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MICROMORPHOLOGY OF CYPSELA AND ITS TAXONOMIC SIGNIFICANCE OF SOME GENERA IN THE TRIBE INULEAE (ASTERACEAE) FROM PAKISTAN

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Abstract

Cypsela morphology of 10 taxa belonging to the tribe Inuleae of the family Asteraceae was examined using light and scanning electron microscopy. The taxa included representatives of the genera *Pegolettia* Cass., *Varthemia* DC., *Asteriscus* Torn.ex Mill., *Carpesium* L., and *Blumea* DC. Cypsela micromorphological characters are found taxonomically significant both at generic and specific levels.

Introduction

Tribe Inuleae of the family Asteraceae is represented in Pakistan by 11 genera 49 species (Qaiser & Abid, 2003). Micromorphological characters of cypsela in the family Asteraceae have been studied by a number of workers (Dittrich, 1968; Kynclova, 1970; Merxmuller & Grau, 1977; Haque & Godward, 1984; Mateu & Guemes, 1993; Abid & Qaiser, 2002; Ritter & Miotlo, 2006; Zhu *et al*., 2006; Abid & Qaiser, 2007a; Abid & Qaiser, 2007b). To date considerable attention has been given to the cypselas of the tribes Plucheeae (Abid & Qaiser, 2007a), Anthemideae (Kynclova, 1970) and Lactuceae (Naga & Amina, 1977) but in the tribe Inuleae only *Inula* L. (s.l.) (Abid & Qaiser, 2002) and *Pulicaria* Gaertn., were examined (Abid & Qaiser, 2007b). Present paper is the continuity of cypsela morphological studies of the tribe Inuleae where 5 genera viz., *Pegolettia* Cass., *Varthemia* DC., *Asteriscus* Tourn. ex Mill., *Carpesium* L., and *Blumea* DC., are examined for their cypsela characters to strengthen the systematic position of the taxa from Pakistan.

Materials and Methods

Mature cypselas of 10 taxa belonging to *Pegolettia*, *Varthemia*, *Asteriscus*, *Carpesium* and *Blumea* were examined from the herbarium specimens (Appendix-I). Following characters were studied under stereo (Nikon XN Model), compound (Nikon Type 102) and scanning electron microscopes (JSM-6380A).

Cypsela: Shape, colour, size, surface (hairs) and number of ribs.
Pappus: Series, structure, number, length and colour.
Carpopodium: Shape, position, diameter of carpopodium and diameter of foramen of carpopodium.

For scanning electron microscopy dry 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 examined under SEM.

Appendix-I. List of the voucher specimens.

Name of Taxa	Collectors, Number and Herbarium
Asteriscus hierochunticus	A. Ghafoor & Steve M. Goodman, 5028 (KUH).
Blumea axillaris	Hassanuddin 55 (RAW); R.R. Stewart 7095 (RAW); Tahir Ali, M. Qaiser & Ajmal Khan 195 (KUH); Zeenat A. Razzak & Momin A. Razzak 5 (KUH).
B. lacera	S. Abedin & Abrar Hussain 9500 (KUH); R.R. & I.D. Stewart 835 (RAW); E. Nasir & M.A Siddiqi s.n. (RAW).
B. memberanacea	R.R. Stewart 14120 (KUH); R.R. Stewart 27292 (RAW); Prem Singh 40 (KUH).
B. obliqua	S.M.H. Jafri s.n. (KUH); S. Abedin & Abrar Hussain 9511 (KUH); S.R. Baquar s.n. (KUH); S. Abedin 4153 (KUH); S.I. Ali, S.A Farooqi & S. Abedin 4504 (KUH).
Carpesium abrotanoides	A. Ghafoor & T. Ali 3989 (KUH); S.A. Farooqi & M. Qaiser 3080 (KUH); Sadruddin s.n. (KUH); S. Abedin & M. Qaiser 9214 (KUH).
C. nepalense var. *nepalense*	M. Qaiser & A. Ghafoor 6699 (KUH); M. Qaiser & A. Ghafoor 4766 (KUH); Tahir Ali & S. Nadeem Ahsan 1933 (KUH).
C. nepalense var. *glandulosa*	R.R. & I.D. Stewart s.n. (KUH).
Pegolettia senegalensis	Surayya Khatoon 150 (KUH); G.R. Sarwar, M. Qaiser & Jan Alam 1047 (KUH); Abrar Hussain s.n. (KUH); Faheem uddin s.n. (KUH); S.I. Ali 1599 (KUH).
Varthemia persica	Rasool Baksh 8 (KUH); A. Ghafoor & S. Omer 2121 (KUH); Mohinder Nath 2360 (RAW); M. Hanif s.n. (RAW).

