

## CYPSELA MORPHOLOGY OF SOME GENERA IN THE TRIBE GNAPHALIEAE (ASTERACEAE) FROM PAKISTAN

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### Abstract

Micromorphological characters of cypselae of the tribe Gnaphalieae were studied using light and scanning electron microscopy. In all 19 taxa including in *Cymbolaena* smoljan, *Filago* L., *Ifloga* Cass., *Lasiopogon* Cass., *Leontopodium* R.Br. ex Cass., and *Phagnalon* Cass., were examined. Cypselae features were found useful for assessing the taxonomic delimitation both at the generic and specific levels.

### Introduction

Tribe Gnaphalieae of the family Asteraceae is represented in Pakistan by 12 genera and 45 species (Qaiser & Abid, 2003) of which genera *Anaphalis* DC., *Gamochaeta* Wedd., *Gnaphalium* L., *Homognaphalium* Kirp., and *Pseudognaphalium* Kirp., have been previously studied for their cypselae features (Abid & Qaiser, 2007b, 2008). Presently the cypselae morphology of the genera *Cymbolaena* smoljan, *Filago* L., *Ifloga* Cass., *Lasiopogon* Cass., *Leontopodium* R.Br. ex Cass., and *Phagnalon* Cass., is studied for evaluating the taxonomic decisions.

### Materials and Methods

Nineteen taxa of the tribe Gnaphalieae assembled in 6 genera viz., *Cymbolaena*, *Filago*, *Ifloga*, *Lasiopogon*, *Leontopodium* and *Phagnalon* were studied for cypselae characters from herbarium specimens (Appendix 1) under stereomicroscope (Nikon XN Model), compound microscope (Nikon Type 102) and scanning electron microscope (JSM-6380A). For scanning electron microscopy mature cypselae 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 following characters were studied: Cypselae: Shape, surface, colour, size. Pappus: Bristle's series, shape, number, degree of fusion, colour, size. Carpopodium: Shape, position, diameter of carpopodium and diameter of foramen of carpopodium were observed under scanning electron microscope.

### Observations

#### General cypselae characters of Gnaphalieae

Cypselae oblong, oblong-ob lanceolate, oblong-ovate, oblanceolate or ellipsoid, 0.75-1.5x0.25-0.5mm, yellowish brown, reddish brown or dark brown, non ribbed, glabrous, long hairy, globose myxogenic twin hairy, papillate or papillate-clavate. Cypselae monomorphic or dimorphic with epipappus female and pappus bisexual

cypselas. Pappus uniseriate, bristles scabrid-barbellate, barbellate, plumose or only apically plumose, 3-24, 1.5-8.0mm long, white or yellow, deciduous. Carpopodium narrow or broad circular without any interruption, subbasal in position, 42-170 µm in diameter. Foramen of carpopodium 30-96 µm in diameter (Table 1).

