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CYPSELAR FEATURES AND THEIR TAXONOMIC SIGNIFICANCE IN THREE GENERA OF THE TRIBE MUTISIEAE (ASTERACEAE) WITH THE AID OF LM AND SEM

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Detailed studies on the mature cypselas of 4 species belonging to 3 genera (*Ainsliaea* DC., *Dicoma* Cass., and *Gerbera* L.) in the tribe Mutisieae have revealed the morphological and anatomical differences at the species level although some similarities exist in the basic structure. Morphological features of the apical part, surface hairs, location of vascular trace, structure of carpopodium and pappus bristles of cypselas are taxonomically significant. Anatomically, testal features are more important than the pericarp in the tribe Mutisieae and have potential value for characterization of taxa. On the basis of thickening of the cell walls in testal epidermis, the studied species can be grouped into 3 categories. On the other hand, the structure of endosperm can not be treated as significant taxonomic parameter. An artificial key is provided on morphological features of cypselas for the identification of species.

Keywords : Asteraceae; Cypselar morpho-anatomy; Mutisieae.

Introduction

Floristically, the tribe Mutisieae usually have unique bilabiate flowers and lack of stylopodium in cypsela. Karis *et al.*[1] have also shown that the tribe Mutiseae (*s.l.*) are devoid of sweeping hairs on the styles which exist in rest of the tribes of Asteraceae. Current classification of the tribe Mutisieae begins with the system of Bentham[2]. Cabrera[3,4] has divided the tribe inti 4 subtribes, i.e. Barnadesiinae, Gochnatiinae, Mutisiinae and Nassauviinae. Very recently the subtribe Barnadesiinae has been recognised as a distinct subfamily Barnadesioideae[5], on the basis of absence of the chloroplast DNA inversion discovered by Jansen and Palmer[6]. Moreover, Bremer[5] has recognised the tribe Mutisieae (*s.s*) as a provisional unclassified group which constitutes the phylogenetically basal complex of the family Asteraceae and known to be a paraphyletic group. Thus the tribe Mutisieae draws more attention to the taxonomists for better understanding of its phylogeny.

Cypselar anatomical features have been successfully employed in the classification of taxa in the Asteraceae, since the work of Lavialle[7] particularly in the tribe Mutisieae, whereas gross morphological features of cypselas have been incorporated in different system of classifications. In recent years, cypselar characters have been successfully used for the identification of plants in different genera and tribes of the family Asteraceae. Many authors[1,4,8-12] have been attracted and facinated by different aspects of this tribe along with cypselar morphological features. Grau[13] has added detailed investigation on the anatomy of fruits.

The present paper deals with both morphological and anatomical features of cypselas of 4 species belong to 3 genera of

Table 1.

Name of the plant	Subtribe	Locality	Collection Number
Ainsliaea latifolia (D. Don) Sch.-Bip.	Gochnatiinae	India (Darjeeling)	S. Mukherjee 17
A. reflexa Merr var. *nimborum* Hand.-Mazz.	Gochnatiinae	TAI	Yuh Fong Chen 3300
Dicoma sessiliflora Harv. in Harv. & Sond. ssp. *sessiliflora*	Gochnatiinae	LISC	A. R. Torre 13
Gerbera jamesonii Bolus ex Hook. f.	Mutisiinae	Z	Nr. 397

the tribe Mutisieae. The aim of the present study is two fold : to describe the cypselar morpho-anatomical features in detail; and to prepare an artificial key based on these observations.

Materials and Methods

Mature dry cypselas of 3 species were obtained from 3 different herbaria of the world i.e. Centro de Botanica da Junta de Investigacoes Cientificas do Ultramar, Rua de Junqueira, Lisboa, Portugal (LISC); Department of Botany, National Taiwan University, Taipei, Taiwan, Republic of China (TAI); Botanischer Garten der Universitat Zurich, Zurich, Switzerland (Z). One specimen was collected by the author from Darjeeling of W. Bengal, India. These are shown in Table 1.

Dry cypselas were softened and stained following Mukherjee and Sarkar[14] for morphological study. For anatomical study, mature cypselas were microtome - sectioned by standard paraffin method[15]. SEM photographs were taken by Philips SEM at RSIC, Bose Institute, Calcutta and by Hitachi SEM at USIC, Burdwan University, Burdwan, West Bengal, for surface study of cypselas.

