



EXOMORPHOLOGY AND INTERNAL STRUCTURE OF CYPSELAS OF SEVEN SPECIES OF THE TRIBE CARDUEAE (COMPOSITAE)

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Cypselar morpho-anatomy is very helpful for the separation of taxa, when flowering condition is unavailable i.e. fruiting condition is available. For this purpose, cypselas of seven species belonging to five genera (*Arctium lappa*, *Cirsium arvense*, *Cirsium candelabrum*, *Cirsium heleniodes*, *Mantiscalca salmantica*, *Saussurea fastuosa* and *Xeranthemum annuum*) of the tribe Cardueae have been investigated. The important morphological features are the presence of surface structure, pappus bristles, stylopodia, carpopodia with cellular orientation etc. Except in the cypselas of *Mantiscalca salmantica* and *Arctium lappa*, the remaining 5 studied cypselas are homomorphic. In the cypselas of *Xeranthemum annuum*, surface is pubescent, whereas in remaining 6 studied cypselas, surface is rough and glabrous. In the cypselas of *Arctium lappa*, *Cirsium arvense*, *Cirsium heleniodes* and *Cirsium candelabrum*, stylopodia are prominent and enlarge than the remaining studied cypselas where they are inconspicuous. Carpopodia are the basal, meristematic zone of cypselas. In the cypselas of *Cirsium arvense*, *Arctium lappa*, *Mantiscalca salmantica* and *Cirsium candelabrum*, pseudocarpopodia are present, whereas in remaining studied cypselas carpopodial cells are arranged from 1 layer (*Cirsium heleniodes*, *Xeranthemum annuum*) to 2 layers (*Saussurea fastuosa*). Pappus structures help in the dispersal of cypselas. In the cypselas of *Saussurea fastuosa*, *Cirsium heleniodes* and *Cirsium candelabrum*, plumose type of pappus bristles are present, whereas in the cypselas of *Mantiscalca salmantica* barbellate pappus bristles are present. In the cypselas of *Xeranthemum annuum*, scaly pappus is present. Among the studied cypselas, in *Arctium lappa* and *Cirsium arvense*, pappus are absent. Anatomically, the mesocarpic region is very interesting than other layer of pericarp. In the cypselas of *Saussurea fastuosa*, *Cirsium heleniodes* and *Xeranthemum annuum*, mesocarpic regions are heterogeneously developed than the other studied cypselas where mesocarpic regions are homogeneously developed. In the cypselas of *Arctium lappa*, crystal is present in the mesocarpic region but in six studied cypselas crystals are absent. Presence of secretory duct is also an important taxonomic character and which is present in the mesocarpic region of the cypselas of *Mantiscalca salmantica* and *Cirsium candelabrum*. In remaining five studied cypselas, secretory ducts are absent. In the cypselas of *Cirsium candelabrum*, internal to the testal region vellicular cavity is present, whereas in the cypselas of *Xeranthemum annuum*, vellicular cavity is present within the mesocarpic region. In the cypselas of *Saussurea fastuosa* and *Xeranthemum annuum*, testal layers are made up of round-elongated, uni-seriately arranged, parenchyma cells, whereas in rest studied cypselas, testal layers are made up of vertically arranged, thick-walled, palisade parenchyma cells.

Key Words : Cypselar exomorphology and internal structures, Cardueae, Compositae

The broadly defined tribe Cardueae consists of four subtribes (Bentham, 1873), which are Echinopsidinae, Carlinae, Carduinae and Centaureinae. Bremer (1996) has recognized the tribe Cardueae as subfamily Carduoideae. The exomorphology and internal structure of cypselas of this tribe has a great importance for the better classification of taxa. Lavalie (1912) has studied the cypselar features of about 15 genera and 83 species of this tribe. He pointed out the importance of crystals and secretory ducts which are present in the mesocarpic region of cypselas of this tribe. Presence of calcium oxalate crystals has been reported by Hanausek (1911) and Singh and Pandey (1984) etc. in this tribe. Importance of cypselar exomorphology and internal structure of cypselas in this tribe has been reported by authors like Mukherjee (2000) Fourment and Rouzet (1957), Carlquist (1958), Chauhan (1972), Jana and Mukherjee (2012), Zarembo and Boyko (2008). According to Roth (1977) not only the exomorphology

of cypselas but also the internal characters are also helpful for better taxonomic treatment. The objective of the present paper is to show the cypselar features of this tribe in detail and to show the relationship on the basis of present observation.

