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DIVERSITY OF CYPSELAR FEATURES OF SEVEN SPECIES OF THE GENUS *CREPIS* L. IN COMPOSITAE

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ABSTRACT

Morphological and anatomical variations of cypselas are very important to distinguish the taxa. For this purpose 7 species of the genus *Crepis* L., such as *Crepisaspera* L., *Crepispulchra* L., *Crepisfoetida* L., *Crepispalaestina* (Boiss.) Bornm., *Crepisdioscoridis* L., *Crepisneglecta* L., *Crepisalpina* L., of the tribe Lactuceae have been studied to search the diversity of cypselar features. All of them exhibit morphological as well as anatomical variations. Special emphasis have been given to the surface configurations, nature of stylopodia, nature and distribution of carpopodial cells, surface hairs, apical beak, vallecular cavity, etc. Morphological variations exhibits on the basis of the arrangement of layers of carpopodial cells; on the basis of presence of beak and its variable shapes and sizes; characteristic features of pappus bristle etc. Anatomical variations are also remarkable among the studied species. Presence of vallecular cavity is one of the most important anatomical characters. This cavity is absent in all the studied species, except in *Crepisalpina* L., and *Crepisfoetida* L. Arrangement of cotyledons and number of resin ducts in each cotyledon are also variable. On the basis of all observed morphological and anatomical characters of cypselas, a key to the studied species has been constructed.

Key Words: Diversity, Cypselar features, *Crepis* L., Lactuceae, Compositae

INTRODUCTION

The genus *Crepis* L. is belonging to the tribe Lactuceae (Asteraceae), having 200 species, distributed throughout the globe (Mabberley, 2008) except in Australia and some parts of America, whereas in India the genus is represented by 9 species and 4 sub species (Hajra et al., 1995). Florets are usually yellow in colour and are commonly known as Hank's beard. The genus is characterized by the presence of two rows of involucre bracts, mostly shorter in length in outer row than the inner row. Floral and vegetative features of different species of *Crepis* are available in the floristic description of the plant from any flora, but the detailed description of cypselar features is not available there. Cypselar features can be available in fragmentary way in different literatures (Mukherjee and Sarkar, 1995; Pandey, Singh and Chopra 1978; Jeffrey, 1966; Mukherjee and Nordenstam, 2004) but these works may not be sufficient and up-to-date regarding the cypselar morpho-anatomical features of *Crepis*. Therefore, the present study has been undertaken to study in details the cypselar features of seven species of the genus *Crepis* L., with the help of light microscopic observations only. The objective of the present study is three folds; one to find out its cypselar features in some great details, to find out the correlations among the taxa and to construct a key to the species on the basis of observed morphological and anatomical features of cypselas.

MATERIALS AND METHODS

Mature cypselas of 7 species were procured from – Botanic Garden of the University of Copenhagen, Denmark. A few randomly selected dry cypselas from the procured mass were immersed in 5% NaOH solution for 2-3 days. After that, the cypselas were softened. The softened cypselas were stained in aqueous safranin solution (1%) and dissected the different parts of cypselas with the help of 2 sharp needles under dissecting microscope and stereo dissecting binocular microscope. Different parts of cypselas such as structure of epicarpic cells in cypselar surface, distribution of vascular trace through the ribs, relative thickness of ribs and furrows, structure of pappus bristle and scales were observed and were

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drawn in both compound research microscope as well as stereo dissecting binocular microscope. For anatomical study, free hand cross sections were done preferably from the middle part of cypsels with the aid of sharp razor blade. Selected sections were stained in safranin- lightgreen combination following standard method of staining. Properly stained good sections were observed under compound Research Microscope.