**Appendix 1. List of voucher specimens.**

Taxa	Collector, number, herbarium
<i>Cymbolaena griffithii</i>	<i>M. Qaiser &amp; S. Abedin</i> 5930 (KUH); <i>S. Omer</i> 1265 (KUH); <i>S.M.H. Jafri</i> s.n. (KUH); <i>S.Omer</i> 1192 (KUH); <i>A. Ghafoor &amp; Steve M. Goodman</i> 5063 (KUH).
<i>Filago arvensis</i>	<i>A. Ghafoor &amp; S. Omer</i> 3266 (KUH); <i>S. Omer &amp; M. Qaiser</i> 2317 (KUH); <i>S.M.H. Jafri &amp; Akbar</i> 2121 (KUH); <i>R.R. Stewart &amp; A. Rahman</i> 25151 (RAW).
<i>F. desertorum</i>	<i>M. Qaiser, Asad Raza &amp; A. Hussain</i> 1000 (KUH); <i>A. Ghafoor &amp; Steve. M. Goodman</i> 4745 (KUH).
<i>F. hundwarica</i>	<i>Tahir Ali &amp; G.R. Sarwar</i> 2798 (KUH); <i>Kamal A. Malik, S. Omer &amp; A. Wahid</i> 2314 (KUH); <i>Y. Nasir &amp; M.A. Siddiqui</i> 8241 (RAW).
<i>F. paradoxa</i>	<i>A. Ghafoor &amp; S. Omer</i> 3023 (KUH); <i>S. Omer &amp; M. Qaiser</i> 2703 (KUH); <i>A. Ghafoor &amp; Steve M. Goodman</i> 4587 (KUH); <i>R.R. Stewart</i> 27293 (RAW).
<i>F. pyramidata</i>	<i>R.R. Stewart</i> 13805 (KUH); <i>A. Ghafoor &amp; S. Omer</i> 2150 (KUH).
<i>Ifloga spicata</i>	<i>M. Qaiser &amp; A. Ghafoor</i> 7438 (KUH); <i>R.R. Stewart</i> 15311 (KUH); <i>A. Ghafoor &amp; M. Qaiser</i> 62 (KUH); <i>S. Abedin &amp; Abrar Hussain</i> 7252 (KUH); <i>A. Ghafoor &amp; Steve M. Goodman</i> 4458 (KUH); <i>Malhotra</i> s.n. (RAW).
<i>Lasiopogon muscoides</i>	<i>S. Omer, M. Qaiser &amp; Y. Nasir</i> 2159 (KUH); <i>A. Ghafoor &amp; Steve M. Goodman</i> 5057 (KUH); <i>Kamal A. Malik et al.</i> 2380 (KUH).
<i>Leontopodium brachyactis</i>	<i>S.M.A. Kazmi</i> s.n. (KUH); <i>M. Qaiser &amp; A. Ghafoor</i> 1833 (KUH); <i>S. Abedin &amp; M. Qaiser</i> 9033 (KUH); <i>S.M.H. Jafri &amp; Ali</i> 3173 (KUH).
<i>L. himalayanum</i>	<i>R.R. Stewart</i> 6634 (RAW).
<i>L. jacobianum</i>	<i>R.R. Stewart</i> s.n. (KUH); <i>S. Omer &amp; M. Qaiser</i> 2640 (KUH); <i>F. Schmid</i> 326 (RAW).
<i>L. leontopodinum</i>	<i>Jan Alam &amp; Aziz</i> 1068 (KUH); <i>Jan Alam &amp; Fazal Karim</i> 1303 (KUH); <i>S.I. Ali, W. Sugong &amp; Tahir Ali</i> 3389 (KUH); <i>R.R. Stewart</i> 12642 (RAW).
<i>L. nanum</i>	<i>Walter Koelz</i> 2179 (RAW); <i>Jan Alam &amp; A. Aziz</i> s.n. (KUH).
<i>Phagnalon acuminatum</i>	<i>Ulfat Hussain zargar</i> 495 (KUH); <i>S. Omer &amp; A. Ghafoor</i> 1824 (KUH); <i>M. A. Siddiqui</i> 27100 (RAW); <i>Dick-Peddie</i> 26 (RAW).
<i>P. daravazicum</i>	<i>S. Omer &amp; A. Ghafoor</i> 1797 (KUH).
<i>P. niveum</i>	<i>Ali</i> 1109 (KUH); <i>M. Qaiser &amp; S. Abedin</i> 5624 (KUH); <i>Sadruddin</i> s.n. (KUH); <i>Tahir Ali &amp; G.R. Sarwar</i> 2738 (KUH); <i>A. Ghafoor &amp; Tahir Ali</i> 3700 (KUH).
<i>P. pycnophyllum</i>	<i>S. Nazimuddin &amp; S. Abedin</i> 1071 (KUH); <i>S.M.A. Kazmi</i> 1698 (RAW); <i>R.R. Stewart</i> 570 (RAW).
<i>P. schweinfurthii</i> var. <i>androssovii</i>	<i>S. Omer &amp; A. Ghafoor</i> 1381 (KUH); <i>S.M.H. Jafri &amp; Akbar</i> 2331B (KUH); <i>S.M.H. Jafri</i> 2925 (KUH).
<i>P. schweinfurthii</i> var. <i>lamondae</i>	<i>S.M.A. Kazmi</i> 1149 (RAW).

### Key to the genera

- 1 + Cypselas epappose in only female florets and pappose in bisexual ones ..... 2  
   - Cypselas pappose in both female and bisexual florets ..... 4
- 2 + Cypselas oblong-oblanceolate, oblong-obovate, obovate, pappillate, clavate or with globose myxogenic twin hairs. Pappus bristles 8-16 and 2-3.5mm long ..... 3  
   - Cypselas oblanceolate, glabrous. Pappus bristles 3-4 and 1.5mm long .....  
        ..... *Cymbolaena*
- 3 + All cypselas of female florets epappose. Pappus bristles plumose apically and barbellate at base, free ..... *Ifloga*  
   - Cypselas of outer female florets epappose and pappose of inner ones. Pappus bristles barbellate throughout ..... *Filoga*
- 4 + Cypselas with globose myxogenic twin hairs. Pappus bristles plumose. Carpopodium narrow circular ring like ..... *Lasiopogon*  
   - Cypselas glabrous, papillate, papillate-clavate or long hairy. Pappus bristles scabrid -barbellate or barbellate. Carpopodium broad circular disc like ..... 5
- 5 + Cypselas long hairy. Pappus bristles yellow and free ..... *Phagnalon*  
   - Cypselas glabrous, papillate or papillate-clavate. Pappus bristles white and basally fused ..... *Leontopodium*

#### *Cymbolaena* Smoljan

It is represented by single species viz., *C. griffithii* (A.Gray) Wagenitz

Cypselas dimorphic, bisexual (functionally male) pappose, female ones epappose, oblanceolate, 1.5x0.5, yellowish brown, glabrous. Pappus uniseriate, barbellate, free, deciduous white, 3-4, 1.5mm long. Carpopodium broad circular disc like without any interruption subbasal in position, 90µm in diameter. Foramen of carpopodium 50µm in diameter (Table 1; Fig. 1A-D).

#### *Filago* L.

It is represented by 5 species viz., *F. arvensis* L., *F. desertorum* Pomel, *F. hundwarica* (Wall.ex DC.) Wagenitz, *F. paradoxa* Wagenitz, *F. pyramidata* L.

Cypselas dimorphic, outer female epppose, inner female and bisexual ones pappose, obovate or oblong-oblanceolate, 0.75-1.5x0.25-0.5mm,yellowish brown, sparsely papillate, papillate-clavate or globose-clavate hairy. Pappus uniseriate, barbellate, basally fused, deciduous, white, 8-16, 2.5 -3.5mm long. Carpopodium narrow circular ring without any interruption, subbasal in position, 72-88µm in diameter. Foramen of carpopodium 53-66µm in diameter (Table 1; Fig. 2A-O).

