

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 cypselas features. Micromorphological characters of cypselas including position of corolla scar on cypselas, shape, surface, colour and carpodium 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 cypselas 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 cypselas features (Kynclova, 1970; Lovell *et al.*, 1986; Swelankomo *et al.*, 2007) but the genus *Artemisia* has not received due attention for its cypselas morphology. In the present work cypselas 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 cypselas 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:

Cypselas: Shape, surface, colour, size

Carpodium: Shape, position, diameter of carpodium and diameter of foramen of carpodium were observed under scanning electron microscope.

Observations

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

Table 1. Cypselas morphological characters of *Artemisia* L.

Name of species	Cypselas			
	Shape	Surface (hairs)	Colour	Size (mm)
<i>Artemisia absinthium</i>	Oblong with oblique corolla scar	Deeply striate	Dark brown	0.5-1.0x0.25-0.5
<i>A. amygdalina</i>	Oblong with terminal corolla scar	Finely striate	Dark brown	0.8-1.0x0.25
<i>A. annua</i>	Oblong with terminal corolla scar	Finely striate	Dark brown	0.5-0.8x0.25
<i>A. biennis</i>	Oblanceolate with oblique corolla scar	Deeply striate	Dark brown	1.0x0.5
<i>A. capillaris</i>	Obovate with terminal corolla scar	Deeply striate	Yellowish brown	0.75x0.25
<i>A. desertorum</i>	Ovate with terminal corolla scar	Deeply striate	Dark brown	1.5x0.75
<i>A. dracunculus</i>	Oblong with terminal corolla scar	Finely striate	Yellowish brown	1-1.5x0.75
<i>A. dubia</i>	Oblong with terminal corolla scar	Deeply striate	Yellowish brown	1-1.5x0.5
<i>A. elegantissima</i>	Oblanceolate with terminal corolla scar	Deeply striate	Dark brown	1-1.5x0.25-0.5
<i>A. gmelini</i>	Oblong-oblanceolate with terminal corolla scar	Deeply striate	Dark brown	1-1.5x0.5
<i>A. incisa</i>	Ellipsoid with terminal corolla scar	Finely striate	Yellowish brown	1-1.5x0.5
<i>A. japonica</i>	Oblanceolate with terminal corolla scar	Finely striate	Blackish brown	1.0x0.5
<i>A. laciniata</i>	Oblong-oblanceolate with oblique corolla scar	Finely striate	Yellowish brown	0.75x0.25
<i>A. macrocephala</i>	Oblanceolate with oblique corolla scar	Deeply striate	Yellowish brown	1-1.5x0.5
<i>A. moercoffiana</i>	Linear-oblong with terminal corolla scar	Finely striate	Yellowish brown	1-1.5x0.25
<i>A. persica</i>	Oblong with oblique corolla scar	Deeply striate	Yellowish brown	1-1.5x0.25-0.5
<i>A. roxburghiana</i>	Oblong with terminal corolla scar	Deeply striate	Dark brown	1-1.5x0.25-0.5
<i>A. rutifolia</i>	Oblanceolate with terminal corolla scar	Deeply striate	Dark brown	1-1.5x0.25-0.5
<i>A. salsoloides</i>	Oblong-oblanceolate with terminal corolla scar	Finely striate	Dark brown	1-1.5x0.25-0.5
<i>A. santolinifolia</i>	Oblong with terminal corolla scar	Finely striate	Dark brown	1x0.5
<i>A. scoparia</i>	Oblong-oblanceolate with terminal corolla scar	Deeply striate	Dark brown	1-1.5x0.25-0.5
<i>A. sieversiana</i>	Oblanceolate with terminal corolla scar	Deeply striate	Yellowish brown	1-1.5x0.5
<i>A. stricta</i>	Oblong-elliptic with terminal corolla scar	Deeply striate	Dark brown	1.0x0.5
<i>A. vulgaris</i>	Oblong-oblanceolate with terminal corolla scar	Deeply striate	Dark brown	1.0-1.5x0.5

Table 1. (Cont'd).

