Pak. J. Bot., 41(2): 555-579, 2009.

TAXONOMIC SIGNIFICANCE OF THE CYPSELA MORPHOLOGY IN THE TRIBE ANTHEMIDEAE (ASTERACEAE) FROM PAKISTAN AND KASHMIR

RUBINA ABID AND MUHAMMAD QAISER*

Department of Botany, University of Karachi, Karachi-75270, Pakistan
**Federal University of Arts, Science and Technology, Karachi, Pakistan.*

Abstract

The present paper deals with the study of 44 species included in 15 genera of the tribe Anthemideae from Pakistan and Kashmir. Micromorphological characters of cypselas were found significant for taxonomic delimitation for most of the taxa both at the generic and specific levels.

Introduction

Tribe Anthemideae of the family Asteraceae is represented in Pakistan by 22 genera and 91 species (Ghafoor, 2002) distributed in 9 subtribes *viz*., Achilleinae, Anthemidinae, Artemisiinae, Chrysantheminae, Cancriniinae, Handeliinae, Leucantheminae, Matricariinae, and Tanacetinae (Bremer, 1994). In the family Asteraceae, micromorphological characters of cypsela have been proved very rewarding to delimit the various taxa (Dittrich, 1968; Merxmuller & Grau, 1977; Haque & Godward 1984; Mateu & Guemes, 1993; Abid & Qaiser, 2002; 2007a,b; 2008a,b; Zhu *et al*., 2006). Attention was also paid to the cypsela to some of the genera of the tribe Anthemideae (Kynclova, 1970; Lovell *et al.*, 1986; Swelankomo *et al.*, 2007; Abid & Qaiser, 2008c) but still there is no detail information about the cypsela morphology for entire tribe of Anthemideae. Studies on micromorphology of cypselas were carried out to provide the strength to the systematic position of taxa in the tribe Anthemideae from Pakistan.

Materials and Methods

Forty four taxa of the tribe Anthemideae assembled in 15 genera *viz.*, *Achillea, Ajania, Allardia, Anthemis, Chrysanthemum, Cotula, Leucanthemum, Matricaria, Microcephala, Richteria, Seriphidium, Tanacetopsis, Tanacetum ,Tripleurospermum* and *Xylanthemum* were studied for cypsela 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 cypselas 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: Cypsela: Shape, surface, colour, size. Pappus: Stucture, number, colour, size. Carpopodium: Shape, position, diameter of carpopodium and diameter of foramen of carpopodium were observed under scanning electron microscope.

Appendix-1. List of voucher specimens.