MATERIALS AND METHODS

Mature, dry, identified cypselas were collected from 4 Herbaria of the world and 1 specimen from Sikkim, by first author, which are given in the Table -1.

For morphological observation, cypselas were softened by NaOH (2 %) solution and after that they were stained by using safranin-light green combination (4 %) and finally observed under simple dissecting microscope (Meopta, Praha, 65301, made in Czechoslovakia) and stereo biocular dissecting microscope (Olympus, made in Tokyo, Japan). For anatomical observation, hand sections

Table-1: List of taxa studied and their sources.

Sl. No.	Name of Taxa	Source
1	<i>Arctium lappa</i> L.	Humboldt- Universitat zu Berlin. Institut fur Biologie, Spezielle Botanik u. Arboretum, Berlin, Germany. Collection Number- 704.
2	<i>Cirsium arvense</i> (L.) Scop.	Conservatoire Et Jardin Botaniques Geneve- Geneva, Switzerland. Collection Number- 107.
3	<i>Cirsium candelabrum</i> Griseb.	Botanic Garden and Museum of the University of Copenhagen (Natural History Museum of Denmark). Collection Number- 268 S2000-0876 A W Kit Tan 24698.
4	<i>Cirsium heleniodes</i> (L.) Hill	Botanischer Garten der Universitat Zurich. Collection Number- CHOZ -20031567
5	<i>Mantiscalca salmantica</i> (L.) Brig. Et casill.	Botanic Garden and Museum of the University of Copenhagen (Natural History Museum of Denmark). Collection Number- 389 E 2867-B001 A G
6	<i>Saussurea fastuosa</i> (Decne.) Sch. Bip.	Sikkim. Collection Number- 52.
7	<i>Xeranthemum annuum</i> L.	Botanischer Garten der Universitat Zurich. Collection Number- XXOZ 20040897

were done by sharp razor blade from the middle part of cypsela and finally the good sections were taken for anatomical observation under compound light microscope (Metzer).

OBSERVATIONS AND DISCUSSION

Arctium lappa

Morphology (Fig 1 A-E)

Cypsela heteromorphic. Ray cypsela 5 mm x 2 mm, creamy brown, blotched, narrow oblanceolate, slightly curved, upper part truncate whereas lower part narrow. Disk cypsela 6 mm x 2 mm, offwhite, blotched, straight, upper part truncate, whereas lower part tapered. Ellipsoidal in cross sectional configuration. Surface rough and glabrous containing 14-18 ribs, alternating with furrows. Furrows wider than the ribs. Pappus absent. At the upper part of cypsela, stylopodium present; enlarge, cylindrical. At the basal region of cypsela, carpodium present, narrower than the base, quadrangular. Carpodial cells are not clearly distinct from the remaining part of cypselas.

Anatomy (Fig 2 A)

Cypsela elliptic in cross section. Ribs present; 14-18 in number, conspicuous. Cypselar wall 0.04 mm and 0.06 mm wide at ribs and furrow region re-

spectively. Pericarp thick, differentiated into epicarp, mesocarp and endocarp. Epicarp uni-seriate, thin - walled, triangular – quadrangular, compactly arranged, parenchyma cells provided with cuticle. Internal to the epicarp, mesocarp present; made up of thin - walled, rounded, compactly arranged, parenchyma cells containing crystals. Internal to the mesocarp, endocarp present; thin walled, parenchymatous, uniseriately arranged. Testa attached with cypselar wall, approximately 0.04 mm thick, made up of thick-walled, vertically placed, palisade parenchyma cells. Endosperm persists in mature cypsela, uniseriate, thick-walled, parenchymatous. Mature embryo occupies a major part of cypsela; cotyledons 2 in number, arranged oblique to the axis of cypsela, containing 6 resin ducts (3 ducts in each cotyledon).

