

## NATURE OF COTYLEDONS IN SOME MATURE CYPSELAS OF THE FAMILY COMPOSITAE

\***Bidyut Kumar Jana, H.V. Hansen<sup>3</sup> and Sobhan Kr. Mukherjee<sup>2</sup>**

<sup>1</sup>*Department of Botany, Kanchrapara College,  
Kanchrapara, North-24 Pgs.*

<sup>2</sup>*Taxonomy and Biosystematics Laboratory, Department of Botany, University of Kalyani,  
Kalyani-741235, Nadia, West Bengal, India.*

<sup>3</sup>*Curator and University Botanic Garden of Copenhagen (DK),  
Gothersgade 130, DK -1123, Copenhagen, Denmark.*

\**Author for Correspondence: [janabotanytaxonomy@gmail.com](mailto:janabotanytaxonomy@gmail.com)*

### ABSTRACT

The present paper deals with the plane of arrangement of cotyledons with respect to the cypselar axis and number of resin ducts in each cotyledon. Each cotyledon usually has 3 resin ducts. The number is also variable, in some species; and the number may be more than three. The plane of arrangement of cotyledon with the cypselar axis is also variable. Cotyledons are arranged either at right angle to the axis of cypsela or parallel to the axis of cypsela or oblique to the axis of cypsela.

**Keywords:** *Nature of Cotyledons, Number of Resin Ducts, Cypsela, Compositae*

### INTRODUCTION

The family Asteraceae is one of the largest and highly evolved family among the dicotyledons, consisting of 43 tribes, 1600- 1700 genera and 24000 species (Funk *et al.*, 2009). India has about 177 genera and 1,052 species belonging to this family (Rao *et al.* 1988). The family is very interesting to the taxonomist, due to its great diversity of habit, habitat, morphology and histology of vegetative and reproductive structures (Bremer, 1994; Takhtajan, 1997). It is generally considered that the Asteraceae is a natural family, similar to Cruciferae, Poaceae and Apiaceae. The members of this family are easily recognized by some characteristic features which are pseudoanthial heads with a specialized type of pollen presentation mechanism and pappus structure (Mukherjee and Nordenstam, 2008), nature of fruit (Das and Mukherjee, 2008) and their particular array of chemical weapons (Heywood *et al.*, 1977).

The fruits of Asteraceae are technically termed as achene or cypsela which is developed from bicarpellary, hypogynous, unilocular ovary. The fruit is basically non endospermous or with scanty endospermus, but it has one to three layers of endosperms at mature state of cypselas. Within the endosperm, embryo exist; and the each embryo consist of 2 cotyledons, since it is a members of dicotyledonous group. The plane of arrangement of cotyledons and number of resin ducts are variable in different taxa. Mainly cotyledons are arranged in three ways, such as parallel to the axis of cypselas, right angle to the axis of cypselas and oblique to the axis of cypselas (Corn, 1993). Short *et al.* (1988), have done a revisionary work of some Australian genera of Compositae and have provided a sketch, regarding the plane of arrangement of cotyledons with the cypselar axis. Few work had been done previously, regarding the plane of arrangement of cotyledons and number of resin ducts in each cotyledon. Therefore an preliminary work has been undertaken to show the variations of mode of arrangement of cotyledons in relation to floral axis along with variation of number of resin ducts in each cotyledon and their taxonomic significance. Present study has been restricted on 150 species of the family Compositae.

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**MATERIALS AND METHODS**

The present study is mainly based on the dried cypselas, from different foreign herbaria of the world, abbreviated as in Holmgren *et al.* (1990): AD, LISC, SRGH, TAI, Z, LUAI, USA, B, WU, G, S, RB, H, DK, and few specimens from Kalyani University Campus.

For this study, cross sections of cypselas have been taken with the help of a sharp razor blade. The good sections were taken for this study. Sections were stained in 0.2 % aqueous safranin solution for 2-3 minutes and finally were placed under compound light microscope, to observe the anatomical structure, specially the plain of arrangements of cotyledon and number of resin ducts in each cotyledon.

