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Inter tribal variations of fruit structure among four tribes of the family Compositae

Bidyut Kumar Jana* **and Sobhan Kr. Mukherjee**

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

Abstract

Variations of fruit structure of six species (*Aster albanicus*, *Carpesium cernuum*, *Helianthus debilis*, *Leptorhynchos elongates*, *Podotheca angustifolia* and *Zinnia haageana*), under four tribes- Astereae, Heliantheae, Inuleae and Gnaphaleae of the family Compositae have been studied to observe the detailed morpho-anatomical features, among them. In all the studied fruits, there are great variations of morpho-anatomical features. Morphologically, special attention has been taken to the shape, size, colour, pappus type, stylopodia, carpopodia of the fruits. Among the studied cypselas, in case of *Carpesium cernuum* and *Helianthus debilis*, pappus bristles are absent. In the cypsela of *Zinnia haageana*, insteade of pappus bristle, awn like structure is present. In the cypsela of *Carpesium cernuum*, surface is glabrous than the remaining five studied cypselas, where the surface is pubescent. Morphologically, phytomelanin layer is exist in the cypselar wall of *Helianthus debilis* and *Zinnia haageana*. As, the two species are belongs to the tribe Heliantheae and phytomelanin layer is an important characteristic features of the tribe Heliantheae. Anatomically, mesocarpic region is well studied than another region of the pericarp due to the greait cellular variations in mesocarpic region. In the cypsela of *Aster albanicus*, *Leptorhynchos elongates* and *Zinnia haageana*, vellicular cavity is exists in the mesocarpic region. In the cypsela of *Carpesium cernuum*, secretary cavity is present in the mesocarpic region. Among the studied cypselas, testal layer is also interesting. In the cypsela of *Leptorhynchos elongates* and *Podotheca angustifolia*, testal layer is made up of U-shaped parenchyma cells. The orientation of cotyledons in relation to the cypselar wall is taxonomically significant.The number of resin ducts in each cotyledon is greatly variable.

Key words: Variations of fruit structure; four tribes; Compositae

The family Compositae is one of the largest and highly evolved family among the dicotyledons, consisting of 43 tribes, 1600-1700 genera and 24000 species[5]. In India, there are about 177 genera and 1,052 species belonging to this family[17] and which is very interesting to the taxonomist, due to the great diversity of habit, habitat, morphology and histology of vegetative and reproductive structures[2]. The members of the family Compositae are easily recognized by some characteristic features, which are pseudoanthial heads with a specialized type of pollen presentation mechanism and pappus structure[14], nature of fruit[4] and their particular array of chemical weapons[6]. In spite of the presence of these aforesaid features of this family, in the present study, special attention has been taken to the morpho-anatomical features of fruits of seven species of this family.There is a requirement of detailed information about the cypselar features for the all the tribes of Asteraceae. In this connection, the present study has been taken.

Dry, mature, identified, disease free fruits were procured from the different foreign herbaria of the world, which are given in the table below.

Aster albanicus :

Morphology (Fig. 1 A-E)

Cypsela homomorphic, 8 mm x 1 mm including pappus, 4 mm x 1 mm excluding pappus, yellow brown, slightly curved, upper part truncate whereas lower part tapered, ellipsoidal in cross sectional configuration. Surface pubescent. Surface hair ascending in orientation with the surface, made up of body and basal cells. Surface containing 6 ribs, alternating with furrows. Furrows wider than the ribs. The tip portion of body cell with bifercation, arranged in different plane. At the upper portion of cypsela, stylopodium present; inconspicuous, fully immersed into the nectary. Pappus homomorphic, represented by 15-20, yellowish, unequal, serrulate-setose type of pappus bristles. At the basal region of cypsela, carpopodium present; narrow than the base, symmetric. Carpopodial cells with thick-walled, large, rectangular-square, arranged in 3 rows.