Table 1. Cypsela characters in the tribe Gnaphalieae.

Name of taxa	Cypsela				Size (mm)
	Shape	Surface (hairs)	Colour		
<i>Cymbolaena griffithii</i>	Oblanceolate	Glabrous	Yellowish brown	1.5x 0.5	
<i>Filago arvensis</i>	Oblong-oblanceolate	Sparingly papillate	Yellowish brown	1-1.5x0.25-0.5	
<i>F. desertorum</i>	Oblong-oblanceolate	Sparingly papillate-clavate	Yellowish brown	1.0x0.5	
<i>F. hundwaria</i>	Obovate	Sparingly papillate-clavate	Yellowish brown	1.0x0.5	
<i>F. paradoxa</i>	Oblong-oblanceolate	Globose-clavate hairy	Yellowish brown	0.75x0.25	
<i>F. pyramidata</i>	Oblong-oblanceolate	Globose-clavate hairy	Yellowish brown	0.75-1.0x0.5	
<i>Ifloga spicata</i>	Oblong-ovoid	Globose myxogenic twin hairs	Reddish brown	0.5-0.75x0.25	
<i>Lasiopogon muscoides</i>	Ellipsoid	Globose myxogenic twin hairs	Yellowish brown	0.5x0.25	
<i>Leontopodium brachyactis</i>	Ellipsoid	Sparingly papillate	Dark brown	1.5x0.5	
<i>L. himalayanum</i>	Oblong or ellipsoid	Sparingly papillate-clavate	Dark brown	1.5x0.5	
<i>L. jacquinianum</i>	Oblong	Sparingly papillate-clavate	Dark brown	1.0x0.25	
<i>L. leontopodium</i>	Ellipsoid	Glabrous	Dark brown	1.5x0.5	
<i>L. nanum</i>	Ellipsoid	Sparingly papillate	Dark brown	1.5x0.5	
<i>Phagnalon acuminatum</i>	Oblong	Sparingly long hairy	Dark brown	1.0x0.25-0.5	
<i>P. daravazicum</i>	Oblong	Sparingly long hairy	Dark brown	1.5x0.25-0.5	
<i>P. niveum</i>	Oblong	Sparingly long hairy	Dark brown	1.0x0.25-0.5	
<i>P. pycnophyllum</i>	Ellipsoid	Sparingly long hairy	Dark brown	1.0x0.25-0.5	
<i>P. schweinfurthii</i> var. <i>androssovii</i>	Ellipsoid	Sparingly long hairy	Dark brown	1.5x0.5	
<i>P. schweinfurthii</i> var. <i>lamondiae</i>	Ellipsoid	Sparingly long hairy	Dark brown	1.5x0.5	

Table 1. (Cont'd.).

Name of taxa	Pappus					Number	Length (mm)	Colour
	Bisexual cypselae	Female cypselae	Bristles					
<i>Cymbolaena griffithii</i>	Pappose	Epappose	Uniseriate, barbellate, free	3-4	1.5			
<i>Filago arvensis</i>	Pappose	Outer ones epapple; inner ones pappose	Uniseriate, barbellate, basally fused	12-14	3-3.5			
<i>F. desertorum</i>	Pappose	Outer ones epapple; inner ones pappose	Uniseriate, barbellate basally fused	12-16	2.5			
<i>F. hirsutavarica</i>	Pappose	Outer ones epapple; inner ones pappose	Uniseriate, barbellate, basally fused	14-16	2.5			
<i>F. paradoxa</i>	Pappose	Outer ones epapple; inner ones pappose	Uniseriate, barbellate, basally fused	10-12	2.5			
<i>F. pyramidata</i>	Pappose	Outer ones epapple; inner ones pappose	Uniseriate, barbellate, basally fused	8-10	2.5			
<i>Ifloga spicata</i>	Pappose	Epappose	Uniseriate, barbellate, apically plumose, free	8-10	2.0			
<i>Lasiopegon muscoides</i>	Pappose	Pappose	Uniseriate, plumose, free	8-10	2.0			
<i>Leontopodium brachyactis</i>	Pappose	Pappose	Uniseriate, barbellate, basally fused	12-14	4.5-5			
<i>L. himalayanum</i>	Pappose	Pappose	Uniseriate, barbellate, basally fused	20-24	4.5			
<i>L. jacotianum</i>	Pappose	Pappose	Uniseriate, barbellate, basally fused	20-24	4.0			
<i>L. leontopodinum</i>	Pappose	Pappose	Uniseriate, barbellate, basally fused	18-20	3-3.5			
<i>L. nanum</i>	Pappose	Pappose	Uniseriate barbellate, basally fused	32	7-8			
<i>Phagnalon acuminatum</i>	Pappose	Pappose	Uniseriate, barbellate, free	6-9	5-6	Yellow		
<i>P. daravizicum</i>	Pappose	Pappose	Uniseriate, sebrid-barbellate, free	5-6	5.0	Yellow		
<i>P. niveum</i>	Pappose	Pappose	Uniseriate, sebrid-barbellate, free	5.0	5.0	Yellow		
<i>P. pycnophyllum</i>	Pappose	Pappose	Uniseriate, barbellate, free	5.0	5.0	Yellow		
<i>P. schweinfurthii</i> var. <i>androssovii</i>	Pappose	Pappose	Uniseriate, barbellate, free	5.0	5.0	Yellow		
<i>P. schweinfurthii</i> var. <i>lamondiae</i>	Pappose	Pappose	Uniseriate, barbellate, free	5.0	5.0	Yellow		

Table 1. (Cont'd.).

