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CYPSELAR ANATOMY OF FIVE SPECIES OF THE TRIBE CALENDULEAE, FAMILY ASTERACEAE

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ABSTRACT

Detailed anatomical features of cypselas of five species (*Calendula arvensis* L., *Calendula maderensis* DC., *Calendula stellata* Cav., *Calendula suffruticosa* Vahl ssp. *suffruticosa* and *Osteospermum vaillantii* (Decne.) Norl.) of the tribe Calenduleae have been studied to observe the variation pattern among them. Among the five cypselas, in case of *C. stellata*, mesocarpic region is made up of only parenchyma cells, containing pits. In remaining four cypselas, mesocarpic region is made up of both parenchyma and sclerenchyma cells. In the cypsela of *O. vaillantii*, vallecular cavity is present in mesocarpic region. This cavity is absent in remaining four cypselas. In the cypsela of *C. arvensis* and *C. suffruticosa*, secretory duct exists in mesocarpic region, which is absent in remaining three cypselas. In the cypsela of *C. arvensis* and *C. maderensis*, six vascular traces are present in mesocarpic region, whereas in *O. vaillantii*, eight vascular traces; in *C. stellata*, five vascular traces; in *C. suffruticosa*, four vascular traces are present in mesocarpic region. Based on the above mentioned anatomical features, an artificial key to the species has been constructed.

Key words: Cypselar anatomy, Five species, Calenduleae

INTRODUCTION

The tribe Calenduleae is considered as probably the most complex tribe in the Asteraceae (Nordenstam 1977) on the basis of morphological observation. The tribe consists of 12 genera and approximately 120 species (Jeffrey 2007). The name of this tribe was first recognised by Cassini (1821) as a natural group. Later, it was recognized as a distinct tribe by Bentham (1873). According to Norlindh (1943) this tribe is fairly well understood at the species level. The cypselar features of this tribe is interesting to taxonomists. Cypselas are generally homomorphic-polymorphic, terete, may be either winged or wingless, and may be either straight or slightly curved, provided with beak or without beak etc. (Kadereit and Jeffrey 2007). Different types of secondary metabolites, such as calendic acid, dimorphecolic acid etc. are present in some members (*Calendula*, *Dimorphotheca* etc.) of this tribe (Smith *et al*. 1960, Barclay and Earle 1965). The tribe Calenduleae as a whole shows a very uniform embryological character, but the members,

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differ in cypselar characters (Ahlastrand 1985). The work regarding the cypselar characters has been undertaken by several authors, such as Jana *et al.* (2013), Mukherjee and Sarkar (1999), Nordenstam (1977) and Norlindh (1943). The present paper deals with the detailed anatomical features of cypselas of five species of the tribe Calenduleae.

MATERIALS AND METHODS

Mature, identified cypselas were procured from different foreign herbaria of the world. The name of the taxa and their sources were given in the Table 1.

Table 1. Showing the name of taxa with their sender address.

Name of taxa	Sender address
1. *Calendula arvensis* L.	Botanic Garden and Museum of the University of Copenhagen (Natural History Museum of Denmark) DK.
2. *Calendula maderensis* DC.	DO
3. *Calendula stellata* Cav.	DO
4. *Calendula suffruticosa* Vahl ssp. *suffruticosa*	DO
5. *Osteospermum vaillantii* (Decne.) Norl.	Botanischer Garten der Universitat Zurich

For the study, cross sections were taken with the help of a sharp, razor blade through the middle region of cypselas. Sections were stained by immersing in 0.2% acquous saffarin solution. Good sections were placed under compound microscope with (5 × 6, 5 × 20, 5 × 45 and 6 × 45) magnification to observe different anatomical regions.

RESULTS AND DISCUSSION

Anatomically the studied cypselas are triangular – quadrangular - elliptic in outline. Epicarp is made up of uni-seriately arranged parenchyma cells. Internal to the epicarpic region, mesocarp is present. In the cypsela of *C. stellata*, mesocarp is made up of only parenchyma cells with vascular trace just below the ribs, whereas in remaining four studied cypselas, mesocarpic region is made up of both parenchyma and sclerenchyma cells.