Table-1. Showing the number of studied species and their sources

Name of studied taxa	Sources
1. *Aster albanicus* Degen.	Botanic Garden of the University of Copenhagen, Danmark. 211S2000-0862*A
2. *Carpesium cernuum* L.	Botanischer Garten der Universitat Zurich, Zollikerstrasse 107, CH-8008, Zurich, Switzerland. XXOZ-20051457
3. *Helianthus debilis* Nutt.	North Central Regional Plant Introduction Station, Ames.
4. *Leptorhynchos elongates* DC.	Herbarium CBG, CBG-8906276
5. *Podotheca angustifolia* (Labill.) Less.	Botanic Garden of Adelaide, South Australia.
6. *Zinnia haageana* Regel	Botanic Garden of the University of Copenhagen, Danmark. 497 E2493-0005*AG

Cypselas were processed following the methodology of Jana and Mukherjee[7].

Anatomy *(Fig. 3 A-B) :*

Cypsela elliptic in cross-sectional configuration. Ribs present; 6 in number, conspicuous. Cypselar wall 0.04 mm and 0.01 mm thick in ribs and furrow region respectively. Pericarp thick and devided in to epicarp and mesocarp.Epicarp uni-seriate, made up of thick-walled, rectangular-quadrangular, parenchyma cells, provided with cuticle. Internal to the epicarp, mesocarp present. Outer region of mesocarp made up of dark colour, pigment containing tissue region. Inner region of mesocarp made up of penta-hexagonal, sclerenchyma cells, containing vascular trace. Internal to the mesocarpic region, vellicular cavity present. Testa attached with cypselar wall, approximately 0.008 mm thick, made up of rectangular, thick-walled, horyzontally placed, parenchyma cells, uni-seriately arranged. Endosperm layer not clearly observed. Mature embryo occupies a major part of cypselas. Cotyledons 8 in number, arranged at right angle to the axis of cypselas, containing 8 resin ducts (4 ducts in each cotyledon).

Carpesium cernuum :
Morphology: (Fig. 1 F-J) :

Cypsela homomorphic, 2 mm x 0.5 mm, light brown, slightly curved, upper part blunted whereas lower part slightly tapered, round to ellipsoidal in cross sectional configuration. Surface glabrous, containing 15 ribs, alternating with furrows. Furrows wider than the ribs. Pappus absent. Stylopodium inconspicuously developed. At the basal region of cypsela, stylopodium present; narrow than the base, symmetric, triangular. Carpopodial cells with thick walled, rectangular, horizontally placed, uniseriately arranged.

Anatomy: (Fig. 3 C-D) :

Cypsela round to ellipsoidal in cross sectional configuration. Ribs present, 15 in number, conspicuous. Cypselar wall 0.03 mm and 0.02 mm wide at ribs and furrow region respectively. Pericarp thick, differentiated into epicarp and mesocarp. Epicarp uni-seriate, made up of thin walled, rectangular, horizontally placed, parenchyma cells, provided with cuticle. Internal to the epicarpic region, mesocarp present. Outer region of mesocarp made up of thick walled, pentangular-hexagonal, compactely arranged, sclerenchyma cells, containing secretary cavity just below the furrow region. In the ribs region, this cavity absent. Inner region of mesocarp made up of, dark coloured, pigment containing, sclerenchyma tissue region. Tesata attached with cypselar wall, approximately 0.01 mm thick, differentiated into outer and inner testal region. Outer testal layer made up of elongated, thick-walled, horizontally placed, parenchyma cells whereas inner testal layer made up of crusted layer of parenchyma cells. Endosperm persists in mature cypselas, made up of, thick walled, horizontally placed, parenchyma cells, uniseriately arranged. 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).

Helianthus debilis :
Morphology (Fig. 1 L-O) :

Cypsela heteromorphic. Ray cypsela 8 mm x 3 mm while disk cypsela 8 mm x 2.5 mm. Ray cypsela white brown, straight, upper part truncate whereas lower part blunted. Disk cypsela black brown, straight, upper part truncate

whereas lower part slightly tapered. Surface slightly pubescent, containing 12 ribs, alternating with furrows. Furrows wider than the ribs. Surface hair made up of body and basal cells. The tip portion of body cells with bifurcation and arranged in different plane. At the upper portion of cypsela, stylopodium present; rounded, partially immersed into the nectar. Within the surface, phytomelanin layer present. Pappus absent. At the basal region of cypsela, Carpopodium present, rounded, narrow than the base.

