Indian J. Applied & Pure Bio. Vol. 29(2), 199-205 (2014).

Diversity of cypselar features of five species of the tribe – Heliantheae (Asteraceae)

***Bidyut Kumar Jana, Ruksona Auju and Sobhan Kr. Mukherjee**

Taxonomy and Biosystematics Laboratory, Department of Botany, University of Kalyani, Kalyani-741235, Nadia, West Bengal (India)
Emails: *janabidyutkumar@yahoo.com, sobhankr@yahoo.com, sobhankr@gmail.com

Abstract

The present paper deals with the detailed morpho-anatomical features of cypselas among 5 species of the tribe Heliantheae (Asteraceae). Among the studied species, in case of *Cosmos sulphureus* and *Bidens frondosa*, cypselas are heteromorphic than the remaining 3 other studied cypselas, where they are homomorphic. Except the cypsela of *Bidens frondosa*, in remaining 4 studied cypselas, pappus are absent. In the cypsela of *Bidens frondosa*, pappus is awn like in nature.In all the studied cypselas, phytomelanin layer exists in the surface, in the form of different ornamentation. Cross sections of cypselas show variable outline, *i.e.* more or less rounded (*Bidens*), tetrangular (*Cosmos*), triangular (*Sclerocarpus*), and oval (*Zinnia*). Anatomically, phytomelanin layer is present in the mesocarpic region of each studied cypselas. Each cypsela has 2 cotyledons and their orientation is also variable. In *Bidens frondosa*, cotyledons are arranged at right angle to the axis of cypsela whereas in case of *Cosmos sulphureus*, *Sclerocarpus africanus*, *Zinnia pauciflora* and *Zinnia verticillata*, cotyledons are placed obliquely to the axis of cypsela.

Key words : Cypselar features; Heliantheae; Asteraceae

The tribe Heliantheae is included under the subfamily Asteroideae of the family Asteraceae, having about 196 genera, 2500 species, belonging to 10 subtribes[6]. The tribe is one of the most primitive tribes of the Asteraceae[3] and the tribe is paraphyletic[2,5] in nature. Brief cypselar external features have usually been included by different floristic workers during their preparation of floristic works, during their preparation of floristic accounts, but detailed features including both morphological and anatomical characters of cypselas have potential value for characterization of taxa. In this respect Roth[10] has pointed out that 'not only is the external morphology of the achenium very characteristic, but also inner structure shows certain qualities which can be used taxonomically'.

Cypselar features both morphological and anatomical studies or either anyone of them have been used for taxonomic evalution of the tribe-Heliantheae by some workers like Pandey *et al.*[9], Mukherjee and Sarkar[7]. Although these works have significant value, yet more works in this respect are needed to fulfill the lacunae of the previous data. The purpose of the present study is three fold; first to supplement the previous works for better understanding of taxa; second to distinguish between the taxa simply on the basis of cypselar structure in five species belonging to the tribe Heliantheae and third to identify the species on the basis of cypselar micromorphological and anatomical features.

Table-1. Showing the studied species of the tribe Heliantheae

Serial No.	Name of taxa	Source
1.	*Bidens frondosa* L.	Botanic Garden of Copenhagen, Copenhagen, Denmark.
2.	*Cosmos sulphureus* Cav.	Botanic Garden of Copenhagen, Copenhagen, Denmark.
3.	*Sclerocarpus africanus* Jacq.	Botanic Garden of Copenhagen, Copenhagen, Denmark.
4.	*Zinnia pauciflora* L.	Botanic Garden of Copenhagen, Copenhagen, Denmark.
5.	*Zinnia verticillata* Andreues.	Botanic Garden of Copenhagen, Copenhagen, Denmark.

Mature, identified cypselas of five species were obtained as gift from Prof. Hans Vilhelm Hansen, Curator, University Botanic Garden of Copenhagen, Copenhagen, Denmark, which are mentioned alphabetically in table 1.

Some fully mature cypselas of each species were selected from the mass of each sample. These were boiled for few minutes with water by adding few drops of glycerol. All the specimens were preserved in FAA solution for study. After that, five cypselas were immersed within the 2-5% NaOH solution for few days, depending upon the amount of mechanical tissue of cypselas. Different parts of cypselas were stained in 0.5% aqueous safranin solution and different parts of cypselas were studied with the help of light compound microscope. Cross sections from each cypselas were taken from the middle part.

