

POLLEN FLORA OF PAKISTAN-XXXVII. TAMARICACEAE

MOHAMMAD QAISER AND ANJUM PERVEEN

*Department of Botany,
University of Karachi, Karachi - 75270, Pakistan.*

Abstract

Pollen morphology of 35 taxa of the family Tamaricaceae from Pakistan has been examined by light and scanning electron microscope. Pollen grains usually radially symmetrical, isopolar prolate-subprolate, rarely prolate-spheroidal, colpate. Sexine thinner or thicker than nexine. Tectum reticulate to reticulate – rugulate or foveolate or areolate. On the basis of tectum and relative thickness of sexine and nexine three distinct pollen types are recognized viz., *Myricaria squamosa* - type, *Reaumuria alternifolia* -- type and *Tamarix aphylla* – type. Pollen of the genus *Tamarix* are divided into two groups viz., columellae present inside the luminae and luminae without columellae. Palynological data has been useful at generic and specific level.

Introduction

Tamaricaceae is a small family of about 4 genera and 110 species (Mabberly, 1987) temperate in distribution, usually in sandy tracts and maritime deserts of Asia, Africa and Europe. In Pakistan it is represented by 4 genera and 35 species (Qaiser, 1982). Erdtman (1952) studied the pollen grains of few common species of *Tamaricaceae* belonging to *Tamarix*, *Myricaria* and *Reaumuria*, but none of the taxa studied by him occur in our region. Nair (1962) studied the pollen morphology of common Indian species belonging to *Tamarix* and successfully delimited *T. dioica* Roxb. ex Roth, *T. ericoides* Rottl. et Willd., *T. indica* Willd., *T. gallica* L. (this species does not occur in Indo-Pak subcontinent) and *T. tetrandra* Pall. ex M. Bieb. (most probably based on misidentification), on the basis of pollen size. While working on the pollen flora of Israel Horwitz & Baum (1967) studied the pollen of some species of *Tamarix*, of which only two species occur in Pakistan. Pollen morphology of the family Tamaricaceae has been examined by Martin & Drew (1970). Baum *et al.*, (1971) studied the pollen grains of the genus *Tamarix* but left number of taxa occurring in Pakistan. Pollen morphology of the family has also been studied by Armbruster & Jacobs (1934-35), Bhaskar & Razi (1973), Kuprianova & Alyoshina (1978), Moore & Webb (1978) and Qaiser & Ali (1978). However, no palynological information is available on a number of new species of the genus *Tamarix* described by Qaiser (1981) from Pakistan and *Myricaria* and *Reaumuria* species. The purpose of this investigation is two fold firstly to provide palynological information of all the species found in Pakistan, secondly to provide additional micro morphological characters in this intricate family. Present investigations are based on the pollen morphology of 35 taxa representing four genera of the family Tamaricaceae by light and scanning electron microscope.

Materials and Methods

Pollen samples were obtained from Karachi University Herbarium (KUH) or collected from the field. The detail of voucher specimens is given in Annexure-1. 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 and 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 15 Å. 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 (Table 1).

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

General pollen characters of the family Tamaricaceae

Pollen grains usually radially symmetrical, isopolar, sub-prolate or prolate, rarely prolate-spheroidal, tricolpate, sexine thinner or thicker than nexine. Tectum reticulate or reticulate-rugulate or aerolate. On the basis tectum and relative thickness of nexine, 3 distinct pollen types are recognized viz., *Myricaria squamosa* - type, *Reaumuria alternifolia* - type and *Tamarix aphylla* - type.

Key to the pollen types

1. + Sexine thicker than nexine *Reaumuria alternifolia*- type
- Sexine as thick as nexine 2
2. + Exine with reticulate sculpturing *Tamarix aphylla* - type
- Exine with aerolate sculpturing *Myricaria squamosa* - type

Pollen type: *Myricaria squamosa* - type (Fig. 1 A-C)

Pollen class: Tricolpate

P/E ratio: 1.16-1.29

Shape: Sub-prolate.

Apertures: Colpus long sunken with acute ends.

Exine: Sexine as thick as nexine.

Ornamentation: Areolate

Measurements: Size: Polar axis P= 22.20x20.72 – 29.71x20.9 µm, and equatorial diameter E = 19.4x19.1-33.6x22.20, (trilobed, with apertures on the angles of the outline of the grain in polar view, colpi (16.61-20.8) µm long. Exine 0.15-3.5 µm thick, sexine as thick as nexine. Tectum areolate.

Species included: *Myricaria davurica* (Willd.) Ehrenb., *M. germanica* (L.) Desv. subsp. *alopecuroides* (Schrenk) Kitam., *M. germanica* (L.) Desv. subsp. *pakistanica* Qaiser, *M. prostrata* Hook. f. et Thoms ex Benth. et Hook. f. *M. squamosa* Desv.

Annexure 1. List of voucher specimens.