Description of morphological and anatomical characters follows the terminology of many workers[4,14,16-18].

Results and Discussion

CYPSELAR MORPHOLOGY

Diagnostic Characters : On the basis of present study, the diagnostic features of cypselas are as follows : cypselas homomorphic, oblanceolate to narrow oblanceolate, narrow elliptic, obovate; truncate, attenuate or beaked at the apex; pubescent; ribbed or non ribbed; stylopodium absent; carpopodium either present or absent; pappus bristles uniseriate or biseriate, usually plumose or seldom scabrous.

Gross Structure : The present study reveals that the cypselas vary in their shape, colour, size, number of ribs or lobes. These featurres of cypselas could be used for identification of genera and even upto species level. Cypselas are attenuate in *Ainsliaea* (Fig. 1 A,G) or truncate in *Dicoma* (Fig. 2A) or beaked in *Gerbera* (Fig. 2F) at the apex.

Hairs : Cypsela surface is usually covered densely by slender twin hairs or sometimes sparsely covered by short twin hairs with bilobed base in *Gerbera* (Fig. 2 H,K,L,M). Tips of the hair cells in *Gerbera* are more or less in same plane. Characteristic type of twin hair is found in *Dicoma* (Fig. 1C; 5D), where the basal glandular cell is much wider

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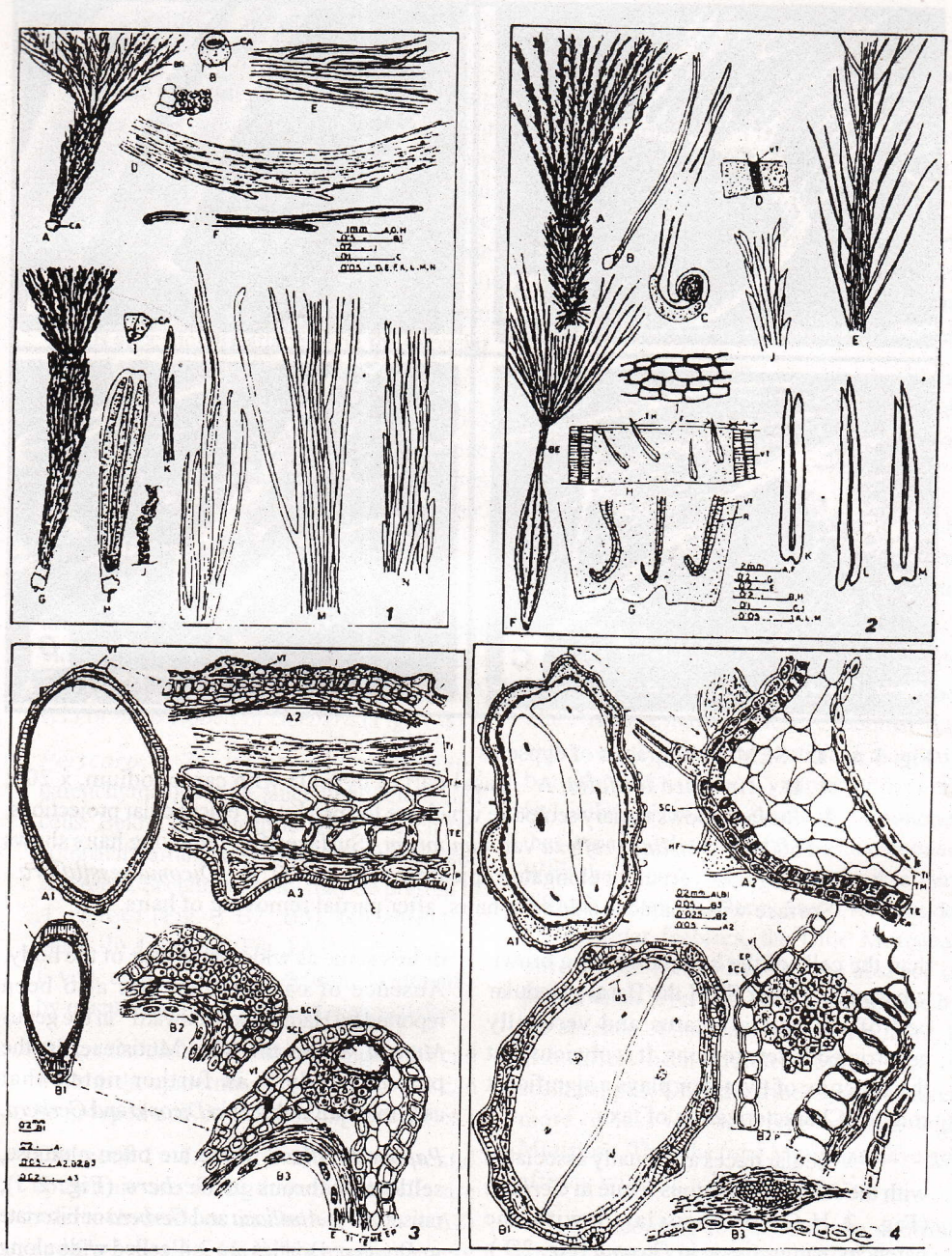
Fig. 1. A - F - *Ainsliaea latifolia*, A - Cypsela; B - Cypselar base; C - Carpopodial cells; D, E - Basal and middle part of pappus birstle; F - Cypselar hair. G - N - *A. reflexa* var. *nimborum*, G - Cypsela; H - Cypsela after clearing and removing pappus bristles and hairs; I - Cypselar base; J - Carpopodial cells; K - Apical part of cypselar hair; L, M, N - Apical, middle and basal part pappus bristle.

