly helpful to distinguish various genera of the family Rosaceae, such as, in the genus *Malus* (*Malus pumila*) pollen grain is tricolpate whereas in the remaining genera have tricolporate pollen. Xiang & Sheng (1991) also reported similar pollen in the genus *Malus*. Similarly, the genus *Agrimonia*, representing a single species (*Agrimonia eupatoria*) is easily delimited by having spinulose tectum. The genus *Alchemilla* is characterized by having scabrate tectum only a single species is included in this genus (*Alchemilla ypsilotoma*). In the genus *Cotoneaster* three

species have been examined all the species is easily delimited on the basis of exine pattern and pollen shape such as, in *Cotoneaster rosea* tectum is striate whereas, in the remaining two species tectum is sub-psilate however, both the species are further delimited on the basis of shape viz., sub-prolate in the *Cotoneaster acutifolia*, prolate-spheroidal in *Cotoneaster affinis*. Similarly, the genus *Geum* is easily recognized from rest of genera by its reticulate exine pattern, it is represented by a single species (*Geum roylei*). Within the genus *Potentilla* 17 species have been examined. All the species are easily recognized by striate exine ornamentation. However, these species are further delimited into three groups on the basis of coarse-fine striae (except *Potentilla supina* L., has striate-rugulate pattern). Group-I is easily recognized by its medium striate patterns, 9 species are included in this pollen type viz., *Potentilla anserine* L., *Potentilla desertorum* Bunge, *Potentilla gerardiana* Lindl. ex Lehm., *Potentilla grisea* Juz., *Potentilla multifida* L., *Potentilla ochreatea* Lindl., *Potentilla pamirica* Th.Wolf, *Potentilla pamirica* var. *pamiroalaica* (Juz.) M. Shah & Wilcock, *Potentilla reptans* L.

Group-II is recognized by its coarsely striate tectum. Five species are found in this pollen type viz., *Potentilla dryadanthoides* (Juz.) Virosilov, *Potentilla doubjouneana* Cambess. *Potentilla plurijuga* Hand-Mazz., *Potentilla reptans* L., *Potentilla sundaica* (Blume) O.Kuntz, *Potentilla sino-nivea* Hulten. Group-III Tectum finely striate like, *Potentilla bannehalensis* Cambess., *Potentilla chrysantha* Treir, *Potentilla monanthes* Lindl. All these species is further delimited on the basis of shape, size and exine thickness (Table 2). From the genus *Rosa* pollen morphology of 12 species was examined viz., *Rosa banksiae* W.T Aiton., *Rosa beggeriana* Schrenk. *Rosa brunonii* Lindle., *Rosa canina* L., *Rosa chinensis* Jacq., *Rosa ecae* Aitch.; *R. foetida* J. Herm, *Rosa kokanica* (Regel) Juz., *Rosa laevigata* Rich., *Rosa multiflora* Thunb., and *Rosa webbiana* Wall.ex Royle. Ueda & Tomita (1989), Ueda (1992). distinguished six types and three subtypes of exine sculpture in species of *Rosa* genus. All these species show considerable variation in exine ornamentation and shape class. Hebda & Chinnappa (1994) reported that the subfamily Rosoideae is the most heterogeneous subfamily within the family Rosaceae. Popek (1996) distinguished two types of sculpture in the genus *Rosa* reticulate and striate. Pollen morphology of the genus *Rosa* is significant enough to delimit the *Rosa* species (see Key to the species). Shinwari & Khan (2004) reported the pollen characters such as, exine thickness, shape, pollen size, and colpi length have been found to be a useful criteria for delimiting species of the genus *Rosa* (Wronske-Pilarek, (2011). However, remaining genera viz., *Duchesnea*, *Fragaria*, *Eriobotrya*, *Filipandula*, *Pyrus*, *Sorbaria*, *Sibaldia* and *Sorbus* represent a single species (except *Prunus*). From the *Prunus* three species were studied, easily separated on the basis of pollen shape. However, *Filipendula*, *Fragaria* and *Sorbus* have striate-rugulate tectum. Lee, et al., (2009) examined 15 species from the genus *Filipendula* and reported scabrate- microechinate

tectum. Where as we found striate-rugulate tectum in the genus *Filipendula vesitita* (the only species examined in the present study) *Eriobotrya*, *Pyrus*, *Sorbaria*, *Sibaldia* have fine to coarsely striate pattern.

Kalkman (1988) divided the family Rosaceae into four subfamilies on the basis of fruits types viz., Spiraeoideae, Maloideae, Rosoideae and Prunoideae. Seven pollen types recognized on the basis of apertural types and exine ornamentation in the present study do not correspond with the subfamilial classification of the family Rosaceae. For instance, in pollen type *Potentilla pamirica* species of three subfamilies viz., Rosoideae, Maloideae and Prunoideae are found. Similarly, in the subfamily Rosoideae Species of two pollen types are found such as *Alchemilla ypsilotoma*-type and *Agrimonia eupatoria* -type. However, pollen morphology of the family is more or less significantly helpful at the specific level.

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