Taxa	Locality	Collector
<i>Myricaria davurica</i> (Willd.) Ehrenb.	Gilgit, Sholkar Shai	Wendelbo s.n. (W)
<i>Myricaria germanica</i> (L.) Desv. ssp. <i>alopecuroides</i> (Schrenk) Maxim.	Bombrait	Y. Nasir 5030 (RAW)
<i>Myricaria germanica</i> (L.) Desv. spp. <i>pakistanica</i> Qaiser	Above Rattu, Astor valley ± 9000 Swat, Gabral Khawaja Khela	R.R. & I.D. Stewart 19771 (RAW); F. Grobman 6271 (KUH). S.I. Ali 25997 (RAW)
<i>Myricaria prostrata</i> Hk. f. et Thoms ex Benth. et Hook.f.	Lanak pass Sikkim	Strachey (K), Hook.J. (K)
<i>Myricaria squamosa</i> Desv.	Naltar valleg, Gilgit Naran,	R.R. Stewart 26463 (RAW), S.M.H. Jafri & S.I. Ali 3437 (KUH).
<i>Reaumuria alternifolia</i> (Laill.) Britten ssp. <i>alternifolia</i>	34 miles from Laralai on way to Fortsandeman, Near Kach on way to Ziarat	M. Qaiser & A. Ghafoor, 1539 (KUH). M. Qaiser & A. Ghafoor 1400 (KUH).
<i>Reaumuria alternifolia</i> (Labill.) Britten spp. <i>panijgurica</i> (Blatt & Hallb.) Qaiser	Sorrarge, Quetta 18 miles from Panjgur on way to Hoshab	H. Crookshank s.n. (K) M. Qaiser, Asad Raza & Abrar Hussain 1106 (KUH)
<i>Reaumuria stocksii</i> Boiss.	20 miles from Hoshab Ziarat Park Near Hoshab	S.M.A. Kazi 156 (KUH), S.I. Ali & S.A. Farooqi (KUH) M. Qaiser, Asad Raza & Abrar Hussain 806 (KUH)
<i>Tamarix androssowii</i> Litwin var. <i>androssowii</i>	14 miles from Panjgur on way to Nag. Spin Kareaz near Quetta 1800 – 1900 m 14 miles from Quetta on way to Ziarat Jamgl Bagh	Sultan-ul-Abedin & Abrar Hussain 6771 (KUH) Jennifer Lamond 1144 (KUH) Sultan-ul-Abedin 4670 (KUH)
<i>Tamarix androssowii</i> Litwin.var. <i>transcaucassica</i> (Bge.) Qaiser	Quetta	J.F. Duthie 8622 (KUH)
<i>Tamarix alii</i> Qaiser	Thar Parker, near Saren Lake Ibid Thatta, Gujjo Jam Branch	M. Qaiser, A. Ghafoor & Abrar Hussain 3737 (KUH); S.I. Ali, S.A. Farooqi & Sultan-ul-Abedin 3738 (KUH) M. Qaiser & Sultan-ul-Abedin 4292 (KUH)

Annexure 1. (Cont'd.)

Taxa	Locality	Collector
<i>Tamarix arceuthoides</i> Beg.	15 miles from Gilgit on way to Namal, common near the river bank Bambrait, Chitral Dist.	Sultan-ul-Abedin & M. Qaiser 9074 (KUH) M.A.Siddiqi & Rehman 26769 (RAW)
<i>Tamarix baluchistanica</i> Qaiser	15 miles from Ziarat on way Quetta	M. Qaiser & A. Ghafoor 1435 – 143681437 (KUH)
<i>Tamarix dioca</i> Roxb. ex Roth.	Ayab Park, Rawalpindi one miles from Bella on way to Khuzdar 4 miles from Chauk Munda on way to Bangpur	M.A. Siddiqi 1502 (KUH); M. Qaiser & A. Ghafoor 1143 (KUH) M. Qaiser 2578 (KUH)
<i>Tamarix ericoides</i> Rottl. et Willd.	India: Jabbalpur Dist., Narbada river East Bengal	J.F. Duthie 9283 (K); Griffith 967 (KUH)
<i>Tamarix indica</i> Willd.	About 30 miles from Rangpur on way to Jhang 6 miles from Naushki on way to Quetta About 3 miles from Gharo on way to Thatta	M. Qaiser 2581 (KUH) M. Qaiser & A. Ghafoor 4379 (KUH) M. Qaiser 4253 (KUH)
<i>Tamarix kermanensis</i> Baum	Pasni	Sultan-ul-Abedin 761, 762 (KUH)
<i>Taxarix korolokawii</i> Rg. f. et Schmth ex Rgl.	Chitral 2 miles from Chitral on way Ayun Village Birir Nisar Chitral	Yasin Nasir 4975 (RAW) M. Qaiser & A. Ghafoor 1874 (KUH) Sultan-ul-Abedin 8155 (KUH)
<i>Tamarix kotschyi</i> Bge.	Mastung	M.A. Farooqi s.n.. (KUH)
<i>Tamarix karelini</i> Bge.	35 miles from Quetta on way to Chaman, road side Mastung Pishin	S.A. Faruqi & M. Qaiser 2552 (KUH) R.H. Rechinger (W) S. Watt 3872 (E)
<i>Tamarix leptostachya</i> Bge.	Matunza, Hunza Valley	E.J. Ecker s.n. (KUH)
<i>Tamarix mascatensis</i> Bge.	Nokkundi 24 miles from Nokundi on way to Zenedan	M. Qaiser 59 (KUH) M. Qaiser & A. Ghafoor 3521 (KUH)
<i>Tamarix pakistanica</i> Qaiser	45/6 miles from Karachi on way Hyderabad	Sultan-ul-Abedin 3535 (KUH);

Annexure 1. (Cont'd.)

Taxa	Locality	Collector
	94 miles from Dadu on way to Larkana Karachi	S.A. Farooqui & M. Qaiser 1225 (KUH) Shamshad Naqvi s.n. (KUH)
<i>Taxarix parviflora</i> DC.	Kaurram valley near Parachinar, rest house	M. Qaiser & Sultan-ul-Abedin 6065 (KUH)
<i>Tamarix passernioides</i> Del. ex Desv. var. <i>macrocarpa</i> Ehrenb.	2 miles from Chilia Band on way to Thatta 8 miles from Diplo on way to Nagar Parker	A. Ghafoor & M. Qaiser 393 (KUH) Sultan-ul-Abedin <i>et al.</i> , 4330 (KUH)
<i>Tamarix ramosissima</i> Ledeb. <i>Tamarix salina</i> Dyer	Quetta Khairpur Miras in saline soil water Hyderabad	A.K. Khan s.n. (PFI-B) M.A. Ali 651 (PBT-B), M. Qaiser 4422 A (KUH)
<i>Tamarix sarenensis</i> Qaiser	Tharparker Dist. Saren Lake near Sreen Lake	S.I. Ali, Farooqi Sultan-ul-Abedin 4335; M. Qaiser, A. Ghafoor & Abrar Hussain 3730 (KUH)
<i>Tamarix smyrnensis</i> Bge.	Quetta, Sariab road ± 3700m, Nullan	Jenniler Lamond 915 (KUH); M. Qaiser & A.Ghafoor 4351 (KUH)
<i>Tamarix stricta</i> Boiss.	34 miles from Turbat Panjur road	S.I. Ali, S.A. Farooqi & Sultan-ul-Abedin 354 (KUH)
	About 35 miles from Sunstar on way to Mand	M. Qaiser & Abrar Hussain (KUH)
	About 1 miles from Awaran on way to Hoshab	Sultan-ul-Abedin, A. Ghafoor & M. Qaiser 3410 (KUH)
	11 miles from Keti Bunder on way to Gharo Mastung	A. Ghafoor 4131 (KUH)
<i>Tamarix szovitisi</i> Beg.		R.H. Rechinger 273529 (KUH)
<i>Tamarix tetragyna</i> Ehrenb. var. <i>meyeri</i> (Boiss) Boiss.	38 miles from Quetta on way to Chaman 35 miles from Quetta on way to Ziarat	Sultan-ul-Abedin 4867 (KUH) Sultan-ul-Abedin 47981 (KUH)
<i>Myrtama elegans</i> (Royle) P.N.Ovchinnikov & G.K. Kinzikaeva	Satpura Nullah, Skardu ± 9000ft	R.R. Stewart, 20308 (RAW)
	Upper Satpur Nullah	M.A. Siddiqui, Y. Nasir & Z. Ali 4146 (KUH)