Taxa	Collector, Number and Herbarium
Achillea filipendulina	M. Qaiser & A. Ghafoor 1409 (KUH, RAW).
A. millefolium subsp. *millefolium*	S. Abedin & M. Qaiser 8927 (KUH); M. Qaiser & A. Ghafoor 5479 (KUH); S. Abedin & M. Qaiser 9206 (KUH); A. Ghafoor & Tahir Ali 4124 (KUH); S.M.H. Jafri 3383 (KUH).
A. setacea	M. Qaiser & A. Ghafoor 2030(KUH).
A. wilhelmsii	Tahir Ali & G. R. Sarwar 2601 (KUH); M. Qaiser & A. Ghafoor 1302 (KUH); M.A. Siddiqui 20586 (RAW); M. Qaiser & A. Ghafoor 1222 (KUH); A. Ghafoor & Steve M. Goodman 5077 (KUH).
Ajania fruticulosa	S.M.H. Jafri 696 (KUH); A. Ghafoor & S. Omer 2194.
Allardia glabra	R.R. Stewart 12604 (RAW); Shaukat Ali 170 (RAW).
A. nivea	R.R. Stewart 20635 (RAW).
A. stoliczkae	R.R. Stewart s.n. (RAW).
A. tomentosa	Sadaqat 89 (RAW); R.R. Stewart 20741 (RAW).
A. tridactylites	Wendelbo s.n. (RAW).
Anthemis arvensis	Hassan Din 121 (RAW).
A.cotula	A. Ghafoor & S. Omer 2976 (KUH); Rasool Baksh 73 (KUH); Tahir Ali & Gohar Khan 1A (KUH).
A. odontostephana	S. Abedin 4967 (KUH); Zaffar Ali 4820 (RAW).
A. rhodocentra	A. Ghafoor & Rizwan Yosuf 1405; Zaffar Ali 5702 (RAW).
Chrysanthemum coronarium	Khursheed Anwar s.n. (KUH).
Cotula anthemoides.	Razia Khan 10 (RAW); R.R.Stewart 15870 (RAW)
C. hemisphaerica	P.C. Joshi s.n. (RAW).
Leucanthemum vulgare	S. Abedin 7633 (KUH).
Matricaria aurea	A.A. Qureshi 52 (KUH); Shaukat Ali 26125 (RAW).
M. recutita	Y. Nasir 5055 (KUH); R.R. Stewart 7096 (RAW).
Microcephala lamellate	A. Ghafoor 1352 (KUH); S. Abedin 4794 (KUH); S. Omer & A. Ghafoor 1728 (KUH); A. Ghafoor & Steve M. Goodman 5230 (KUH)
Richteria pyrethroides	David Broadhead 7787 (KUH).
Seriphidium brevifolium	A. Rashid 377 (KUH); R.R. Stewart s.n. (RAW); R.R.Stewart 19283 (RAW)
S.freitagii	A. Ghafoor & S. Omer 1924 (KUH); A. Ghafoor & S. Omer 1974 (KUH);
S. glanduligerum	Vaid Parkash s.n. (RAW).
S. kurramense	S.M.H. Jafri s.n. (KUH); R.R. Stewart s.n. (RAW).
S. leucotrichum	Tahir Ali 2302 (KUH)
S.oliverianum	Mohinder Nath 2020 (RAW).
S. quettense	A. Ghafoor & S. Omer 2169, 2170 (KUH).
S. sieberi	M. Qaiser & A. Ghafoor 4336 (KUH); A. Ghafoor & S. Omer 1984 (KUH).
S. stenocephalum	Jafri 93 (RAW).
S. turanicum	S. Nizamuddin & S. Abedin 637 (KUH); A. Ghafoor & Steve M. Goodman 5235 (KUH); S. Omer & A. Ghafoor 1423 (KUH).
Tanacetopsis afghanica	Haji Rozi Mohammad 12 (RAW).
Tanacetum artemisioides	Kamal A. Malik & S. Nazimuddin 1863 (KUH).
T. baltistanicum	R.R. Stewart 26241, 26242 (RAW).
T. chitralense	A. Ghafoor & S. Omer 2712 (KUH); Hassan Din 83 (RAW); Hakim Khan s.n. (RAW).
T. cinerariifolium	Tahir Ali & Gohar Khan s.n. (KUH).
T. falconeri	S. Omer & M. Qaiser 2508 (KUH); R.R. Stewart 26373 (KUH).
T. griffithii	Grohmann 6244 (KUH); Kamal Malik & M. Qaiser 413 (KUH).
T. pakistanicum	Grohmann 6318 (KUH); Nasir & Siddiqui 2926 (KUH).
T. parthenium	Mohinder Nath 2344 (KUH).
Tripleurospermum disciforme	A. Ghafoor & S. Omer 2864 (KUH).
T. parviflorum	Hassan Din 15 (KUH); A. Rehman 25915 (RAW).
Xylanthemum macropodum	S. Omer & A. Ghafoor 1778 (KUH); M. Qaiser 2453; A. Ghafoor & Rizwan Yosuf 1468 (KUH).

Observations

General cypsela characters of Anthemideae

Cypselas homomorphic or heteromorphic, oblong, oblanceolate, oblong-oblanceolate, ellipsoid, obconic, obovoid or elliptic-oblong, 0.5-3.5 x 0.25-1 mm, colour varies from yellow to yellowish brown, dark brown, reddish brown or greyish brown; ribbed or non-ribbed, glabrous, glandular or papillate. Pappus absent or present, bristly or scaly, one sided auricle or forming a crown of minute teeth or lacerate scales, off white, golden brown or brown, 0.1-6 mm long. Carpopodium absent or present, sub basal, distorted, slightly angular, narrow circular or broad circular disc like, 125-545 µm in diameter. Foramen of carpopodium 84-412 µm in diameter (Table 1).

Key to the genera

1 + Cypselas with 2 reddish brown and abaxial resinous glands at the apices …….. …….. *Tripleurospermu*m
- Cypselas without such glands ……...… 2

2 + Cypselas epappose ..…….. 3
- Cypselas pappose ..……..…….. 9

3 + Cypselas homomorphic and wingless ...…… 4
- Cypselas heteromorphic and winged ……... 8

4 + Carpopodium distorted …….. *Leucanthemum*
- Carpopodium circular or not developed …...…… 5

5 + Cypselas 0.5–1.0 mm long ……... *Seriphidium*, *Matricaria*
- Cypselas 1.5–3.0 mm long .....…….. 6

6 + Carpopodium not developed ...……. *Anthemis*
- Carpopodium well developed ……... 7

7 + Cypselas obovoid-oblanceolate. Carpopodium broad circular disc like, 159 µm in diameter ……...…. *Ajania*
- Cypselas oblong or oblong-oblanceolate. Carpopodium narrow circular ring or 4-6 lobed ring, 200-246 µm in diameter ……..…… *Achillea*

8 + Cypselas slightly ribbed, 2.5-3.0 mm long ..…….… *Chrysanthemum*
- Cypselas non ribbed, 1-1.5 mm long ...……..…….. *Cotula*

9 + Pappus bristly …… *Allardia*
- Pappus scaly forming an auricle or short crown ……. 10

10 + Carpopodium not developed …… *Anthemis*
- Carpopodium well developed ……. 11

11 + Pappus of one sided auricle ……... *Xylanthemum*
- Pappus crowned by scarious, lacerate or minutely toothed scales ……..… 12

12 + Cypselas monomorphic, all pappose …….…….. 13
- Cypselas dimorphic, atleast of disc epappose ……... *Matricaria*

13 + Carpopodium distorted ……...…….. *Richteria*
- Carpopodium circular or angular …… 14

14 + Cypselas ventrally-3-5 ribbed ...……...……. *Microcephala*
- Cypselas entirely 5-8 ribbed ..……..…….. *Tanacetopsis, Tanacetum*

Achillea L.