Cirsium arvense

Morphology (Fig 1 F-H)

Cypsela homomorphic, 3 mm x 0.5 mm, black brown, obovate, slightly curved, upper part truncate whereas lower part tapered, ellipsoidal in cross sectional configuration. Surface glabrous, ribs absent. Pappus absent. At the upper portion of cypsela, stylopodium present, enlarge, dome shape, free. At the basal region of cypsela, carpodium present, narrow than the base, irregular ring like. Carpodial cells not

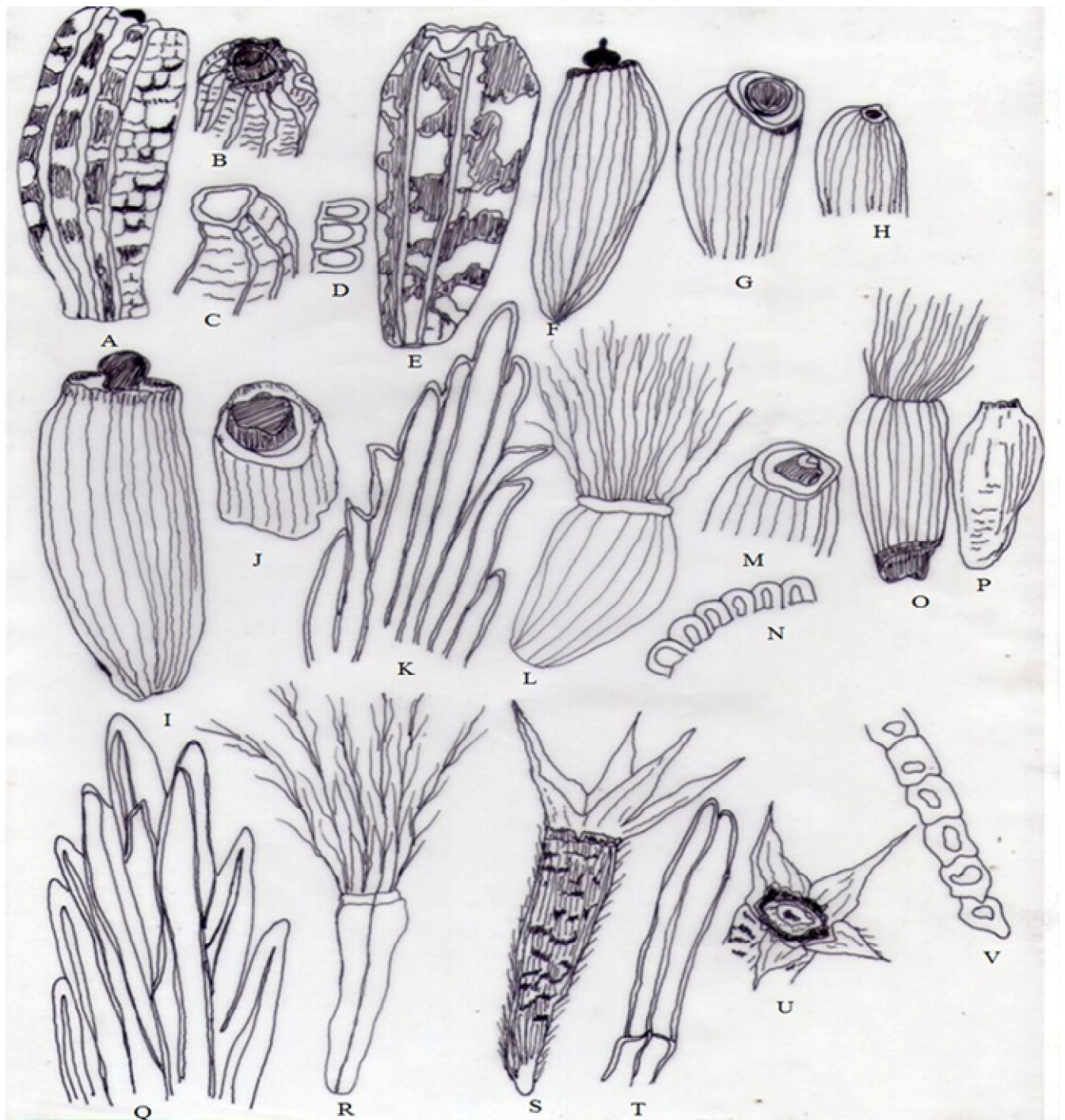


Figure 1. A-V. Cypselar morphology of studied species.

Figs. A-E- *Arctium lappa*: A- Ray cypsela, B- Upper part of cypsela, C- Lower part of cypsela, D- Carpopodial cells, E- Disk cypsela; F-H- *Cirsium arvanse*: F-Cypsela, G- Upper part of cypsela, H- Lower part of cypsela; I-K: *Cirsium candelabrum* : I- Cypsela, J- Upper part of cypsela, K- Upper part of pappus bristles; L-N: *Cirsium heleniodes*: L- Cypsela, M-Upper part of cypsela, N- Carpopodial cells; O-Q- *Montisalea salmantica*: O- Ray cypsela, P- Disk cypselas, Q- Upper part of pappus bristles; R-Cypsela of *Saussurea fastuosa*; S-V- *Xeranthemum annuum* : S-Cypsela, T- Surface hair, U- Upper part of cypsela, V- Carpopodial cells.

clearly distinguish from the remaining part of cypsela i.e. pseudocarpopodium.