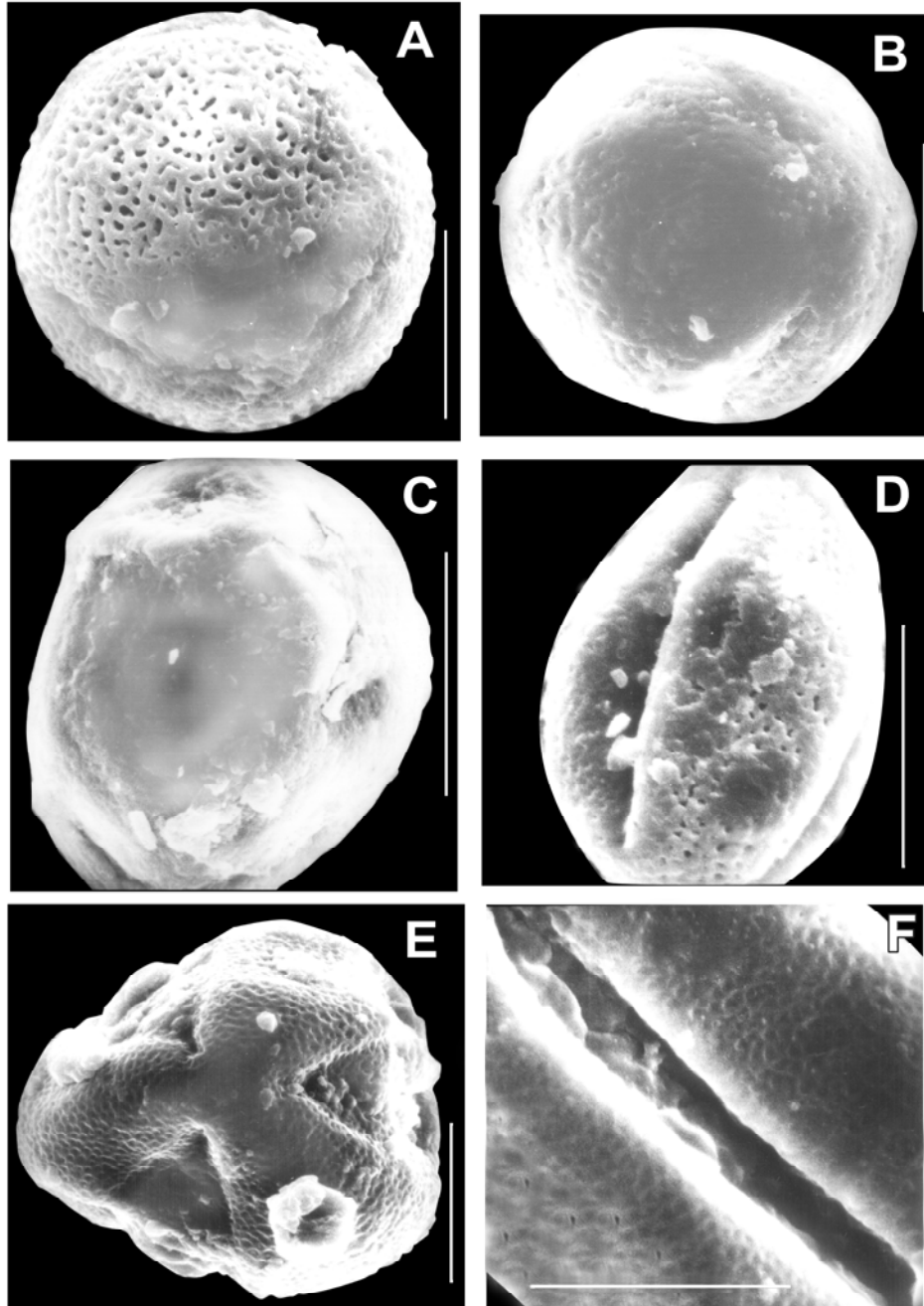


Fig. 1. Scanning Electron micrographs of pollen grains. *Myrtama elagens*: A, Equatroyal view. *Myricaria davurica*: B, Equatroyal view. *M.squamosa*: C, Equatorial view. *Reaumuria alternifolia* subsp. *panjugurica*: D, Equatroyal view. *R. stocksii*: E, Polar view; F, Exine pattern. Scale bar = 1 μ m.

Table I. Important pollen characters of Tamaricaceae.

