

Pollen Atlas of the Flora of Egypt

3. Taxa of Pteridophyta and Gymnospermae*

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The spore and pollen morphology of 15 species of Pteridophyta and Gymnospermae represented in the flora of Egypt is reported and described. These belong to four types: inaperturate (alete) with elaters (one species) and aperturate without elaters (14 species). The latter group comprises the monolete, trilete and polycolpate types. A key for the separation of the pollen types and genera is provided. The pollen morphology in relation to taxonomy is briefly discussed.

Key words: Gymnospermae, pollen morphology, Pteridophyta, spore morphology.

Introduction

This account deals with the spore and pollen morphology of 15 species of vascular Cryptogamas, among which *Pteris vittata* L. (Pteridaceae) is a new record to the Flora of Egypt (El Hadidi, 2000). Species of Marsiliaceae and Azollaceae are excluded. The national numbers preceding each species or family are those of El Hadidi (2000).

Material and Methods

Pollen and spores samples were collected from herbarium specimens kept in the herbarium of Cairo University (CAI, Holmgren *et al.* 1981) and the herbarium of Botany Department, faculty of Science, Assiut University (AST, abbreviation proposed); (Table 1). Material for light microscopy was acetolyzed essentially according to Erdtman (1960). The acetolyzed pollen grains were mounted in glycerin jelly onto glass slides prior to their examination and study of pollen morphological features by Leitz Laborlux D microscope.

Material for SEM was prepared by mounting acetolyzed pollen onto clean stubs using double-sided cellotape. These stubs were coated with gold in a JEOL JFC 1100 E ion sputtering Device. Pollen grains were then examined in a JEOL JSM 5400LV Scanning electron microscope which is operated at accelerated voltage of 15 kv, at the Electron Microscope Unit, Assiut University.

The terminology used here for pollen description is that of Reitsma (1970); Erdtman & Sorsa (1971) and Punt *et al.* (1994).

* Continued from *Taeckholmia* 21 (1): 143-151 (2001)

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Table (1): Details of studied specimens, National numbers (El Hadidi, 2000)

No	Taxon	Locality, collector, Herbaria
I. Pteridophyta		
1.	Equisetaceae Michx. Ex. DC	
1.1.	<i>Equisetum</i> L.	
1.1.1.	<i>Equisetum ramosissimum</i> Desf.	Wadi Gaza, Aug. 1953, <i>L. Boulos</i> , CAI.; Wadi Gaza, Aug. 1955, <i>L. Boulos</i> , CAI.
2.	Ophioglossaceae (R. Br.) C. Agardh	
2.2.	<i>Ophioglossum</i> L.	
2.2.2.	<i>Ophioglossum polyplum</i> A.Braun	Gebel Shandoda, Elba, 10.2.1962, <i>V. Tackholm et al.</i> , CAI.
3.	Cryptogrammeae Pic. Serm.	
3.3.	<i>Onychium</i> Kaulf.	
3.3.3.	<i>Onychium divaricatum</i> (Poir.) Alston	Gebel Elba, 23.2.1929, <i>G. Tackholm</i> , CAI.
4.	Sinopteridaceae Koidz.	
4.4.	<i>Cheilanthes</i> Sw.	
4.4.4.	<i>C. vella</i> (Aiton.) F. Muell.	Wadi Rak, Gebel Elba, 2.10.1962, <i>V. Tackholm et al.</i> , CAI.
4.4.5.	<i>C. pteridioides</i> (Reichard) C. Chr.	Wadi El Kauf, Gebel Akhdar upper part, Libya, 12.3.1968, <i>L. Boulos</i> , CAI.
4.4.6.	<i>C. coriacea</i> Decne	Gebel Shandadi, Gebel Elba, 10.2.1962. <i>V. Tackholm et al.</i> , CAI.
5.	Adiantaceae (C. Presl) Ching	
5.5.	<i>Adiantum</i> L.	
5.5.7.	<i>A. capillus-veneris</i> L.	On canal bank, Sahel Selim, Assiut, 30.3.1999, <i>El Nagggar</i> , AST.
6.	Pteridaceae (S.F. Gray) Gaudich	
6.6.	<i>Pteris</i> L.	
6.6.8.	<i>Pteris vittata</i> L.	On canal banks between Sohag and Qena, 18.5.1998, <i>El Nagggar</i> , AST.
7.	Aspleniaceae Mett. ex A.B. Frank	
7.7.	<i>Asplenium</i> L.	
7.7.9.	<i>A. ceterach</i> L.	4 km east of El Marj along the south Road, Gebel Al Akhdar, Libya, 23.1.1967, <i>L. Boulos</i> , CAI.
7.7.10.	<i>A. adiantum-nigrum</i> L.	Preussen prov. Schlesier, Breslani weiberg bei Zobten. 26.7.1908, CAI.
8.	Actiniopteridaceae Pic. Serm.	
8.8.	<i>Actiniopteris</i> Link	
8.8.11.	<i>A. semiflabellata</i> Pic. Serm.	Gebel Koran, 7.2.1962. <i>V. Tackholm et al.</i> , CAI.
9.	Gymnogrammeae Ching	
9.9.	<i>Anogramma</i> Link	
9.9.12.	<i>A. leptophylla</i> (L.) Link	Wadi El Kouf, Gebel Al Akhdar, Libya, 12.3.1968, <i>L. Boulos</i> , CAI.
II. Spermatophyta-Gymnospermae		
13.	Ephedraceae Dumort.	
13.13.	<i>Ephedra</i> L.	
13.13.24.	<i>E. alata</i> Decne.	Kilo 2, Suez Road, 10.3.1930, <i>Oliver</i> , CAI.; Burg el Arab. 1.4.1960. <i>El-Batanony</i> , CAI.
13.13.25.	<i>E. aphylla</i> Forssk.	Bramly's grotto, Burg el Arab. 1.4.1960. <i>El-Batanony</i> , CAI.
13.13.26.	<i>E. foliata</i> Boiss. ex C.A. Mey.	Gebel Hamata, Red Sea Coast, 7.2.1961, <i>V. Tackholm et al.</i> , CAI. Mersa Halaib, 22.1.1929, <i>G. Tackholm</i> , CAI.