The features of cypselas in different species of the tribe Heliantheae are as follows.

***Bidens frondosa* L.**

Morphology (Fig. 1 A-F)

Cypsela heteromorphic, *i.e.* differentiated into disk and ray cypselas, 5-7x1-15 mm. Cypselas ray florets nature usually yellow; disk florates brownish in colour. Cypselas linear, oblong-ellipsoid. After clearing, the cypselar wall shows numerous irregular lobe, horizontally oriented phytomelanin braces, stylopodium prominent, represented by a short, terete, tube like structure. At the basal region of cypsela,

carpopodium present. Pappus represented by 2 slightly bent, incurved, brownish awn, 4-5 x 1.5-2.0 mm long. Each awn bears numerous twin hairs.

Anatomy (Fig. 2 A-B) :

Cross section of cypsela appear more or less rounded with ribs and furrows and irregular lobed margin. Outer most epidermis is made up of parenchyma cells. Below the epidermis many layered elongated, palisade parenchyma cells present. The presence of phytomelanin layer is a common character of the tribe Heliantheae. Below the parenchyma cells, one layer, thick-walled, phytomelanin layer exists. Large vellicular cavity exists within the phytomelanin zone. Testal zone is represented by a single layered of thin-walled cells. Endosperm not clearly observed. Cotyledons 2 in number, arranged at right angle to the axis of cypselas.

***Cosmos sulphureus* Cav.**

Morphology (Fig 1 G-J) :

Cypsela heteromorphic *i.e*. differentiated into ray and disk cypselas, 18-23 x 1-1.5 mm. Ray florets variously coloured; disk florets numerous, yellowish. Filaments hirsute. After clearing the cypselar wall shows, many rows of horizontally oriented phytomelanin braces, which are circular, bordered pit like. Stylopodium prominent, triangular, upwardly directed. Carpopodium ring like. Hair present. Pappus absent.

Anatomy (Fig. 2 C-D) :

Cross sections of cypselas appear more or less tetrangular in outline with 4 lobe; 2 anterior-posterior lobes and 2 lateral lobes. Outer epidermal layer is made up of parenchyma cells. Below the epidermal layer, many layer of horizontally oriented phytomelanin braces exists which are circular bordered pit like. Large vellicular cavity exists within the mesocarpic zone. Mesocarpic zone made up of thick-walled, sclerenchyma cells. Testal zone 1 layere. Endosperm zone 2 layered. Cotyledons 2 in number, arranged obliquely to the axis of the cypselar wall.

Sclerocarpus africanus

Morphology (Fig. 1 K-N) :

Cypsela homomorphic *i.e.* not differentiated into ray and disk cypsela, 7-8x3-4 mm, slightly curved, blackish in colour, more or less oblong to oblanceolate. Cypselar surface rough due to the presence of small tubercles but absence of hairs. After clearing, the cypselar wall shows numerous horizontal rows of phytomelanin layers which ultimately form reticulate structure. Stylopodium obliquely oriented. Carpopodium trilobed, ringlike, strongly developed, formed by thick-walled, parenchyma tissue. Pappus absent.

Anatomy (Fig. 2 E-F):

Cross sections of cypselas exhibits triangular in outline with irregular margin. The outer most layer epidermis. Below the epidermis thick-wallwd, pitted, parenchyma cells present. Below the parenchyma cells, phytomelanin layer exists. Thick-walled sclerenchymatous zone also present. Testal zone single layer. Cotyledons 2.

Zinnia pauciflora
Morphology (Fig. 1 O-R):

Cypsela homomorphic *i.e.* not differentiated into ray and disk cypselas, 9-10x1-1.5 mm, anterior-posteriorly compressed, greenish brown, more or less oblanceolate. Cypselar surface possess microtubules and twin hairs. After clearing, the cypselar wall shows numerous horizontal rows of phytomelanin layers which ultimate form reticulate structure. Cypselar surface shows ridges and furrows. Stylopodium bilobed. Pappus absent.