It is represented by 4 species *i.e.*, *A. filipendulina* Lam., *A. millefolium* L., *A. setacea* Waldst. & Kit., and *A. wilhelmsii* C. Koch.

Cypselas oblong or oblong-oblanceolate, 1.5-2x0.75-1.0 mm, light brown or yellowish brown, non-ribbed or 8-12-ribbed, glabrous. Pappus absent. Carpopodium 4-6 lobed ring or narrow circular ring without any interruption, 200-246 µm in diameter. Foramen of carpopodium 122-198 µm in diameter (Table 1; Fig. 1A-F).

Key to the species of *Achillea*

1 + Cypselas non-ribbed. Carpopodium with 4-6 lobed ring ……..… *A. wiihelmsii*
- Cypselas ribbed. Carpopodium with circular ring …… 2

2 + Cypselas yellowish-brown, 10-12 ribbed …… *A. millefolium*
- Cypselas light brown, 8-10 ribbed ……... *A. filipendulina, A. setacea*

Ajania Poljakov

It is represented by single species *viz*., *A. fruticulosa* (Ledeb.) Poljakov

Cypselas obovoid-oblanceolate, 2x0.75 mm, brown, 10-12 ribbed, glabrous. Pappus absent. Carpopodium broad circular ring without any interruption, 159 µm in diameter. Foramen of carpopodium 88 µm in diameter (Table 1; Fig. 1G-I).

Allardia Decne.

It comprises 5 species *i.e.*, *A glabra* Decne., *A. nivea* Hook. f. & Thomson ex C.B. Clarke, *A. stoliczkae* C.B. Clarke, *A. tomentosa* Decne., and *A. tridactylites* (Kar.&Kir) Schultz- Bip.

Cypselas oblong, 2-2.5x0.5-1 mm, yellowish-dark brown, non ribbed or 6-8 ribbed, glabrous or papillate or glabrous-papillate. Pappus uniseriate, bristly, barbellate or scabrid, golden brown, bristles 22-60, 3-4 mm long. Carpopodium narrow or broad circular or angular without any interruption, 355-545 µm in diameter. Foramen of carpopodium 205 -412 µm in diameter (Table 1; Figs. 1J-O; 2A-I)

Fig. 1. Scanning Electron Micrographs. *Achillea millifolium*: A, cypsela; B, surface; C, carpopodium. *A. wilhelmsii*: D, cypsela; E, surface; F, carpopodium. *Ajania fruticulosa*: G, cypsela;. H, surface; I, carpopodium. *Allardia glabra*: J, cypsela; K, surface; L, carpopodium. *A. nivea*: M, cypsela; N, surface; O, carpopodium (undeveloped) (scale bar: A,D,G,J,M=200µm; B, C, E, F, H, I, K, L, N, O=50µm).

Fig. 2. Scanning Electron Micrographs. *Allardia stolickzkae*: A, cypsela; B, surface; C, carpopodium. *A. tomentosa*: D, cypsela; E, surface; F, carpopodium. *A. tridactylites*: G, cypsela;. H, surface; I, carpopodium. *Anthemis arvensis*: J, cypsela; K, surface; L, carpopodium (undeveloped). *A. cotula*: M, cypsela; N, surface ; O, carpopodium (undeveloped) (scale bar: A,D,G,J,M=200µm;B,E,K=20µm;C,H,I,O=50 µm ; F,N,L=100µm)

Key to the species of *Allardia*

1 + Cypselas non-ribbed …….. 2
- Cypselas 6-8 ribbed ……... 3

2 + Cypselas glabrous. Pappus bristles 4.mm long …… *A. glabra*
- Cypselas sparsely papillate. Pappus bristles 5-6 mm long …….. *A. tridactyliles*

3 + Cypselas papillate ……..… *A. nivea*
- Cypselas glabrous ……. 4

4 + Carpopodium broad circular disc like, 355µm in diameter …… *A. stoliczkae*
Carpopodium narrow angular ring like, 545µm in diameter ……. *A. tomentosa*

Anthemis L.

It is represented by 4 species *viz.*, *A. arvensis* L., *A. cotula* L., *A. odontostephana* Boiss., and *A. rhodocentra* Iranshahr.