Name of taxa	Polar Length in μm	Equatorial Breadth in μm	Shape	Colpus length	Polar area index	Exine thickness μm	Tectum
<i>Myricaria prostrata</i> Hk. f. et Thoms. ex Bth.	22.2	19.1	Sub-Prolate	16.28	0.2		Areolate
<i>M. germanica</i> (L.) Desv. Subsp. alopecuroides (Schrenk) Kitam.	23.32	18.9	Sub-Prolate	18.34	0.2-0.24	0.25	Areolate
<i>M. germanica</i> (L.) Desv. subsp. <i>pakistanica</i> Qaiser	23.68	19.72	Sub-Prolate	19.5	0.2-0.21	0.2	Areolate
<i>M. davurica</i> (Willd.) Ehrenb.	24.4	20.45	Sub-Prolate	20.5	0.22-0.24	0.2	Areolate
<i>M. squamosa</i> Desv.	29.71	23.0	Sub-Prolate	20.8	0.25-0.27	1.2	Areolate
<i>Reaumuria stocksii</i> Boiss.	20.74	20.38	Prolate-Spheroidal	26.60	0.2-0.25	0.2	Areolate-reticulate
<i>Reaumuria alternifolia</i> (Labill.) Britten subsp. <i>alternifolia</i>	19.93	17.5	Prolate-Spheroidal	20.72	0.14-0.18	2.2	Areolate-reticulate
<i>R. alternifolia</i> (Labill.) Britten subsp. <i>panjgurica</i>	17.3	19.24	Sub-Prolate	19.24	0.14-0.16	2.92	Areolate-reticulate
<i>Myrtama elegans</i> (Royle) P.N.Ovehinnikov & G.K.Kinzikaeva	24.7	17.6	Prolate	20.72	0.1	1.48	Medium-coarse reticulate
<i>Tamarix alii</i> Qaiser	22.64	15.72	Prolate	17.75	0.12-0.3	2.26	Finely medium-reticulate
<i>T. androssowii</i> Litwin var. <i>androssowii</i>	23.1	18.5	Sub-Prolate	21	0.15	-	Medium-fine reticulate
<i>T. androssowii</i> Litwin var. <i>transcaucasica</i> (Bge.) Qaiser	20.5	17.8	Sub-Prolate	21	0.12-0.16	1.48	Fine-medium reticulate
<i>T. aplylla</i> (L.) Karst.	14.94	12.13	Sub-Prolate	12.5	0.21	2.02	Medium to fine reticulate
<i>T. sarensis</i> Qaiser	18.5	15.66	Sub-Prolate	14.5	0.1-0.3	1.48	Medium-reticulate
<i>T. ericoides</i> Rottl. et Willd.	23.3	17.4	Prolate	17.76	0.01	1.48	Fine reticulate
<i>T. kermanensis</i> Baum	15.63	12.60	Prolate	14.6	0.1	1.49	Medium-reticulate
<i>T. parvijflora</i> DC.	19.68	15.68	Sub-Prolate	15.25	0.19	1.48	Finely reticulate

Table 1. (Cont'd.)

No.	Name of taxa	Polar Length in μm	Equatorial Breadth in μm	Shape	Colpus length	Polar area index	Exine thickness μm	Tectum
8.	<i>T. smyrnensis</i> Bge.	14.94	12.43	Sub-Prolate	13.3	-	1.48	Medium-line
9.	<i>T. arceuthoides</i> Bge.	15.83	13.02	Sub-Prolate	11.46	0.1-0.14	0.1	Finely reticulate
0.	<i>T. sultanii</i> Qaiser	18.9	14.6	Sub-Prolate	14.6	0.1-0.14	2.2	Medium-reticulate
1.	<i>T. stricta</i> Boiss.	19.44	16.07	Sub-Spheroidal	16.02	0.14-0.19	2.2	Medium-reticulate
2.	<i>T. mascatensis</i> Bge.	16.23	12	Prolate	12.49	0.14-0.16	1.48	Finely reticulate
3.	<i>T. korolkowii</i> Rgl. & Schmlh.	15.39	12.94	Prolate	11.64	0.01-0.12	2.2	Fine to medium reticulate
4.	<i>T. baluchistanica</i> Qaiser	15.54	12.72	Sub-Prolate	14.3	0.15-0.18	2.2	Medium-coarse reticulate
5.	<i>T. kotschyi</i> Bge.	16.12	14.6	Prolate	14.16	0.17-0.2	1.48	Medium coarse reticulate
6.	<i>T. szovitsiana</i> Bge.	16.9	16.5	Spheroidal Prolate	20	0.1-0.14	1.48	Medium coarse reticulate
7.	<i>T. karelini</i> Bge.	16.2	13.5	Sub-Prolate	14.2	0.17-0.2	1.40	Medium - coarse reticulate
8.	<i>T. ramosissima</i> Ledeb.	15.5	12.32	Sub-Prolate	11.84	0.11-0.5	1.48	Finely to medium reticulate
9.	<i>T. leptostachya</i> Bge.	14.3	12.0	Prolate	13.2	0.1-0.5	1.48	Finely reticulate
0.	<i>T. tetragyna</i> Enrenb. var. <i>meyeri</i> (Boiss.) Boiss.	16.2	12.11	Prolate	15.40	0.1-0.14	1.85	Coarse reticulate
1.	<i>T. salina</i> Dyer	18.8	14.75	Sub-Prolate	18.25	0.15-0.15	1.48	Fine to coarse reticulate
2.	<i>T. dioica</i> Roxb. ex Roth	19.36	16.9	Prolate-Spheroidal	-	0.2	-	Coarsely reticulate
3.	<i>T. pakistanica</i> Qaiser	19.26	15.12	Sub-Prolate	16.28	0.0	1.48	Medium reticulate
4.	<i>T. passernioides</i> Del. ex. Desv. var. <i>macrocarpa</i> Ehrenb.	17.76	14.50	Sub-Prolate	15.94	0.12-0.15	1.48	Medium reticulate
5.	<i>T. indica</i> Willd.	16.4	13.7	Sub-Prolate	14.06	0.11-0.12	1.48	Fine to medium reticulate

Key to the species

1. + Equatorial diameter of pollen grain 26µm 2
 - Equatorial diameter of pollen grain 23 µm *M. prostrata*
2. + Tectum areolate, areoli spanse ± indistinct 3
 - Tectum areolate, areoli distinct closely *M. germanica* subsp. *alopecuroides*
3. + Polar area index 0.22 – 0.27 4
 - Polar area index less than 0.22 *M. germanica* subsp. *pakistanica*
4. + Exine 1.48 µm thick luminae very sparse *M. squamosa*
 Exine 2.5 µm thick luminae close *M. davurica*

Pollen type: *Reaumuria alternifolia* - type (Fig. 1D-F).

Pollen class: Tricolpate

P/E ratio: 1.16-1.29

Shape: Sub-prolate.

Apertures: Colpus long sunken with acute ends.

Exine: Sexine thicker than nexine.

Ornamentation: Areolate or areolate – reticulate.