Anatomy (Fig. 2 G-H)

Crosssection of cypselas exhibits oval outline with weakly developed lobes and furrows. Epidermis uniseriate, thick-walled, parenchymatous. Outer layer is also represented by palisade parenchyma cells. Below the palisade parenchyma cells, phytomelanin layer exists. Hypodermis is constituted by few layers of sclerenchyma cells. Testal zone is two layered. Cotyledons 2 in number.

Zinnia verticillata (Fig. 1 S-U)
Morphology:

Cypsela homomorphic, *i.e.* not differentiated into ray and disc cypselas, 9-10x1-1.5 mm, anterior-posteriorly compressed, greenish brown, more or less oblanceolate. Cypselar surface possess twin hairs. After clearing, the cypselar wall shows numerous horizontal rows of phytomelanin layers, which ultimately form reticulate structures, situated at the apical sinus of the body. Carpopodium bilobed. Pappus absent.

Anatomy (Fig. 2 I-J):

Cross section of cypselas exhibits oval outline with weakly developed lobes and furrows. Epidermis uni-seriate, thick-walled, parenchymatous. Inside the epidermis, presence of one layer, palisade parenchyma cells. Phytomelanin layer exhists inside. Hypodermis is constituted by few layers of sclerenchymatous tissue. Cotyledons 2 in number, each brings single apical notch.

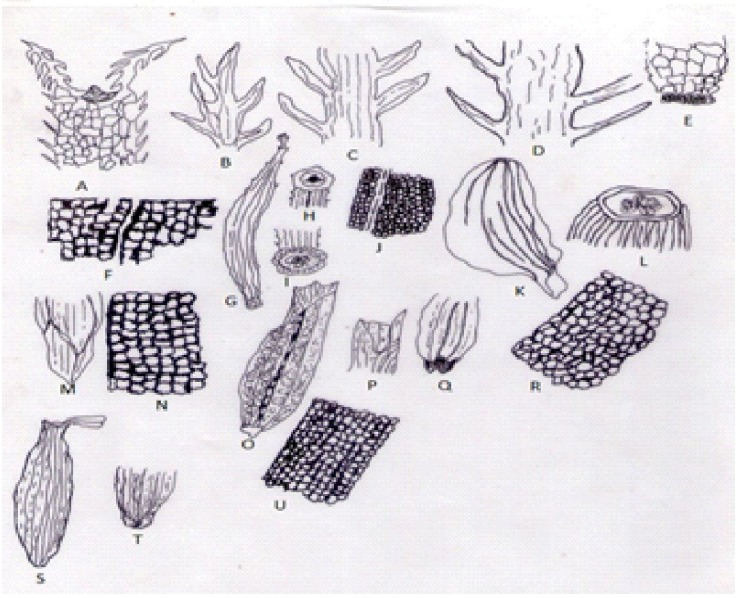

Fig. 1. Morphology of studied cypselas
A-F-*Bidens fromdosa:* A- Cypsela, B-Upper part of awn, C-Middle part of awn, D-Lower part of awn, E-Basal part of cypsela, F- Surface, showing phytomelanin layer; G-J-*Cosmos sulphureus*: G-Cypsela, H-Upper part of cypsela, I-Lower part of cypsela, J-Surface, showing phytomelanin layer; K-N-*Sclerocarpus africanus*: K-Cypsela, L-Upper part of cypsela, M-Lower part of cypsela, N-Surface showing phytomelanin layer; O-R-*Zinnia pauciflora*: O-Cypsela, P-Upper part, Q-Lower part, R-Surface showing phytomelanin layer; S-U-*Zinnia verticillata*: S-Cypsela, T-Lower part, U- Surface showing phytomelanin layer.