RESULTS AND DISCUSSION

Crepisalpina

MORPHOLOGY(Fig. 1E)

Cypselas homomorphic, 18 mm x 1 mm with beak, 8mm x 1mm without beak, yellow brown in colour, linear, slightly curved, upper part truncate, whereas basal part tapered, cylindrical. Surface pubescent; surface hair appressed-ascending in orientation with the surface, containing body cells and basal cells. Surface hair twin type. On the surface, 17 ribs present, alternating with furrows; furrows wider than ribs. The distance between 2 ribs 0.12 mm. Within the ribs vascular supply clearly observed. Morphologically, phytomelanin layer not observed. At the upper surface of cypselas, pappus present, made up of 16-22 barbellate pappus bristle, white in colour, unequal in arrangement, approximately 4mm-5 mm in length. Within the pappus crystal formation not observed. At the upper part of cypselas, stylopodium present, inconspicuous. At the basal region of cypselas, carpopodium present, arranged in irregular ring, asymmetric; diameter of carpopodium narrow than the base; carpopodial cells thick-walled, arranged in 3-4 rows.

ANATOMY (Fig.2D)

Cross section of cypselas shows more or less quadrangular. Pericarp 0.07 mm thick in ribs and 0.02 mm thick in furrow region. Epicarp made up of uniseriately arranged parenchyma cells, without having cuticle. Internal to epicarpic zone, a mesocarpic zone exists, made up of compactly arranged thick-walled sclerenchyma cells, containing vascular bundle. Vallicular cavity, secretory ducts, etc. not observed in mesocarpic region. Crystal formation not observed in pericarpic region. Anatomically phytomelanin layer not observed in mesocarpic zone. In the furrow region mesocarp absent, pericarp represented by only epicarp. Extra layer formation not observed in pericarp. Endocarp absent. Hence, pericarp represented by epicarp and mesocarp in rib region and only by epicarpic zone in furrow region. Internal to the mesocarpic zone, testal layer present, uniseriately arranged and parenchymatous. Internal to the testal layer; endosperm layer biseriately arranged, parenchymatous, thick-walled. Cotyledons 2 in numbers, arranged oblique to the axis of cypselas, containing 6 resin ducts (3 ducts in each cotyledon).

Crepisaspera

MORPHOLOGY(Fig. 1H)

Cypselas homomorphic 5mm x 1 mm, whitish brown, lanceolate, one side straight, another side curved, beak absent, upper part tapered, basal part truncate, dorsiventrally flattened. Surface pubescent; containing spine like structure. Surface hair twin type, exhibit great diversity, made up of body cells and basal cells, ascending-inclined in orientation with the surface. Surface cells thick-walled, irregular in shape. Ribs and furrow not clearly observed on the surface. Phytomelanin layer not observed on the surface. At the upper surface of cypselas pappus absent, stylopodium not clearly observed. At the basal region of cypselas, carpopodium present, diameter of carpopodium equal to the base, asymmetric; carpopodial cells thick-walled, arranged 3-4 rows.

ANATOMY (Fig.2E)

Cross section of cypselas elliptical in outline. Epicarp made up of uniseriately arranged parenchyma cells, provided with cuticle. Mesocarp made up of parenchyma cells containing calcium oxalate crystals and fiber cells. Endocarp absent, so, pericarp made up of only epicarp and mesocarp. As in the mesocarpic region, crystal formation noticed; so phytomelanin layer absent. Vallicular cavity, secretory ducts etc., not observed. Testa uniseriately arranged, parenchymatous. Endosperm biseriately arranged, parenchymatous. Cotyledons not clearly observed.

Table 1: Name of studied taxa and their source of origin and their collection numbers

NAME OF TAXA	SOURCE OF ORIGIN	COLLECTION NUMBER
<i>Crepisalpina</i> L.	Botanic Garden of the University of Copenhagen, Denmark.	288 E3022-0024*AG
<i>Crepisaspera</i> L.	DO	289 E3022-0021*AG
<i>Crepisdioscoridis</i> L.	DO	294 E3022-0022*AG
<i>Crepisfoetida</i> L.	DO	295 E3022-0027*AG
<i>Crepisneglecta</i> L.	DO	296 E3022-0004*AG
<i>Crepispalaestina</i> (Bois.) Bornm	DO	297 S1921-1474*AG
<i>Crepispulchra</i> L.	DO	298E3022-0011*AG