Anatomy: (Fig. 3 E) :

Cypsela elliptic in cross sectional configuration. Ribs present; 12 in number, inconspicuous. Cypselar wall, 0.08 mm and 0.07 mm wide at ribs and furrow region respectively. Pericarp thick, differentiated into epicarp and mesocarp. Epicarp uniseriate, made up of thick walled, horizontally placed, parenchyma cells. Internal to the epicarp, mesocarp present. Outer region of mesocarp made up of dark coloured, pigment containing tissue region. Internal to this region, phytomelanin layer present, continuously arranged. Internal to the phytomelanin layer, made up of thick-walled, penta-hexagonal, compactely arranged, sclerenchyma cells, containing pigment containing tissue zone just below the furrow region. Testa attached with cypselar wall, approximately 0.01 mm thick, devided into outer and inner testal region. Outer testal layer made up of, thick-walled, uniseriately arranged, parenchyma cells. Inner testal layer also parenchymatous but comparatively thinner than the outer testal layer. Endosperm layer not clearly observed.

Leptorhynchos elongates :
Morphology (Fig. 1 P-T) :

Cypsela homomorphic, 5 mm x 0.5 mm including pappus, 3 mm x 0.5 mm excluding pappus, linear, slightly curved, truncate at both ends. Surface pubescent. Surface hair inclined in orientation with the surface, made up of body and basal cells. Surface containing 10- 12 ribs, inconspicuous, alternating with furrow. Furrows wider than the ribs. Stylopodium inconspicuously developed, fully immersed into the nectary. At the upper portion of cypsela, pappus present; homomorphic, represented by 25-30, unequal, serrulate- setose type of pappus bristles, white, arranged in a single circle. At the basal region of cypsela, Carpopodium present, homogenous, narrow than the base, irregular, ring like. Carpopodial cells with thick walled, elongated-square, arranged in 3 rows.

Anatomy (Fig. 4 H-I) :

Cypsela, elliptic in cross sectional configuration. Ribs present, 10-12 in number, inconspicuous. Cypselar wall, 0.01 mm and 0.008 mm wide at ribs and furrow region respectively. Pericarp thick, differentiated into epicarp and mesocarp. Epicarp uniseriate, made up of, thick-walled, elongated, horizontally placed, parenchyma cells, provided with cuticle. Internal to the epicarpic region, mesocarp present, made up of thin-walled, elongated, parenchyma cells, arranged in 2-3 rows. Testa attached with cypselar wall, approximately 0.01 thick, made up of thick-walled, U- shape, parenchyma cells, uniseriately arranged. Endosperm persists in mature cypselas,

biseriate. Outer layer made up of thick-walled, elongated, compactly arranged, parenchyma cells whereas inner layer made up of comparatively thin-walled, elongated, parenchyma cells. Internal to the endosperm layer, just below the ribs, vellicular cavity present. Mature embryo occupies a major part cypselas. Cotyledons 2 in number, arranged at right angle to the axis of cypselas, containing 10 resin ducts (5 ducts in each cotyledon).

Podotheca angustifolia :
Morphology: (Fig. 1 U-W) :

Cypsela homomorphic, 9 mm x 1 mm including pappus, 3 mm x 1 mm excluding pappus, brownish, obovate, straight, upper part truncate whereas lower part tapered, rounded in cross sectional configuration. Surface pubescent, surface hair made up of body and basal cells, ascending in orientation with the surface. With in the surface, ribs absent. At the upper portion of cypsela stylopodium present, inconspicuous, fully immersed in to the nectary. Pappus represented by, 5-7, unequal, yellowish, plumose type of pappus bristles, arranged in a single whorl. At the basal region of cypsela, Carpopodium present, narrow than the base, irregular, reing like. Carpopodial cells not clearly distinguish from the remaining part of cypselas, *i.e.* presence of pseudocarpopodium.

Anatomy: (Fig. 4 J-K) :

Cypsela rounded in cross sectional configuration. Pericarp 0.005 mm thick, represented by only epicarp. Epicarp, uniseriate, made up of thin-walled, horizontally placed, parenchyma cells. Mesocarp absent. Testa attached with cypselar wall, devided into outer and inner testal region. Outer layer made up of thick-walled, vertically placed, palisade like parenchyma cells. Inner testal layer made up of crusted parenchyma cells. Endosperm persists in mature cypselas, made up of thick-walled, horizontally placed, paren chyma cells, uni-seriately arranged. 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).