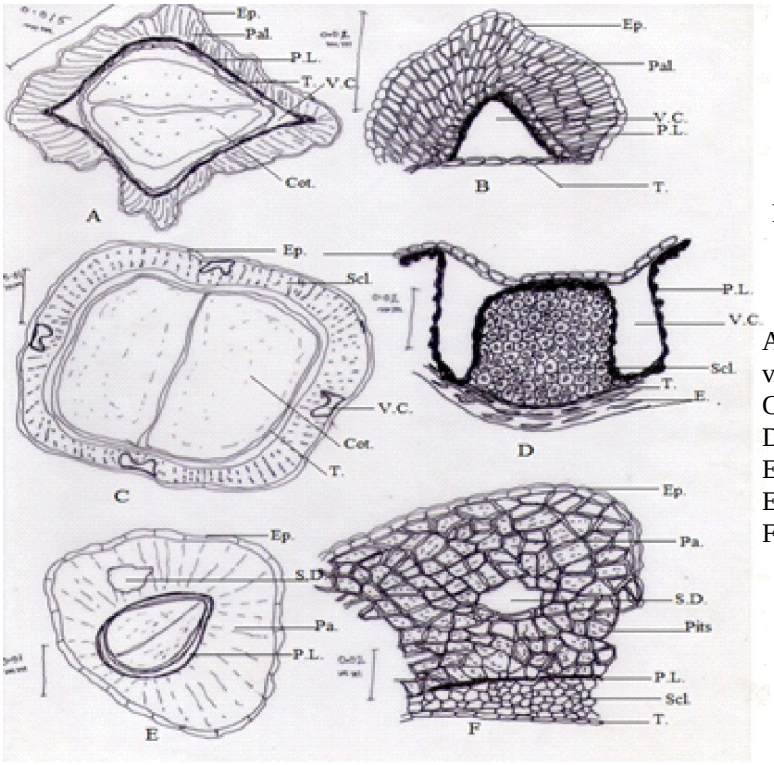

Fig. 2. Anatomy of studied cypselas

A-B-*Bidens frondosa*: A-Diagramatic view, B-Cellular view; C-D-*Cosmos sulphureus*: C-Diagramatic view, D-Cellular view; E-F-*Sclerocarpus africanus*: E-Diagramatic view, F-Cellular view.

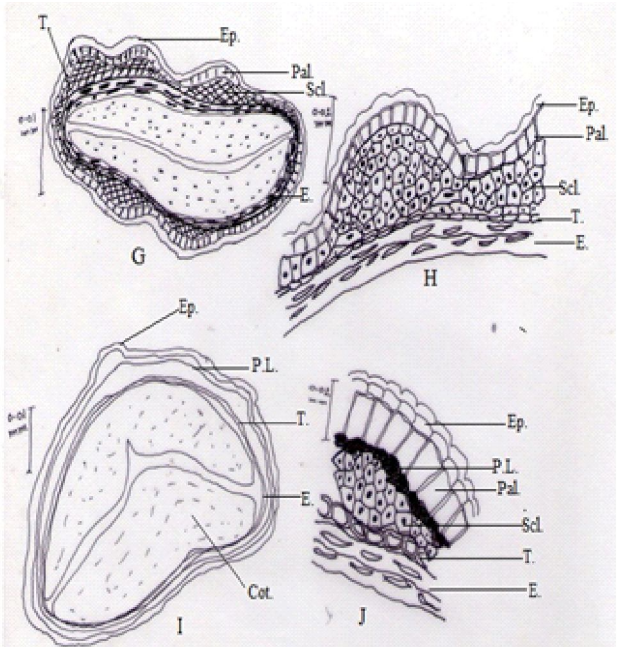

Fig. 3. Anatomy of studied cypselas

G-H-*Zinnia pauciflora*: G-Diagramatic view, H-Cellular view; I-J- *Zinnia verticillata*: I-Diagramatic view, J-Cellular view.

Abbriviations: Ep.-Epicarp, Pa.-Parenchyma, Scl.-Sclerenchyma, P.L.-Phyto-melanin layer, T-Testa, Cot.-Cotyledon, E.-Endosperm, V.C.-Vellicular cavity.

Among the studied taxa, cypselas are largest in *Cosmos sulphureus* and smallest in *Bidens frondosa*. Shape of cypsela varies from oblanceolate-oblong-ellipsoidal. Colour of cypselas may be variable, depending on the stage of maturity. So, this character is not significant taxonomically. Apical; part of cypsela is usually truncate. Occassionally sinuate as in *Zinnia* sp. After clearing the cypselar wall *i.e.* pericarp shows different types of ornamentation formed by the deposition of unique type of resinous substance, which is known as phytomelanin. Phytomelanin layer reticulate or nate like in appearance. Stylopodium prominent. Carpopodium may be present or absent. When present, it oftain forms a continuous ring like structure or bilobed.