Crepisdioscoridis

MORPHOLOGY(Fig.1 C,D)

Cypsela heteromorphic. Disk cypsela 4mm x 1mm, dark brown, oblanceolate, slightly curved, apical portion truncate, basal part slightly tapered, cylindrical. Ray cypsela 5mm x 1mm, light yellow in colour, oblanceolate, slightly curved, upper part rounded, basal part tapered, dorsoventrally compressed. In disk cypsela surface pubescent; surface hair appressed-ascending in orientation with the surface. Surface containing 11 ribs alternating with furrow; furrows wider than ribs. The distance between 2 ribs 0.12mm-0.23 mm. In ray cypsela, surface glabrous, containing 6 ribs alternating with furrows. In both the cypsela apical beak absent. Morphologically, phytomelanin layer not observed. In disk cypsela, at the upper part of cypsela stylopodium present, in ray cypsela, this structure not prominently observed. In both the cypsela pappus absent. At the basal region of cypsela, carpopodium present, arranged in irregular ring, asymmetric; diameter of carpopodium narrow than the base; carpopodial cells thick-walled, arranged in a single row.

ANATOMY(Fig.2B)

Cross section of cypsela shows elliptical out line. Pericarp 0.19mm thick. Epicarp made up of uniseriately arranged parenchymatous cells provided with cuticle. From epicarp pitted type of surface hair projecting. Internal to the epicarpic zone, a mesocarpic zone exist, made up of thick walled sclerenchyma cells, compactly arranged. Mesocarp with one layer. Anatomically phytomelanin layer inhibits crystal formation. Resin duct not observed. Within the mesocarpic region just below the ribs, a pair of vallicular cavity present. Vascular trace also present in mesocarpic region just below the ribs. Within the furrow region, mesocarpic layer absent. Endocarpic zone absent. Internal to the mesocarpic layer, testal layer present, which are uniseriately arranged, parenchymatous. Internal to the testal layer; endosperm layer biseriately arranged, thick-walled, parenchymatous. Cotyledons 2 in number, arranged at right angle to the axis of cypsela, containing 10 resin ducts (5 ducts in each cotyledon).

Crepisfoetida

MORPHOLOGY(Fig.1B)

Cypsela homomorphic, 13mm x 0.1 mm with beak, 5mm x 0.1mm without beak, yellow brown in colour, linear, straight, upper part truncate where as basal part slightly tapered, cylindrical. Surface pubescent; surface hair twin type, oppressed –ascending in orientation with the surface, made up of body cell and basal cell. At the upper part of cypsela, stylopodium present, cylindrical. Pappus absent. On the surface 13 ribs present, containing vascular supply, alternating with furrow; furrows wider than ribs. The distance between 2 ribs 0.1mm-0.2 mm. Phytomelanin layer not observed. At the basal region of cypsela, carpopodium present, arranged in irregular ring, asymmetric; diameter of carpopodium narrow than the base. Carpopodial cells with thick-walled, arranged in single row.

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ANATOMY (Fig.2F)

Cross section of cypsela shows elliptical out line. Pericarp 0.02 mm thick in ribs and 0.005 mm thick in furrow. Epicarp made-up of uniseriately arranged parenchyma cells, provided with cuticle, from which surface hair projecting. Internal to the epicarpic zone, a mesocarpic zone exist, made up of compactly arranged, thick-walled, sclerenchyma cells containing vascular bundle below each ribs. In the furrow region, mesocarp absent, pericarp represented by only epicarp. In the furrow region, Vallicular cavity present. Endocarp absent. Hence pericarp represented by epicarpic zone and mesocarpic zone. Phytomelanin layer not observed. Secretary duct, crystal formation not observed anatomically. Internal to the mesocarpic zone, testal layer present, uniseriately arranged; cells with thick walled, parenchymatous. Internal to the testal layer; endosperm layer biseriately arranged, parenchymatous. Cotyledons 2 in number, arranged at right angle to the axis of cypsela, containing 8 resin ducts, 4 ducts in each cotyledon.