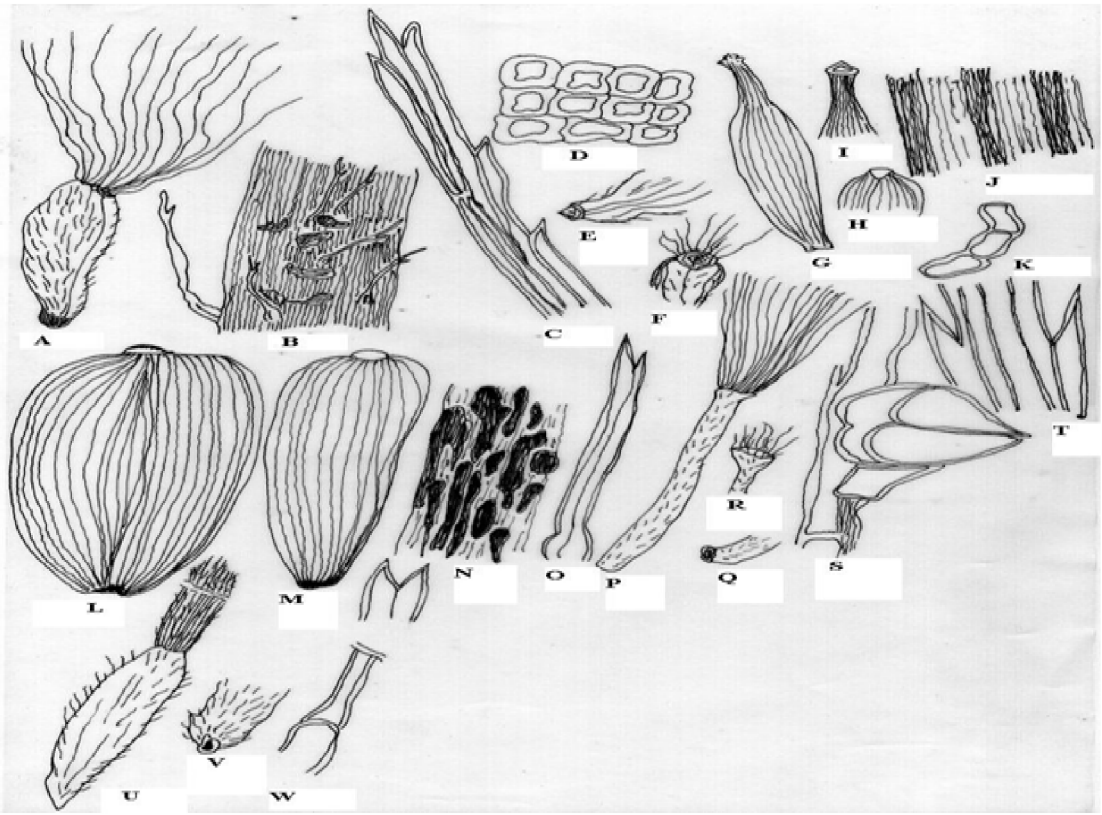
Zinnia haageana :
Morphology: (Fig. 2 X-Z) :

Cypsela heteromorphic. Ray cypsela 7.5 mm x 2.5 mm including awn, 5 mm x 2.5 mm excluding awn. Disk cypsela 7 mm x 1.5 mm including awn, 4.5 mm x 1.5 mm excluding awn. Ray cypsela yellow brown in colour whereas disk cypsela black brown in colour. In both the cypselas, upper part truncate whereas lower part tapered, straight. Surface slightly pubescent. In case of ray cypsela, surface hair situated in marginal region whereas in case of disk cypsela, surface hair present in the entire body of cypsela. Surface hair made up of body and basal cells. The tip portion of body cell with bifurcation. Pappus represented by a single awn, yellow brown in colour. Stylopodium prominent, blunted, partially immersed into the nectary. At the basal region of cypsela, Carpopodium present, narrow than the base, biconvex. Carpopodial c ells not clearly distinct from the remaining part of cypselas.