Cypselas angular or non-angular, obconical or oblong-oblanceolate, 2-3x1 mm, 8-10 ribbed, glabrous, tuberculate or tuberculate-muricate. Pappus short, undulating or dentate rim. Carpopodium not developed (Table 1; Figs. 2J-O; 3A-F).

Key to the species of *Anthemis*

1 + Cypselas obconical, angular and yellowish brown …….. 2
- Cypselas oblong-oblanceolate, non-angular and greyish black ……...……. 3

2 + Cypselas glabrous. Pappus short, thickened, forming an undulating rim …….
…… *A. arvensis*
- Cypselas tuberculate. Pappus absent …… *A. cotula*

3 + Cypselas tuberculate-muricate. Pappus short, slightly dentate rim ……..…
…… *A. odontostephana*
- Cypselas glabrous. Pappus absent …….. *A. rhodocentra*

Chrysanthemum L.

It comprises single species *i.e.*, *C. coronarium* L.

Cypselas heteromorphic, oblanceolate; ray cypselas triquetrous, winged; disc cypselas laterally flattened, unwinged with small spine-like appendages at the rim, 2.5-3x1.5mm, reddish brown, slightly ribbed, glandular. Pappus absent. Carpopodium not developed (Table 1; Figs. 3G-I).

Cotula L.

It is represented by 2 species *i.e.*, *C. anthemoides* L., and *C. hemisphaerica* (Roxb.) Wall. ex Benth. & Hook. f.

Fig. 3. Scanning Electron Micrographs. *Anthemis odontostephana*: A, cypsela; B, surface; C, carpopodium (undeveloped). *A. rhodocentra*: D, cypsela; E, surface; F, carpopodium (undeveloped). *Chrysanthemum coronarium* (Disc floret): G, cypsela;. H, surface; I, carpopodium (undeveloped). *Cotula anthemoides*: J, cypsela; K, surface; L, carpopodium (undeveloped). *A. hemisphaerica*: M, cypsela; N, surface; O, carpopodium (undeveloped) (scale bar: A,J =200µm; B,C,F,H,I,L,M=100µm; D,G=500µm; E,K,N =50µm; O=10µm).

Fig. 4. Scanning Electron Micrographs. *Leucanthemum vulgare* (Disc floret): A, cypsela; B, surface ; C, carpopodium. *Matricaria aurea*: D, cypsela; E, surface; F, carpopodium. *M. recutita* (Ray floret): G, cypsela;. H, surface; I, carpopodium. *Microcephala lamellata*: J, cypsela; K, surface; L, carpopodium. *Richteria pyrethroides*: M, cypsela; N, surface; O, carpopodium (undeveloped) (scale bar: A,G,J=200µm; B=5µm; C,N,O=50µm; D=100µm; E,H=10µm; F,I,K,L= 20µm; M=500 µm).

Cypselas heteromorphic, ovate or oblong-ovate, winged or unwinged, 1-1.5x0.75-1mm, yellowish or reddish brown, non-ribbed, glabrous or sessile glandular. Pappus absent. Carpopodium not developed (Table 1; Fig. 3J-O).

Key to the species of *Cotula*

1 + Cypselas yellowish brown and monomorphic ……... *C. anthemoides*
- Cypselas reddish brown and dimorphic …….. *C. hemisphaerica*

Leucanthemum Miller

It comprises single species *viz*., *L. vulgare* Lam.

Cypselas heteromorphic, oblanceolate, 1.5x0.75 mm, dark brown, 8-10-ribbed, glabrous. Ray cypselas with one sided auricle, 0.3-0.5 mm, off white pappus; disc cypsela epappose. Carpopodium distorted, 275µm in diameter. Foramen of carpopodium 170 µm in diameter (Table 1; Fig. 4A-C).

Matricaria L.

It comprises 2 species *i.e*., *M. aurea* (Loefl.) Schultz-Bip., and *M. recutita* L.

Cypselas monomorphic or dimorphic, oblong, oblong-oblanceolate 1-2.5x0.25-1mm, yellowish brown or dark brown, 5-10- ribbed, glabrous or with sessile glands. Pappus absent or only ray cypselas with one sided auricle, offwhite, 0.3-0.5mm. Carpopodium narrow circular ring without any interruption, 145-338µm in diameter. Foramen of carpopodium 110-268µm in diameter (Table 1; Fig. 4D-I)

Key to the species of *Matricaria*

1 + Cypselas monomorphic, epappose. Carpopodium 145µm in diameter …… *M. aurea*
- Cypselas dimorphic outer ones with membranous auricled pappus; inner ones epappose. Carpopodium 348µm in diameter …… *M. recutita*

Microcephala Pobed.

It is represented by single species *viz*., *M. lamellata* (Bunge) Pobed.

