

## THE SEED ATLAS OF PAKISTAN-VIII. FUMARIACEAE

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### Abstract

Seed morphology of 12 taxa belonging to the family Fumariaceae, was examined using light and scanning electron microscopy (SEM). The seed morphological data fully support the gross morphological and palynological data and also found useful for the taxonomic delimitation at the generic and the specific levels.

### Introduction

The family Fumariaceae comprises 18 genera and 450 species distributed in temperate and tropical regions (Mabberley, 2008). In Pakistan it is represented by 30 species distributed in 2 genera viz., *Corydalis* Medik and *Fumaria* L. (Jafri, 1974). Some workers treated Fumariaceae as a subfamily of Papaveraceae (Davis & Cullen, 1965; Steven, 2001 onwards). However, in most of the taxonomic treatments the family is recognised as a separate family Papaveraceae under the order Papaverales (Kubitzki, 1990; APG II system, 2003; Anon., 2012).

The use of seed micro morphological characters has played an important role to solve the various taxonomic and evolutionary problems (Bergreen, 1981; Ahmed & Qaiser, 1989; Muñoz-Centeno *et al.*, 2006; Abid & Ali, 2010; Cabi *et al.*, 2011; Ackin & Binzet 2011). Similarly the seed characters of the genus *Fumaria* were found significant for the specific delimitation. (Araii *et al.*, 2011). Moreover, Fukuhara (1992, 1999) studied the seed coat ornamentation and morphology of the genus *Corydalis* for tracing the evolutionary patterns. But there are no detailed reports available on the seed morphology of the family Fumariaceae from Pakistan. Presently 12 specific and infra specific taxa distributed in two genera are investigated for their seed macro and micro morphological characters by light and scanning electron microscope.

### Material and Methods

Mature and healthy seeds of 12 taxa of the family Fumariaceae were collected from herbarium specimens. Mostly 10 plants/species and 10 seeds/plant were studied (Appendix I) and examined under stereomicroscope (Nikon XN Model), compound microscope (Nikon type 102) and scanning electron microscope (JSM-6380A). For scanning electron microscopy dry seeds were directly mounted on metallic stub using double adhesive tape and coated with gold for a period of 6 minutes in sputtering chamber and observed under SEM. The terminology used is in accordance to Lawrence (1970), Radford (1974) and Stearn (1983) with slight modifications. The characters of seed viz., size, shape, colour, surface, and hilum were studied.

### Observations

#### General seed characters of the family Fumariaceae

Seeds 1.5-2.2x1-2mm, angular, non angular, symmetrical or asymmetrical reniform, sub reniform, oblong, globose or elliptic pyriform, centrally grooved or not, depressed or not depressed, light brown, black or blackish brown, shiny or unshiny, surface favulariate, tuberculate, reticulate, apressedly reticulate, ruminat-rugose or psilate, hilum arillate lateral, laterally central or sub central.

Represented by 2 genera viz., *Corydalis* Medik and *Fumaria* L.

### Key to the genera

1. + Seeds reniform, subreniform-oblong or ellipticpyriform ..... *Corydalis*  
- Seeds globose, oblong or broadly elliptic ..... *Fumaria*

#### *Corydalis* Medik.

Seeds 1.5-2.2x1-2mm, angular, non angular, symmetrical or asymmetrical reniform, sub reniform-oblong or elliptic pyriform, black or blackish brown, shiny or unshiny, surface favulariate, tuberculate, apressedly reticulate or psilate, hilum arillate laterally central or sub central (Table 1; Figs. 1A-O, 2A-F).

Represented by 10 species viz., *Corydalis adiantifolia* Hook. f. & Thoms. var. *adiantifolia*, *C. cornuta* Royle, *C. crassifolia* Royle, *C. crithmifolia* Royle, *C. falconeri* Hook. f. & Thoms., *C. govaniana*

Wall. var. *goviana*, *C. pseudocrithmifolia* Jafri, *C. stewartii* Fedde., *C. thyriflora* Prain and *C. vaginans* Hook. f. & Thoms.

#### *Fumaria* L.

Seeds 1.5-1.8x1.5mm, non angular, globose, oblong, dorsally centrally grooved, light brown, ruminat-rugose or reticulate, hilum lateral. (Table 1; Figs. 2G-K). Represented by 2 species viz., *Fumaria indica* (Hausskn.) Pugsley and *F. vaillantii* Lois.