Anatomy: (Fig. 4 F-G):

Cypsela elliptic in cross sectional configuration. Ribs present, 2 in number, conspicuous. Pericarp thick, differentiated into

epicarp and mesocarp.Epicarp uniseriarte, made up of thin walled, rectangular, compactely arranged, parenchyma cells. Internal to the epicarp, mesocarp present, made up of thick-walled, compactely arranged, sclerenchyma cells. Vellicular cavity present in mesocarpic region near the lateral lobe region. Internal to the mesocarpic region, phytomelanin layer present, discontinuously arranged. Testa, parenchymatous, biseriate,. Endosperm parenchymatous, uniseriate.



1 mm. A, E,F,G,H,I,L,M,P,Q,R,U,V,

0.1 mm. B,J.

0.05 mm. B,C,D,J,K,N,O,S,T,W.

Fig. 1. Morphology of studied cypselas

A-F- *Aster albanicus*: A-Cypsela, B-Surface, showing surface hair, C-Upper part of pappus bristle, D-Carpopodial cells, E-Lower part of cypsela, F-Upper part of cypsela; G-K- *Carpesium cernuum*: G-Cypsela, H-Basal part of cypsela, I-Upper part of cypsela, J- Surface of cypsela, K- Carpopodial cells; L-O- *Helianthus debilis*: L-Ray cypsela, M-Disk cypsela, N-Surface, O-Surface hair; P-T- *Leptorhynchos elongates*: P-Cypsela, Q-Lower part of cypsela, R-Upper part of cypsela, S-Surface showing, surface hair, T-Part of pappus bristles; U-W- *Podotheca angustifolia*: U-Cypsela, V-Lower part of cypsela, W-Surface hair.

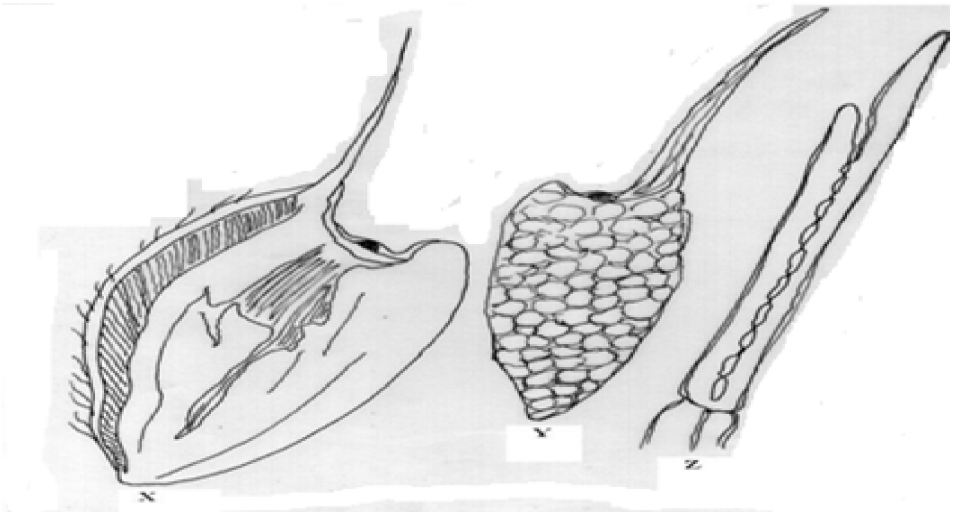


Fig. 2: Morphology of studied cypsela. 1 mm. X,Y 0.05 mm Z.
X-Z- *Zinnia haageana*: X-Ray cypsela, Y-Disk cypsela, Z- Surface hair