**Sources of cypselas**

For this purpose, cypselas were procured from different herbaria of the world as gift.

**1.** *Acanthospermum hispidum* DC.; Tribe-Millarieae; LUAI, **2.** *Achillea ageratifolia* (Sibth. & Sm.) Boiss; Tribe-Anthemideae; Z; Nr. 335, **3.** *Achillea macrophylla* L.; Tribe-Anthemideae; Z; Nr.337, **4.** *Acmella oleracea* (L.) R.K. Jansen; Tribe-Heliantheae; XXOZ-20021797, **5.** *Adenostyles alliariae*; Tribe-Senecioneae; Z; CHOZ20031693, **6.** *Anacyclus depressum*; Tribe-Anthemideae; Z; Nr. 339, **7.** *Anthemis maritime*; Anthemideae; Z; XXOBRIS-20053261, **8.** *Anthemis tinctoria* L.; Tribe-Anthemideae; Z; Nr.342, **9.** *Arctium lappa* L.; Tribe-Cardueae; Germany, **10.** *Arctotis venusta* Norlin.; Tribe-Arctotideae; Z; CCOZ-20020220, **11.** *Arnica chamissonis* Less.; Tribe-Senecioneae; Z; Nr.347, **12.** *Artemisia annua* L.; Tribe-Anthemideae; Z; XXOZ-20040114, **13.** *Artemisia vulgaris* L.; Tribe-Anthemideae; Finland, **14.** *Aster albanicus* Degen.; Tribe-Astereae; DK; 211S2000-0862A, **15.** *Aster amellus* L.; Tribe-Astereae; Z; Nr.350, **16.** *Aster thomsonii* C.B. Clarke; Tribe-Astereae; SM-3, **17.** *Bahia absinthifolia* Benth. Tribe-Bahieae; S, **18.** *Bidens cernua* L.; Tribe-Coreopsidae; XXOZ-19780082, **19-** *Bidens frondosa* L.; Tribe-Coreopsidae; Germany, **20.** *Bidens pilosa* L.; Tribe-Coreopsidae; Kalyani Township; B.K.J. 92, **21.** *Calea cymosa* Less.; Tribe-Neuroleae; S, **22.** *Calendula arvensis* L. Tribe-Calenduleae; DK, **23.** *Calendula maderensis* DC.; Tribe-Calenduleae; DK., **24.** *Carduus acanthoides* L.; Tribe-Cardueae; DK.; 235 E 2884-0001 AG, **25.** *Carduus defloratus* L.; Tribe-Cardueae; Z; Nr. 359, **26.** *Carlina acanthifolia* All. Ssp. Cynara (Pourret ex Duby) Rouy; Tribe-Cardueae; Z; Nr. 360, **27.** *Carpesium cernuum* L.; Tribe-Inuleae; Z; XXOZ-20051457, **28.** *Centaurea aspera* L.; Tribe-Cardueae; Z.; XXOBRIS-20093677, **29.** *Centaurea cyanus* L.; Tribe-Cardueae; Z; Nr. 364, **30.** *Centaurea maculosa* Lam. Ssp. *maculosa*; Tribe-Cardueae; Z.; Nr. 369, **31.** *Centaurea scabiosa* L.; Tribe-Cardueae; Germany, **32.** *Centaurea spinosa* L.; Tribe-Cardueae; Z, **33.** *Centaurea stoebe* L.; Tribe-Cardueae; Germany, **34.** *Chaenactis fremontii* A.Gray; Tribe-Chanticitideae; S, **35.** *Chondrilla juncea* L.; Tribe-Lactuceae; Germany; **36.** *Chrysanthemum weyrichii* Miyabe & Miyake; Tribe-Anthemideae; Z; Nr. 376, **37.** *Cicerbita cyanea* (D. Don) Beauv; Tribe-Lactuceae; Z; SM-18, **38.** *Cicerbita macrorrhiza*(Royle)Beauv; Tribe-Lactuceae; Z; SM.19, **39.** *Cichorium endivia* L.; Tribe-Lactuceae; B, **40.** *Cichorium intybus* L.; Tribe-Lactuceae; Austria, **41.** *Cirsium canadelabrum* Griseb.; Tribe-Cardueae; DK, **42.** *Cirsium helenioides* (L.) Hill.; Tribe-Cardueae; Z; CHOZ-20031567, **43.** *Cirsium japonicum* DC.; Tribe-Cardueae; Z; Nr.378, **44.** *Cirsium spinosissimum* (L.) Scop.; Tribe-Cardueae; Z; CHOZ-20110617, **45.** *Cirsium vulgare* (Savi)Ten; Tribe-Cardueae; BRI; Nr. 378, **46.** *Cirsium arvense* (L.)Scop.; Tribe-Cardueae; G; Collection Number-107, **47.** *Cirsium eriophorum* Scop.; Tribe-Cardueae; Z; Collection Number. FROZ-20090558, **48.** *Cladanthus arabicus* (L.) Cass; Tribe-Anthemideae; Z; Collection Number. XXOZ-20040466, **49.** *Coleostephus multicaulis* (Desf.) Durieu; Tribe-Anthemideae; DK., **50.** *Coreopsis tinctoria* Nutt.; Tribe-Coreopsidae; Z; Nr. 381, **51.** *Cosmos sulphuralis* Cav.; Tribe-Coreopsidae; Kalyani township; B.K.J.-1, **52.** *Cousinia pterocaulos* (C.A. Mey.) Rech.; Tribe-Cardueae; DK., **53.** *Crassocephalum crepidioides* (Benth.) Moore; Tribe-Senecioneae; BRI; Nr. 347, **54.** *Crassocephalum rubens* (Juss. Ex Jacq.) Moore; Tribe-Senecioneae; SRGH; M. Mavi 13, **55.** *Crepis palaestina* (Bois.)Bornm; Tribe-Lactuceae; DK., **56.** *Crepis alpina* L.; Tribe-Lactuceae; DK., **57.** *Crepis dioscoridis* L.; Tribe-Lactuceae; DK., **58.** *Crepis foetida* L.; Tribe-Lactuceae; DK., **59.** *Crepis neglecta* L.; Tribe-Lactuceae; DK., **60.** *Crepis pulchra* L. Tribe-Lactuceae; DK., **61.** *Crepis pyrenaica* ; Tribe-Lactuceae; Z; Nr. 363, **62.** *Crepis vesicaria* L.; Tribe-Lactuceae;