Measurements: Size: Polar axis P=17.35x16.6 – 20.74x21.87 µm and equatorial diameter E = 24.02x14.98-31.52x20.8 µm, trilobed, with apertures on the angles of the outline of the grain in polar view, colpi (19.24 – 26.24) µm long. Exine 0.2-2.92 µm thick, sexine thicker than nexine. Tectum areolate or areolate – reticulate.

Species included: *Reaumuria alternifolia* (Labill) Britten subsp. *alternifolia*, *R. alternifolia* (Labill) Britten subsp. *panjugurica* (Ballt. & Halb.) Qaiser, *R. stockssii* Boiss.

Key to the species

1. + Pollen grains prolate-spheroidal, > 26 x 16 µm 2
 - Pollen grains subprolate, < 25 x 16 µm *R. alternifolia* subsp. *panjugurica*
2. + Pollen diameter > 30 x 20 µm. Exine 3 µ thick. Colpi 26.6 µ long *R. stockii*
 - Pollen diameter < 30 x 20 µm. Exine c. 2.2 µ thick. Colpi < 21 µm long
 *R. alternifolia* subsp. *alternifolia*

Pollen type: *Tamarix aphylla* - type (Fig. 2 A-F; Fig. 3 A-F; Fig. 4 A-F).

Pollen class: Tricolpate

P/E ratio: 1.02-1.44

Shape: Prolate to sub-prolate or prolate – spheroidal.

Apertures: Colpus long sunken with acute ends.

Exine: Sexine as thick as nexine.

Ornamentation: Coarse to fine reticulate.

Measurements: Size: Polar axis P = 14.3x13.3 – 23.3x19.1 µm and equatorial diameter E = 13.2-25.75x15.72 (trilobed, with apertures on the angles of the outline of the grain in polar view, colpi = 11.61–17.5) µm long. Exine = 1.0-2.2 µm thick, sexine as thick as nexine. Tectum coarse - fine reticulate. This type is further divided in to two subtypes on the basis of pollen size viz., *Myrtama elegans* - subtyp and *T. indica* - subtype.

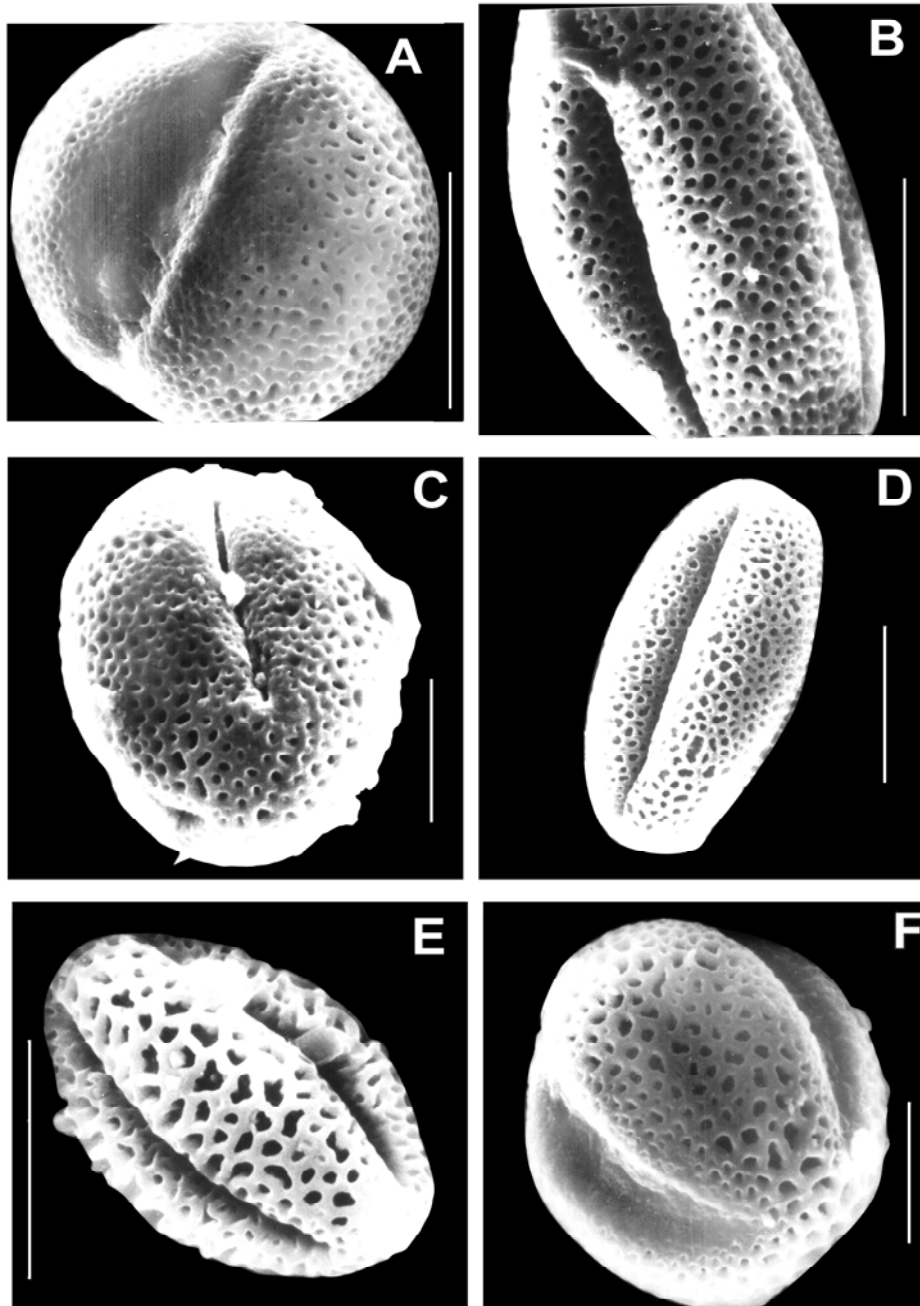


Fig. 2. Scanning Electron micrographs of pollen grains. *Tamarix alii*: A & B, Equatorial view. *T. aphylla*: C, Polar view. *T. baluchistanica*: D, Equatorial view. *T. dioca*: E, Equatorial view. *T. indica*: F, Equatorial view. Scale bar = A, D & E = 1 μm ; B, C & F = 2 μm .