Crepisneglecta

MORPHOLOGY (Fig.1G)

Cypsela homomorphic, 3mm x 0.5mm without beaked, yellow brown in colour, lanceolate, curved, cylindrical, upper part truncate whereas basal part tapered. Surface pubescent; surface hair twin type, oppressed to ascending in orientation with the surface, made up of body cells and basal cells. On the surface, 12 ribs present, alternating with furrows; furrows wider than ribs. The distance between 2 ribs 0.17mm-0.2 mm. Morphologically phytomelanin layer not observed. At the upper portion of cypsela, stylopodium present, cylindrical. At the basal region of cypsela, carpopodium present, symmetric, diameter of carpopodium narrow than the base, pentangular; carpopodial cells thick-walled, arranged in 2-3 rows. Pappus absent.

ANATOMY (Fig. 2G)

Crosssection of cypsela shows elliptical out line. Pericarp 0.05 mm thick in ribs and 0.02 mm thick in furrow. Epicarp made-up of uniseriately arranged parenchyma cells provided with cuticle. Internal to epicarpic zone, a mesocarpic zone exist, made-up of compactly arranged thick-walled sclerenchyma cells containing vascular bundle. In the furrow region, mesocarpic zone absent, pericarp represented by only epicarp. Anatomically phytomelanin layer not observed in mesocarpic zone. Vallicular cavity, secretary duct, crystal formation not observed in pericarpic region. Endocarpic zone absent. Hence, pericarpic zone madeup of epicarp and mesocarp. Internal to the mesocarpic zone, testal layer present, uniseriately arranged, cells with thick-walled, parenchymatous. Internal to the testal layer; endosperm layer biseriately arranged, parenchymatous. An extra layer observed in between testa and endosperm layers. Cotyledons 2 in number, arranged oblique to the axis of cypsela, containing 10 resin ducts (5 ducts in each cotyledon).

Crepispalaestina

MORPHOLOGY(Fig.1A) Cypsela homomorphic, 8mmx1mm with beak, 5mmx1mm without beak, yellow brown in colour, lanceolate, cylindrical, straight in direction, upper part tapered whereas lower part truncate. Surface pubescent; surface hairs twin type, ascending to inclined in orientation with the surface. Glandular type of surface hairs absent. On the surface, 13-15 ribs present, alternating with furrow; furrows wider then ribs. The distance between 2 ribs 0.1mm-0.2mm. Morphologically, phytomelanin layer not observed. At the upper portion of cypsela, cylindrical stylopodium present. At the basal region of cypsela, carpopodium present, arranged in irregular ring, asymmetric; diameter of carpopodium equal to the base; carpopodial cells thick-walled, arranged in one row. At the upper part of cypsela, a prominent beak present, approximately 2-3 mm long. Pappus absent.

ANATOMY(Fig. 2A)

Cross section of cypsela shows irregularly circular out line. Pericarp 0.17 mm thick in ribs and 0.11mm thick in furrow region. Epicarpic zone made up of uniseriately arranged pitted parenchyma cells provided with cuticle. Cells in the epicarpic region radially arranged. Just internal to the epicarpic zone, a mesocarpic zone exist, made up of alternating arrangement of both parenchymatous and sclerenchymatous cells. Sclerenchyma cells with thick-walled, compactly arranged. Parenchyma cells

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with thin walled and compactly arranged. There is no extra layer in mesocarpic zone. Within the sclerenchyma zone of mesocarpic region vascular trace present. Every sclerenchyma zone in mesocarpic region contains single vascular trace. Vallicular cavity absent. Anatomically phytomelanin layer also absent. Crystal formation not observed. Endocarpic zone absent. Hence, pericarpic zone made up of epicarpic and mesocarpic zone. Just internal to the mesocarpic zone, atestal layer present, uniseriately arranged; cells with thick-walled, parenchymatous. Internal to the testal layer; endosperm layer exist, biseriately arranged, parenchymatous. Cotyledons 2 in number, arranged at right angle to the axis of cypsela, containing 6 resin ducts (3 resin ducts in each cotyledon).