Results

Description of spore and pollen types

I. Alete type (*Equisetum*)

1.1.1. *Equisetum ramosissimum* Desf. (Fig. 1. a)

Spores subspherical; circular; 32 x 37 µm; inaperturate (alete); perine wrinkled with hollow, regular or irregular granules; exine 1.5 µm thick, psilate; spore usually with 4 elaters.

II. Monolete type (*Asplenium*)

7.7.9. *Asplenium ceterach* L.

Spores heteropolar; biconvex; 27 x 38 µm; monolete; perine slightly more than 0.5 µm thick, folded, folds short (up to 10 µm high), its outer surface with spinule-like processes (0.1 µm high), its inner surface baculate (baculum c. 2.0 µm high, 0.5 µm in diameter); exine 1.5 µm thick, psilate.

7.7.10. *Asplenium adiantum-nigrum* L. (Fig. 1. b)

Spores heteropolar; planoconvex to slightly biconvex; 30 x 43 µm; monolete; perine c. 0.5 µm thick, wrinkled or folded, folds sharp-edged (c. 3-5 µm high), its outer surface smooth or beset with spinules, (1-2 µm high), its inner surface baculate (baculum c. 2.0 µm high and 0.5 µm in diameter); exine c. 1.0 µm thick, psilate.

III. Trilete type

III. 1- Subtype A: Laesura arms not reaching to the equator

2. 2. 2. *Ophioglossum polyphyllum* A. Braun (Fig. 1. c)

Spores heteropolar; subspherical; amb. circular-subtriangular; 24 x 29 µm; trilete; laesura arms raised, medium-narrow, straight, 0.3-0.6 of radius, not reaching to the equator; exine reticulate-foveolate; reticulum developed distally extending to proximal faces but dissolving in the polar area; brochi variable; muri undulate or curved, irregular in thickness; lumina narrow, 2-4 µm width.

3.3.3. *Onychium divaricatum* (Poir.) Alston

Spores heteropolar; subspheroid-triangular, obtuse; amb. rounded-triangular with slightly convex sides; 30 x 32 µm; trilate, laesura arms raised, then, straight, 0.6-0.8 of radius; perine very thin, < 0.5 µm, tightly surrounding the exine, often cracked; exine, 5.0 µm thick, mainly tuberculate in the proximal faces, the tubercles are irregular in shape and size, situated parallel to the laesurae in distal faces.