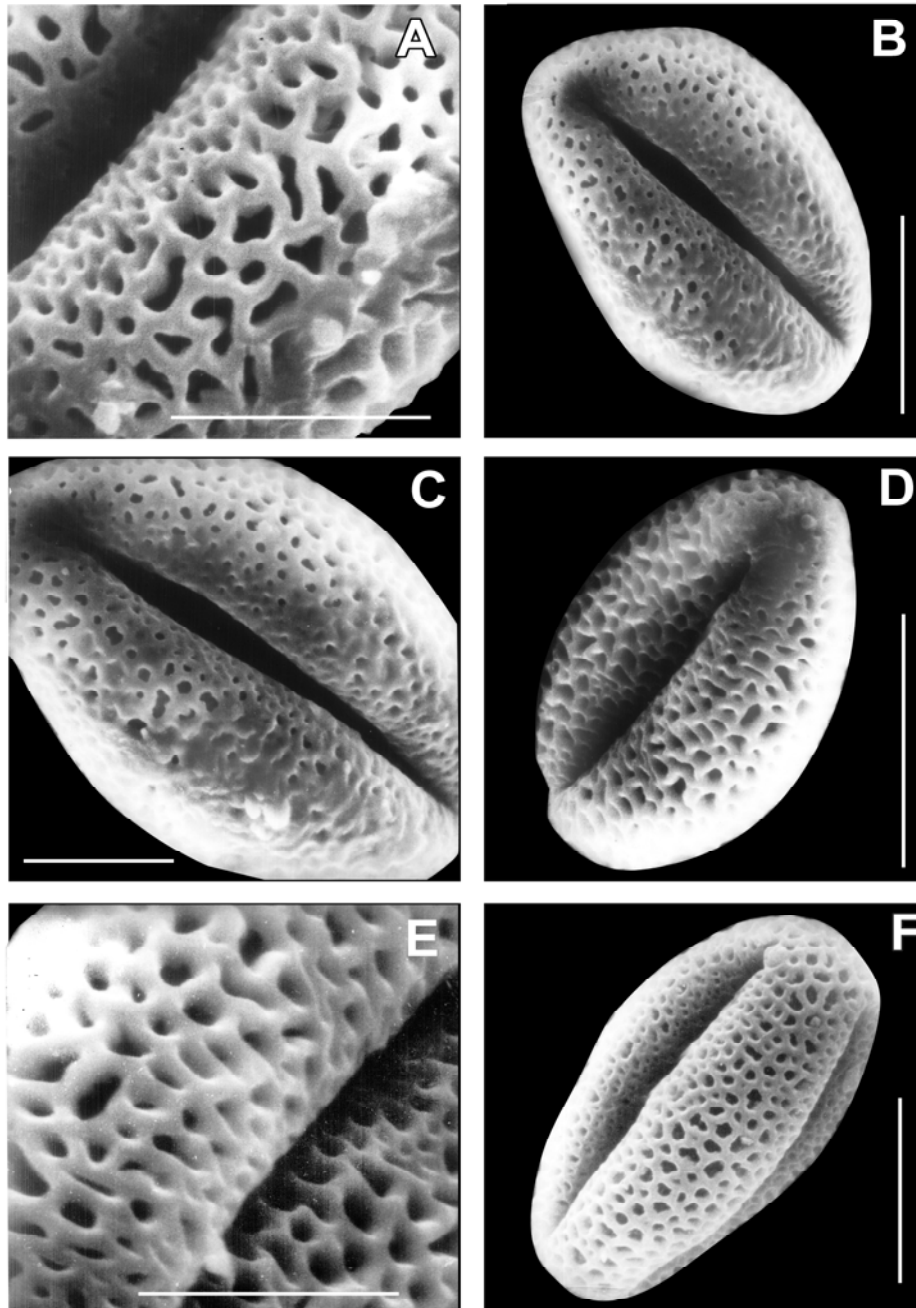


Fig. 3. Scanning Electron micrographs of pollen grains. *Tamarix pakistanica*: A, Exine pattern. *T. salina*: B, Equatorial view; C, Exine pattern. *T. sarenensis*: D, Equatorial view; E, Exine pattern. *T. smyrnensis*: F, Equatorial view. Scale bar = A, C & E = 2 μ m, B, D & F = 1 μ m.