Name of taxa	Shape	Carpopodium			Diameter of foramen of carpopodium ( $\mu\text{m}$ )
		Position	Diameter of carpopodium ( $\mu\text{m}$ )		
<i>Cymbolaena griffithii</i>	Broad circular disc without any interruption	Subbasal	90		50
<i>Filago arvensis</i>	Narrow circular ring without any interruption	Subbasal	83		54
<i>F. desertorum</i>	Narrow circular ring without any interruption	Subbasal	88		66
<i>F. hardwarica</i>	Narrow circular ring without any interruption	Subbasal	80		62
<i>F. paradoxa</i>	Narrow circular ring without any interruption	Subbasal	80		53
<i>F. pyramidata</i>	Narrow circular ring without any interruption	Subbasal	72		53
<i>Ifloga spicata</i>	Broad circular disc without any interruption	Subbasal	68		55
<i>Lasiosiphon muscoides</i>	Narrow circular ring without any interruption	Subbasal	42		30
<i>Leontopodium brachyactis</i>	Broad circular disc without any interruption	Subbasal	117		62
<i>L. himalayanum</i>	Broad circular disc without any interruption	Subbasal	170		60
<i>L. jacotianum</i>	Broad circular disc without any interruption	Subbasal	160		96
<i>L. leontopodium</i>	Broad circular disc without any interruption	Subbasal	105		48
<i>L. nannum</i>	Broad circular disc without any interruption	Subbasal	135		80
<i>Phagnalon acuminatum</i>	Broad circular disc without any interruption	Subbasal	135		40
<i>P. daravazicum</i>	Broad circular disc without any interruption	Subbasal	164		60
<i>P. niveum</i>	Broad circular disc without any interruption	Subbasal	112		42
<i>P. pycnophyllum</i>	Broad circular disc without any interruption	Subbasal	145		55
<i>P. schweinfurthii</i> var. <i>androssovii</i>	Broad circular disc without any interruption	Subbasal	155		63
<i>P. schweinfurthii</i> var. <i>lamondae</i>	Broad circular disc without any interruption	Subbasal	152		65

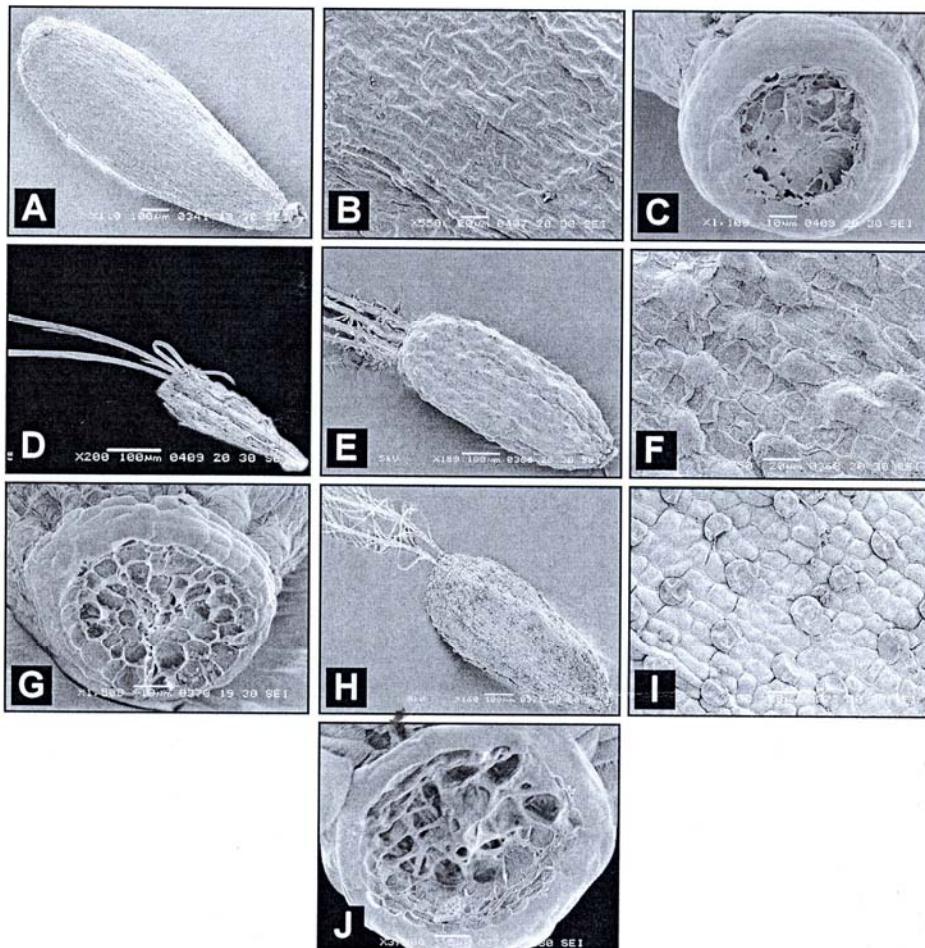


Fig. 1. Scanning Electron Micrographs. *Cymbolaena griffithii*: A, female cypsela; B, surface; C, carpopodium; D, bisexual cypsela. *Ifloga spicata*: E, cypsela; F, surface; G, carpopodium. *Lasiopogon muscoides*: H, cypsela; I, surface; J, carpopodium (scale bar: A, D, E, H= 100  $\mu\text{m}$ ; B, F, I= 20  $\mu\text{m}$ ; C, G= 10  $\mu\text{m}$ ; J= 15  $\mu\text{m}$ ).

