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CYPSELA MORPHOLOGY AND ITS TAXONOMIC SIGNIFICANCE OF THE GENUS *ARTEMISIA* L. (ANTHEMIDEAE-ASTERACEAE) FROM PAKISTAN

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Abstract

Twenty four species of the genus *Artemisia* L., were examined from Pakistan for their cypsela features. Micromorphological characters of cypsela including position of corolla scar on cypsela, shape, surface, colour and carpopodium have been found very useful to evaluate the taxonomic significance for the specific delimitation in the genus *Artemisia*.

Introduction

The genus *Artemisia* L., belongs to the tribe Anthemideae of the family Asteraceae and 25 species are recognized from Pakistan (Ghafoor, 2002). There is a large variety of cypsela features in the family Asteraceae which has been used as a taxonomic tool for the delimitation of various taxa (Abid & Qaiser, 2002; 2007a,b; 2008a,b). Within the tribe Anthemideae various workers gave the attention to the cypsela features (Kynclova, 1970; Lovell *et al.*, 1986; Swelankomo *et al*., 2007) but the genus *Artemisia* has not received due attention for its cypsela morphology. In the present work cypsela features of the genus *Artemisia* were studied to evaluate their taxonomic significance.

Materials and Methods

Cypselas of 24 species of the genus *Artemisia* L., were collected from the herbarium specimens (Appendix 1) and examined for their cypsela features under stereomicroscope (Nikon XN Model) 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 under light microscopy:

Cypsela: Shape, surface, colour, size
Carpopodium: Shape, position, diameter of carpopodium and diameter of foramen of carpopodium were observed under scanning electron microscope.

Observations

General cypsela characters of *Artemisia*

Cypselas with terminal or oblique corolla scar, ovate, obovate, ellipsoid, oblong, oblanceolate, oblong-elliptic or linear-oblong, terete, 0.5-1.5 x 0.25-0.75mm, colour

varies from yellowish brown to dark brown or blackish brown, finely or deeply striate, glabrous. Pappus absent. Carpopodium undeveloped or fully developed, narrow circular ring like, broad circular disc or broad angular disc-like, without any interruption, subbasal in position, 79-203µm in diameter. Foramen of carpopodium 50-120µm in diameter (Table 1; Figs. 1-4).

Appendix 1. List of voucher specimens.

Taxa	Collector, number and herbarium
Artemisia absinthium	*R.R. Stewart* 28031 (RAW); *R.R. Stewart* s.n. (RAW); *R.R. Stewart* 14050 (RAW).
A. amygdalina	*R.R. Stewart* 141 (RAW); *R.R. Stewart* & *E. Nasir* 24086 (RAW).
A. annua	*R.R. Stewart* s.n. (RAW).
A. biennis	*Surayya Khatoon et al*., 484 (KUH); *A. Ghafoor* & *S. Omer* 2140 (KUH); *S.A. Farooqui* & *M. Qaiser* 3484 (KUH); *Tahir Ali* 4045 (KUH); *R.R. Stewart* 24335 (RAW).
A. capillaris	*A. Ghafoor* 964 (KUH); *M. Qaiser* & *A. Ghafoor* 4658 (KUH); *M.A. Siddiqui* 136 (RAW)
A. desertorum	*F. Schmid* 2221 (RAW)
A. dracunculus	*Nazimuddin* 1760 (KUH); *J.F. Duthie* s.n. (RAW); *J.D. A.Stainton* 2890 (RAW).
A. dubia	*A.H. Khan* 192 (RAW); *A. Rashid Khan* s.n. (RAW).
A. elegantissima	*M. Qaiser* & *Rizwan Yusuf* 7608 (KUH).
A. gmelini	*R.R. Stewart* 3356 (KUH); *G. Hussain Dar* 3903 (KUH); *R.R. Stewart* 24228 (RAW).
A. incisa	*M. Qaiser* & *A. Ghafoor* 4743 (KUH); *R.R. Stewart* 23257 (RAW); *A.R. Baig* 1327 (RAW).
A. japonica	*S. Omer* & *M. Qaiser* 2737 (KUH); *Tahir Ali et al*., 535 (KUH); *S. Abedin* & *M. Qaiser* 8886 (KUH).
A. laciniata	*F. Schmid* s.n. (RAW)
A. macrocephala	*Walter Koelz* 2196 (RAW).
A. moorcroftiana	*R.R. Stewart* s.n. (RAW); *R.R. Stewart* s.n. (RAW).
A. persica	*A. Ghafoor* & *S. Omer* 2571 (KUH); *Kamal A. Malik* & *Nazimuddin* 1705 (KUH); *Hassan Din* 111 (RAW).
A. roxburghiana	*G.D. Samson* 15335 (RAW); *R.R. Stewart* 10426 (RAW)
A. rutifolia	*A. Ghafoor* & *S. Omer* 3114 (KUH); *Kamal A. Malik* & *M. Qaiser* 564 (KUH); *R.R. Stewart* 20624 (RAW).
A. salsoloides	*Webster* & *E. Nasir* 6516 (RAW).
A. santolinifolia	*S. Omer* & *M. Qaiser* 2490 (KUH); *A. Ghafoor* 6863 (KUH); *Hans Hartman* 1308 (RAW).
A. scoparia	*S.M.A. Kazmi* s.n. (KUH); *S. Abedin* 8357 (KUH); *A. Ghafoor* & *S. Omer* 2071 (KUH); *A. Ghafoor* & *S. Omer* 2244 (KUH).
A. sieversiana	*A. Ghafoor* & *S. Omer* 3111 (KUH); *S. Abedin* & *M. Qaiser* 9141 (KUH); *E. Nasir* & *Webster* 5874 (RAW).
A. stricta	*R.R. Stewart* s.n. (RAW); *R.R. Stewart* 20795 (RAW).
A. vulgaris	*S.A. Farooqui* & *M. Qaiser* 3040 (KUH); *M. Qaiser* & *A. Ghafoor* 4950 (KUH); *A. Ghafoor* 943 (KUH).