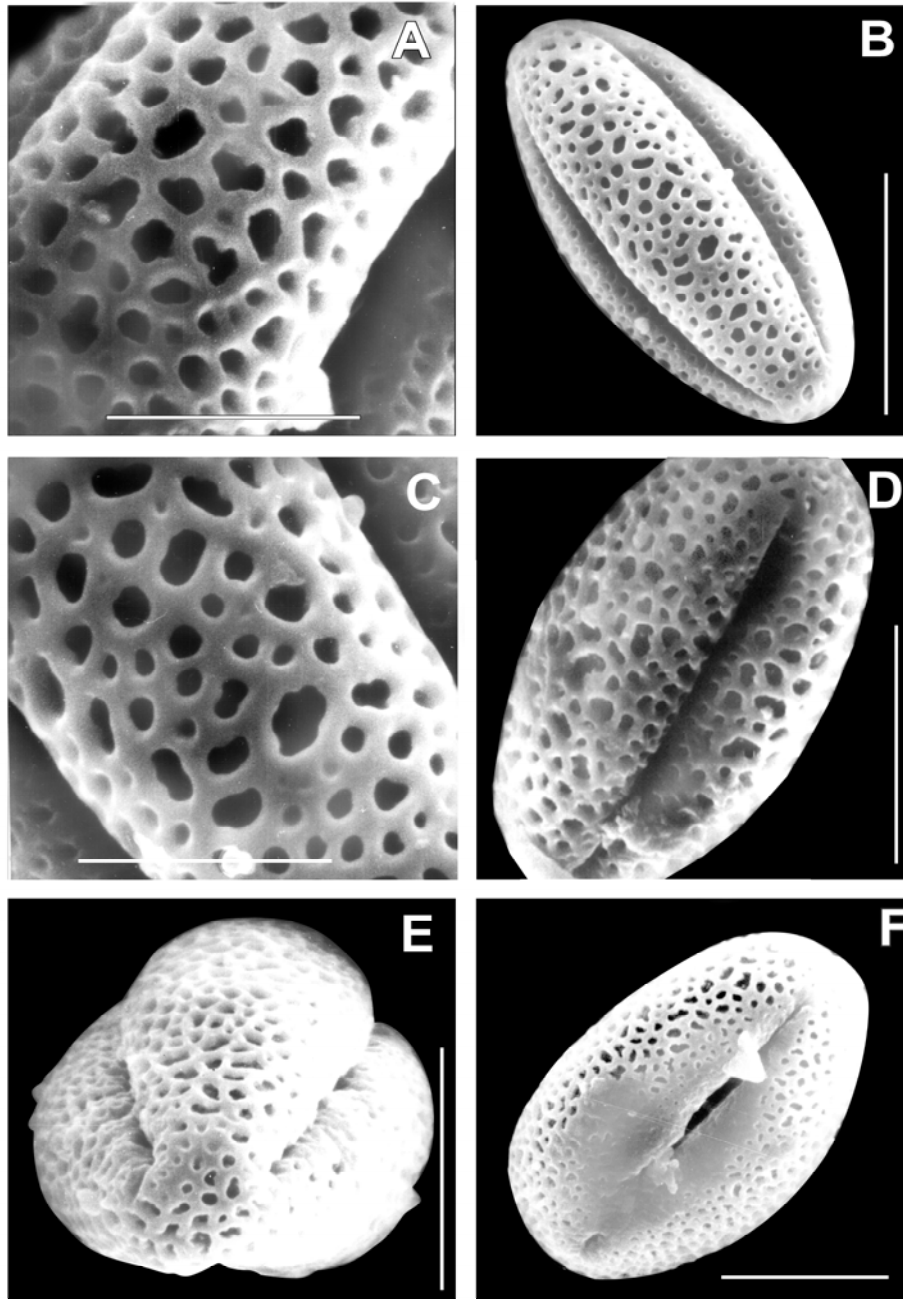


Fig. 4. Scanning Electron micrographs of pollen grains. *Tamarix smyrnensis* : A, Exine pattern. *T. stricta*: B, Equatorial; C, Exine pattern. *T. sutanii*: D, Polar view. *T. szovitsiana* E, Polar view; E, Equatorial view.

Scale bar = A & C = 2 μ m; B, D, E, F = 1 μ m.

Key to the subtype

1. + Polar length > then 28 μm long *Myrtama elegans* – subtype
(*Myrtama elegans* (Royle) P.N.Ovchinnikov & G.K.Kinzikaeva)
- Polar length < then 25 μm long *Tamarix indica* – subtype
(*Tamarix alii* Qaiser, *T. androssowii* Litw. var. *androssowii*, *T. androssowii* Litw. var. *transcaucassica* (Bge.) Qaiser, *T. aphylla* (L.) Kast. *T. sarenensis* Qaiser, *T. ericoides* Rottl. et Willd., *T. dioca* Roxb & Roth., *T. indica* Willd., *T. kermanensis* Baum, *T. parviflora* DC., *T. smyrnensis* Bge., *T. arceuthoides* Bge., *T. passeriioides* Del. Ex Desv. var. *macrocarpa* Ehrenb. , *T. sultanii* Qaiser *T. stricta* Boiss., *T. mascatensis* Bge., *T. korolkowii* Regl. & Schmlh. ex Regl., *T. baluchistanica* Qaiser, *T. kotschyi* Bge., *T. szovitsiana* Bge., *T. karelini* Bge., *T. ramosissima* Ledeb., *T. leptostachya* Bge. *T. tetragyna* Ehrenb. var. *meyeri* (Boiss.) Boiss., *T. salina* Dyer .)

Key to the species

1. + Sculpturing very coarse. Luminae upto 2.5 μm in diameter *T. dioca*
- Sculpturing fine to medium coarse. Luminae much smaller < 1.25 μm in diameter 2
2. + Muri elevated 3
- Muri not elevated 6
3. + Luminae distinct at the edge of the furrows 4
- Luminae indistinct at the edge of the furrows
..... *T. androssowii* var. *androssowii*
4. + Pollen grains >22 μm long in equatorial view
..... *T. androssowii* var. *transcaucassica*
- Pollen grains < 19 μm long in equatorial view 5
5. + Pollen prolate-spheroidal. Colpi c. 14.6 μm long *T. kotschyi*
- Pollen subprolate - subspheroidal. Colpi c. 11.84 μm long *T. ramosissima*
6. + Luminae with distinct columellae inside 7
- Luminae without columellae 17
7. + Pollen prolate *T. kermanensis*
- Pollen sub-spheroidal 8
8. + Luminae distinctive at the edge of the furrows 9
- Luminae not distinctive at the edge of the furrows *T. indica*
9. + Luminae 0.4 μm long (average) 10
- Luminae 0.6 μm long (average) 11
10. + Pollen grains >21 μm long, exine 1.48 μm thick *T. salina*
- Pollen grains < 18 μm long, exine 2.02 μm thick *T. aphylla*

11. +	Polar area index 0.2	12
-	Polar area index < 0.2	13
12. +	Luminae arranged in a distinct pattern	14
-	Luminae not arranged in a distinct pattern	15
13. +	Exine 1.85 μm thick, groove 1.48 μm deep, pattern distinctive to somewhat irregular	<i>T. tetragyna</i> var. <i>meyeri</i>
-	Exine 1.48 μm thick, groove 2.22 μm deep, pattern very distinctive	<i>T. baluchistanica</i>
14. +	Exine 1.48 μm thick	16
-	Exine 2.2 μm thick	<i>T. sultanii</i>
15. +	Muri 0.3-0.4 μm broad	<i>T. szovitsiana</i>
-	Muri 0.5-0.8 μm broad	<i>T. passerinioides</i> var. <i>macrocarpa</i>
16. +	Pollen grains prolate	18
-	Pollen grains sub-spheroidal	20
17. +	Pollen grains > 22 μm long in equatorial view	19
-	Pollen grains < 18 μm long in equatorial view	<i>T. mascatensis</i>
18. +	Exine 1.48 μm thick, luminae rounded, distinct at the edge of the furrows	<i>T. ericoides</i>
-	Exine 2.36 μm thick. Luminae polygonal to irregular indistinct at the edge of the furrows	<i>T. alii</i>
19. +	Luminae becoming obscure at the edge of the furrows	<i>T. arceuthoides</i>
-	Luminae distinct at the edge of the furrows	21
20. +	Luminae increasing in size from the pole to the equator	<i>T. pakistanica</i>
-	Luminae almost equal, not increasing in size from pole to equator	22
21. +	Pollen grains tricolp(or)ate	<i>T. parviflora</i>
-	Pollen grains tricolpate	23
22. +	Luminae arranged with a distinct pattern	24
-	Luminae not arranged with distinct pattern	25
23. +	Pollen grains > 22 μm long in equatorial view. Muri 0.2-0.4 μm broad	<i>T. stricta</i>
-	Pollen grains < 18 μm long in equatorial view. Muri 0.6-0.8 μm broad	<i>T. leptostachya</i>
24. +	Pollen grains > 20 μm long in equatorial view. Exine 1.48 μm thick, luminae 0.2-0.3 μm long	<i>T. sarenensis</i>
-	Pollen grains < 17 μm long in equatorial view. Exine 2.2 μm thick, luminae 0.4-0.7 μm long	<i>T. korolkowii</i>