Calendula arvensis (Fig. 1 A-E)	*Calendula maderensis* (Fig. 1 F-G)	*Calendula stellata* (Fig. 2 A-C)	*Calendula suffruticosa* (Fig. 2 D-E)	*Osteospermum vaillantii* (Fig. 2 F-G)
Cypsela tri-angular in cross sectional configuration	Cypsela elliptic in cross sectional configuration	Cypsela quadrangular in cross sectional configuration	Cypsela elliptic in cross sectional configuration	Cypsela elliptic in cross sectional configuration
Epicarp uni-seriate, parenchymatous, containing pigmentation	Epicarp uni-seriate, parenchymatous, pigmentation absent	Epicarp uni-seriate, parenchymatous, pigmentation absent	Epicarp uni-seriate, parenchymatous, pigmentation absent	Epicarp uni-seriate, parenchymatous, pigmentation absent

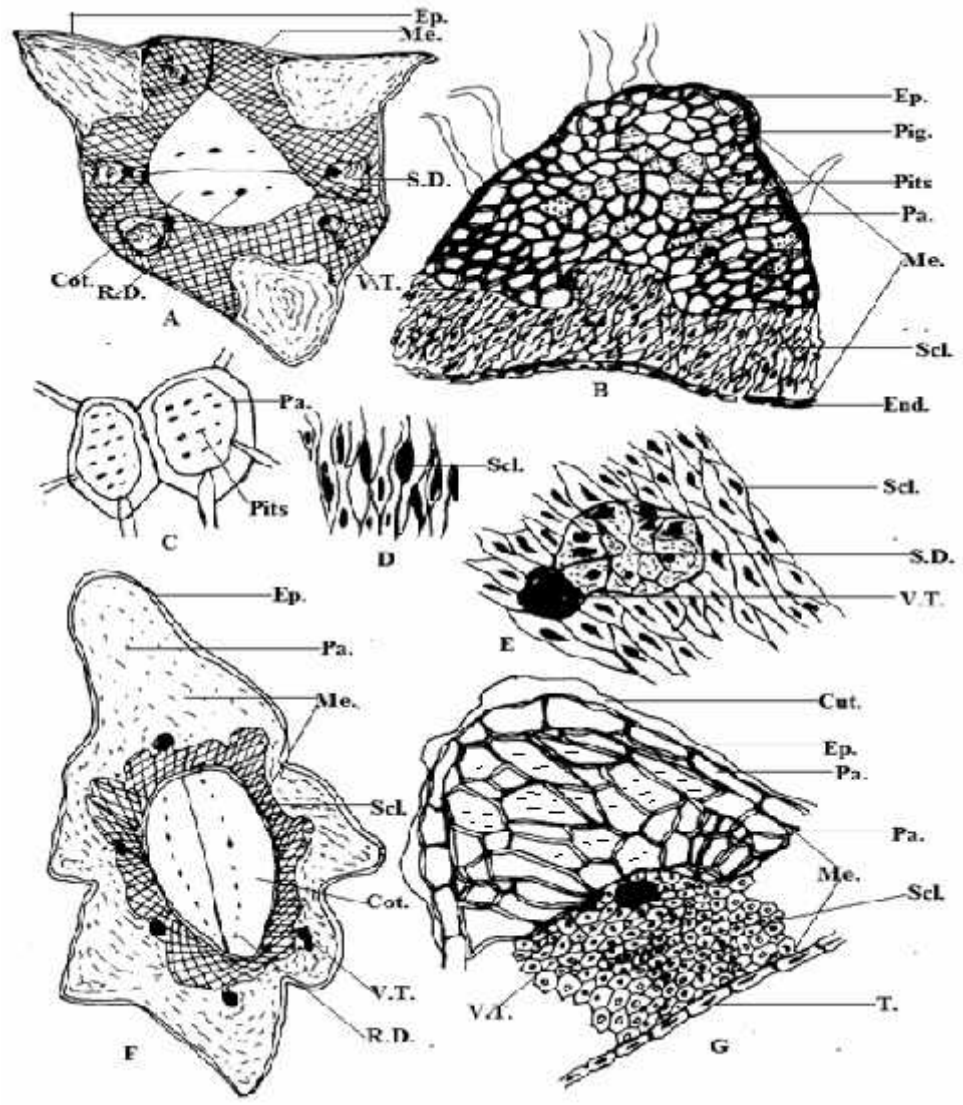
(*Conted.*)

(*Contd*.)