Anatomy (Fig 2 B)

Cypsela elliptic in cross section. Ribs absent. Pericarp thin, on an average 0.02 mm, differentiated in to epicarp and mesocarp. Epicarp uniseriate, made up of thin walled, compactly arranged, rectangular, parenchyma cells, provided with cuticle. Internal to the epicarp, mesocarp present; homogenous, made up of thick-walled, rounded, compactly arranged, parenchyma cells. Testa attached with cypselar wall, approximately 0.02 mm thick, made up of thick-walled, elongated, vertically oriented, palisade parenchyma cells, uniseriately arranged. Endosperm persists in mature cypsela, biseriate, outer layer made up of crusted layer of parenchyma cells whereas inner layer made up of thick walled, barrel shape parenchyma cells. Mature embryo occupies a major part of the cypsela; cotyledons two in number, arranged at right angle to the axis of cypsela, containing 6 resin ducts (3 ducts in each cotyledon).

Cirsium candelabrum

Morphology (Fig 1 I-K)

Cypsela homomorphic, 4 mm x 1 mm, brownish, oblong, straight, margin entire, upper part truncate whereas lower part slightly tapered. Surface glabrous. Ribs absent. Stylopodium prominent, enlarge, dome shape. Pappus homomorphic, represented by 20-29, unequally arranged, plumose type of pappus bristles, brownish, arranged in single whorl. At the basal region of cypsela, carpopodium present, symmetric, biconvex. Carpopodial cells not clearly distinct from the remaining part of cypsela i.e. pseudocarpopodium.

Anatomy (Fig 2 C)

Cypsela elliptic in cross sectional configuration. Ribs absent. Pericarp thick, on an average 0.02 mm wide, differentiated into two zones- epicarp and mesocarp. Epicarp uniseriate, made up of thin walled, cubical, parenchyma cells, provided with cuticle. Internal to the epicarp, mesocarp present; made up of thick walled, rounded, compactly arranged, parenchyma

cells, containing secretary duct. At the basal region of secretary duct, vascular trace present. Testa attached with cypselar wall, approximately 0.029 mm thick, uniseriate, made up of thick walled, vertically placed, palisade parenchyma cells. Internal to the testal region, vellicular cavity present. Endosperm persists in mature cypsela; biseriate. Outer layer made up of thick walled, rectangular, parenchyma cells with vascular trace whereas inner layer made up of thick walled, barrel shaped, compactly arranged, parenchyma cells. Mature embryo occupies a major part of the cypsela; cotyledons two in number, arranged oblique to the axis of cypsela, containing 10 resin ducts (5 ducts in each cotyledon).

Cirsium heleniodes

Morphology (Fig 1 L-N)

Cypsela homomorphic, 24 mm x 1 mm with pappus, 6 mm x 1 mm without pappus, light brown, oblanceolate, curved, margin entire, upper part truncate where as lower part compressed, ellipsoidal in cross sectional configuration. Surface rough and glabrous containing 6 ribs, alternating with furrow. Furrows wider than ribs. At the upper part of cypsela, stylopodium present, enlarge, cylindric. Pappus homomorphic, represented by 18-22, unequally arranged, white, plumose type of pappus bristles. At the basal region of cypsela, carpopodium present, narrow than the base, biconvex, symmetric. Carpopodial cells with thick-walled, medium, not pitted, arranged in single row.

Anatomy (Fig 2 D)

Cypsela elliptic in cross section. Ribs present; 6 in number, inconspicuous. Cypselar wall 0.19 mm and 0.14 mm wide at ribs and furrow region respectively. Pericarp thick, differentiated into two zones- epicarp and mesocarp. Epicarp uniseriate, made up of thin walled, rectangular, compactly arranged, parenchyma cells, provided with cuticle. Internal to the epicarp, mesocarp present, heterogenous, made up of thin walled, circular, compactly arranged parenchyma cells and thickwalled, circular, compactly arranged, sclerenchyma cells containing vascular trace. Testa attached with cypselar wall, approximately 0.02 mm thick, made up of vertically placed, thick-walled, palisade parenchyma cells, uniseriately

arranged. Endosperm persists in mature cypselas, uniseriate, made up of thick walled, horizontally placed, parenchyma cells. Mature embryo occupies a major part of cypselas, cotyledons 2 in number, arranged oblique to the axis of cypselas, containing 6 resin ducts (3 ducts in each cotyledon).