8.8.11. *Actiniopteris semiflabellata* Pic. Serm. (Fig. 1. d)

Spores heteropolar; tetrahedral-sub spherical; amb. circular-subtriangular with convex sides; 41 x 46 µm; trilete, laesura arms raised, thick, (3 µm thick), straight, 0.5-0.6 of radius, not reaching to the equator; perine verrucate; verrucae irregular on distal faces, regular on proximal faces.

4.4.5. *Cheilanthes pteridioides* (Reichard) C. Chr. (Fig. 1. f)

Spores heteropolar; spherical; amb. circular; 26 x 38 µm; trilete; laesura arms flat, narrow, curved, 0.5-0.6 of radius, not reaching to the equator; perine verrucate-granulate; verrucae irregular in size.

4.4.6. *Cheilanthes coriacea* Decne.

Spores heteropolar; spherical; amb circular; 27 x 31 µm; trilete, laesura arms flat, narrow, curved, 0.5-0.6 of radius, not reaching to the equator; perine reticulate.

III. 2- Subtype B: Laesura arms reaching to the equator

4.4.4. *Cheilanthes vella* (Aiton.) F. Muell. (Fig. 1. e)

Spores heteropolar; tetrahedral-subspheical; amb. triangular obtuse, with slightly concave sides; 35 x 38 µm; trilete, laesura arms flat, thin, straight, 0.7-0.8 of radius, reaching to the equator, flanked with two large, thick, smooth ridges; perine verrucate to micro-granulate; verrucae usually regular in size in the proximal and distal faces.

5.5.7 *Adiantum capillus-veneris* L. (Fig. 2. a)

Spore heteropolar; subspherical-triangular, obtuse; amb. circular-subtriangular with convex sides; 27 x 29 µm; trilete, laesura arms raised, thick (4 µm thick), straight, 0.6-0.8 of radius, reaching to the equator; perine verrucate in distal and proximal faces; verrucae irregular in size.

9.9.12. *Anogramma leptophylla* (L.) Link (Fig. 2. b)

Spores heteropolar; triangular, obtuse with straight or slightly convex sides; amb. circular-subtriangular; 23 x 29 µm; trilete, laesura arms raised, thick, straight, 0.6-0.8 of radius, reaching to the equator, flanked with regular verruca; perine verrucate; verrucae usually of regular size on proximal and distal faces

6.6.8 *Pteris vittata* L. (Fig. 2. c)

Spores heteropolar; subspherical-triangular, obtuse; amb. circular; 33-47 µm; trilete, laesura arms raised, thin (< 1µm), straight, 0.6-0.8 of radius, not reaching to the equator, flanked with conical verrucae; perine verrucate-gemmate or reticulate; verrucae irregular in shape and size.

IV. Polycolpate (*Ephedra*) type

13.13.24. *Ephedra alata* Decne. (Fig. 2. d)

Grains monad; radially symmetric; isopolar; prolate-perprolate; 32 - 43 x 14 - 17 µm; 6-polycolpate, each mesocolpium is seen as a marked ridge between the valley where the colpi are, some ridges with zig-zag outline; exine psilate.

13.13.25. *Ephedra aphylla* Forssk. (Fig. 2. e)

Grains monad; radially symmetric; isopolar; perprolate; 32 - 35 x 14 - 16 µm; 8 colpate, each mesocolpium is seen as a marked ridge between the valley where the colpi are; exine psilate.

13. 13. 26. *Ephedra foliata* Boiss. ex C.A. Mey.

Grains monad; radially symmetric; isopolar; perprolate; 25 - 34 x 14 - 16 µm; 8 colpate, each mesocolpium is seen as a marked ridge between the valley where the colpi are; exine psilate.