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AD., **63.** *Dicoma sessiliflora* Harv. In Harv. & Sond. ssp. *sessiliflora*; Tribe-Mutisieae; LISC; A.r. Torre 13, **64.** *Dimorphotheca pluvialis* Moench; Tribe-Calenduleae; Z.; Nr.384, **65.** *Doronicum grandiflorum* Lam.; Tribe-Senecioneae; Z.; Collection Number-CHOZ 20031709, **66.** *Echinacea purpurea* Moench; Tribe-Heliantheae; Z.; Nr.385, **67.** *Echinops sphaerocephalus* L.; Tribe-Cardueae; Z.; Nr. 386, **68.** *Elephantopus carolinianus* Raeusch; Tribe-Vernonieae; DK., **69.** *Elephantopus scaber* L.; Tribe-Vernonieae; Kalyani township; B.K.J. 9, **70.** *Emilia coccinea* G. Don; Tribe-Senecioneae; Z.; Collection Number-XXOZ-19963273, **71.** *Erigeron acer* L.; Tribe-Astereae; Z.; Nr. 388, **72.** *Erigeron villarsii* Bell.; Tribe-Astereae; Z.; Nr.389, **73.** *Eupatorium chinense* L.; Tribe-Eupatorieae; TAI.; Y.F. Chen 3898, **74.** *Felicia heterophylla* (Cass.) Grau; Tribe-Astereae; DK., **75.** *Felicia tenella* (L.) Ness; Tribe-Astereae; DK., **76.** *Gizania krebsiana* Less.; Tribe-Arctotideae; Z.; Collection Number. XXOZ-19810083, **77.** *Glossogyne bidens* (Retz.) Alston; Tribe-Heliantheae; Z.; SM. 9, **78.** *Glossogyne tenuifolia* Cass.; Tribe-Heliantheae; BRI.; SM. 9, **79.** *Gnaphalium pennsylvanicum* Willd.; Tribe-Inuleae; SRGH; M.Mavi 3, **80.** *Grindelia camporum* Greene; Tribe-Astereae; DK., **81.** *Grindelia robusta* Nutt.; Tribe-Astereae; Z.; Collection Number. XXOZ-20051345, **82.** *Helianthus nuttallii* Torr. & A.Gray; Tribe-Heliantheae; USA; Collection Number- 420182, **83.** *Hieracium racemosum* W. & K. ex Willd. ; Tribe-Lactuceae; WU, **84.** *Homogyne alpina* Cass.; Tribe-Senecioneae; Z.; Collection Number- CHOZ-20042004, **85.** *Hypochoeris uniflora* (L.) Greuter; Tribe-Lactuceae; Z.; Collection Number-CHGZ-20TI0589, **86.** *Hypochoeris glabra* L.; Tribe-Lactuceae; AD.; A.A. Munir 8601, **87.** *Hypochoeris radicata* L.; Tribe-Lactuceae; BRI; A.A. Munir 8601, **88.** *Inula ensifolia* L.; Tribe-Inuleae; Z., **89.** *Inula helenium* L.; Tribe-Inuleae; Z., **90.** *Inula Britannica* L. ; Tribe-Inuleae; Z.; Collection Number- XXOZ-20060389, **91.** *Inula hirta* L.; Tribe-Inuleae; Z., **92.** *Lactuca pseudoumbrella* D. Maity & Maiti; Tribe-Lactuceae; Sikhim, **93.** *Lactuce serriola* L.; Tribe-Lactuceae; BHU, **94.** *Lapsana communis* L.; Tribe-Lactuceae; BHU, **95.** *Layia platyglossa* (Fisch. & C.A. Mey.) A. Gray; Tribe-Madieae; Z.; Collection Number- XXOZ-20050466, **96.** *Leontodon aisterminalis* L.; Tribe-Lactuceae; BHU, **97.