Fig. 2. A - E - *Dicoma sessiliflora* ssp. *sessiliflora*, A - Cypsela; B, C - Cypselar hairs; D - Cypselar wall after clearing, showing vascular trace; E - A part of pappus bristle. F - M - *Gerbera jamesonii*, F - Cypsela; G - Basal part of Cypselar wall after clearing; H - Middle part of Cypselar wall after clearing; I - Epicarpic cells; J - Part of pappus bristle; K, L, M - Cypselar hairs.

Fig. 3. Cross section of cypselas
A1 - A3 - *Ainsliaea latifolia*, A1 - Diagrammatic; A2, A3 - A part of cypselar wall, B1 - B3 - *Ainsliaea reflexa* var. *nimborum*, B1 - Diagrammatic, at the basal end of cypsela; B2, B3 - Part of cypselar wall at the ribs.

Fig. 4. Cross section of cypselas
A1 - A2 - *Dicoma sessiliflora* ssp. *sessiliflora*, A1 - Diagrammatic; A2 - A part of cypselar wall at the elevated region. B1 - B3 - *Gerbera jamesonii*, B1 - Diagrammatic; B2 - A part of cypselar wall at the rib; B3 - A part of testa and endosperm.



Abbreviations used in illustrations

BE - Beak; BR - Bristle; C - Cuticle; CA - Carpopodium; E - Endosperm; EP - Epicarp; F - Furrow; HF - Hair foot or base; P - Pericarp; R - Ridge or rib; SCL - Sclerenchyma; SCV - Secretory cavity; TE - Testa epidermis; TH - Twin hair; TI - Testal inner zone; TM - Testal middle zone; VT - Vascular trace or vascular tissue.