#### Key to the species of *Filago*

- 1 + Cypselas globose-clavate hairy, 0.75mm long ..... 2
  - Cypselas papillate or papillate-clavate hairy, 1-1.5mm long ..... 3
- 2 + Pappus bristles 8-10. Carpopodium 72  $\mu\text{m}$  in diameter ..... *F. pyramidata*
  - Pappus bristles 10-12. Carpopodium 80  $\mu\text{m}$  in diameter ..... *F. paradoxa*
- 3 + Cypselas papillate-clavate ..... 4
  - Cypselas papillate ..... *F. arvensis*
- 4 + Cypselas obovate. Carpopodium 80  $\mu\text{m}$  in diameter ..... *F. hundwarica*
  - Cypselas oblong-oblanceolate. Carpopodium 88  $\mu\text{m}$  in diameter ..... *F. desertorum*

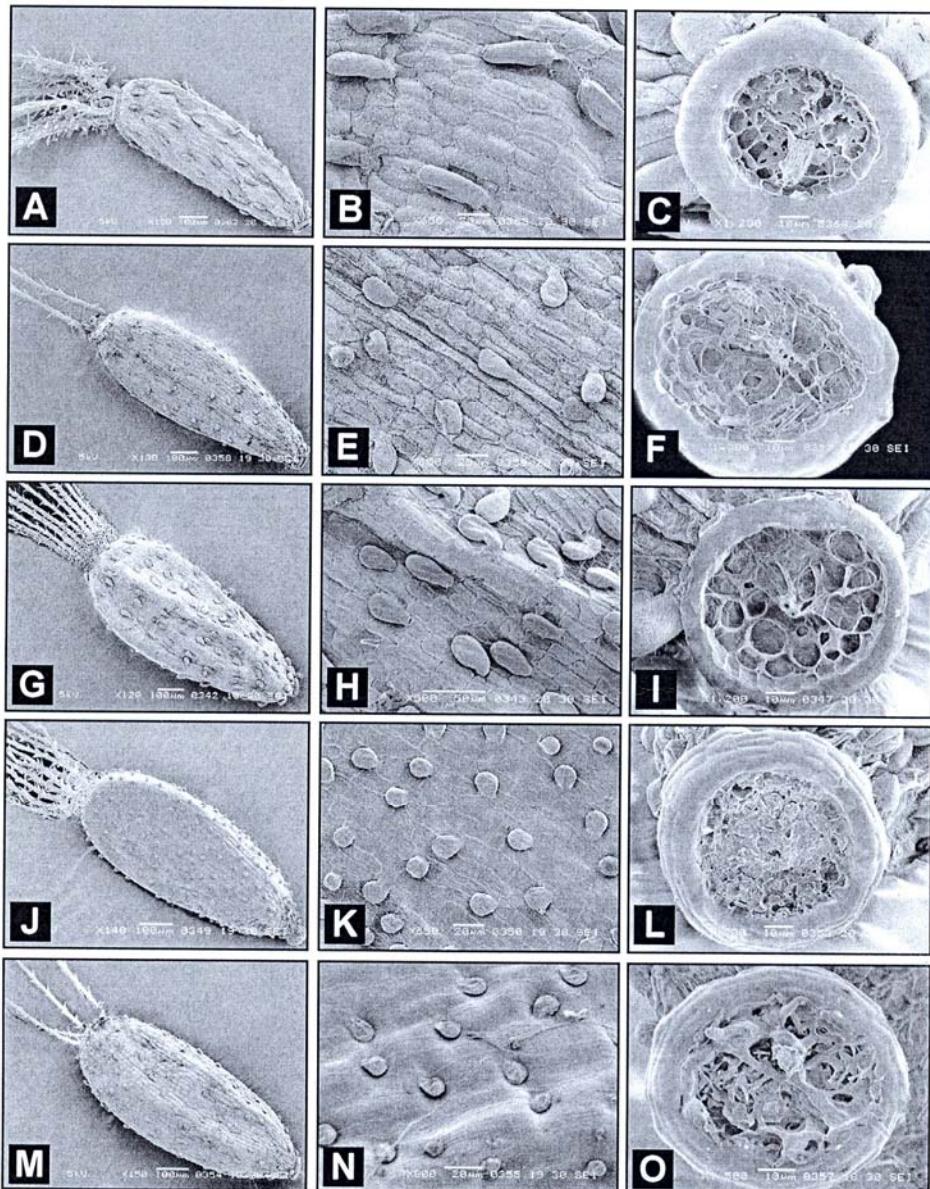


Fig. 2. Scanning Electron Micrographs. *Filoga arvensis*: A, cypselae; B, surface; C, carpopodium. *F. desertorum*: D, cypselae; E, surface; F, carpopodium. *F. hundwarica*: G, cypselae; H, surface; I, carpopodium. *F. paradoxa*: J, cypselae; K, surface; L, carpopodium. *F. pyramidata*: M, cypselae; N, surface; O, carpopodium (Scale bar: A, D, G, J, M= 100 $\mu$ m; B, E, K, N= 20 $\mu$ m; H= 50 $\mu$ m; C, F, I, L, O= 10 $\mu$ m).