** *Leontodon crispus* Vill.; Tribe-Lactuceae; DK., **98.** *Leontodon muelleri* (Sch. Bip.) Fiori; Tribe- Lactuceae; DK., **99.** *Leptorhynchos elongates* DC.; Tribe-Gnaphaleae; CBG; 8906276, **100.** *Leucanthemum vulgare* Lam.; Tribe-Anthemideae; H, **101.** *Ligularia dentata* (A. Gray) Hara; Tribe-Senecioneae; Z.; Nr. 415, **102.** *Lindhemera texana* A. Gray & Engelm.; Tribe-Heliantheae; Z.; Collection Number. XXOZ-19963438, **103.** *Madia elegans* D.Don; Tribe-Madieae; DK., **104.** *Melampodium perfoliatum* Kunth; Tribe-Millarieae; Z.; Collection Number-XXOMJG 19-46810, **105.** *Microseris lanceolata* Sch. Bip.; Tribe-Lactuceae; AD.; Collection Number. 4695, **106.** *Montisalca salmantica* (L.) Brig. Et casill.; Tribe-Cardueae; DK., **107.** *Myriactis humilis* Merr.; Tribe-Astereae; TAI; Chen. 3363, **108.** *Osteospermum vaillantii* (Decne.) Norl.; Tribe-Lactuceae; Z., **109.** *Picris hieracioides* L.; Tribe-Lactuceae; WU, **110.** *Podotheca angustifolia* (Labill.) Less.; Tribe-Gnaphaleae; AD., **111.** *Prenanthes purpurea* L.; Tribe-Lactuceae; Z.; Collection Number- CHOZ-20100751, **112.** *Ptilostemon diacantha* (Lab.) Greuter; Tribe-Cardueae; Z.; Nr. 377, **113.** *Pulicaria dysenterica* (L.) Bernh.; Tribe-Inuleae; Z.; Collection Number- BEOZ-19840270, **114.** *Rolandra fruticosa* (L.) o. Kuntze; Tribe-Vernonieae; RB.; SN 255, **115.** *Saussurea fastuosa* (Decne.) Sch. Bip.; Tribe-Cardueae; Kalyani University Campus; B.K.J.-15, **116.** *Schkuhria pinnata* (Lam.) Kuntze; Tribe-Bahieae; S, **117.** *Senecio alpines* (L.) Scop; Tribe-Senecioneae; Z.; Collection Number. CHOZ-20080791, **118.** *Senecio ovatus* (G. Gaerten et al.) Willd; Tribe-Senecioneae; Z.; Collection Number. CHOZ-20080790, **119.** *Serratula tinctoria* L.; Tribe-Cardueae; Z., **120-** *Solidago Canadensis* L.; Tribe-Astereae; BHU, **121.** *Solidago gigantean* Aiton; Tribe-Astereae; BHU, **122.** *Solidago virgaurea* L.; Tribe-Astereae; Z.; Collection Number. CHOZ-20080796, **123.** *Sonchus megalocarpus* (Hook. f.) J. M. Black; Tribe-Lactuceae; AD., **124.** *Sonchus oleraceous* L.; Tribe-Lactuceae; WU, **125.** *Sonchus wightianus* L.; Tribe-Lactuceae; Kalyani Township; B.K.J.201, **126.** *Synedrella nodiflora* Garten.; Tribe-Heliantheae; Kalyani township; B.K.J.-12, **127.** *Tagetes lucida* Cave.; Tribe-Tageteae; Z.; Collection Number. XXOZ-20031315, **128.** *Tagetes tenuifolia* L.; Tribe-Tageteae; Z.; Collection Number. XXOZ-20110213, **129.** *Tanacetium vulgare* L.; Tribe-Anthemideae; BHU, **130.** *Tanacetum parthenium* Sch. Bip.; Tribe-