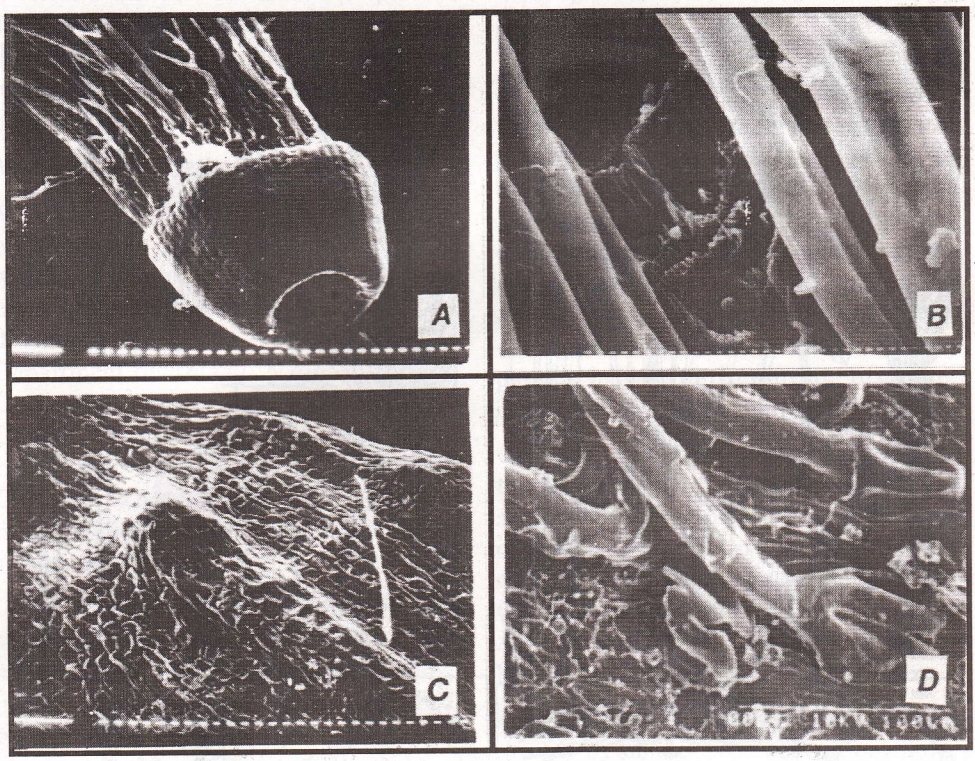


Fig. 5 A - D - SEM photographs of cypselas
A, B - *Ainsliaea latifolia*, A - Basal part of cypsela with carpopodium, x 200; B - Surface shows tertiary sculpture which are formed by the epicuticular projections, x 1600. C - *Ainsliaea reflexa* var. *nimborum* - Surface after removing hairs shows rectangular, vertically elongated epicarpic cells, x 100. D - *Dicoma sessiliflora* - Surface with characteristic twin hairs, after partial removing of hairs.

than the cells of the hair, containing brown substances. Under SEM the Basal glandular cell of the hair is ovatus and vertically constricted in few regions. It is obvious that the structure of twin hair plays a significant role for Characterization of taxa.

Vascular traces are usually associated with the sclerenchymatous tissue in *Gerbera* (Fig. 2 H,G) or associated with the parenchymatous tissue in *Dicoma* (Fig. 2D). In mature cypsela, stylopodium is absent in all species.

Carpopodium : It is present in *Ainsliaea* (Fig. 1 B,I). In *A. latifolia* (Fig. 5 A) carpopodium is circular and prominently wider than the base of the body, while in *A. reflexa* var. *nimborum* (Fig. 1 I), it is obscurely pentagonal in outline and more or less same as wide as the base of the body. Absence of carpopodium has also been reported by Haque and Godward[18] in the genus *Mutisia* within the tribe Mutisieae. In the present study it is further noted that carpopodium is absent in *Dicoma* and *Gerbera*.

Pappus Bristles : These are often plumose, seldom scabrous in *Gerbera* (Fig. 2 J), uniseriate in *Ainsliaea* and *Gerbera* or biseriate in *Dicoma*. Bristles are 3-4-celled wide along with barbellate structure in *Gerbera* (Fig. 2 J), whereas 7-12-celled wide in *Ainsliaea* (Fig. 1 D,E,M,N) and *Dicoma* (Fig. 2 E) and devoid of barbellate structure. Hansen[12] has mentioned that *Gerbera* has 3 cells wide bristles. He has also noted that "A midrib many cells wide is clearly primitive." In case of plumose pappus, the length of the lateral projections of the

pappus bristles is sometimes important for identification of species in *Ainsliaea*.

SEM studies show the following features of the cypselas : i) In *Ainsliaea latifolia* (Fig. 5 B) - cypsela surface reveals tertiary sculpture which is formed by the epicuticular projections and these are represented by large number of wax platelets, arranged side by side very compactly over the epicarpic cells; ii) In *Dicoma* (Fif. 5 D) - basal cell of the twin hair is superficially attached on the cypselar surface, ovatus and vertically constricted.

It is evident from the present studies on the cypselar morphology that these exomorphic microfeatures and macrofeatures can be used as diacritical taxonomic parameter.

CYPSELAR ANATOMY

The present study reveals that the cypselas are often ellipsoid in outline with prominent elevations and depressions in *Dicoma* (Fig. 4 A1) or wavy in *Ainsliaea latifolia* (Fig. 3 A1) or 9-10-ribbed in *Gerbera* (Fig. 4 B1).

Pericarp : It is usually uniseriate, parenchymatous with tangentially elongated cells. Below the epicarpic layer of each rib, compactly arranged sclerenchymatous tissue is present. Secretory cavity may be present in *A. reflexa* (Fig. 3 B2, B3), but absent in others. In *A. latifolia* (Fig. 3 A3) epicarpic zone is very unique since it is delimited externally by epicuticular projections of wax platelets.