Fig. 1. Scanning Electron Micrographs. *Artemisia annua*:: A, cypsela; B, carpopodium (undevelop); C, surface. *A. biennis*: D, cypsela; E, carpopodium; F, surface. *A. capillaris*: G, cypsela;. H, carpopodium; I, surface. *A. desertorum*: J, cypsela; K, carpopodium; L, surface. *A. dracunculus*: M, cypsela; N, carpopodium; O, surface (scale bar: A,D,G,J,M = 100 µm; B, E,F,H,I,K,O = 20µm; C =5µm; L = 50µm).

Fig. 2. Scanning Electron Micrographs. *Artemisia dubia:* A, cypsela; B, carpopodium; C, surface. A. *elegantissima:* D, cypsela; E, carpopodium; F, surface. *A. gmelini*: G, cypsela; H, carpopodium; I, surface. *A. incisa:* J, cypsela; K, carpopodium; L, surface. *A. japonica*: M, cypsela; N, carpopodium; O, surface (Scale bar: A,I = 50µm; B,E,F,H,K,L,N,O = 20µm; C = 10µm; D,G,J,M = 100µm).

Fig. 3. Scanning Electron Micrographs. *Artemisia laciniata:* A, cypsela; B, carpopodium; C, surface. *A.macrocephala:* D, cypsela; E, carpopodium; F, surface. . *A.moorcroftiana*: G, cypsela; H, carpopodium; I, surface. *A. persica*: J, cypsela; K, carpopodium; L, surface. *A. roxburghiana:* M, cypsela; N, carpopodium; O, surface. (Scale bar: A,F,O = 50 µm; D,G, J,M = 100µm;; B,H,K,L,N = 20µm; C,I = 10µm ; E=30µm).

Fig. 4. Scanning Electron Micrographs. *Artemisia rutifolia:* A, cypsela; B, carpopodium; C, surface. *A. salsoloides:* D, cypsela; E, carpopodium; F, surface. *A. santolinifolia:* G, cypsela; H, carpopodium; I, surface. *A.sieversiana:* J, cypsela; K, carpopodium; L, surface. *A. vulgaris:* M, cypsela; N, carpopodium; O, surface (Scale bar: A = 200µm; B, C,G,N = 50µm; D, J, M = 100µm; E, H, K, L, O =20µm; F, I = 10µm).

Key to the species

1 + Cypsela with oblique corolla scar ……... 2
– Cypsela with terminal corolla scar ……..……... 6

2 + Carpopodium narrow circular ring-like ……..…… *A. absinthium*
– Carpopodium broad circular disc-like …… 3

3 + Cypsela oblanceolate ……. 4
– Cypsela oblong or oblong-oblanceolate …… 5

4 + Cypsela dark brown. Carpopodium 83.0µm in diameter. Foramen of carpopodium 74µm in diameter …… *A. biennis*
– Cypsela yellowish brown. Carpopodium 135µm in diameter. Foramen of carpopodium 110µm in diameter ……... *A. macrocephala*

5 + Cypsela oblong, deeply striate …….. *A. persica*
– Cypsela oblong oblanceolate, finely striate ……..... *A. laciniata*

6 + Carpopodium undeveloped ……. *A. annua*
– Carpopodium broad circular disc like ……. 7

7 + Cypsela finely striate ……..……. 8
– Cypsela deeply striate ……..……. 13

8 + Cypsela oblanceolate, blackish brown ……... *A. japonica*
– Cypsela oblong, oblong-oblanceolate, linear-oblong or ellipsoid, yellowish brown or dark brown ...…… 9