Mantisalca salmantica

Morphology (Fig 1 O-Q)

Cypselas heteromorphic. Ray cypselas 5 mm x 1 mm including pappus, 3 mm x 1 mm excluding pappus, yellow brown, oblanceolate, straight, upper part truncate, whereas lower part slightly tapered with entire margin. Disk cypselas 3 mm x 0.5 mm, light yellow, oblanceolate, straight, middle part slightly swollen, tapered at both ends. Ellipsoidal in cross sectional configuration. Surface glabrous. At the upper part of cypselas, stylopodium present, inconspicuously develop, fully immersed into the nectar. Pappus homomorphic, represented by 19-24, unequally arranged, barbellate setose type of pappus bristles, white yellow, arranged in 3 rows. Carpopodium basal in position, symmetric, biconvex. Carpopodial cells not clearly observed from the remaining part of cypselas i.e. pseudocarpodia.

Anatomy (Fig 2 E)

Cypselas elliptic in cross section. Ribs absent. Pericarp thick, approximately 0.02 mm, differentiated into three zones- epicarp, mesocarp and endocarp. Epicarp uniseriate, made up of thin walled, rectangular, compactly arranged, parenchyma cells, provided with cuticle. Internal to the epicarp, mesocarp present, made up of thick walled, rounded, compactly arranged, parenchyma cells, with secretory duct. Internal to the mesocarpic region, endocarp present, parenchymatous, uniseriately arranged. Testa attached with cypselar wall, approximately 0.06 mm thick, made up of, vertically arranged, thickwalled, palisade parenchyma cells. Endosperm persists in mature cypselas, uniseriate, made up of thick walled, barrel shaped, parenchyma cells. Mature embryo occupies a major part of cypselas; cotyledons 2 in number, arranged oblique to the axis of cypselas, containing 16 resin ducts (8 ducts in each cotyledon).

Saussurea fastuosa

Morphology (Fig 1 R)

Cypselas homomorphic, 15 mm x 1.5 mm including pappus, 6 mm x 1.5 mm excluding pappus, black brown, linear, straight, upper part truncate whereas lower part tapered. Irregular in cross sectional configuration. Surface rough and glabrous, containing 10 ribs, alternating with furrow. Furrows wider than the ribs. At the upper portion of cypselas, stylopodium present; inconspicuously arranged, fully immersed in the nectar. Pappus represented by 10-17, unequally arranged, plumose type of pappus bristles, light yellow in colour. At the basal region of cypselas, carpopodium present, narrow than the base, irregular ring like. Carpopodial cells with thick walled, biseriately arranged.

Anatomy (Fig 2 F)

Cypselas irregular in cross section. Ribs present, 10 in number, conspicuous. Cypselar wall 0.05 mm and 0.01 mm wide at rib and furrow region respectively. Pericarp thick, differentiated into two zones-epicarp and mesocarp. Epicarp uniseriate, made up of thin walled, rectangular, compactly arranged, parenchyma cells provided with cuticle. Internal to epicarp, mesocarp present; heterogenous, made up of thin walled, circular, compactly arranged, parenchyma cells and thick walled, circular, compactly arranged, sclerenchyma cells. Testa attached with cypselar wall, approximately 0.014 mm thick, made up of thick walled, round to square, compactly arranged, parenchyma cells, uniseriately arranged. Endosperm persists in mature cypselas, biseriate. Outer cells wide-barrel shaped and inner cells narrow-barrel shaped. Cells of both the layers thick walled, parenchymatous, compactly arranged. Mature embryo occupies a major part of the cypselas. Cotyledons 2 in number. Cotyledonary resin ducts are not clearly distinguish.