Testa : On the basis of thickening of the cell walls in the epidermis of testa the species can be grouped into three following categories :

Category I - Lateral walls of the testal epidermis are strengthened and cells are sclerenchymatic as in *Dicoma* (Fig. 4 A2) and *Gerbera* (Fig. 4 B2). These cells are very larger in *Gerbera* than *Dicoma*. Grau[13] has reported the presence of these type of cells in *Gerbera* and has stated that the cells of the epidermis are prosenchymatic.

Category II - Lateral and basal walls of the testal epidermis strengthened and cells are sclerenchymatic in *Ainsliaea latifolia* (Fig. 3 A3) as has been reported by Grau[13].

Category III - All walls of the testal epidermis are more or less equally strengthened and cells are prosenchymatic in *Ainsliaea reflexa* var. *nimborum* (Fig. 3 B3) and thus the genus *Ainsliaea* has both sclerenchymatic and prosenchymatic cells.

Middle parenchymatous zone of testa may be present or absent in *Ainsliaea reflexa* (Fig. 3 B3) and *Gerbera* (Fig. 4 B2). Inner zone of testa is taxonomically not significant.

Endosperm : It is usually present and uniseriate except in *A. latifolia* (Fig. 3 A2, A3), where this layer is disintegrated in mature cypsela.

Conclusion

From the present investigation it can be concluded that the testal features are more important than the pericarpic features of the cypsela within the tribe Mutisieae.

According to Hansen[12], the tribe Mutisieae is closely related with the tribes like Cynareae and Arctoteae. Cronquist[19] has expressed that the tribe Mutisieae may have been derived from the Cynareae or from the Heliantheae. However, Small[20] has mentioned that it may be developed from Senecioneae. With the help of this short study it is very difficult to draw its affinity. But if we consider the cypselar features, the tribe Mutisieae differs from Heliantheae by the absence of phytomelan layer and from Senecioneae by the absence of biseriate endosperm layer. It also differs from Arctoteae by the lack of scale pappus. Only the tribe Cynareae have more or less identical type of testa with Mutisieae. Thus the tribe Mutisieae have got affinity with the tribe Cynareae[12,19].

According to Cabrera[4] the subtribe Gochnatiinae (*Ainsliaea* and *Dicoma*) is more primitive than Mutisiinae (*Gerbera*). Present study also supports the view of Cabrera[4] regarding the primitiveness of the subtribe Gichnatiinae, because *Gerbera* has some advanced features like beaked cypsela, structure of surface hairs, scabrous pappus bristles and cypselar configuration.

From the phylogenetic view point[5,6]

this tribe is as "unclassified" and as "basal complex of the family Asteraceae".

Thus evidently some cypselar features are worthy in taxonomic point of view. So the cypselar characters can be used as significant taxonomic parameter for construction of more convenient system of classification along with other characters derived from different disciplines in taxonomy.

Key to the studied taxa based on cypselar morpho-anatomical features

1. Pappus plumose; cypsela surface densely covered by twin hairs without any bilobed hair base; cypsela attenuate or truncate at the apex, not ribbed and furrowed or if so, upto 8 - ribbed.....2
2. Lateral walls of the sclerenchymatic testal epidermal cells strengthened; basal glandular cell of the hair much wider than the base of the body cells of the hair; carpopodium absent; pappus bristles biseriate. ....*Dicoma sessiliflora* ssp. *sessiliflora*

2' All walls or lateral and basal walls of the testal epidermal cells strengthened; basal glandular cell of the hair absent; carpopodium present; pappus bristles uniseriate.....3

3. Lateral and basal walls of the testal epidermal cells strengthened; epicuticular projections of wax platelets present; cypsela not ribbed; carpopodium circular; lateral projections of the pappus bristles 1.5 - 2.3 mm long ..... *Ainsliaea latifolia*

3' All walls of the testal epidermal cells more or less equally strengthened; epicuticular projections absent; cypsela 8-ribbed; carpopodium obscurely pentagonal; lateral projections of the pappus bristles 0.7 -1.3 mm long ..... *Ainsliaea reflexa*

1' Pappus scabrous; cypsela surface sparsely covered by very short twin hairs with bilobed base; cypsela beaked at the apex and prominently 9 to 10 - ribbed ..... *Gerbera jamesonii*

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