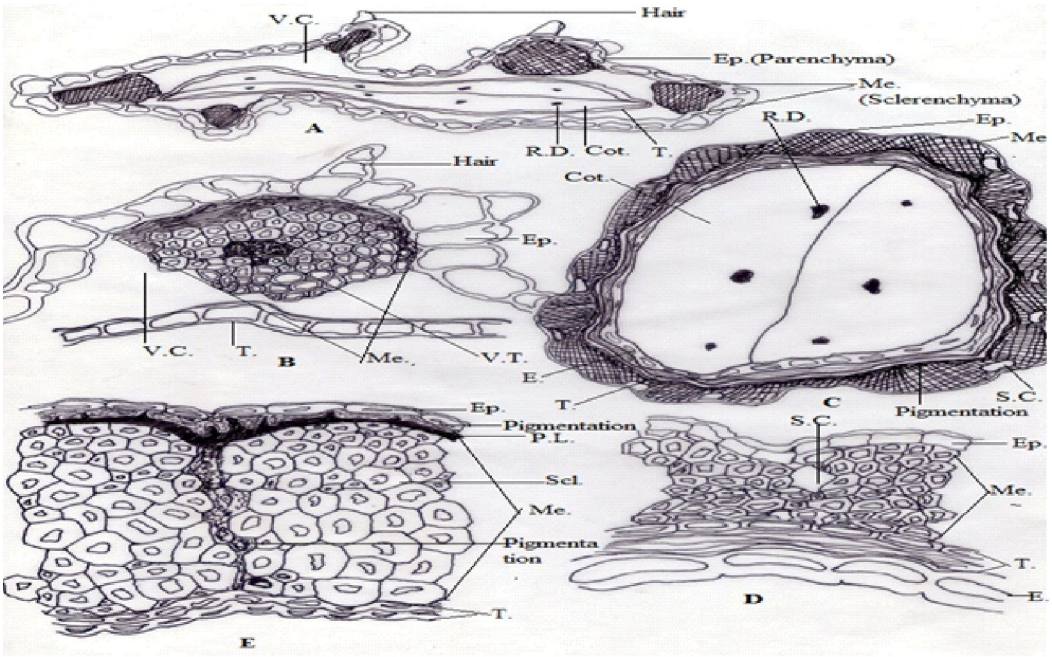


Fig. 3: Anatomy of studied cypselas. 0.1 mm. A,C. 0.05 mm B,D,E.
A-B- *Aster albanicus*: A-Diagramatic view, B-Cellular view; C-D- *Carpesium cernuum*: C-Diagramatic view, D-Cellular view; E- *Helianthus debilis* (Cellular view)