Cypselas oblanceolate, 1.5x0.5, yellowish brown, ventrally 3.5-ribbed, dense mucilaginous hairs with myxogenic twin hairs. Pappus of lacerate scales, offwhite, 6-10 in number, 0.75mm long. Carpopodium broad circular ring without any interruption, 207µm in diameter. Foramen of carpopodium 116µm in diameter (Table 1; Fig. 4J-L).

Richteria Kar. & Kir.

It comprises single species *i.e.*, *R.* pyrethroides Kar. & Kir.

Cypselas oblong-oblanceolate, 2-2.5x0.75mm, dark brown, 6-8 ribbed, sparsely papillate. Pappus forming corona of dissected scales, off white, 6-9 in number, 0.75 mm long. Carpopodium distorted, 390µm in diameter. Foramen of carpopodium 310µm in diameter (Table 1; Fig. 4M-O).

Seriphidium (Besser ex Hook.) Fourr.

It is represented by 10 species *i.e., S. brevifolium* (Wall. ex DC.) Ling & Y.R. Ling, *S. freitagii* (Podl.) Y.R. Ling, *S. glanduligerum* (Krash. ex Poljakov) Poljakov, *S. Kurramense* (Qazilb.) Y.R. Ling, *S. leucotrichum* (H. Krasch ex. Ladyg.) K. Bremer & Humphries ex Y.R. Ling, *S. oliverianum* (J. Gray ex Besser) K. Bremer & Humphries ex Y.R. Ling, *S. quettense* (Podl.) Ling, *S. sieberi* (Besser) K. Bremer & Humphries ex Y.R. Ling, *S. stenocephalum* (Krasch. ex Poljakov) Poljakov and *S. turanicum* (Krasch.) Poljakov.

Cypselas oblong-oblanceolate, oblanceolate, ellipsoid or obovoid, 0.5-1.0x2.5-0.5mm, yellowish brown or dark brown, 6-16-ribbed, glabrous. Pappus absent. Carpopodium absent or narrow-broad circular ring without any interruption, 125-229µm in diameter (Table 1; Figs. 5A-O; 6A-F).

Key to the species of *Seriphidium*

1 + Carpopodium not developed ……. 2
- Carpopodium narrow circular or broad disc like …….. 4

2 + Cypselas ellipsoid ……. *S. brevifolium*
- Cypselas oblanceolate or oblong-oblanceolate ...…….. 3

3 + Cypselas oblong-oblanceolate, 0.5x0.25 mm ……..……..…… *S. freitagii*
- Cypselas oblanceolate, 10-12 ribbed, 1.0x0.5 mm ... *S. kurramense, S. leucotrichum*

4 + Cypselas obovoid. Carpopodium narrow circular ring ……... *S. stenocephalum*
- Cypselas ellipsoid or oblanceolate. Carpopodium broad circular disc …….… 5

5 + Cypselas ellipsoid ……... *S. turanicum*
- Cypselas oblanceolate ……... 6

6 + Cypselas dark brown …….……. *S. quettense, S. oliverianum*
- Cypselas yellowish brown ……...…….*S. sieberi*

Tanacetopsis (Tzvelev) Kovalevsk.

It comprises single species *i.e., T. afghanica* (Gilli) K. Bremer & Humphries.

Cypselas oblong, 2-2.5x0.25-0.5 mm, yellowish brown, 5-ribbed, sessile glandular. Pappus forming a crown of lacerate scale, off-white, 0.5mm long. Carpopodium broad circular disc like without any interruption, 150µm in diameter. Foramen of carpopodium 109 µm in diameter (Table 1; Fig. 6G-I).

Tanacetum L.

It is represented by 8 species *i.e., T. artemisioides* Schulz-Bip. ex Hook. f., *T. baltistanicum* Podlech, *T. chitralense* (Podl.) K. Bremer & Humphries, *T. cinerariifolium* (Trevir) Schultz-Bip., *T. falconeri* Hook. f., *T. griffithii* (C.B. Clarke) Muradyan, *T. pakistanicum* Podl. and *T. parthenium* (L.) Schultz-Bip.

Fig. 5. Scanning Electron Micrographs. *Seriphidium kurramense*: A, cypsela; B, surface; C, carpopodium (Undeveloped). *S. leucotrichum*: D, cypsela; E, surface; F, carpopodium (Undeveloped). *S. oliverianum*: G, cypsela;. H, surface; I, carpopodium. *S. quettense*: J, cypsela; K, surface; L, carpopodium. *S. sieberi*: M, cypsela; N, surface; O, carpopodium (scale bar: A,D,G,J,M=100µm B,E,F,H,L,N,O=20µm; C,K=10µm ;I=50µm).

Fig. 6. Scanning Electron Micrographs. *S. stenocephalum*: A, cypsela; B, surface; C, carpopodium . *S. turanicum*: D, cypsela; E, surface; F, carpopodium. *Tanacetopsis afghanica*: G, cypsela;. H, surface; I, carpopodium. *Tanacetum artemisioides*: J, cypsela; K, surface; L, carpopodium. *T. chitralense* : M, cypsela; N, surface ; O, carpopodium (scale bar: A,D=100µm G,J,M= 200µm ; E,F,H,I,K=20µm ; C,L,N,O= 50µm).