Observations

General characters of Inuleae: Cypsela oblong, linear-oblong, ellipsoid or oblanceolate, angular or non angular, 0.5-4.5 x 0.25-1.5mm, brown or yellowish brown in colour, ribbed or non-ribbed, glandular, pubescent, villous or hirsute. Pappus uniseriate monomorphic, either bristly or scaly or biseriate, dimorphic outer paleaceous and inner ones bristly, scales 4-10 and bristles 7-20. Colour of pappus varies from white-pale white, golden, yellowish brown or brown. Carpopodium circular or U-V- shaped or incompletely developed into segments, subbasal in position, 86-255µm in diameter. Foramen of carpopodium 46-132µm in diameter.

***Pegolettia** Cass.*

It is represented by a single species viz., *P. senegalensis* Cass.

Cypsela oblanceolate, non-angular, 4.0-4.5 x 1.0-1.5 mm, brown, 10-12- ribbed, pubescent. Pappus biseriate, outer ones paleaceous, brown, 4-5 in number, 2mm long; inner ones bristly, plumose, golden, 17-20 in number, 6mm long. Carpopodium U-V-shaped, subbasal in position, 255µm in diameter. Foramen of carpopodium 126 µm in diameter (Table 1; Fig. 1A, B).

Table 1. ***Cypsela characters*** **in the tribe Inuleae**

Name of taxa	Cypsela				
	Shape	**Surface (hairs)**	**No. of ribs**	**Colour**	**Size (mm)**
Asteriscus hierochunticus	Oblanceolate, slightly angular	Villous	0	Yellowish brown	1.0-1.5 x 0.5-1.0
Blumea axillaris	Oblong, non angular	Sparsely pubescent	0	Brown	0.5 x 0.25
B. lacera	Oblong, non angular	Sparsely pubescent	6-8	Brown	1.5 x 0.25
B. memberanacea	Ellipsoid, slightly angular	Sparsely pubescent	6-8	Brown	1.0 x 0.25
B. obliqua	Ellipsoid, non angular	Sparsely pubescent	6-8	Brown	1.0 x 0.5
Carpesium abrotanoides	Linear-oblong, shortly beaked, non-angular	Glandular towards the beak and base	10-12	Brown	3.5 x 0.5
C. nepalense var. *nepalense*	Linear-oblong, shortly beaked, non angular	Glandular towards the beak and base	8-10	Brown	4- 5x 0.75
C. nepalense var. *glandulosa*	Linear-oblong, shortly beaked, non-angular	Glandular towards the beak and base	8-10	Brown	4-5 x 0.75
Pegolettia senegalensis	Oblanceolate, non angular	Pubescent	10-12	Brown	4.0 x 1.0
Varthemia persica	Oblong, non angular	Hirsute	10-12	Yellowish brown	2.0 x 0.5

Table 1. (Cont'd.).

Name of taxa	Pappus						
	Scales			Bristles			
	Number	Length (mm)	Colour	Structure	Number	Length (mm)	Colour
Asteriscus hierochunticus	8-10	1.5-2.0	Yellowish brown	-	-	-	-
Blumea axillaris	-	-	-	Barbellate	7-8	3-4	White
B. lacera	-	-	-	Barbellate	12.14	3-4	White
B. memberanacea	-	-	-	Barbellate	10.12	3-4	Pale-white
B. obliqua	-	-	-	Barbellate	10	3-4	Pale-white
Carpesium abrotanoides	-	-	-	-	-	-	-
C. nepalense var. *nepalense*	-	-	-	-	-	-	-
C. nepalense var. *glandulosa*	-	-	-	-	-	-	-
Pegolettia senegalensis	4-5	2.0	Brown	Plumose	17-20	6.0	Golden
Varthemia persica	-	-	-	Barbellate apically plumose	14-15	3-4	Yellowish brown

Table 1. (Cont'd.).