On the basis of presence or absence of pappus, cypselas can be divided into two groups.

1. Without pappus eg. *Cosmos, Sclerocarpus* etc.
2. With pappus eg. *Bidens*

   Different forms of pappus structure in Heliantheae have been reported by Bremer[1]. Therefore pappus structure plays an important role for characterization of taxa in Heliantheae.

   Cross sections of cypselas shows variable outline, *i.e.* more or less rounded (*Bidens*), tetrangular (*Cosmos*), triangular (*Sclerocarpus*), oval (*Zinnia*). Phytomelanin layer exists inside the epidermis. Mesocarpic zone is formed by both sclerenchyma and parenchyma cells. Each cypsela always has two cotyledons and their position is often parallel to the axis. Inner surface of cotyledon is usually plane but grooved cotyledons exists in *Zinnia verticillata.*

The tribe Heliantheae is primitive amongst the tribes of Asteraceae[3], whereas Bremer[1] has mentioned it as an advanced tribe in Asteraceae. Within this study, it is not possible to predict whether it is advanced or not. Presence of phytomelanin clearly indicates that this tribe is obviously related with other phytomelanin bearing tribe, e.e. Eupatorieae, as has been reported by Bremer[1]. Pandey & Sing[8], Saenz[11] and Jansen *et al.*[4], have shown the affinity between those two groups on the basis of cladistic analysis of chloroplast D NA. Karis[5], has shown the affinity of this tribe with Senecioneae on the basis of cladistic analysis of molecular data together with morphological features. From this study it is obvious that cypselar features are diacritical atleast in some taxa. Therefore, these features should be taken as a parameter for isolation of taxa at or below the rank of genera.

Key to the studied cypselas:

A. Cypsela heteromorphic.

B. Cypselas 5-7x 1-1.5 mm; without beak; pappus presented by two slightly bent incurved, brownish awn; shaggy hairs absent; velicular cavity present with the pericarp.....*Bidens frondosa*
BB. Cypselas 18-23 x 1-1.5 mm with beak; pappus absent; shaggy hairs exists on the cypselar surface; vellicular cavity absent..... *Cosmos sulphureus*
AA. Cypselas homomorphic.

C. Cypselas 7-8 x 3-4 mm, twin absent; secretary duct present; testal zone unilayered ..... *Sclerocarpus africanus*

CC. Cypselas 9-10 x 1-1.5 mm; twin hair present; secretary duct absent.

D. Cotyledon with apically notched..... *Zinnia verticillata*
DD. Cotyledons not apically notched..... *Zinnia pauciflora*

We are thankful to Prof. Hans Vilhelm Hansen, Curator, University Botanic Garden of Copenhagen, Copenhagen, Denmark, for sending mature, identified seeds for our study.

References :

1. Bremer, K. (1994). Asteraceae: Cladistics and classification. Timber Press, Portland, USA.
2. Bremer, K. (1996). Major clades and grades of the Asteraceae. Proceedings of the International Copmositae conference. 1: 1-7. (Hind, D.J.N. and Beentje, H.J. eds), Royel Botanic Garden, Kew.
3. Cronquist, A. (1955). *Amer. Midl. Nat. 53:* 478-511.
4. Jansen, R. K., Michaels, H.J. and J.D. Palmer (1991). *Syst. Bot. 16:* 98-115.
5. Karis, P.O. (1993). *P1. Syst. Evol. 186:* 69-93.
6. Mabberley, D.J. (1997). The Plant Book. Cambridge University Press, Cambridge, U.K.
7. Mukherjee, S.K. and A.K. Sarkar (1998). *Bull. Bot. Surv. India. 40: (1-4):* 34-46.
8. Pandey, A.K. and R.P. Singh (1982). *J. Indian Bot. Soc. 61(4):* 417-425.
9. Pandey, A.K. and R.P. Singh (1986). *J. Indian Bot. Soc. 61(4):* 417-425.
10. Roth, I. (1977). Fruits of Angiosperms, *Handbuch der Pflanzenanatomie, Band X, Teill, Gebruder Bomtraeger,* Berlin.
11. Saenz, A.A. (1981). *Darwiniana. 23(1):* 37-49.