Cypselas oblong, oblanceolate or oblong-oblanceolate, 1.5-3.5x0.5-1mm, yellowish brown or greyish brown, 4-8-ribbed, glabrous, glandular or papillate. Pappus a crown of minute teeth or lacerate scale, off-white, 0.1-1mm long. Carpopodium slightly angular or broad circular without any interruption, 160-326µm in diameter. Foramen of carpopodium 104-240µm in diameter (Table 1; Figs. 6J-O; 7A-O).

Key to the species of *Tanacetum*

1 + Cypselas glabrous ……. 1
- Cypselas papillate or glandular ……. 4

2 + Carpopodium broad circular disc like ……... *T. cinerariifolium*
- Carpopodium slightly angular ring like ……..…… 3

3 + Cypselas oblanceolate. Carpopodium 240 µm in diameter …….. *T. baltistanicum*
- Cypselas oblong-oblanceolate. Carpopodium 160µm in diameter …….. ……... *T. artemesioides*

4 + Cypselas 4 ribbed …….……. *T. chitralense*
- Cypselas 5-8 ribbed ……...… 5

5 + Cypselas greyish-brown …… 6
- Cypselas yellowish brown …… 7

6 + Pappus with a crown of lacerate scales ……... *T. falconeri*
- Pappus with a minutely toothed corona ……... *T. parthenium*

7 + Cypselas 6-8 ribbed. Pappus 1.0 mm long …… *T. griffithii*
- Cypselas 5-ribbed. Pappus 0.2 mm long ..……. *T. pakistanicum*

Tripleurospermum Schiltz-Bip.

It is represented by two species *i.e.*, *T. disciforme* (C.A. Mey) Schultz-Bip., and *T. parviflorum* (Willd.) Pobed.

Cypselas oblong or oblong-oblanceolate, 1.5-2x0.5-1mm, yellow or reddish brown, apically with 2 reddish-brown glands, ventrally 3-ribbed, dorsally 2-ribbed, glabrous or tuberculate. Pappus absent or crowned with scarious scales, brown, 0.75mm. Carpopodium broad circular disc without any interruption, 183-192µm in diameter. Foramen of carpopodium 122-127µm in diameter (Table 1; Fig. 8A-F).

Key to the species of *Tripleurospermum*

1 + Cypselas yellow. Pappus absent ..…….……. *T. disciforme*
- Cypselas reddish-brown. Pappus with a crown of scarious scales ..... *T. parviflorum*

Xylanthemum Tzvelev

It is represented by a single species *i.e.*, *X. macropodum* (Hemsl. & Lace) K. Bremer & Humphries.

Fig. 7. Scanning Electron Micrographs. *Tanacetum cinerariifolium:* A, cypsela; B, surface; C, carpopodium. *T. falconeri*: D, cypsela; E, surface; F, carpopodium. *T. griffithii*: G, cypsela;. H, surface; I, carpopodium. *T. pakistanicum:* J, cypsela; K, surface; L, carpopodium. *T. parthenium*: M, cypsela; N, surface; O, carpopodium (scale bar: A,G=500 µm; D,J,M=200µm; B,E,O= 20µm; K=100µm; C,F,H,I,L,N=50µm).

Fig. 8. Scanning Electron Micrographs. *Tripleurospermum disciforme*: A, cypsela; B, surface; C, carpopodium. *T. parviflorum*: D, cypsela; E, surface; F, carpopodium. *Xylanthemum macropodum*: G, cypsela;. H, surface; I, carpopodium. (scale bar: A,D,G=200µm ; B,C,F,H= 20µm; E,I=50µm).

Cypselas elliptic-oblong, 1.5-2.5x0.75-1mm, yellow, 5-6-ribbed, glabrous. Pappus forming one sided entire auricle, off white, 1mm long. Carpopopdium broad circular disc like without any interruption, 380µm in diameter. Foramen of capopodium 290µm in diameter (Table 1; Fig. 8G-I).

Results and Discussion

The tribes Inuleae, Heliantheae and Eupatoreae of the family Asteraceae are characterized due to their cypsela features (Bremer, 1994; Qaiser & Abid, 2003). However, similar to those of tribes Plucheeae and Gnaphalieae (Abid & Qaiser, 2007b, 2008b) Anthemideae does not have characteristic cypsela. Although on the basis of cypsela morphology 44 species distributed in 15 genera of the tribe Anthemideae could be recognized from Pakistan (Table 1; Figs. 1-8).

All the genera of the Anthemideae can be divided into two main groups on the basis of pappose or epappose cypsela except that of the three genera *viz.*, *Anthemis*, *Matricaria* and *Tripleurospermum* where both the pappose and epappose cypselas are found so these genera are discussed in both the groups. Besides this, *Tripleurospermum* is the only genus which has two abaxial resinous glands towards the cypsela apices (Ghafoor, 2002).