Crepis pulchra

MORPHOLOGY (Fig.1F)

Cypsela homomorphic, 5mm x 5mm, yellow in colour, lanceolate, slightly curved, truncate at both apex and base, cylindric. Surface glabrous, rough in texture, containing 7 ribs, alternating with furrows; furrow wider than ribs. The distance between 2 ribs 0.15mm-0.2mm. Morphologically, phytomelanin layer not observed. At the apical region of cypsela, beak absent. At the upper part of cypsela, stylopodium present, cylindric. At the basal region of cypsela, carpopodium present, arranged in irregular ring, symmetric, hexagonal, diameter of carpopodium equal to the base; Carpopodial cells thick walled, arranged in single row. At the upper part of cypsela pappus present, made up of barbellate pappus bristles, whitish in colour, 18-22 in number, unequally arranged. Lateral cell of pappus bristle as wider as rachis. Within the pappus bristle crystal formation not observed.

ANATOMY (Fig.2C)

Cross section of cypsela shows irregularly circular outline. Pericarp 0.08mm-0.1mm thick. Epicarp made up of uniseriately arranged parenchyma cells without cuticle. Just internal to epicarpic zone, mesocarpic zone exist, made up of both compactly arranged pitted parenchyma and sclerenchyma cells, containing vascular bundle in sclerenchyma cells. Sclerenchyma cells discontinuous in arrangement. Anatomically vallicular cavity, secretory duct, phytomelanin layer absent. Any type of crystal formation not found. Endocarp absent. Hence pericarp 2 layered in nature i.e., epicarp and mesocarp. Any extra layer formation not seen in pericarpic zone. Internal to mesocarpic zone testal layer present, biseriately arranged; thick-walled, parenchymatous. Internal to the testal layer; endosperm layer biseriately arranged, parenchymatous. Cotyledons 2 in number, arranged at right angle to the axis of cypsela, containing 10 resin duct (5 ducts in each cotyledon).

Seven (7) species belonging to the tribe Lactuceae have been studied. On the basis of studied species, cypselas are homomorphic (*Crepis palaestina*, *Crepis pulchra*, *Crepis alpine*, *Crepis neglecta*, *Crepis foetida*, *Crepis aspera*) and heteromorphic (*Crepis dioscoridis*). The colour of cypsela is greatly variable; this is due to the state of maturity of cypselas as well as inherent features. The size of cypsela is also variable. Among the studied species smallest cypsela has been reported in *Crepis neglecta*- 3mm x 0.5 mm and largest cypsela has been reported in *Crepis alpine* - 15mm x 1 mm. Shape of cypsela is not an important characters in the studied species. Some of the studied species beaks are present (*C. palaestina*, *C. alpine*, *C. foetida*), whereas in some other studied species beaks are absent (*C. aspera*, *C. neglecta*, *C. pulchra*, *C. dioscoridis*). On the surface of cypsela number of ribs is also variable. In *C. palaestina* cypsela has 15 ribs, *C. dioscoridis* containing 11 ribs, *C. pulchra* containing 7 ribs, *C. alpine* containing 17 ribs, *C. neglecta* containing 12 ribs, *C. foetida* containing 13 ribs, *C. aspera* ribs are not observed after clearing. Surface is pubescent in all studied species except *C. pulchra*, where surface is glabrous type. Different forms of cypselar morphology have been noticed by Mukherjee & Sarkar (1995) in the tribe- Lactuceae. In beaked cypsela (*C. palaestina*, *C. alpine*, *C. foetida*) length of the beak smaller than body. In some other species of tribe-Lactuceae beak is longer than body (Das & Mukherjee, 2008).