Name of taxa	Carpopodium			
	Shape	Position	Diameter of carpopodium (µm)	Diameter of foramen of carpopodium (µm)
Asteriscus hierochunticus	-	-	-	-
Blumea axillaris	Broad circular disc without any interruption	Sub-basal	86	46
B. lacera	Broad circular disc without any interruption	Sub-basal	132	56
B. memberanacea	Broad circular disc without any interruption	Sub-basal	150	59
B. obliqua	Broad circular disc without any interruption	Sub-basal	106	45
Carpesium abrotanoides	Circular ring without any interruption	Sub-basal	117	98
C. nepalense var. *nepalense*	Incompletely develop into segments	Sub-basal	180	116 – 120
C. nepalense var. *glandulosa*	Incompletely develop into segments	Sub-basal	180	116
Pegolettia senegalensis	U-V- shaped	Sub-basal	255	126
Varthemia persica	Broad circular disc without any interruption	Sub-basal	211	132

Key to the genera

1 + Pappus biseriate and dimorphic. Carpopodium U-V-shaped ……. P*egolettia*
- Pappus uniseriate and monomorphic or epappose. Carpopodium circular or segmented or undeveloped …… 2

2 + Cypsela beaked and epappose ……... *Carpesium*
- Cypsela non-beaked and pappose ……. 3

3 + Pappus scaly. Carpopodium undeveloped …….. *Asteriscus*
- Pappus bristly. Carpopodium circular ……... 4

4+ Pappus bristles plumose apically and barbellate at the base. Carpopodium > 200µm in diameter …….. *Varthemia*
- Pappus bristles barbellate throughout. Carpopodium upto 150µm in diameter ……. *Blumea*

Varthemia DC**.**

It is represented by single species i.e., *V. persica* DC.

Cypsela oblong, non-angular, 2.0 x 0.5 mm, yellowish brown, 10-12- ribbed, hirsute. Pappus uniseriate, bristles barbellate, apically plumose, yellowish brown, 14-15 in number, 3-4mm long. Carpopodium broad circular disc without any interruption, subbasal in position, 211µm in diameter. Foramen of carpopodium 132µm in diameter (Table 1; Fig. 1C, D).

Asteriscus Tourn. ex Mill.

It is represented by single species i.e., *A. hierochunticus* (Michon) Wikl.

Cypsela oblanceolate, slightly angular, 1.0-1.5 x 0.5-1.0 mm, yellowish brown, ribs inconspicuous, villous. Pappus uniseriate scaly, yellowish brown, 8-10 in number, 1.5-2.0 mm long. Carpopodium not developed (Table 1; Fig. 2A-D).

Carpesium L.

It is represented by 3 specific and infra- specific taxa viz., *C. abrotanoides* L., *C. nepalense* Less. var. *nepalense* and *C. nepalense* Less. var. *glandulosa* (Hook.f. & Thomson ex C.B. Clarke) Qaiser & R. Abid

Cypsela linear- oblong, non angular, 3.0-5.0 x 0.5-0.75 mm, brown, 8-12- ribbed, glabrous, but glandular at the base and beak, shortly beaked, surmounted by a short corona, epappose. Carpopodium circular ring without any interruption or incompletely developed into small segments, subbasal in position, 117-180µm in diameter. Foramen of carpopodium 98.0-120 µm in diameter (Table 1; Fig.2E-H)

Key to the species of *Carpesium*

1 + Carpopodium circular ring without any interruption, 117µm in diameter. Foramen of carpopodium 98.0µm in diameter ……..…… *C. abrotanoides*
- Carpopodium segmented, 180µm in diameter. Foramen of carpopodium 116-120µm in diameter …….. *C. nepalense*

Fig. 1. Scanning electron micrographs. *Pegolettia senegalensis*: A, cypsela; B, carpopodium. *Varthemia persica*: C, cypsela; D, carpopodium. *Blumea obliqua*: E, cypsela; F, carpopodium. *B. axillaris*: G, cypsela; H, carpopodium. *B. lacera*: I, cypsela; J, carpopodium. *B. memberanacea*: K, cypsela; L, carpopodium (Scale bar = A: 1mm; B: 50µm; C: 500µm; E, G, I, K: 100µm; D, F, J, L: 20µm; H: 10µm).