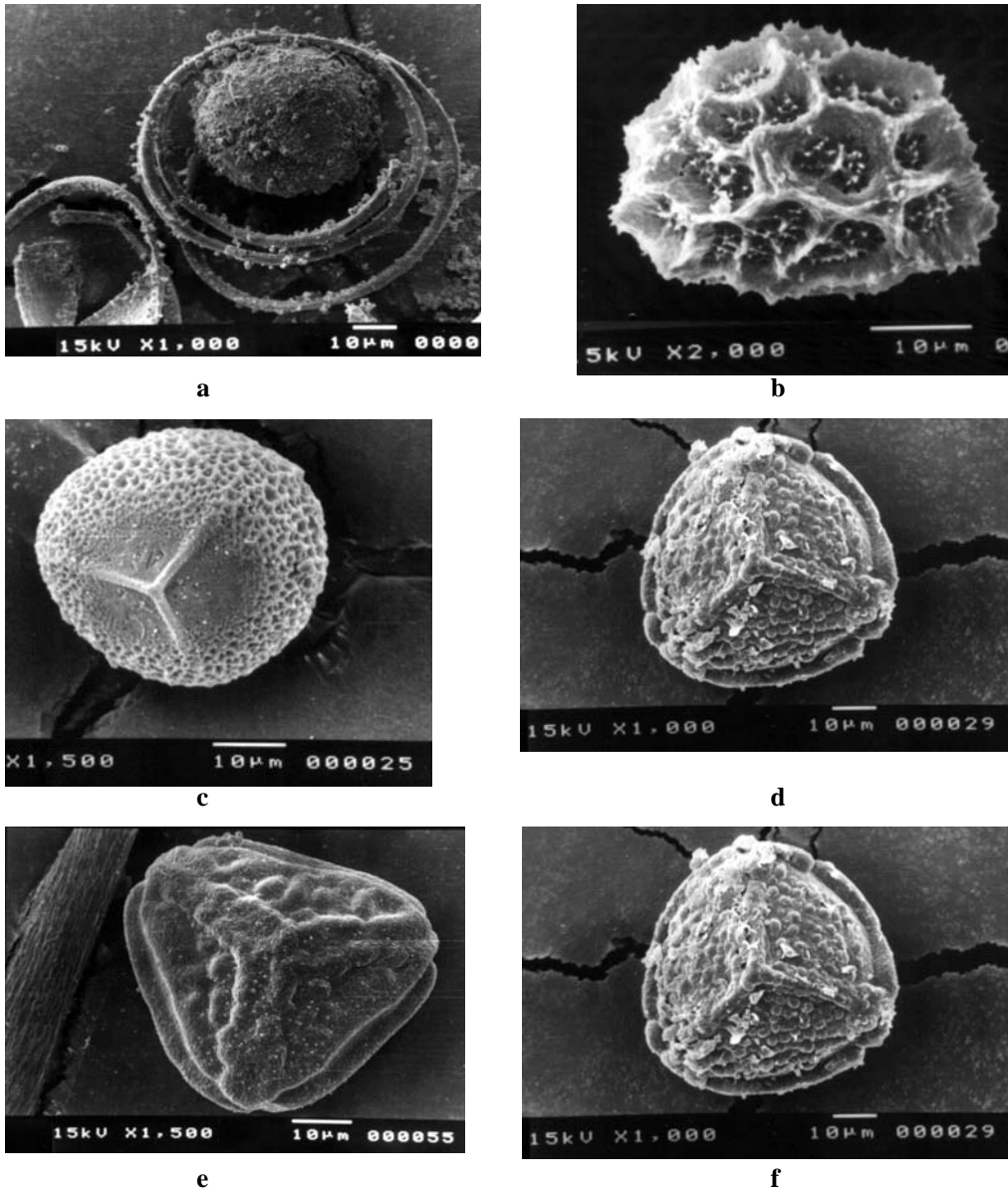


Figure 1: SEM micrographs of spores and pollen of vascular cryptogams.

- | | |
|------------------------------------|--|
| a- <i>Equisetum ramosissimum</i> | b- <i>Asplenium adiantum-nigrum</i> |
| c- <i>Ophioglossum polyphyllum</i> | d- <i>Actiniopteris semiflabellata</i> |
| e- <i>Cheilanthes vella</i> | f- <i>Cheilanthes pteridioides</i> |