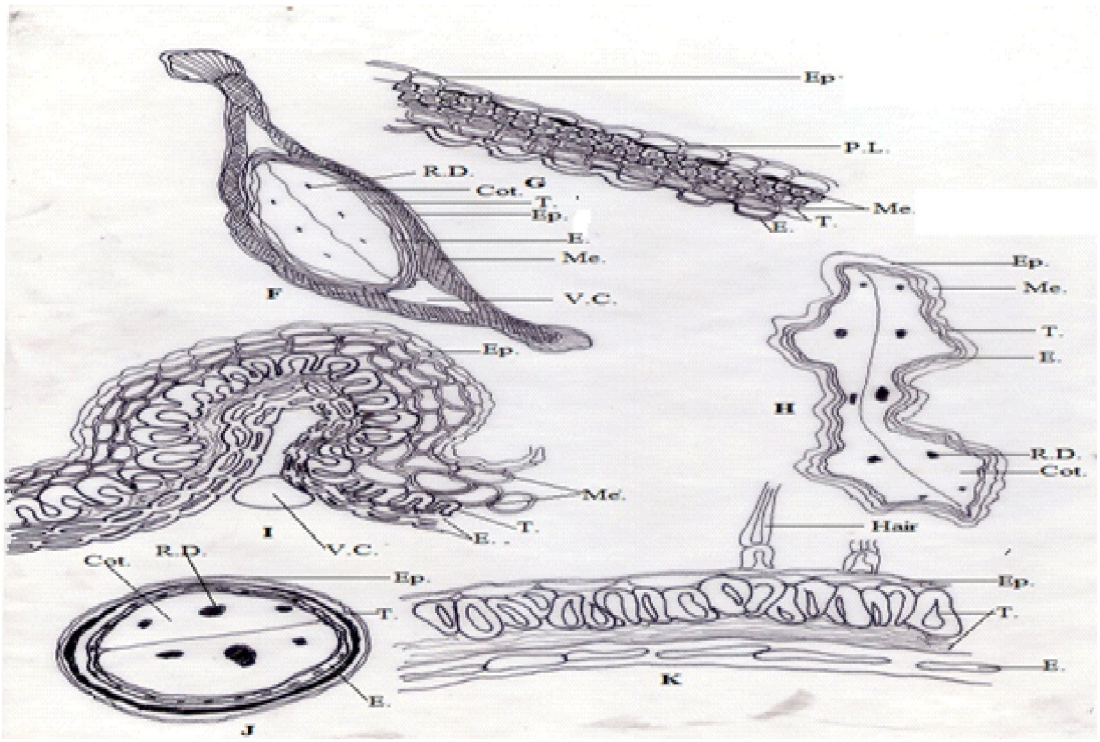


Fig. 4: Anatomy of studied cypselas ——— 0.1 mm.F,H,J. ——————— 0.05 mm G,I,K.
F-G- *Zinnia haageana*: F-Diagramatic view, G-Cellular view; H-I- *Leptorhynchos elongates*: H-Diagramatic view, I-Cellular view; J-K- *Podotheca angustifolia*: J-Diagramatic view, K-Cellular view.

Six species, belongs to the four tribes of compositae (Astereae-*Aster albanicus*, Inuleae- Carpesium cernuum, Heliantheae-*Helianthus debilis, Zinnia haageana,* Gnaphaleae- *Leptorhynchos elongates, Podotheca angustifolia*) have been studied to observe the morpho-anatomical variation pattern among them and as well as among the different tribes, as the studied six cypselas are belongs to the four different tribes. The species examined here demonstrated mature ovarian structure (Cypsela), on the basis of morpho-anatomical study.

Cypselar morphology :

Among the studied cypselas, *Aster albanicus* belongs to the tribe Astereae. Cypsela is homomorphic, 8 mm x 1 mm including pappus, 4 mm x 1 mm excluding pappus. Homomorphism is also present in another species (*Solldago virgaurea, Solidago Canadensis*) of this tribe[8]. Surface is pubescent type. Surface hair is distributed in the furrow region. At the upper portion of cypsela, pappus is present, numerous, free, persistent, represented by serrulate-setose type of pappus bristles. Not only bristilate pappus,

scaly type of pappus is found to be present in case of *Aster alpinus*, of this tribe[7]. Stylopodium is inconspicuous, fully immersed into the nectary. At the basal region of cypsela, carpopodium is present, which is narrow than the base, symmetric. Carpopodial cells are thick-walled, large, rectangular-square, arranged in 3 rows. Carpopodium may be symmetric or asymmetric type. Within the studied cypsela in *Aster albanicus*, carpopodium is symmetric type. The cellular arrangement in carpopodium is also variable. Hare, carpopodial cells are arranged in 3 rows.

Among the studied cypselas, *Helianthus debilis* and *Zinnia haageana* belong to the tribe Heliantheae. In both the studied cypselas, surface is slightly pubescent. At the upper portion of the cypsela of *Zinnia haageana*, awn like structure is present, whereas in the cypsela of *Helianthus debilis*, awn like structure is absent. Morphologically, phytomelanin deposition is seen in cypselarv wall during morphological study. Presence of phytomelanin layer in the cypselar wall, is an important features of the tribe Heliantheae, though in case of *Helianthus annus*, phytomelanin layer is absent[11]. Pandey[16], has reported that phytomelanin layer is secreted by the glandular activity of hypodermal cells. In case of both the cypselas, pappus is absent. Pappus structure is also found to be present in some other species (*Bidens cernua, Bidens pilosa, Tithonia diversifolia* etc) of the tribe Heliantheae[13]. In both the cypselas, stylopodia are prominently developed.

Among the studied cypselas, the tribe Gnaphaleae has 2 species, which are- *Leptorhynchos elongates* and *Podotheca angustifolia*.