***Ifloga*** Cass.

It is represented by single species viz., *I. spicata* (Forssk.) Sch.-Bip. Cypselas dimorphic, bisexual pappose, female epappose, oblong-obovoid, 0.5-0.75x0.25mm, reddish brown with globose myxogenic twin hairs. Pappus uniserial, barbellate but apically plumose, deciduous, white, 6-10, 2mm long. Carpopodium broad circular disc like without any interruption, subbasal in position, 68 $\mu$ m in diameter. Foramen of carpopodium 55  $\mu$ m in diameter (Table 1; Fig. 1E-G).

***Lasiopogon*** Cass.

It is represented by single species viz., *L. muscoides* (Desf.) DC. Cypselas monomorphic, ellipsoid, 0.5x0.25mm, yellowish brown, globose myxogenic twin hairy. Pappus uniserial, plumose, free, deciduous, white, 8-10, 2mm long. Carpopodium narrow circular ring like without any interruption, subbasal in position, 42 $\mu$ m in diameter. Foramen of carpopodium 30  $\mu$ m (Table 1; Fig. 1H-J).

***Leontopodium*** R. Br. ex Cass.

It is represented by five species viz., *L. brachyactis* Gaudiger, *L. himalayanum* DC. *L. jacotianum* Beauv., *L. Leontopodium* (DC.) Hand.-Mazz., *L. nanum* (Hook f. & Thomson ex C.B. Clarke) Hand.-Mazz.

Cypselas monomorphic, oblong or ellipsoid, 1-1.5x0.25-0.5 mm, dark brown, glabrous, sparsely papillate or papillate-clavate. Pappus uniserial, barbellate, basally fused, deciduous, white, 12-32, 3-8mm long. Carpopodium broad circular disc like without any interruption, subbasal in position, 105-170 $\mu$ m in diameter. Foramen of carpopodium 48-96 $\mu$ m in diameter (Table 1; Fig. 3A-O).

**Key to the species of *Leontopodium***

- 1 + Cypselas glabrous. Carpopodium 105  $\mu$ m in diameter ..... *L. Leontopodium*
  - Cypselas papillate or papillate-clavate. Carpopodium 117-170 $\mu$ m in diameter ..... 2
- 2 + Cypselas sparsely papillate. Carpopodium 117-135 $\mu$ m in diameter ..... 3
  - Cypselas sparsely papillate-clavate. Carpopodium 160-170 $\mu$ m in diameter ..... 4
- 3 + Pappus bristles 12-14, upto 5mm long. Carpopodium 17  $\mu$ m in diameter ..... *L. brachyactis*
  - Pappus bristles 24-32, 7-8mm long. Carpopodium 135  $\mu$ m in diameter ... *L. nanum*
- 4 + Cypselas oblong. Carpopodium 160 $\mu$ m in diameter. Foramen of carpopodium 96 $\mu$ m in diameter ..... *L. jacotianum*
  - Cypselas oblong or ellipsoid. Carpopodium 170  $\mu$ m in diameter. Foramen of carpopodium 60 $\mu$ m in diameter ..... *L. himalayanum*