Group of epappose cypselas includes *Achillea, Ajania, Anthemis* (p.p.), *Chrysanthemum, Cotula, Leucanthemum, Matricaria* (p.p.), *Seriphidium* and *Tripleurospermum* (p.p.). From these *Chrysanthemum, Cotula* and *Leucanthemum* are grouped together due to the winged and heteromorphic cypsela and *Leucanthemum* further remains distinct by the presence of distorted carpopodium. While in *Chrysanthemum* and *Cotula,* carpopodium does not develop and both the genera could be separated with each other by having ribbed or non-ribbed cypselas respectively. Another sub-group of eppapose genera including *Achillea, Ajania, Matricaria, Seriphidium* and *Tripleurospermum,* is characterized by homomorphic and unwinged cypselas. Within this *Seriphidium* is distinguished due to smaller cypselas. *Ajania* remains distinct from *Achillea* and *Matricaria* by the presence of broad circular disc like carpopodium while in the above two genera carpopodium is narrow circular or 4-6-lobed ring like but still these two genera are distinguished by having smaller cypselas in *Matricaria* as compared to *Achillea*. Similarly, the genus *Anthemis* is characterized by the absence of carpopodium and long sized cypselas. The second group of genera with pappose cypselas comprises *Allardia, Anthemis* (p.p.), *Matricaria* (p.p.), *Microcephala, Richteria, Tanacetum, Tanacetopsis, Tripleurosspermum* (p.p.) and *Xylanthemum*. Amongst these genera *Allardia* is characterized by bristly pappus while in rest of the genera scaly pappus forming an auricle or short crown. Similarly, *Xylanthemum* is distinguished by the presence of one-sided auricled pappus and in other genera pappus is coronate. On the other hand *Matricaria* species have dimorphic cypsela with atleast epappose disc cypselas while in remaining genera cypselas are monomorphic. *Anthemis* remains distinct due to the absence of carpopodium. Like wise, *Richteria* is characterized by the presence of distorted carpopodioum but the other genera are characterized by circular or angular carpopodium. Amongst the remaining three genera, *Microcephala* is characterized by the presence of 3-5 ribs on only ventral side while in *Tanacetum* and *Tanacetopsis,* ribs are all sided and both of the genera could not be separated from each other due to indistinct cypsela.

Similar to that of generic delimitation, cypsela features may also be utilized for specific delimitation as the species of *Achillea* are grouped on the basis of ribbed and non-ribbed cypselas. *A. millefolium* is characterized by yellowish-brown and 10-12 ribbed cypselas while light brown and 8-10 ribbed cypselas are found in *A. filipendulina* and *A. setacea*. While non-ribbed cypselas are characterstic for *A. wilhelmsii*. Similarly, in the genus *Allardia* species may also be separated on the basis of ribbed or non-ribbed cypselas. Within the group of non-ribbed cypselas *A. glabra* and *A. tridactylites* are distinguished respectively by having glabrous and papillate cypselas. On the other hand group of ribbed cypselas is further divided by having papillate cypselas in *A. nivea* and glabrous cypselas in *A. stoliczkae* and *A. tomentosa* but both the species remain distinct due to the different shapes and diameter of carpopodium. Species of another genus *Anthemis* may also be divided into two groups by having greyish black and terete cypselas. While another group is characterized by angular and yellowish brown cypselas. The first group including *A. odontostephana* and *A. rhodocentra*, and both the species remain distinct by the presence of tuberculate and pappose cypselas and glabrous cypselas without pappus respectively. Similarly the species of *Cotula* are distinguished due to the colour of cypsela. Likewise, the species of the genera *Matricaria* and T*ripleurospermum* could be separated by the presence or absence of pappus. Within the genus *Seriphidium* all the species are grouped by the presence or absence of carpopodium taxa where carpopodium is absent including *S. brevifolium, S. glanduligerum, S. freitagii,*

S. kurramense and *S. leucotrichum* from which two of the first species are grouped by the presence of ellipsoid cypselas while in remaining species cypselas are oblanceolate or oblong-oblanceolate from this *S. freitagii* remains distinct by oblong-oblanceolate and 0.5mm long cypselas. Rest of the two species *S. kurramense* and *S. leucotrichum* are grouped due to the presence of oblanceolate and 1 mm long cypsela. The species of second group with well developed carpopodium may be further distinguished by having obovoid cypsela in *S. stenocephalum*, ellipsoid cypsela in *S. turanicum* and oblanceolate cypselas are present in *S. sieberi*, *S. quettense* and *S. oliverianum*. These species could be further separated by having yellowish brown cypsela in *S. sieberi* and in remaining two species cypselas are dark brown but these two species could not be separated due to similar cypsela features. For the specific delimitation of the genus *Tanacetum* surface pattern of cypsela was found very useful as all the species are separated into two main groups *i.e*., cypselas glabrous or with papillate or glandular surface. Group of glabrous cypselas including *T. cinerariifolium*, *T. baltistanicum* and *T. artemisioides*, amongst them *T. cinerariifolium* remains distinct by having broad circular disc like carpopodium while in remaining two species carpopodium is slightly angular but both the species are separated by having oblanceolate or oblong-oblanceolate cypselas respectively. *T. chitralense* is separated by having 4-ribbed cypselas while in remaining species of this group cypselas are 5-8 ribbed. From these two species *viz.*, *T. falconeri* and *T. parthenium* are separated from the remaining species by having greyish-brown cypselas, furthermore both the species remain distinct due to the difference in pappus structure. In rest of the two species *viz. T. grifftihii* and *T. pakistanicum* cypselas are yellowish brown but both the species could be further separated from each other by having 6-8 ribbed and 5-ribbed cypselas, respectively.