Name of species	Carpopodium		
	Shape	Position	Diameter of carpopodium(µm)
<i>Artemisia absinthium</i>	Narrow circular ring without any interruption	Subbasal	85.0
<i>A. amygdalina</i>	Broad circular disc without any interruption	Subbasal	90.0
<i>A. annua</i>	Undeveloped	Subbasal	-
<i>A. biennis</i>	Broad circular disc without any interruption	Subbasal	83.0
<i>A. capillaris</i>	Broad circular disc without any interruption	Subbasal	95.0
<i>A. desertorum</i>	Broad circular disc without any interruption	Subbasal	95.8
<i>A. dracunculoides</i>	Broad circular disc without any interruption	Subbasal	125
<i>A. dubia</i>	Broad circular disc without any interruption	Subbasal	127
<i>A. elegantissima</i>	Broad circular disc without any interruption	Subbasal	152
<i>A. gmelini</i>	Broad circular disc without any interruption	Subbasal	130
<i>A. incisa</i>	Broad circular disc without any interruption	Subbasal	142
<i>A. japonica</i>	Broad circular disc without any interruption	Subbasal	84.0
<i>A. laciniata</i>	Broad circular disc without any interruption	Subbasal	138
<i>A. macrocephala</i>	Broad circular disc without any interruption	Subbasal	135
<i>A. moorcroftiana</i>	Broad circular disc without any interruption	Subbasal	122
<i>A. persica</i>	Broad circular disc without any interruption	Subbasal	113
<i>A. roxburghiana</i>	Broad circular disc without any interruption	Subbasal	163
<i>A. ruifolia</i>	Broad angular disc without any interruption	Subbasal	174
<i>A. salsoloides</i>	Broad circular disc without any interruption	Subbasal	93
<i>A. santalinifolia</i>	Broad circular disc without any interruption	Subbasal	131
<i>A. scoparia</i>	Broad circular disc without any interruption	Subbasal	79
<i>A. sieversiana</i>	Broad circular disc without any interruption	Subbasal	166
<i>A. stricta</i>	Broad circular disc without any interruption	Subbasal	90.0
<i>A. vulgaris</i>	Broad circular disc without any interruption	Subbasal	203
			72.5
			55.0
			-
			74.0
			68.0
			58.7
			85.0
			105
			106
			76.0
			95
			50.0
			110
			116
			84.0
			90.0
			99.0
			103
			56
			89.0
			50
			106
			55.0
			120

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 μ m; B, E,F,H,I,K,O = 20 μ m; C = 5 μ m; L = 50 μ m).

Fig. 2. Scanning Electron Micrographs. *Artemisia dubia*: A, cypsela; B, carpodium; C, surface. *A. elegantissima*: D, cypsela; E, carpodium; F, surface. *A. gmelini*: G, cypsela; H, carpodium; I, surface. *A. incisa*: J, cypsela; K, carpodium; L, surface. *A. japonica*: M, cypsela; N, carpodium; 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, carpodium; C, surface. *A. macrocephala*: D, cypsela; E, carpodium; F, surface. *A. moorcroftiana*: G, cypsela; H, carpodium; I, surface. *A. persica*: J, cypsela; K, carpodium; L, surface. *A. roxburghiana*: M, cypsela; N, carpodium; O, surface. (Scale bar: A,F,O = 50 μ m; D,G, J,M = 100 μ m;; B,H,K,L,N = 20 μ m; C,I = 10 μ m ; E=30 μ m).

Fig. 4. Scanning Electron Micrographs. *Artemisia rutifolia*: A, cypsela; B, carpodium; C, surface. *A. salsoloides*: D, cypsela; E, carpodium; F, surface. *A. santolinifolia*: G, cypsela; H, carpodium; I, surface. *A. sieversiana*: J, cypsela; K, carpodium; L, surface. *A. vulgaris*: M, cypsela; N, carpodium; 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 carpodium 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 stechn. Amongst all of these species *A. rutifolia* is characterized by angular disc like carpodium and in remaining species carpodium is circular disc like. Furthermore, the above remaining species have proved distinct from each other due to the differences in cypsela shapes and carpodium 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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