Table 1. Seed morphological characters of the family Fumariaceae.

Name of taxa	Size (mm)	Angular or Non angular	Shape	Colour	Surface	Hilum
<i>Corydalis adiantifolia</i> var. <i>adiantifolia</i>	1.5-2x1-1.5	Non-angular	Reniform, depressed, symmetrical	Black, shiny	Favariate	Laterally central, arillate
<i>C. cornuta</i>	1.5x1.2	Angular	Reniform, depressed, asymmetrical	Black, unshiny	Tuberculate	Laterally central, arillate
<i>C. crassifolia</i>	2x2	Non-angular	Reniform, depressed, ± symmetrical	Blackish brown, shiny	Appressedly reticulate	Laterally central, arillate
<i>C. crithmifolia</i>	2x2	Non-angular	Reniform, depressed, asymmetrical	Black, shiny	Psilate	Laterally central, arillate
<i>C. falconeri</i>	2-2.2x1.5-2	Non-angular	Reniform, Not depressed, symmetrical	Black, shiny	Psilate	Laterally central, arillate
<i>C. govaniana</i> var. <i>govaniana</i>	2x1.5	Non-angular	Reniform, Not depressed, ± symmetrical	Black, shiny	Psilate	Laterally central, arillate
<i>C. pseudocrithmifolia</i>	1.5x1.5	Angular	Reniform, depressed, asymmetrical	Black, unshiny	Tuberculate	Laterally central, arillate
<i>C. stewartii</i>	1.5x1.5	Non-angular	Reniform, depressed, symmetrical	Black, shiny	Psilate	Laterally central, arillate
<i>C. thyrsoiflora</i>	2x1.5	Non-angular	Sub reniform-oblong, depressed, symmetrical	Black, shiny	Psilate	Laterally central, arillate
<i>C. vaginans</i>	1.8-2x1.2-1.5	Angular	Reniform-elliptic pyriform, depressed, asymmetrical	Black, shiny	Appressedly reticulate	Laterally sub central, arillate
<i>Fumaria indica</i>	1.8x1.5	Non-angular	Globose-oblong, dorsally centrally grooved	Light brown	Ruminant-rugose	Lateral
<i>F. vaillantii</i>	1.5x1.5	Non-angular	Globose, dorsally centrally grooved	Light brown	Reticulate	Lateral