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Anthemideae; Z.; Collection Number. XXOZ 19965019, **131.** *Telekia speciosa* Baumg.; Tribe-Inuleae; Z., **132.** *Tithonia diversifolia* (Hemsl.) A.Gray; Tribe-Heliantheae; AD.; Nr. 398, **133.** *Tithonia rotundifolia* (Mill.) Blake; Tribe-Heliantheae; SRGH; M. Mavi 17, **134.** *Tragopogon porrifolius* L.; Tribe-Lactuceae; AD.; N.N. Donner 8606, **135.** *Tragopogon pratensis* L.; Tribe-Lactuceae; BHU, **136.** *Tridax procumbens* L.; Tribe-Millarieae; S., **137.** *Tripleurospermum inodorum* (L.) Sch. Bip.; Tribe-Anthemideae; H., **138.** *Tripleurospermum maritimum* (L.) W.D.J. Koch; Tribe-Anthemideae; BHU, **139.** *Urospermum dalechampii* (L.) F.W. Schmidt; Tribe-Lactuceae; Z.; Collection Number. XXOZ 19950008, **140.** *Vernonia anthelmintica* Willd.; Tribe-Vernonieae; Kalyani township; B.K.J. 30, **141.** *Vernonia ceneria* Less.; Tribe-Vernonieae; Kalyani township; B.K.J. 30, **142.** *Vernonia galamensis* Less.; Tribe-Vernonieae; USA, **143.** *Vernonia hymenolepis* A. Rich.; Tribe-Vernonieae; USA, **144.** *Vernonia melleri* Oliv.; Tribe-Vernonieae; LISC, **145.** *Vernonia poskeana* Vatke & Hildeb.; Tribe-Vernonieae; LISC; A.R. Torr & Paiva 11332, **146.** *Vernonia stenolepis* Oliv.; Tribe-Vernonieae; USA, **147.** *Villanova oppositifolia* Lag.; Tribe-Perityleae; S., **148.** *Vittadinia gracilis* (Hook. f.) Burbidge; Tribe-Astereae; AD; N.N. Donner 8633, **149.** *Xeranthemum annuum* L.; Tribe-Cardueae; Z.; Collection Number. XXOZ 20040897, **150.** *Zinnia haageana* Regel; Tribe-Heliantheae; DK.; Collection Number. 497E2493-0005 AG.