Acknowledgement

We are grateful to the Director, Karachi University Herbarium, University of Karachi for providing the facilities of Scanning Electron Microscopy.

References

Abid, R.D. and M. Qaiser. 2002. Cypsela morphology of *Inula* L. (s.str.) and its allied genera (Inuleae-Compositae) from Pakistan and Kashmir. *Pak. J. Bot*., 34(3): 207-223.

Abid, R. and M. Qaiser. 2007a. Micromorphology of cypsela in the tribe Plucheeae from Pakistan. *Pak. J. Bot*., 39(3): 671-677.

Abid, R. and M. Qaiser. 2007b. Cypsela morphology of the genus *Anaphalis* DC. (Gnaphalieae-Asteraceae) from Pakistan. *Pak. J. Bot*., 39(6): 1897-1906.

Abid, R. and M. Qaiser 2008a. Cypsela morphology of G*naphalium* L. and its allied genera (Gnaphalieae-Asteraceae) from Pakistan. *Pak. J. Bot*., 40(1): 25-32.

Abid, R. and M. Qaiser .2008b. Cypsela morphology of some genera in the tribe Gnaphalieae(Asteraceae) from Pakistan. *Pak. J. Bot*., 40(2): 473-485.

Abid, R. and M. Qaiser .2008c. Cypsela morphology and its taxonomic significance of the genus *Artemisia* L. tribe (Anthemideae-Asteraceae) from Pakistan. *Pak. J. Bot*., 40(5): 1827-1837.

Bremer, K. 1994. *Asteraceae Cladistics & Classification*, p.321. Timber Press, Portland, Oregon.

Dittrich, M. 1968. Morphologische Utersuchungen an den Fruchten fer subtribus Cardueae-Centaureinae (Compositae). *Willdenowia*, 5: 67-107.

Ghafoor, A. 2002. *Flora of Pakistan. Asteraceae (I) Anthemideae*. No. 207. (Eds.): S.I. Ali and M. Qaiser. Dept. Bot. Univ. Karachi and Missouri Press. Missouri Botanical Garden, U.S.A.

Haque, M.Z. and M.B.E. Godward. 1984. New records of the carpopodium in Compositae and its taxonomic use. *Bot. J. Linn. Soc*., 89: 321-340.

Kynclova, M. 1970. Comparative morphology of achenes of the tribe *Anthemideae* Cass. (Asteraceae) and its taxonomic significance. *Preslia (Praha)*, 42: 33-53.

Lovell, P.H., C.D. Maxwell and N. Jacob. 1986. Varieties in cypsela morphology in *Soliva valdiviana* and *S. pterosperma* (Anthemideae, Asteraceae) in a local population at Auckland, Newzealand. *Newzealand J. Bot*., 24: 657-664.

Mateu, I. and J. Guemes. 1993. Estudio carpologico del genero *Launaea* Cass. (Asteraceae) en europa. *Bot. Soc. Brot. Ser*., 2(66): 85-95.

Merxmuller, H. and J. Grau. 1977. Fruchtanatomische Untersuchungen in der Inula-Gruppe (Asteraceae). *Publ. Cairo Univ*., 7-8: 9-20.

Qaiser, M. and R. Abid. 2003. *Flora of Pakistan. Asteraceae (II) Inuleae, Plucheeae & Gnaphalieae*. No. 210. (Eds.): S.I. Ali and M. Qaiser. Dept. Bot. Univ. Karachi and Missouri Press. Missouri Botanical Garden, U.S.A.

Swelankomo, N., L. Mucina and P.P.J. Herman. 2007. Phenetic classification of cypselas in *Ursinia* (Anthemideae, Asteraceae). *S. Afr. J. Bot*., 73(2): 316.

Zhu, SX., HN. Qin and C. Shih. 2006. Achene wall anatomy and surface sculpturing of *Lactuca* L. and related genera (Compositae: Lactuceae) with notes on their systematic significance. *J. Integ. Pl. Bio*., 48(4): 390-399.

(Received for publication 5 January 2009)