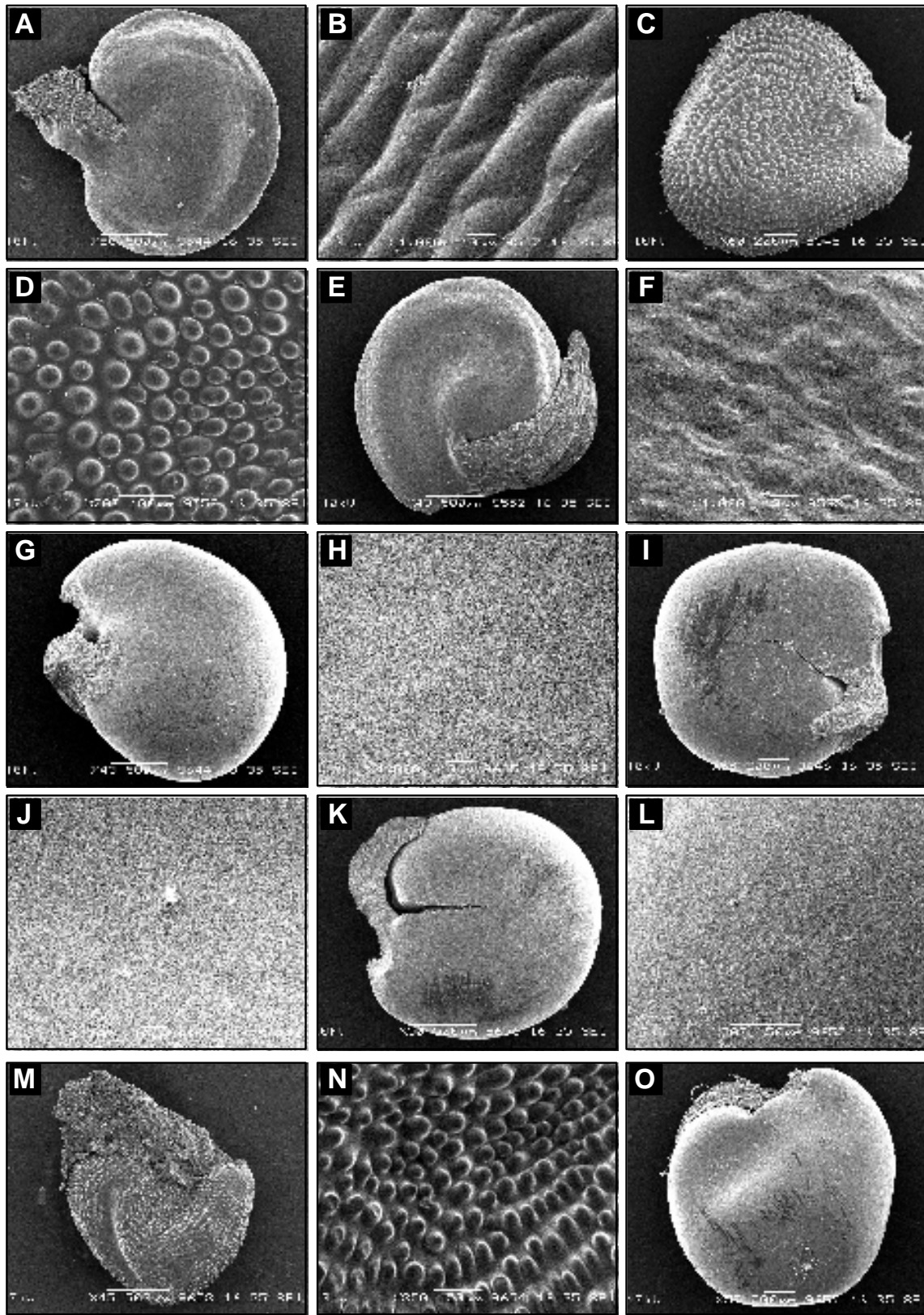


Fig. 1. Scanning electron micrographs. *Corydalis adiantifolia* var. *adiantifolia*: A, seed; B, surface. *C. cornuta*: C, seed; D, surface. *C. crassifolia*: E, seed; F, surface. *C. crithmifolia*: G, seed; H, surface. *C. falconeri*: I, seed; J, surface. *C. govaniana* var. *govaniana*: K, seed. L, surface. *C. pseudocrithmifolia*: M, seed; N, surface. *C. stewartii*: O, seed. (Scale bars: A, E, G, K, M = 500µm; C, I, O = 200µm; D = 100µm; L, N = 50µm; B, F, H, J = 10 µm).

## Appendix I. List of voucher specimens.

S. No.	Taxa	Collector, number and herbarium
1.	<i>Corydalis adiantifolia</i> var. <i>adiantifolia</i>	Jan Alam & A. Aziz 1133 (KUH); Jan Alam & A. Hameed 1186 (KUH); Webster & Nasir 6333 (RAW); S. I. Ali <i>et al.</i> , 3433 (KUH).
2.	<i>C. cornuta</i>	M. Qaiser & A. Ghafoor 5091 (KUH); M. Qaiser & R. Yusuf 7837 (KUH).
3.	<i>C. crassifolia</i>	Jan Alam & A. Hameed 1136, 1136-B (KUH); Jan Alam <i>et al.</i> , 3991 (KUH).
4.	<i>C. crithmifolia</i>	R. R. Stewart 26467 (RAW); Jan Alam & Fazal Karim 1295 (KUH).
5.	<i>C. falconeri</i>	Sher Wali Khan & Shabbir 445 (KUH); M. Qaiser & R. Yusuf 8055 (KUH).
6.	<i>C. govaniana</i> var. <i>govaniana</i>	R. R. Stewart 19748 (KUH).
7.	<i>C. pseudocrithmifolia</i>	Jan Alam <i>et al</i> 3906 (KUH); Jan Alam 721 (KUH).
8.	<i>C. stewartii</i>	S. Omer & M. Qaiser 2611 (KUH); Tahir Ali <i>et al.</i> , 547, 627 (KUH).
9.	<i>C. thyrsoflora</i>	Jan Alam & Fazal Karim 1300 (KUH).
10.	<i>C. vaginans</i>	K. A. MALIK & M. Qaiser 629 (KUH); M. Qaiser & A. Ghafoor 5351 (KUH).
11.	<i>Fumaria indica</i>	Haider Ali 287 (KUH); S. Omer & A. Ghafoor 5351 (KUH); S. Nazimuddin <i>et al.</i> , 603 (KUH); M. Qaiser & A. Ghafoor 7266 (KUH); S. I. Ali & S. A. Farooqi 1603 (KUH).
12.	<i>F. vaillantii</i>	Haider Ali 146 (KUH).