Among the studied cypselas, *Carpesium cernuum*, is belonging to the tribe Inuleae. In the tribe Inuleae, pappus is usually absent. Though, pappus structure has been observed in some other species (*Inula ensifolia, I. Britannica, I. helenium*) of this tribe[9]. Surface features of cypselas are diagnostic for characterization of taxa.Surface is glabrous, in case of *Carpesium cernuum*. Multicellular, conical glandular structure is found at the apical and basal region of cypsela. This observation is closely allied with the observation of Mukherjee and Sarkar. At the basal region of cypsela, carpopodium is present. In the studied cypsela, carpopodial cells are uni-seriately arranged and horizontally placed. Carpopodium may be present or absent in the cypsela. In the studied cypsela, carpopodial cells are present. Mukherjee & Sarkar[12], have pointed out that the absence of carpopodium in *Carpesium cernuum*.

Cypselar anatomy:

Anatomically, all the studied cypselas are round to elliptic in cross-sectional configuration. Epicarp is uni-seriate, made up of horizontal (*Carpesium cernuum*, *Helianthus debilis*, *Leptorhynchos elongates*, *Podotheca angustifolia*, *Zinnia haageana*) or radially (*Aster albanicus*) placed, parenchyma cells. Internal to the epicarpic region, mesocarp present (except in *Podotheca angustifolia*, where mesocarp is absent). Mesocarpic region may be continuous (*Carpesium cernuum*, *Helianthus debilis*, *Leptorhynchos elongates*, *Podotheca angustifolia*, *Zinnia haageana*) or discontinuous (*Aster albanicus*). In the

cypsela of *Zinnia haageana* and - *Helianthus debilis* (Tribe-Heliantheae), outer region of mesocarp, phytomelanin layer is present. In the cypsela of *Helianthus debilis*, phytomelanin layer is continuously developed, than the cypsela of *Zinnia haageana*, where, phytomelanin layer is discontinuously developed. Presence of phytomelanin layer is a very important character in case of the tribe Heliantheae. Phytomelanin is a unique type of resinous substance, which is usually present in the members of the tribe Heliantheae, Helenieae etc. [11]. In respect to this features, Heliantheae is closely related to the tribe Eupatorieae, but apert from other some tribes, such as- Astereae, Inuleae, Anthemideae, Arctotideae[3]. In the cypsela of *Zinnia haageana, Leptorhynchos elongates* and *Aster albanicus*, vellicular cavity is present in the pericarpic region. In remaining three studied cypselas (*Podotheca angustifolia, Helianthus debilis, Carpesium cernuum*), vellicular cavity is absent. The function of this cavity is still unknown. In the cypsela of *Carpesium cernuum*, secretary cavity is present in the mesocarpic region. This cavity is absent in remaining five studied cypselas. In *Carpesium cernuum* (Inuleae), crystal formation is absent in pericarpic region. Though, crystal formation has been reported by Mukherjee and Sarkar[12], in some other species (*Buphthalmum, Inula* etc) of the tribe Inuleae. Crystal formation in the tribe-Inuleae, is also reported by Anderberg[1]. Testal layer is also variable. In the cypsela of *Zinnia haageana* (Heliantheae), *Helianthus debilis* (Heliantheae), *Podotheca angustifolia* (Gnaphaleae), and *Carpesium cernuum* (Inuleae), testal layer is bi-seriately arranged but in remaining two studied cypselas [*Leptorhynchos elongates* (Gnaphaleae) and *Aster albanicus* (Astereae)], testal layer is uni-seriately arranged. Testal layer is greatly variable in structure. In the cypsela of *Podotheca angustifolia*, out of two testal layers, outer layer is made up of U-shaped, parenchyma cells and inner layer is made up of crusted layer of parenchyma cells. In the cypsela of *Leptorhynchos elongates*, testal layer is uni-seriately arranged and is made up of U-shaped, parenchyma cells. In the cypsela of *Carpesium cernuum*, outer testal layer is parenchymatous and inner testal layer is made up of crusted layer of cells. In the cypsela of *Aster albanicus, Zinnia haageana, Helianthus debilis* testal layer is made up of only parenchyma cells. In the cypsela of *Aster albanicus* and *Helianthus debilis*, endosperm layer is not clearly observed.The information about the endosperm layer has been reported by Pandey and Sing[15]. Within the cotyledons, resin ducts are also variable. The presence of fixed number of resin ducts in each cotyledon has been reported by Pandey and Sing[15].

From the above discussion, it can be concluded that cypselar features are not only variable among the same tribe but also among the different tribes of Asteraceae.

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