Xeranthemum annuum

Morphology (Fig 1 S-V)

Cypselas homomorphic, 6 mm x 0.5 mm including pappus, 4 mm x 0.5 mm excluding pappus, black brown, oblanceolate, straight, upper part truncate

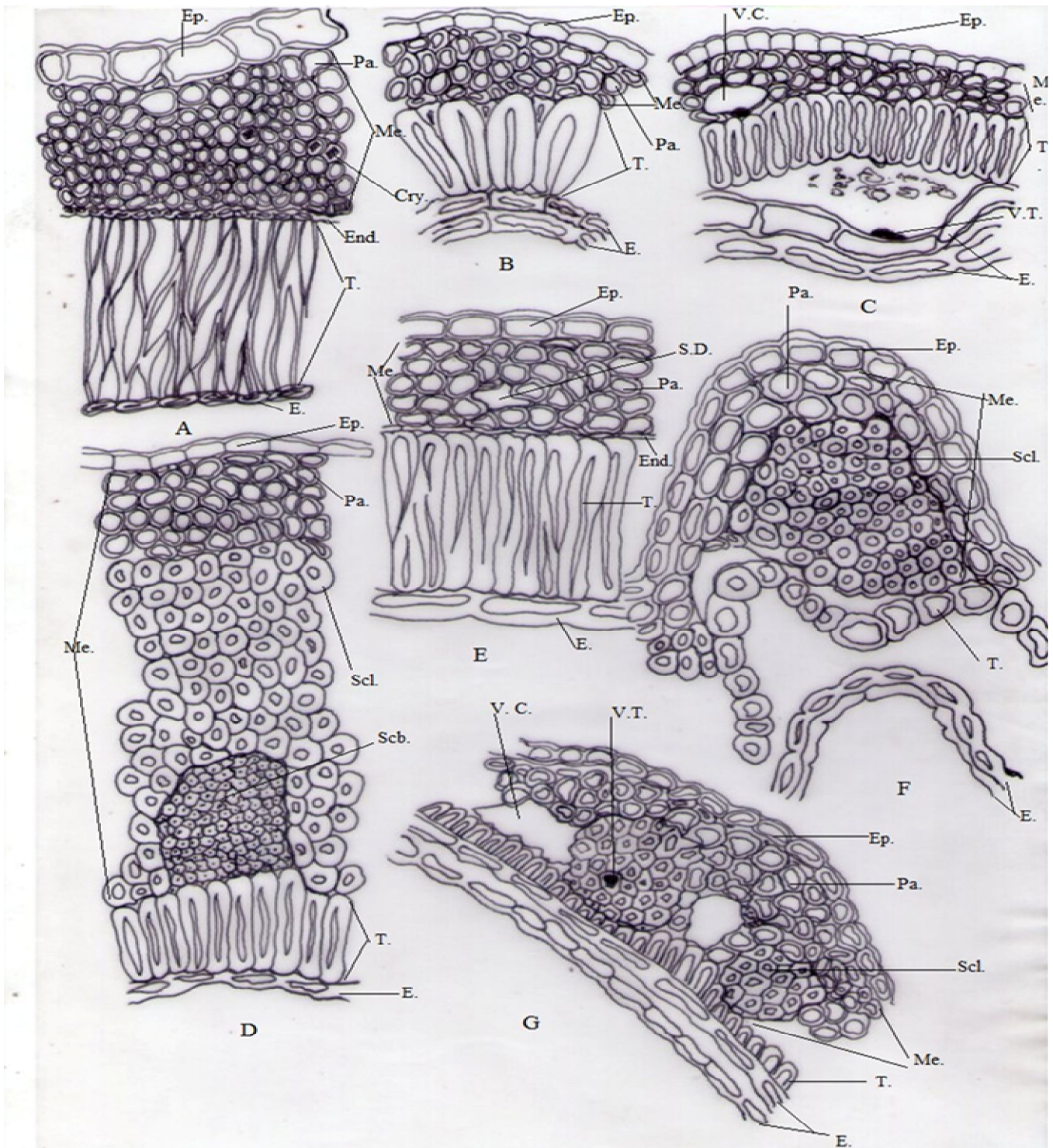


Figure 2. A-G. Cypselar anatomy of studied species.

A. *Arctium lappa*, B. *Cirsium arvanse*, C. *Cirsium candelabrum*, D. *Cirsium heleniodes*
 E. *Montisalea salmantica*, F. *Saussurea fastuosa*, G. *Xeranthemum annuum*

List of abbreviations:

Ep.- Epicarp, Me.- Mesocarp, T.- Testa, End- Endocarp, E- Endosperm, Pa- Parenchyma, Scl- Sclerenchyma, V.T.- Vascular trace, V.C.- Vellicular cavity, S.D.- Secretory duct, Scb- Sclerenchyma bundle.

whereas lower part tapered, entire margin. Ellipsoidal in cross sectional configuration. Surface pubescent. Surface hair ascending-inclined in orientation with the surface, made up of body and basal cells. The tip portion of body cells with bifurcation and arranged in different plain. Surface containing 16-18 ribs, alternating with furrows. Furrows wider than ribs. The distance between two ribs 0.17 mm. At the upper portion of cypsela, stylopodium present, inconspicuous, fully immersed into the nectar. Pappus represented by 4 scarious, subulate, apically pinnate scale, equal. At the basal region of cypsela, carpodium present, narrower than the base, asymmetric, irregular ring like. Carpodial cells with thick walled, rectangular, not pitted, arranged in single row.