## Key to the species

1. + Seeds psilate ..... 2  
 - Seeds favulariate, tuberculate or appressedly reticulate ..... 6  
 2. + Seeds symmetrical ..... 3  
 - Seeds asymmetrical ..... *C. crithmifolia*  
 3. + Seeds depressed ..... 4  
 - Seeds not depressed ..... 5  
 4. + Seeds reniform ..... *C. stewartii*  
 - Seeds sub reniform-oblong ..... *C. thyrsoflora*  
 5. + Seeds 2mm broad ..... *C. falconeri*  
 - Seeds 1.5mm broad ..... *C. govaniana*  
 6. + Seeds symmetrical ..... 7  
 - Seeds asymmetrical ..... 8  
 7. + Seed surface favulariate ..... *C. adiantifolia*  
 - Seed surface appressedly reticulate ..... *C. crassifolia*  
 8. + Seed surface appressedly reticulate ..... *C. vaginans*  
 - Seed surface tuberculate ..... *C. cornuta*, *C. pseudocrithmifolia*

## Key to the species

1. + Seeds globose-oblong and surface ruminant-rugose ..... *F. indica*  
 - Seeds globose and surface reticulate ..... *F. vaillantii*

## Results and Discussion

Seed morphological data has been found very useful to correlate the gross morphology and palynological data within the family Fumariaceae both at generic and specific levels. The genus *Corydalis* remains distinct by having 2-4 ternate leaves (Jafri, 1974), colpate pollen grains (Perveen & Qaiser, 2004) and reniform, subreniform or elliptic pyriform seeds. While, the genus *Fumaria* is characterised due to the presence of 2-4 pinnatisect leaves (Jafri, 1974), porate pollen grains (Perveen & Qaiser, 2004) and globose or oblong

seeds. However, the seeds of Papaveraceae are characterised by distinct surfaces like cubical verrucation, reticulate with different anticlinal walls and inermis surface patterns. Similarly, the pollen of both the families are quite distinct (Perveen & Qaiser, 2004). Therefore the Fumariaceae can not be treated as a sub family of Papaveraceae. Similar to that of the generic delimitation seed morphological characters could also be significantly used for specific delimitation. The two species of the genus *Fumaria* could be easily distinguished by having distinct seed shapes and surface patterns as *F. indica* is characterized by globose-

oblong seeds with ruminante-rugose surface. While, *F. vaillantii* remains distinct by having globose seeds with reticulate surface. Previously seed surface ornamentations have also been proved diagnostic feature for the specific delimitation of the genus *Fumaria*. However, present findings are in contrast to the previous finding of Arai *et al.*, (2011) who observed smooth or plicate surface ornamentation in *F. indica* and the seeds of *F. vaillantii* were reported to have scaly form ornamentation. Similarly, the species of *Corydalis* can be separated quite easily from each other mainly due to the differences in seed surface, shape and size,

such as all the species could be divided into two groups by having psilate seed surface in *C. crithmifolia*, *C. stewartii*, *C. thyrsoiflora*, *C. falconeri* and *C. govaniensis*. The second group of species viz., *C. adiantifolia*, *C. cornuta*, *C. crassifolia*, *C. pseudocrithmifolia* and *C. vaginans* having variable seed surface patterns like favulariate, tuberculate or appressedly reticulate which are quite enough for further distinction of these species except that of *C. cornuta* and *C. pseudocrithmifolia* which could not be separated on the basis of seed morphological characters as both the species share common seed characters.