Blumea DC**.**

It is represented by 4 species viz., *B. obliqua* (L.) Druce, *B. axillaris* (Lam.) DC., *B. lacera* (Burm.f.) DC., and *B. memberanacea* DC.

Cypsela oblong or ellipsoid, slightly angular or non angular, 0.5-1.5 x 0.25-0.5 mm, dark-brown, ribbed or non-ribbed, sparsely pubescent. Pappus uniseriate, bristles 7-14, barbellate, white-palewhite, 3-4mm long, deciduous or persistent. Carpopodium broad circular disc without any interruption, subbasal in position, 86.0-150.0µm in diameter. Foramen of carpopodium 45.0-59.0µm in diameter (Table 1; Fig. 1E-L).

Fig. 2. Scanning electron micrographs. *Asteriscus hierochunticus*: A, cypsela of female floret; B, undeveloped carpopodium; C, cypsela of bisexual floret; D, undeveloped carpopodium. *Carpesium abrotanoides*: E, cypsela; F, carpopodium. *C. nepalense* var. *nepalense*: G, cypsela; H, carpopodium (Scale bar = A: 200µm; B, D = 20µm; C, E, G: 500µm; F, H: 50µm).

Key to the species of *Blumea*

1 + Cypsela slightly angular. Pappus persistent ……... *B. memberanacea*
- Cypsela non angular. Pappus deciduous ……... 2

2 + Cypsela 0.5 mm long, non-ribbed ……. *B. axillaris*
- Cypsela 1.0-1.5 mm long, 6-8 ribbed ……... 3

3 + Cypsela ellipsoid. Pappus pale white. Carpopodium 106µm in diameter ……..….. ……. *B. obliqua*
- Cypsela oblong. Pappus white. Carpopodium 132 µm in diameter …… *B. lacera*

Results and Discussion

Cypselas in the tribe Inuleae are usually characterized due to the presence of calcium oxalate crystals in the epidermis (Merxmuller & Grau, 1977; Anderberg, 1991; Breitwiesser & Ward, 2005). Besides, at the tribal level cypsela characters have also been found useful at infratribal level (Abid & Qaiser, 2002; Abid & Qaiser, 2007b). Similarly, cypsela features are also useful to delimit the 5 genera and 9 specific taxa of the tribe Inuleae from Pakistan (Table 1) where the genus *Carpesium* L., is characterized by the presence of beaked and epappose cypselas while in rest of the genera cypselas are non beaked and with distinct pappus. In the genus *Pegolettia* Cass., pappus are biseriate, the outer ones are paleaceous and inner ones are bristly that makes it distinct from the rest of the genera. Similarly, *Asteriscus* Tourn. ex Mill., is distinct due to the presence of scaly pappus and undeveloped carpopodium. It is also noteworthy that previously in this taxon dimorphic cypselas i.e., marginal ones triquetrous and inner ones terete were reported (Qaiser & Abid, 2003) and presently no difference is found in cypsela morphology as all of the cypselas are slightly angular irrespective of marginal or central ones. The genera *Varthemia* DC., and *Blumea* DC., are distinguished from each other by having barbellate bristles in *Blumea* and in *Varthemia* bristles are also barbellate but apically plumose. However, the importance of cypsela characters at infrageneric level is also evident in *Blumea* and *Carpesium*, where *Blumea axillaris* is distinguished from the rest of the species due to non-ribbed cypselas. Furthermore, *B. memberanacea* is separated from the other species by having slightly angular cypselas and persistent pappus while in *B. obliqua* and *B. lacera* cypselas are terete with deciduous pappus and both the species can also be delimited by the presence of ellipsoid cypselas with pale white pappus in *B. obliqua* and *B. lacera* is characterized due to oblong cypsela and white pappus. Similarly *Carpesium abrotanoides* is distinguished from *C. napelense* due to the circular carpopodium while *C. nepalense* has incompletely developed and segmented carpopodium. However, the two varieties of *C. nepalense* could not be clearly separated from each other due to similar cypsela characters. Therefore, the cypsela micromorphological characters in the tribe Inuleae are quite stable and can be used to delimit the taxa both at generic and specific levels.

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