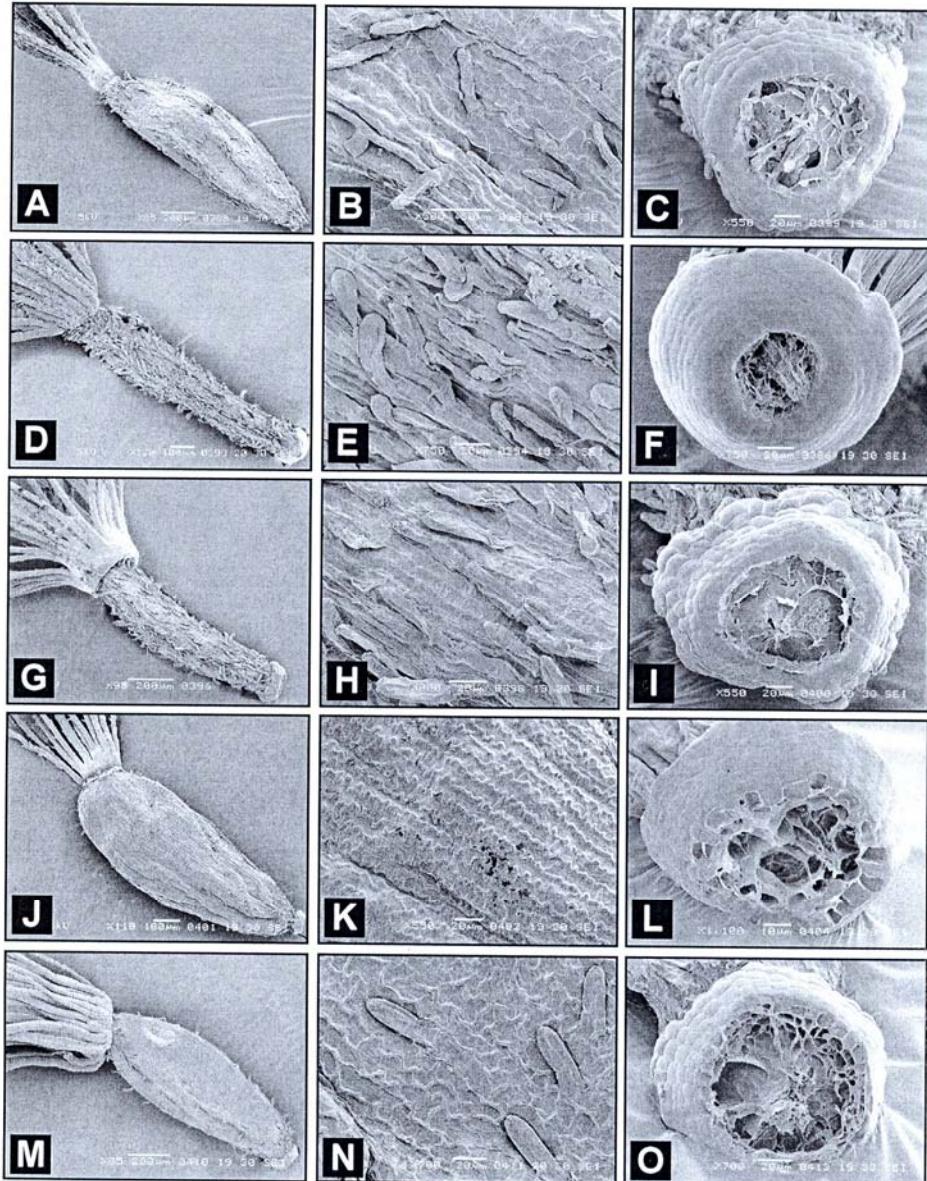


Fig. 3. Scanning Electron Micrographs. *Leontopodium brachyactis*: A, cypselae; B, surface; C, carpopodium. *L. himalayanum*: D, cypselae; E, surface; F, carpopodium. *L. jacotianum*: G, cypselae; H, surface; I, carpopodium. *L. leontopodinum*: J, cypselae; K, surface; L, carpopodium. *L. nanum*: M, cypselae; N, surface; O, carpopodium. (Scale bar: A, G, M= 200  $\mu\text{m}$ ; D, J= 100 $\mu\text{m}$ ; C, E, F, H, I, K, N, O= 20 $\mu\text{m}$ ; B= 50 $\mu\text{m}$ ; L= 10 $\mu\text{m}$ ).

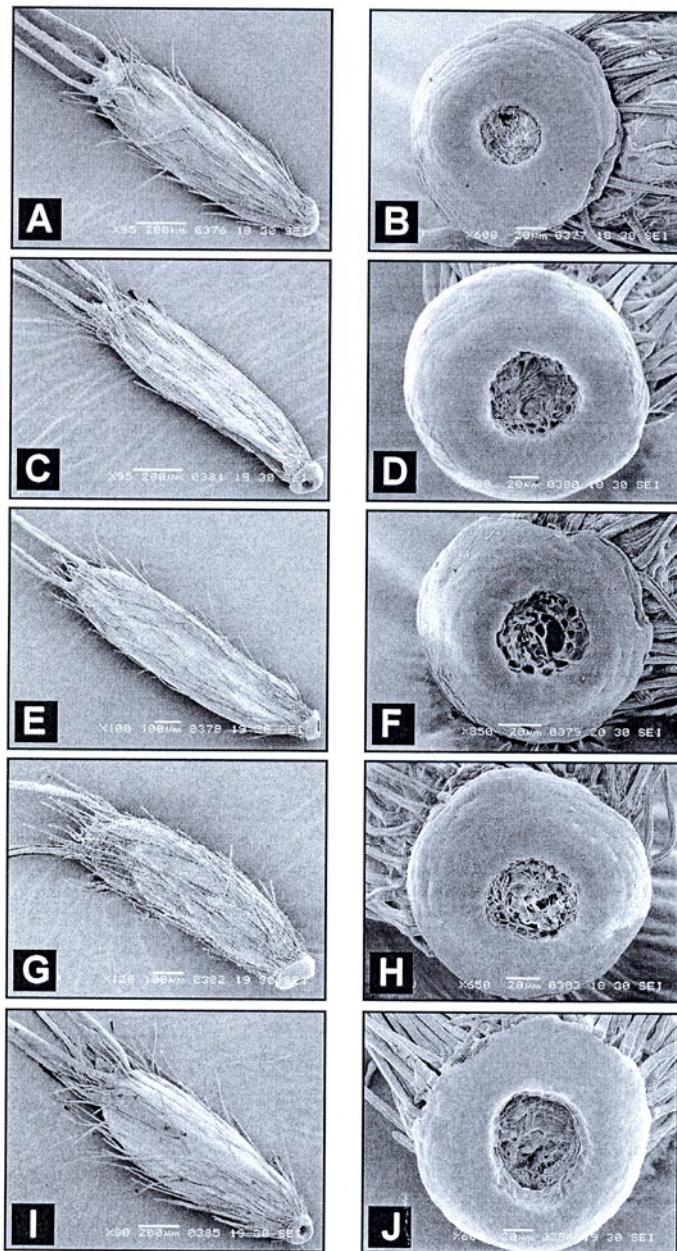


Fig. 4. Scanning Electron Micrographs. *Phagnalon acuminatum*: A, cypsela; B, carpopodium. *P. daravazicum*; C, cypsela; D, carpopodium. *P. niveum*: E, cypsela; F, carpopodium. *P. pycnophyllum*: G, cypsela; H, carpopodium. *P. schweinfurthii* var. *androssovii*: I, cypsela; J, carpopodium. (Scale bar: A, C, I= 200 $\mu$ m; E, G= 100 $\mu$ m; B, D, F, H, J= 20 $\mu$ m).