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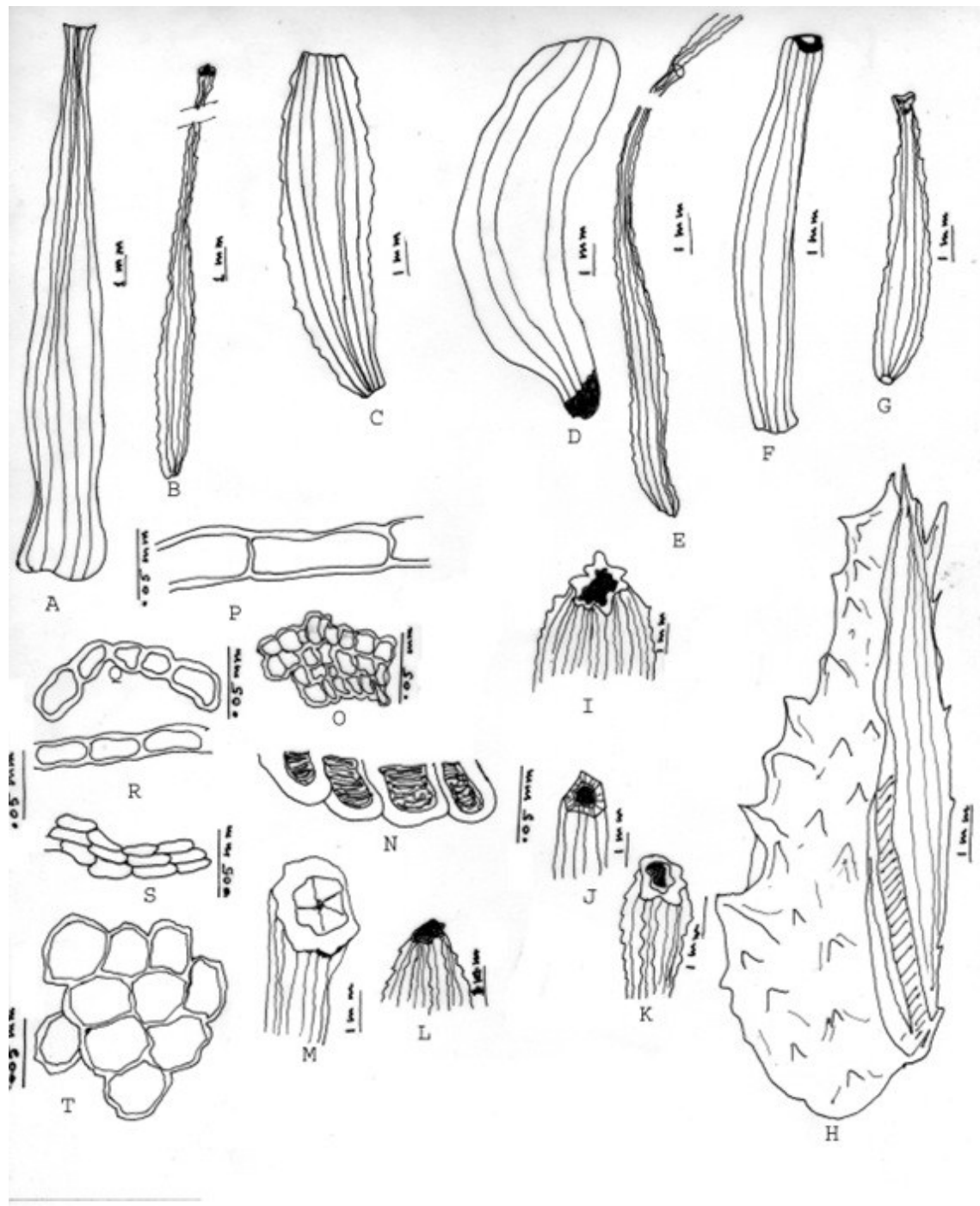