Anatomy (Fig 2 G)

Cypsela elliptic in cross section. Ribs present; 16-18 in number, inconspicuous. Cypselar wall 0.09 mm and 0.03 mm wide at ribs and furrow region respectively. Pericarp thick, differentiated into two zones-epicarp and mesocarp. Epicarp uniseriate, made up of round to ovoid, thin walled, parenchyma cells, provided with cuticle. Internal to the epicarp, mesocarp present, made up of round to ovoid, thick walled, parenchyma cells and thick walled, pentangular, sclerenchyma cells containing vascular bundle near the ribs region. Within the mesocarpic region, vellicular cavity present. Testa attached with cypselar wall, approximately 0.008 mm thick, uniseriate, made up of, thick walled, cubical, parenchyma cells. Endosperm persists in mature cypsela, biseriate. Outer layer made up of, thick walled, rectangular, compactly arranged, parenchyma cells and inner layer made up of thick walled, barrel shaped, parenchyma cells. Mature embryo occupies a major part of the cypsela; cotyledons two in number, arranged at right angle to the axis of cypselar wall, containing 18 resin ducts (9 ducts in each cotyledon).

Cypselar Morphology

Shape of cypselas are usually narrow oblanceolate – linear- narrow oblong-obovate. Cypsela with narrow oblong is also reported by Mukherjee (2000)

in *Carlina* and *Echinops* of this tribe. Except in the cypsela of *Xeranthemum annuum*, the remaining studied cypselas are with rough and glabrous surface, whereas in the cypsela of *Xeranthemum annuum*, surface is pubescent, containing twin hairs. Twin hair is also reported in some other species (*Centaurea cyanus*) of this tribe (Mukherjee 2000, Mukherjee and Nordenstam 2012). At the upper portion of cypselas, stylopodia are present. Among the studied cypselas, in *Xeranthemum annuum*, *Saussurea fastuosa* and *Mantiscalca salmantica* stylopodia are inconspicuously developed but in remaining 4 studied cypselas, stylopodia are very prominent and enlarged. Mukherjee (2005) and Wetter (1983) have studied the stylopodial features in some Asteraceae and they have mentioned the different structures of stylopodia in Asteraceae. Present observation regarding the stylopodial features are clearly indicated with the studies of Mukherjee (2005) and Wetter (1983). At the basal region of cypselas, carpodia are present. Carpodia are usually regular or irregular ring like structure and there are usually symmetric or some time asymmetric in nature (*Cirsium arvense*, *Cirsium canadelabrum*, *Mantiscalca salmantica*). Diameter of carpodia may be as wide as the base of cypsela or narrower than the base of cypsela as in *Arctium lappa*, *Cirsium arvense* etc. Carpodium is a meristematic zone with variable layers of cellular orientation. In the cypsela of *Cirsium arvense*, *Arctium lappa*, *Mantiscalca salmantica* and *Cirsium candelabrum*, pseudocarpodia are present i.e. carpodial cells are not distinguishable from other epicarpic cells of cypselas, whereas in remaining studied cypselas, carpodial cells are arranged from 1 layer (*Cirsium heleniodes*, *Xeranthemum annuum*) to 2 layers (*Saussurea fastuosa*). Carpodial structures of some genera (*Echinops*, *Centaurea*) of this tribe have been reported by Haque and Godward (1984). Mukherjee and Nordenstam (2004), have indicated that majority members of this tribe possess strongly asymmetric ring like carpodia. In the cypsela of *Saussurea fastuosa*, *Cirsium heleniodes* and *Cirsium candelabrum*, plumose type of pappus bristles are present, while the cypsela of *Man-*

tiscalca salmantica pappus bristles are barbellate type. Only in the cypsela of *Xeranthemum annuum*, scaly pappus has been observed. Among the studied cypselas, *Arctium lappa* and *Cirsium arvense* lacks pappus bristles. Pappus is the main organ for the dispersal of cypselas. Dittrich (1977) has contributed regarding the pappus structures of the tribe Cardueae.