Mesocarp made up of both pitted parenchyma and sclerenchyma cells	Mesocarp made up of both pitted parenchyma and sclerenchyma cells	Outer region of mes-ocarp with pigmen-tation, whereas inner region of mesocarp made up of pitted parenchyma cells with pits	Mesocarp made up of both parenchyma and sclerenchyma cells	Mesocarp made up of both pitted parenchyma and sclerenchyma cells
Within the mesocarpic region, just below the furrow region; secretory tissue present Mesocarpic region containing six vascular trace	Secretory tissue absent in mesocarpic region. Mesocarpic region containing six vascular trace	Secretory tissue absent in mesocarpic region. Mesocarpic region containing five vascular trace	Within the mesocarpic region, just below the ribs region; secretory tissue present	Mesocarpic region containing vellicular cavity. Secretory tissue absent
Internal to the mesocarpic region, endocarp present, made up of crusted layer of parenchyma cells	Endocarp absent	Endocarp absent	Endocarp absent	Endocarp absent
Testal layer not clearly documented	Testa uni-seriate, parenchymatous	Testa uni-seriate, parenchymatous	Testa uni-seriate, parenchymatous	Testa not clearly documented
Endosperm layer not clearly documented	Endosperm layer not clearly documented	Endosperm layer not clearly documented	Endosperm uni-seriate, parenchymatous	Endosperm not clearly documented
Cotyledons are placed at oblique to the axis of cypselas, containing three resin ducts in each cotyledon	Cotyledons are placed at oblique to the axis of cypselas, containing nine resin ducts in each cotyledon	Cotyledons are not clearly documented	Cotyledons are placed at oblique to the axis of cypselas, containing three resin ducts in each cotyledon	Cotyledons are placed at right angle to the axis of cypsela, containing nine resin ducts in each cotyledon

In case of *C. officinalis*, mesocarpic region is also made up of both parenchyma and sclerenchyma cells (Mukherjee and Sarker 1999). In the cypsela of *C. suffruticosa* and *C. arvensis*, secretory ducts are present in mesocarpic region, than remaining three studied cypselas, where secretory ducts are absent. In the cypsela of *O. vaillantii*, vallecular cavity exists in mesocarpic region. The function of this cavity is still unknown. In the cypsela of *C. maderensis*, *C. stellata* and *C. suffruticosa*, testal layer is uni-seriately arranged and is made up of parenchyma cells. According to Reese (1989), taxa having well organized testa epidermis has been considered as primitive one in comparison to advanced taxa, which have disorganized testal epidermis i.e. testal epidermal cells lack sclerification and wall thickening. So, according to the observation

of Reese, *C. maderensis*, *C. stellata* and *C. suffruticosa* are most primitive, as they are containing well organized testal layer. In this connection, Jana and Mukherjee (2014) have done a contribution regarding the testal structure in some species of Compositae and also have provided a classification on the basis of 82 studied taxa. Internal to the testal layer, endosperm layer is present. In the cypsela of *C. suffruticosa*, endosperm layer is uni-seriate, made up of parenchyma cells, whereas in remaining studied cypselas, endosperm layer is absent.