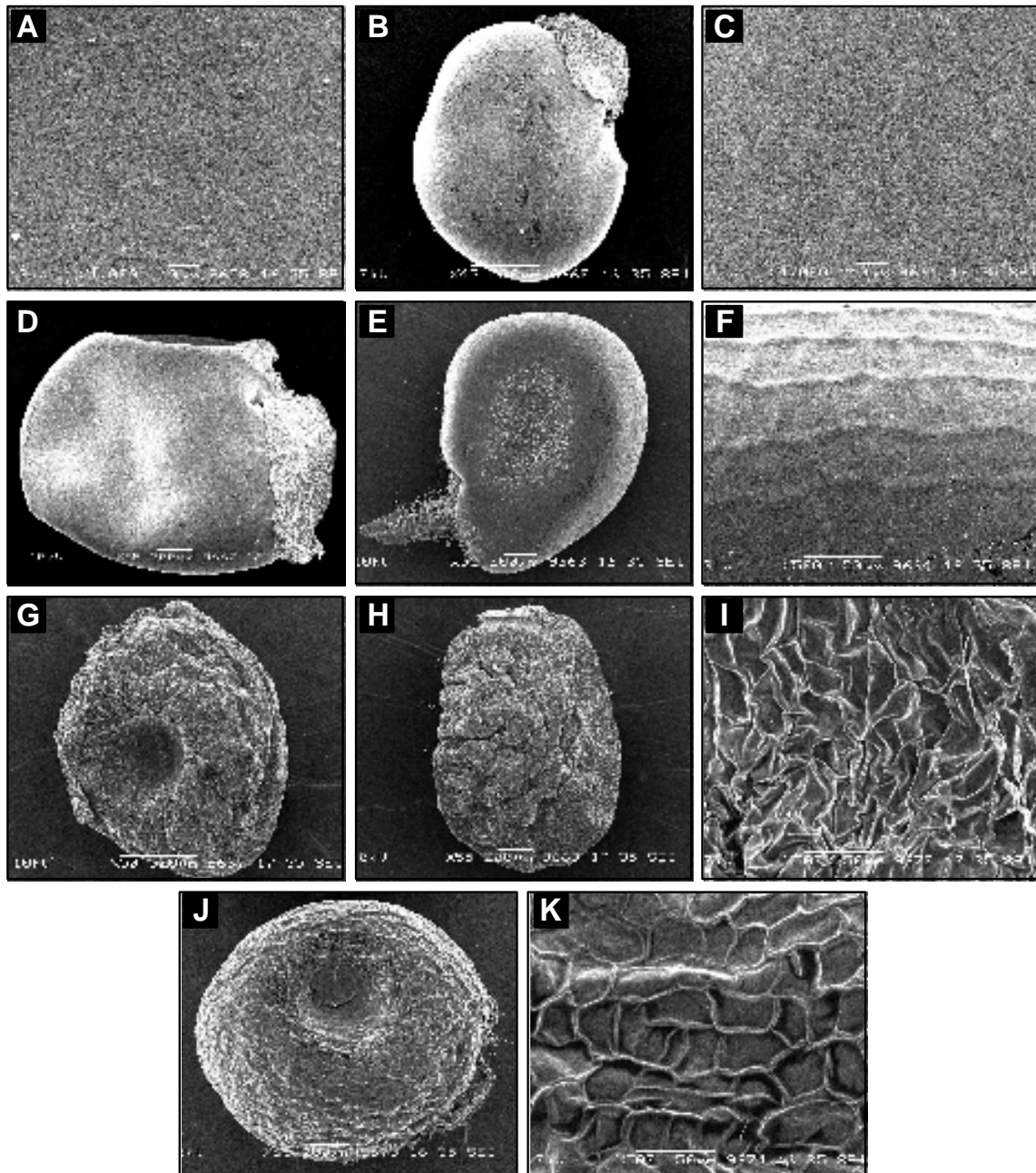


Fig. 2. Scanning electron micrographs. *C. stewartii*: A, surface. *C. thyrsoiflora*: B, seed; C, surface. *C. vaginans*: D, E, seed; F, surface. *Fumaria indica*: G, H, seed; I, surface. *F. vaillantii*: J, seed; K, surface. (Scale bars: B, G = 500 $\mu$ m; D, E, H, J = 200 $\mu$ m; F, I, K = 50 $\mu$ m; A, C = 10  $\mu$ m).

### Acknowledgement

This research work is a part of the project “The Seed Atlas of Pakistan”, sponsored by HEC, which is gratefully acknowledged. Thanks are due to Director, Center for Plant conservation for providing the facilities of scanning electron microscopy.

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(Received for publication 19 January 2012)