9 + Cypsela ellipsoid. Carpopodium 142µm in diameter ……. *A. incisa*
– Cypsela oblong, oblong-oblanceolate or linear-oblong. Carpopodium 90-125µm in diameter …… 10

10+ Cypsela yellowish brown …….. 11
– Cypsela dark brown …….. 12

11 + Cypsela oblong ……..…… *A. dracunculus*
– Cypsela linear-oblong ……..…….. *A. moorcroftiana*

12 + Carpopodium 90µm in diameter. Foramen of carpopodium 55µm in diameter …… *A. amygdalina*
– Carpopodium 131µm in diameter. Foramen of carpopodium 89µm in diameter ……... *A.santolinifolia*

13 + Cypsela yellowish brown …….. 14
– Cypsela dark brown …….. 16

14 + Cypsela oblanceolate. Carpopodium 166µm in diameter …….. *A. sieversiana*
– Cypsela oblong or obovate. Carpopodium 95-127µm in diameter ……... 15

15 + Cypsela oblong. Carpopodium 127µm in diameter ……..... *A. dubia*
– Cypsela obovate. Carpopodium 95µm in diameter ……... *A. capillaris*

16 + Carpopodium broad angular disc- like ……. *A.rutifolia*
– Carpopodium broad circular disc- like ……. 17

17 + Cypsela ovate ……..… *A. desertorum*
– Cypsela oblanceolate, oblong, oblong-oblanceolate or oblong-elliptic …… 18

18 + Cypsela oblong ……... *A. roxburghiana*
– Cypsela oblanceolate, oblong-elliptic or oblong-oblanceolate ……. 19

19 + Cypsela oblanceolate …….. *A. elegantissima*
– Cypsela oblong-elliptic or oblong-oblanceolate ……...… 20

20 + Cypsela oblong-elliptic …….. *A. stricta*
– Cypsela oblong-oblanceolate …… 21

21 + Carpopodium 79-130µm in diameter. Foramen of carpopodium 50-76µm in diameter …… 22
– Carpopodium 203µm in diameter. Foramen of carpopodium 120µm in diameter …….. *A. vulgaris*

22 + Carpopodium 79µm in diameter. Foramen of carpopodium 50µm in diameter ……. *A. scoparia*
– Carpopodium 130µm in diameter. Foramen of carpopodium 76µm in diameter ……... *A. gmelini*

Results and Discussion

Tribe Anthemideae has no characteristic cypsela features although for some of the genera like *ursinia* (Swelankomo *et al*., 2007) and *Soliva* (Lovell *et al*., 1986) cypsela characters have proved very rewarding for the specific delimitation. Similarly, on the basis of position of corolla scar on cypsela the genus *Artemisia* may be distinguished into two different groups such as cypselas with oblique corolla scar or terminal corolla scar. Taxa having cypsela with oblique corolla scar are further separated on the basis of cypsela shape, surface and carpopodium. Among this group *Artemisia absinthium* L., is characterized by narrow circular ring like carpopodium and other species having broad circular disc like carpopodium including *A. biennis* Willd., *A. macrocephala* Jacquem. ex Besser, *A. persica* Boiss., and *A. laciniata* Willd., where *A. biennis* and *A. macrocephala* differ from the other species by the presence of oblanceolate cypsela but both the taxa remain distinct from each other due to cypsela colour. On the other hand, *A. persica* and *A. laciniata* are distinct by the presence of oblong and oblong-oblanceolate cypselas respectively. Another group where cypsela has terminal corolla scar, *A. annua* L., is characterized by the absence of carpopodium while in the remaining species broad circular disc like carpopodium is present, and these species are further distinguished due to surface pattern such as cypselas finely striate or deeply striate. *A. japonica* Thunb., *A.*

incisa Pamp., *A. dracunculus* L., *A. moorcroftiana* Wall. ex. DC., *A. amygdalina* Decne. and *A. santolinifolia* Turcz. ex Krasch., are characterized by finely striate cypsela and all of these species remain distinct with each other due to cypsela shape, colour and carpopodium size. Another subgroup with deeply striate cypselas include *A. sieversiana* Ehrh., *A. dubia* wall. ex Besser, *A. capillaris* Thunb., *A. rutifolia* Spreng., *A. desertorum* Spreng., *A. roxburghiana* Wall. ex Besser, *A. elegantissima* Pamp., *A. stricta* Edgew., *A. vulgaris* L., *A. scoparia* Waldst. & Kit., and *A. gmelini* Web. ex stechm. Amongst all of these species *A. rutifolia* is characterized by angular disc like carpopodium and in remaining species carpopodium is circular disc like. Furthermore, the above remaining species have proved distinct from each other due to the differences in cypsela shapes and carpopodium size (Table 1). Therefore, most of the cypsela features proved to be very informative for the specific delimitation of the genus *Artemisia*.

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