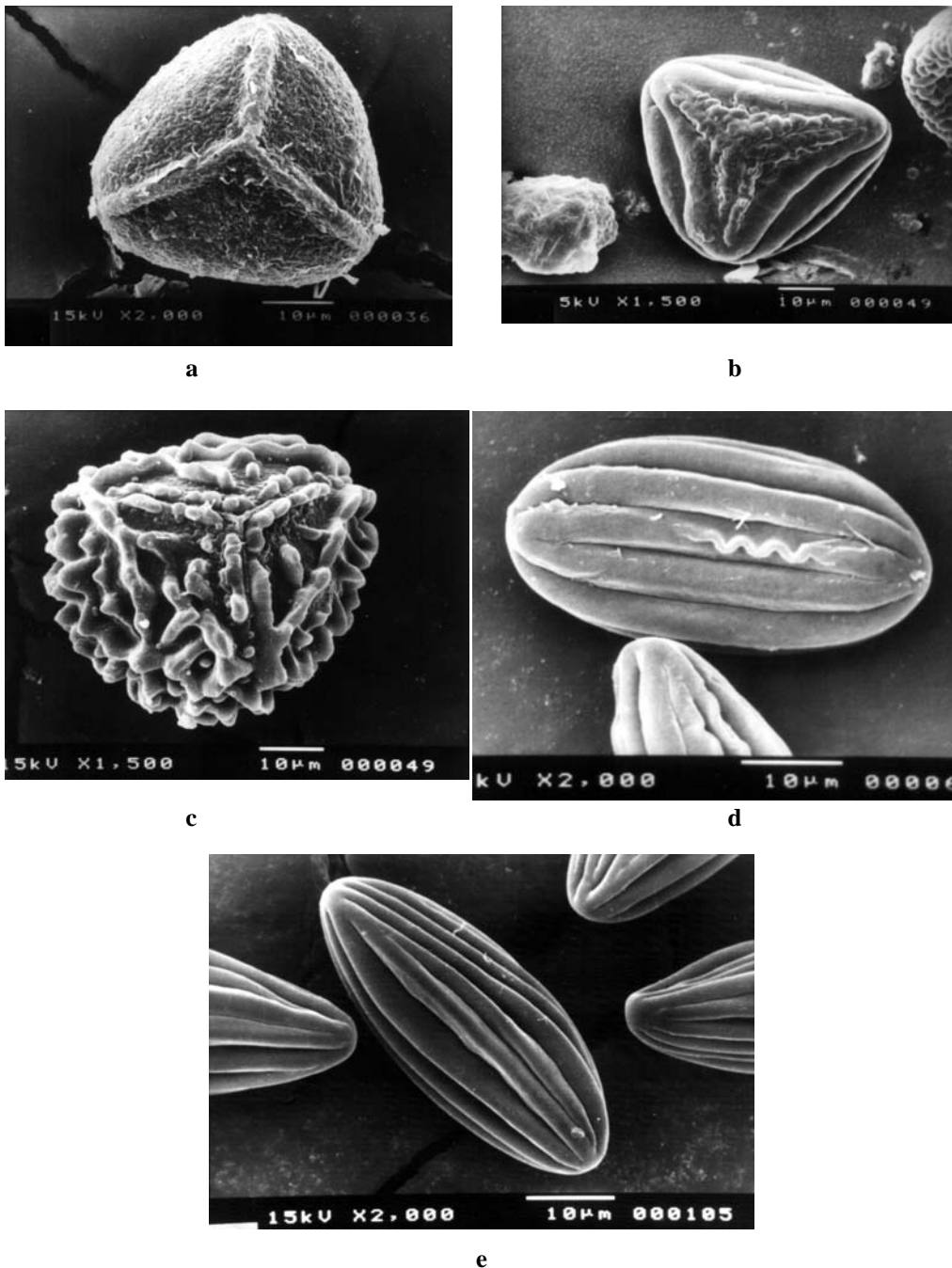


Figure 2: SEM micrographs of spores and pollen of vascular cryptogams.

- a- *Adiantum capillus-veneris*
- c- *Pteris vittata*
- e- *Ephedra aphylla*

- b- *Anogramma leptophylla*
- d- *Ephedra alata*

Key to the types of spores and pollen grains in the studied taxa.

1.a.	Spores inaperturate (alete); elaters present (type 1)	<i>Equisetum</i>
b.	Spores or pollen grains aperturate; elaters absent	2
2.a.	Pollen grains 6-polycolpate (type IV)	<i>Ephedra</i>
b.	Spores mono- or trilete	3
3.a.	Spores monolete (type II)	<i>Asplenium</i>
b.	Spores trilete (type III)	4
4.a.	Laesura arms not reaching to the equator, not ridged (Type III, subtype A)	5
b.	Laesura arms reaching to the equator, with or without ridges (Type III, subtype B)	8
5.a.	Sculpture reticulate-foveolate	<i>Ophioglossum</i>
b.	Sculpture verrucate	6
6.a.	Laesura arms flat.	<i>Cheilanthes</i>
b.	Laesura arms raised.	7
7.a.	Verruca irregular.	<i>Onychium</i>
b.	Verruca regular.	<i>Actiniopteris</i>
8.a.	Laesura arms surrounded by ridges.	9
b.	Laesura arms without ridges.	10
9.a.	Verruca small, rounded and regular shaped; laesume flat	<i>Cheilanthes vella</i>
b.	Verruca large and irregular shaped; laesurae raised	<i>Anogramma</i>
10.a.	Laesura arms thin, sculpture tuberculate	<i>Pteris</i>
b.	Laesura arms thick, sculpture verrucate.	<i>Adiantum</i>