Figure 1. Morphology of cypselas

A. *Crepis palaestina*, B. *Crepis foetida*, C. *Crepis dioscoridis* (Disk), D. *Crepis dioscoridis* (Ray), E. *Crepis alpina*, F. *Crepis pulchra*, G. *Crepis neglecta*, H. *Crepis aspera*, I. Upper view of *Crepis dioscoridis*, J. Basal view of *Crepis pulchra*, K. Basal view of *Crepis alpina*, L. Basal view of *crepis dioscoridis*, M. Basal view of *Crepis palaestina*, N, O, P, Q, R, S, T- Carpodial cell layers of *Crepis foetida*, *C. alpina*, *C. palaestina*, *C. dioscoridis*, *C. pulchra*, *C. neglecta*, *C. -aspera*.

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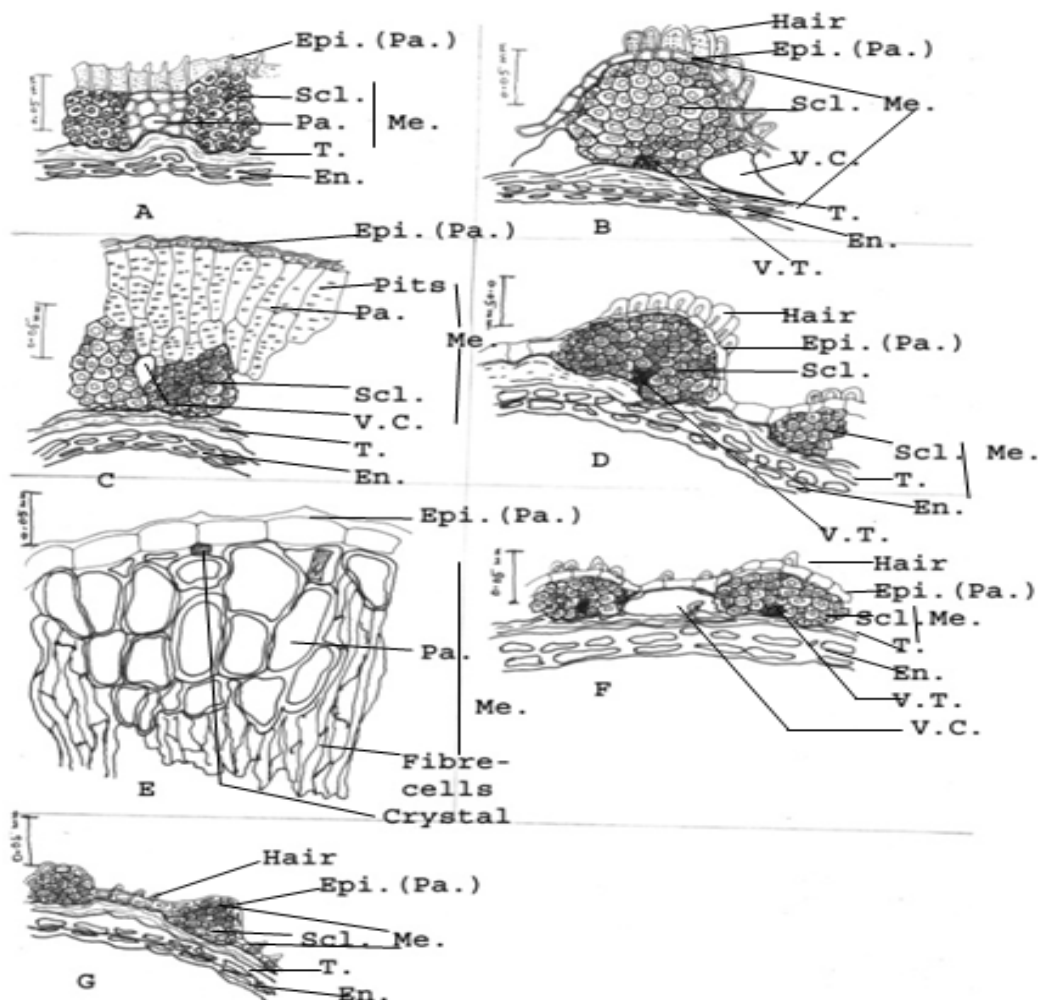


Figure 2: Anatomy of cypsels.