***Phagnalon* Cass.**

It is represented by 5 species viz., *P. acuminatum* Boiss., *P. daravazicum* H. Krasch., *P. niveum* Edgew., *P. pycnophyllum* Rech.f., *P. schweinfurthii* Sch.- Bip. ex Schweinf. var. *androssovii* (B. Fedtsch.) Qaiser & Lack, *P. schweinfurthii* Sch.- Bip. ex Schweinf. var. *lamondae* Qaiser & Lack.

Cypselas monomorphic, oblong or ellipsoid, 1-1.5x0.25-0.5mm, dark brown, long hairy. Pappus uniseriate, barbellate or scabrid-barbellate, free, deciduous, yellow, 5-9mm long. Carpopodium broad circular disc like without any interruption, 112-164 $\mu$ m in diameter. Foramen of carpopodium 40-65  $\mu$ m in diameter (Table 1; Fig. 4A-J).

**Key to the species of *Phagnalon***

- 1 + Carpopodium upto 135 $\mu$ m in diameter. Foramen of carpopodium 40-42  $\mu$ m in diameter ..... 2
- Carpopodium 145-164 $\mu$ m in diameter. Foramen of carpopodium 55-65  $\mu$ m in diameter ..... 3
- 2 + Pappus bristles scabrid-barbellate, 6-9. Carpopodium 135 $\mu$ m in diameter ..... *P. acuminatum*
- Pappus bristles barbellate, 5. Carpopodium 112 $\mu$ m in diameter ..... *P. niveum*
- 3 + Pappus bristles scabrid-barbellate. Carpopodium 164 $\mu$ m in diameter ..... *P. daravazicum*
- Pappus bristles barbellate. Carpopodium 145-155 $\mu$ m in diameter ..... 4
- 4 + Carpopodium 145 $\mu$ m in diameter. Foramen of carpopodium 55 $\mu$ m in diameter ..... *P. pycnophyllum*
- Carpopodium 152-155 $\mu$ m in diameter. Foramen of carpopodium 63-65  $\mu$ m in diameter ..... *P. schweinfurthii*

**Result and Discussion**

In the family Asteraceae cypselas morphology has been proved very useful for the taxonomic delimitation at tribal level such the tribes Helianthae and Eupatoreiae are distinguished from rest of the tribes due to carbonized cypselas (Anderberg, 1991; Bremer, 1994). The tribe Inuleae is usually characterized by the presence of calcium oxalate crystals in the cypselas epidermis (Mermuller & Grau, 1977; Anderberg, 1991; Breitwieser & Ward 2005). However, similar to the tribe Plucheeae (Abid & Qaiser, 2007a) Gnaphalieae do not have characteristic cypselas but cypselas morphology is very helpful for infratribal delimitation. On the basis cypselas morphology all the taxa of Gnaphalieae are divided into two groups such as cypselas monomorphic or dimorphic. Monomorphic cypselas are found in the genera *Lasiopogon*, *Leontopodium* and *Phagnalon*, where the genus *Lasiopogon* is characterized by having the cypselas with globose myxogenic twin hairs and plumose pappus bristles. While in the genus *Leontopodium* cypselas are either glabrous, papillate or papillate-clavate with barbellate and basally fused pappus bristles. *Phagnalon* is distinct due to long hairs on cypselas with free and scabrid-barbellate or barbellate pappus bristles. Taxa with dimorphic cypselas may be further divided into two subgroups one group with epapose cypselas in all

female florets and bisexual ones pappose including *Cymbolaena* and *Ifloga*. Furthermore both the genera are distinct from each other due to glabrous cypselas with 3-4 barbellate pappus bristles in *Cymbolaena* whereas, *Ifloga* cypselas has globose myxogenic hairs with 8-10 barbellate but apically plumose bristles. However, importance of cypselae morphology is also evident at specific level such as species of *Filago* are distinguished on the basis of cypselae surface, as the globose-clavate hairs are found in *F. paradoxa* and *F. pyramidata*. While, *F. desertorum* and *F. hundwarica* are distinct from the other species due to sparsely papillate-clavate cypselas and the species of both groups differ from each other due to the size of carpodium. However, papillate surface is characteristic for *F. arvensis*. All the species of *Leontopodium* are also distinguished from each other as *L. leontopodinum* is characterized by glabrous cypselas and in remaining species cypselas are papillate or papillate-clavate. *L. nanum* is the only species in which pappus bristles are 32 and 7-8mm long, while in rest of the species pappus bristles are 12-24 and 3-5mm long. Furthermore, *L. brachyactis* is distinct from *L. himalayanum* and *L. jacotianum* due to papillate cypselas and smaller carpodium and above two species have papillate-clavate cypselae surface but remain distinct from each other due to the diameter of carpodium and its foramen. Similarly, the species of *Phagnalon* are also separated from each other on the basis of bristles structure and size of carpodium. However, the cypselae characters are not helpful at infraspecific level as both the varieties of *Phagnalon schweinfurthii* i.e., var. *lamondae* and var. *androssovii* have similar cypselae features. Therefore, from the foregoing discussion it is evident that all the taxa of the tribe Gnaphalieae can be easily delimited on the basis of cypselae features.

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