Discussion

Taxa of vascular cryptogamas are among the less known groups in the flora of Egypt and were recently revised by El Hadidi (2000). The spore and pollen morphology of the studied taxa provided additional criteria which show its significance when combined with the other gross morphological characters. The taxa under investigation are grouped under four different types of which three types are characteristic to the taxa of Pteridophyta and one to the species of *Ephedra* (Ephedraceae, Gymnospermae).

1- Taxa of Pteridophyta

Three spore types are distinguished of which the inaperturate (alete) type is confined to *Equisetum ramosissimum* (Equisetaceae) and the monoalete type to *Asplenium* of Aspleniaceae. Both taxa are apparently natural groups with distinct characters. This is the case of *Equisetum* which is characterised by grooved and jointed stem with the nodes bearing whorls of small tooth-like scale leaves. The spores are inaperturate with attached elaters. Species of *Asplenium* are characterized by its pinnatifid fronds and linear and naked sori on the blade veins.

Nine species belonging to seven genera and seven families are characterized by trilete spores. Three are more or less taxonomically related taxa, which can be groupd under two subtypes.

Subtype A, is characterized by ridgeless laesura arms which are not reaching the equator. It is characteristic to five species: *Ophioglossum polyphyllum*, *Actiniopteris semiflabellata*, *Cheilanthes pteridioides*, *Ch. coriacea* and *Onychium divaricatum*. Four of these species belong to Polypodiaceae (Leptosporangiate) while *Ophioglossum polyphyllum* belongs to Ophioglossaceae (Eusoprangiate) (Judd *et al.*, 1999). The laesura arms are flat in *Cheilanthes pteridioides* and *Ch. coriacea* (Fig. 1. f). The first is a fragrant plant with glabrous frond

beneath and the latter is odourless plant with hairy fronds beneath. These arms are raised in *Ophioglossum polyphyllum*, *Actiniopteris semiflabellata* and *Onychium divaricatum* (Figs. 1. c,d). The perine sculpture is reticulate-foveolate in *Ophioglossum polyphyllum* which is a glabrous succulent herb with simple elliptic fronds. It is verrucate in *Actiniopteris semiflabellata* and *Onychium divaricatum*. The verrucae are regular in shape and size in *Actiniopteris semiflabellata* (Fig. 1. d), with tufted fronds, much resembling leaves of a fan palm. These verrucae are irregular in shape and size in *Onychium divaricatum* with its pinnate fronds.

Subtype B, is characterized by laesura arms which reach the equator. The laesura arms are ridgeless in *Adiantum capillus-veneris* and *Pteris vittata*. It is thick in the first and thin and surrounded by tubercles in the latter. The laesura arms are ridged in *Cheilanthes vella* and *Anogramma leptophylla*. It is flat in the first and raised in the latter. Both taxa are characterized by 1-2 pinnate fronds and naked sori. The sori are marginal or scattered over the pinnule in *Cheilanthes vella* and are on the central parts of the pinnule in *Anogramma leptophylla*. It is worthy to mention that *Cheilanthes vella* belongs to subtype B, while *Cheilanthes pteridioides* and *Cheilanthes coriacea* belong to subtype A. This may justify the treatment of *Cheilanthes vella* as *Notholaena vella* (Aiton) R. Br.

2- Taxa of Gymnospermae

Ephedra comprises four species and are characterized by green grooved branches with spiral or whorled leaves often reduced to membranous sheaths. *Ephedra* is characterized by its polycolpate apertures and psilate sculptured pollen grains. *Ephedra alata* is a shrub 1-1.5 m high with female cones which turn dry at maturity. The pollen grains are characterized by its zig-zag ridges. Both of *Ephedra aphylla* and *E. foliata* are shrublets up to 60 cm high with female cones which remain fleshy at maturity. Both species showed very similar pollen grains and can be distinguished morphologically by the bracts of the female cones which are almost completely fused in *E. aphylla* and are fused 1/2 - 1/3 of its length in *E. foliata*.

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