Fig. 5. Scatter diagram, showing various characters of pollen grains of different taxa of Tamaricaceae.

Discussion and Conclusions

Tamaricaceae is a stenopalynous family and the pollen grains do not show much variation in the number and position of apertures. However, two types of sculpturing i.e., areolate and reticulate are found in the family Tamaricaceae. The shape also varies from prolate to sub-prolate or prolate-spheroidal in the genus *Tamarix* and subprolate pollen are rather common in *Reaumuria* and *Myricaria*. The genus *Reaumuria* (*Reaumuria alternifolia* – type) is distinct from the rest of the genera by having the largest pollen grains and comparatively thicker sexine than nexine, while rest of the three genera have sexine and nexine of equal thickness and somewhat smaller pollen grains. *Myricaria* (*Myricaria squamosa*-type) can be delimited by having areolate reticulate sculpturing and comparatively bigger pollen grains than *Tamarix* and *Myrtama*, whereas *Tamarix* and *Myrtama* (*Tamarix aphylla* – type) have medium-coarse reticulate sculpturing. This type is further subdivided into *Tamarix indica* - subtype having smaller pollen grains and *Myrtama elegans* subtype having large pollen grains. The three genera of tribe *Tamarisceae* show a great deal of overlapping and intergradations in their morphological features. This trend is also depicted in pollen morphology and the pollen of three genera share several common characters. Therefore in the scatter diagram (Fig. 5) prepared by based on palynological characters, species of *Tamarix*, *Myrtama* and *Myricaria* come together to some extent, while *Reaumuria* species are quite distinct.

In the scatter diagram (Fig. 5) it is obvious that morphologically similar species form a cluster, while the pollen of morphologically distinct species fall apart. *T. dioica* Roxb. ex Roth is very distinct from rest of the species by having dioecious plants and the pollen grains have the reticulate tectum with very large luminae, on the other hand *T. androssowii* Litwin. var. *androssowii* and *T. androssowii* Litwin. var. *transcaussica* (Bunge) Qaiser come very close and overlap in most of the pollen characters. However, some exceptions to this generalization are also met as *T. smyrnensis* Bge., and *T. ramosissima* Ledeb., are rather closely related species but their pollen are very different in a number of characters i.e., in their polar area index and the size of luminae.

The pollen grains of *Tamarix* can easily be grouped in two sections:

I. Columellae present inside the luminae. II. Columellae absent inside the luminae.

Both the groups are further delimited on the basis of the size of luminae, position of muri, polar area index and thickness of exine. However, these two groups do not agree with the infrageneric classification. For instance, *T. stricta* and *T. aphylla* both belong to the series *Vaginatae* but falling in different groups.

Myricaria species can also be grouped in two sections: I. *M. prostrata* Hk.f.et. Thomson. ex Bth. et Hk.f. having the smallest pollen grains i.e., less than 23 μ in diameter.

II. This group includes remaining four taxa with somewhat larger pollen grains i.e., more than 26 μ in diameter which are further segregated on the basis of their polar area index, position of luminae and thickness of exine.

Baum *et al.*, (1971) pointed out a direct correlation in the size of the flower and the size of pollen grain in the genus *Tamarix*. This is true for the whole family. The flowers in the genus *Reaumuria* are the largest in the whole family, so are the pollen *Tamarix* has the smallest flowers, so the pollen are also the smallest, but considerable exceptions have also been observed e.g., the pollen grains of *T. androssowii* Litwin. var. *androssowii* and var. *transcaucassica* (Bge.) Qaiser, *T. alii* Qaiser and *T. parviflora* DC., are much larger than *T. ericoides* Rottl. et Willd., and *T. passerinioides* Del. ex Desv. var. *macrocarpa*

Ehrenb., despite of their much smaller flowers as compared to the last two species. Gaskin (2002) also reported similar type of pollen in the genus *Tamarix*.

Small pollen size, low pore number and simple apertures are generally considered primitive characters and there exists a correlation between pollen size and poloidal level. (Stone, 1961, 1963). All the genera except *Reaumuria* fall under the class *Minutae* of Erdtman (1945), while the latter falls under the class *Mediae*, *Reaumuria* seems to be more advanced as far as pollen size is concerned and *Tamarix* appears to be least evolved while *Myrtama* and *Myricaria* occupy an intermediate position. The sculpturing pattern also agrees well with this contention. In *Tamarix* and *Myrtama* sculpturing is reticulate which is considered as primitive as compared to areolate sculpturing (Walker & Doyle, 1975). In *Tamarix* and *Myrtama*, the sculpturing is reticulate, whereas in *Myricaria* and *Reaumuria* the sculpturing is areolate. The habit of all the four genera also supports this generalization. The genus *Reaumuria* which seems to be most advanced has mostly herbaceous or under shrub species, whereas in the *Tamarix* mostly large shrub or trees are presented the remaining two genera occupies an intermediate position.

Pollen grains of *Tamaricaceae* resemble very closely with that of *Frankeniaceae* in having mostly 343 NPC i.e. trizonocolpate pollen grains without any spiny exine sculpturing and mostly prolate spheroidal symmetry but deviate considerably from *Foqueriaceae* which has generally tricolporate pollen grains with striate tectum.

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