A. *Crepispalaestina*, **B.** *Crepisdioscoridis*, **C.** *Crepispulchra*, **D.** *Crepisalпина*, **E.** *Crepisaspera*, **F.** *Crepisfoetida*, **G.** *Crepisneglecta*.

Abbreviations: Epi- Epicarp, Me- Mesocarp, T- Testa, En- Endosperm, Pa- Parenchyma, Scl- Sclerenchyma, V.T.- Vascular trace, V.C.- Vellicular cavity.

Carpopodium is the basal meristematic tissue region of the cypsel. Layers of carpopodial cells are also variable. In *C. palaestina*, *C. dioscoridis*, *C. pulchra* and *C. foetida* carpopodial cells are arranged in single layer. In *C. aspera* and *C. alpina* carpopodial cells are arranged in (3-4) layers. In *C. neglecta*, carpopodial cells are arranged in 3 layers. So carpopodial features have definite systematic value for characterization of taxa. Aforesaid carpopodial features have been reported by Mukherjee & Nordenstam (2004) in other taxa of the tribe Lactuceae. Out of the studied species, *C. alpina* and *C. pulchra* pappus present and is made up of barbellate pappus bristles. In other studied species pappus is absent. So pappus structure has paramount taxonomic significance as proposed by Tomb (1977).

Cross section of cypsel shows pericarp, testa and endosperm. In all the studied species, epicarp is made up of uniseriately arranged parenchyma cells. Mesocarpic zone exhibits cellular variations in the studied

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species. In *C. palaestina*, *C. pulchra*, mesocarpic zone is made up of both parenchyma and sclerenchyma cells, which are compactly arranged. In *C. aspera*, mesocarpic zone exhibits both parenchyma cells and fibre cells. So, among the studied species *C. aspera* exhibit fibre cells in mesocarpic region. In *C. dioscoridis*, *C. alpine*, *C. neglecta*, *C. foetida* mesocarpic zone is made up of only parenchyma cells. In *C. aspera* mesocarpic zone contains crystals, which are primitive in nature. In other studied species, crystals are not found. Testa layer is uniseriately arranged in all the studied species except *C. pulchra* where it is made up of outer and inner testal layers. Endosperm layer is biseriately arranged in all the studied species. The arrangement of cotyledons in relation with the axis of cypsela is also variable. In *C. palaestina*, *C. dioscoridis*, *C. pulchra*, *C. foetida*, the orientation of cotyledons is at right angle to the axis of cypsela but in *C. neglecta*, *C. alpina* orientation of cotyledons is quite oblique to the axis of cypsela.

Key to the studied species of *Crepis* 1a. Cypsela

- heteromorphic.....*Crepis dioscoridis*
- 1b. Cypsela homomorphic.....(2)
- 2a. Cypsela glabrous.....*Crepis pulchra*
- 2b. Cypsela pubescent.....(3)
- 3a. Cypsela with crystals inside the pericarp*Crepis aspera*
- 3b. Cypsela without crystals(4)
- 4a. Cypsela homomorphic, with beak.....*Crepis alpine*
- 4b. Cypsela without beak.....(5)
- 5a. Vallicular cavity present.....*Crepis foetida*.
- 5b. Vallicular cavity absent.....(6)
- 6a. Carpopodial cells arranged in single layer.....*Crepis palaestina*
- 6b. Carpopodial cells arranged in 2-3 - layers.....*Crepis neglecta*.

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