Cypselar Anatomy

Anatomically, all the cypselas are elliptic to irregular in cross section. Among the studied cypselas, pericarpic region is differentiated into 2-3 zones. Within the pericarpic region, the mesocarpic region is more interesting than the other layers. In the cypsela of *Saussurea fastuos*, *Cirsium heleniodes* and *Xeranthemum annuum*, mesocarpic regions are heterogeneously developed rather than the other studied cypselas, where mesocarpic regions are homogeneously developed. In the cypsela of *Arctium lappa*, crystals are present in the mesocarpic region but in remaining 6 studied cypselas, crystals are absent. Zarembo and Boyko (2008) have reported the presence of crystals in the inner layer of pericarp and testa. They had also mentioned that the crystals are formed by calcium oxalate and have complex inner organization. Dormer (1961, 1962) has studied the crystal structure in the ovaries of certain Compositae (*Centaurea*, *Cirsium* and others), whereas Mukherjee and Nordenstam (2010), have studied the crystal structure in Compositae and they have mentioned the presence of crystals only in *Arctium lappa* among the studied taxa of this tribe. Taxonomically, secretory ducts have great importance in the tribe Cardueae (Dittrich, 1977). Among the studied cypselas *Mantisalca salmantica* and *Cirsium candelabrum* secretory ducts are present which are absent in five other studied taxa. Secretory ducts are also absent in some genera *Amberboa* (Pers.) Less., *Yunquea* Skotts. in this tribe as has been reported by Chauhan (1972), Carlquist (1958). On the basis of the structure of testal epidermal cells, the studied species could be divided into 2 categories:

1. Testal epidermal cells are palisade like in appearance. e.g. *Arctium lappa*, *Cirsium arvense*, *Cirsium candelabrum*, *Cirsium heleniodes*, *Mantisalca salmantica* and *Saussurea fastuosa*.

11. Testal epidermal cells are cuboidal parenchyma cells. e.g. *Xeranthemum annuum*

In *Arctium lappa*, *Cirsium heleniodes* and *Mantisalca salmantica* endosperm layer is uniseriately develop, whereas in remaining 4 studied cypselas, endosperm layers are biseriately oriented. Biseriately development of endosperm layer have been reported by Singh and Pandey (1984) in some species (*Carthamus baeticus* and *Saussurea heteromella*) of this tribe. Number of resin ducts of each cotyledon is more or less fixed and is one of the diacritical features of cypselas in Compositae. Each cotyledon has 3 (*Cirsium heleniodes*, *Cirsium arvense*, *Arctium lappa*), 5 (*Cirsium candelabrum*), 8 (*Mantisalca salmantica*), or 9 (*Xeranthemum annuum*) resin ducts but in *Saussurea fastuosa*, resin duct is not clearly visible. Variable type of resin ducts have also been reported by Mukherjee (2000) in the same tribe.

From this study, it can be concluded that morpho-anatomical features of cypselas are equally valuable as other taxonomic parameters, which are employed for proper identification of taxa along with other floral and vegetative characters in the tribe Cardueae.

Key to the studied species

- 1a. Pappus absent; 3 resin ducts in each cotyledon.....(2)
- 2a. Mesocarp with calcium oxalate crystals..... *Arctium lappa*
- 2b. Mesocarp without calcium oxalate crystals.....*Cirsium arvense*
- 1b. Pappus present; resin ducts are either not clearly observed or varies from 3-5-8 in each cotyledon.....(3)

- 3a. Carpoid cells not clearly distinguishable from the epidermal cells, i.e. pseudocarpodia; mesocarp homogenous; cotyledonary resin ducts varies from 5-8.....(4)
- 4a. Stylopodium prominent; cotyledonary resin ducts 5 in number... *Cirsium candelabrum*
- 4b. Stylopodium inconspicuous; cotyledonary resin ducts 8 in number..... *Mantisalca salmantica*
- 3b. Carpoid cells distinct from epidermal cells of epicarp; pappus may be either plumose or scaly type; mesocarp heterogenous; cotyledonary resin ducts either not clearly observed or varies from 3-8 in each cotyledon.....(5)
- 5a. Pappus plumose type.....(6)
- 6a. Carpoid cells arranged in 1 layer..... *Cirsium heleniodes*
- 6b. Carpoid cells arranged in 2 layers..... *Saussurea fastuosa*
- 5b. Pappus scaly type..... *Xeranthemum annuum*

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