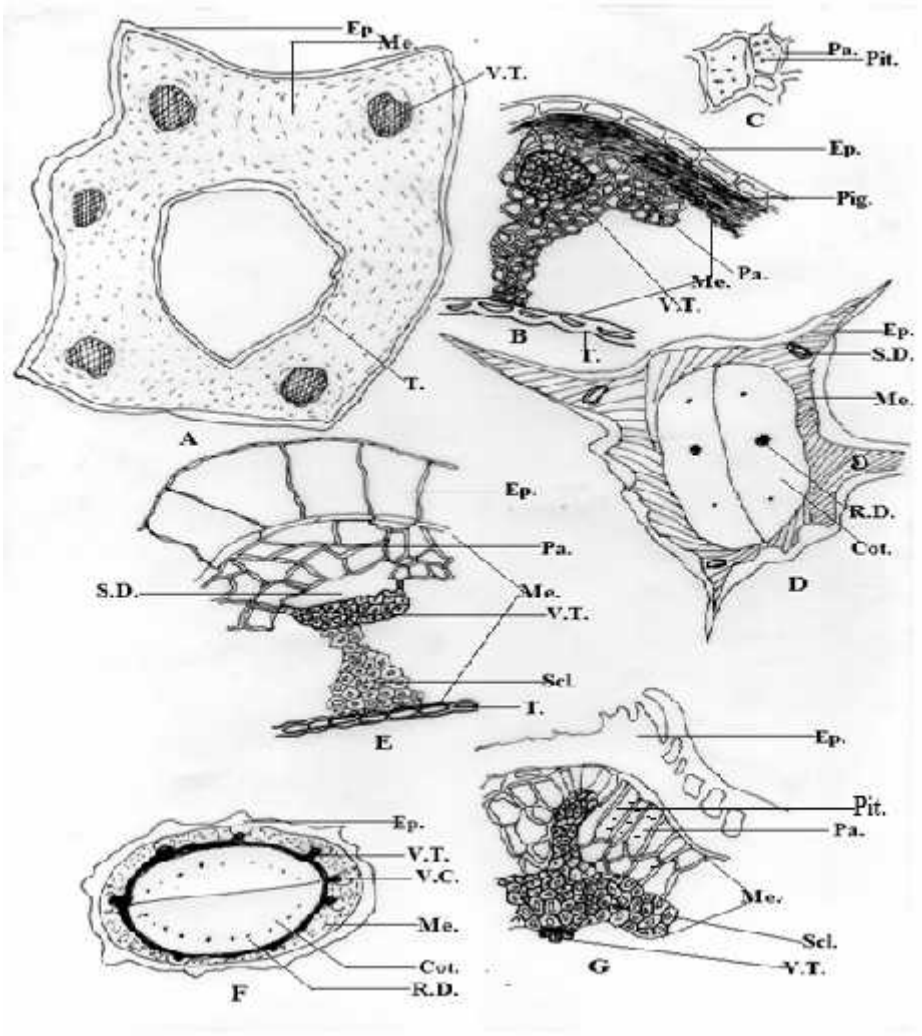


0.1 mm A 0.08 mm B, G 0.05 mm C,D,E 0.2 mm F

Fig. 1. Cypselar anatomy of the five studied species of the tribe Calenduleae.

A-E- *Calendula arvensis*: A- Diagramatic view (5 × 6), B- Cellular view (5 × 20), C- Magnified view of mesocarpic parenchyma containing pits (5 × 45), D- Magnified view of mesocarpic sclerenchyma (5 × 45), E- Magnified view of a portion of mesocarp, showing secretary duct and vascular trace (6 × 45); F-G- *Calendula maderensis*: F- Diagramatic view (5 × 6), G- Cellular view (5 × 45).

Abbreviations: Ep- Epicarp; Me- Mesocarp; S.D.- Secretory duct; V.T.- Vascular trace; Cot- Cotyledon; R.D.- Resin duct; Pig- Pigmentation; Pa-Parenchyma; Scl-Sclerenchyma; End- Endocarp; Cut- Cuticle; T- Testa.



0.1 mm A, D 0.05 mm C 0.08 mm B 0.05 mm E
0.1 mm F 0.08 mm G

Fig 2. Cypselar anatomy of the five studied species of the tribe Calenduleae.

A-C- *Calendula stellata*: A- Diagramatic view (5 × 6), B- Cellular view (5 × 20), C-A part of mesocarpic parenchyma containing pits (5 × 45); D-E- *Calendula suffruticosa*: D-Diagramatic view (5 × 6), E- Cellular view (5 × 45); F-G- *Osteospermum vaillantii*: F-Diagramatic view (5 × 6), G-Cellular view (5 × 20).

Ep- Epicarp; Me- Mesocarp; S.D.- Secretory duct; V.T.- Vascular trace; Cot- cotyledon; R.D.- Resin duct; Pig- Pigmentation; Pa- Parenchyma; Scl- Sclerenchyma; End- Endocarp; Cut- Cuticle; T- Testa.

Key to the studied cypselas:

1a. Cypsela triangular or quadrangular in cross sectional configuration; mesocarpic region containing 5 or 6 vascular traces ... (2)

2a. Cypsela triangular in cross section; epicarp with pigmentation; mesocarp made up of both parenchyma and sclerenchyma cells…*Calendula arvensis*

2b. Cypsela quadrangular in cross section; epicarp without pigmentation; mesocarp made up of only parenchyma cells ... *Calendula stellata*

1b. Cypsela elliptic in cross sectional configuration; mesocarpic region containing 4 or 6 or 8 vascular traces ... (3)

3a. Mesocarpic region containing 4 or 6 vascular traces; cypsela 4 or 6 lobed in cross section ... (4)

4a. Mesocarpic region containing 4 vascular trace; cypsela 4 lobed in cross sectional view; each cotyledon containing 3 resin ducts ... *Calendula suffruticosa*

4b. Mesocarpic region containing 6 vascular traces; cypsela 6 lobed in cross sectional view; each cotyledon containing 9 resin ducts ... *Calendula maderensis*

3b. Mesocarpic region containing 8 vascular traces; cypsela inconspicuously lobed in cross section ... *Osteospermum vaillantii*

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