**RESULTS**

The nature of cotyledons and number of resin ducts in each cotyledon of different studied species are summarized in the following Table 1.

**Table 1. Plane of arrangements of cotyledons and number of resin ducts in each cotyledon of studied species of the family Asteraceae**

Sl. No.	Name of the taxa	Tribe	Arrangement of cotyledons	Number of resin ducts in each cotyledon
1.	<i>Dicoma sessiliflora</i> Harv. In Harv. & Sond. ssp. <i>sessiliflora</i>	Mutisieae	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
2.	<i>Xeranthemum annuum</i>	Cardueae	At right angle to the axis of cypsela	Seven resin ducts in each cotyledon
3.	<i>Serratula tinctoria</i>	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
4.	<i>Saussurea fastuosa</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon.
5.	<i>Ptilostemon diacantha</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
6.	<i>Montisalca salmantica</i> Fig. C-15	„	At oblique to the axis of cypsela	Eight resin ducts in each cotyledon
7.	<i>Echinops sphaerocephalus</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
8.	<i>Cousinia pterocaulos</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon.



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Sl. No.	Name of the taxa	Tribe	Arrangement of cotyledons	Number of resin ducts in each cotyledon
9.	<i>Cirsium eriophorum</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
10.	<i>Cirsium canadelabrum</i> Fig B-11	„	At oblique to the axis of cypsela	Five resin ducts in each cotyledon
11.	<i>Cirsium helenioides</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
12.	<i>Cirsium japonicum</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
13.	<i>Cirsium spinosissimum</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon.
14.	<i>Cirsium vulgare</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
15.	<i>Cirsium arvense</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
16.	<i>Centaurea cyanus</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
17.	<i>Centaurea maculosa</i> Lam. Ssp. <i>maculosa</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
18.	<i>Centaurea scabiosa</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
19.	<i>Centaurea spinosa</i> Fig. B-10	„	At oblique to the axis of cypsela	Seven resin ducts in each cotyledon
20.	<i>Centaurea stoebe</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
21.	<i>Centaurea aspera</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
22.	<i>Carduus defloratus</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
23.	<i>Carlina acanthifolia</i>	„	At oblique to the axis of cypsela	Seven resin ducts in each cotyledon
24.	<i>Carduus acanthoides</i>	„	At oblique to the axis of cypsela	Four resin ducts in each cotyledon
25.	<i>Arctium lappa</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
26.	<i>Elephantopus carolinianus</i>	Vernonieae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
27.	<i>Elephantopus scaber</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
28.	<i>Rolandra fruticosa</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon

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Sl. No.	Name of the taxa	Tribe	Arrangement of cotyledons	Number of resin ducts in each cotyledon
29.	<i>Vernonia anthelmintica</i>	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
30.	<i>Vernonia ceneria</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
31.	<i>Vernonia galamensis</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
32.	<i>Vernonia hymenolepis</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
33.	<i>Vernonia melleri</i>	„	Parallel to the axis of cypsela	Three resin ducts in each cotyledon
34.	<i>Vernonia poskeana</i>	„	Parallel to the axis of cypsela	Three resin ducts in each cotyledon
35.	<i>Vernonia stenolepis</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
36.	<i>Urospermum dalechampii</i>	Lactuceae	At right angle to the axis of cypsela	Seven resin ducts in each cotyledon
37.	<i>Tragopogon porrifolius</i>	„	At right angle to the axis of cypsela	Seven resin ducts in each cotyledon
38.	<i>Tragopogon pratensis</i>	„	Parallel to the axis of cypsela	Three resin ducts in each cotyledon
39.	<i>Sonchus megalocarpus</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
40.	<i>Sonchus oleraceous</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
41.	<i>Sonchus wightianus</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
42.	<i>Prenanthes purpurea</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
43.	<i>Osteospermum vaillantii</i>	„	At oblique to the axis of cypsela	Eight resin ducts in each cotyledon
44.	<i>Picris hieracioides</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
45.	<i>Microseris lanceolata</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
46.	<i>Leontodon aisterminalis</i>	„	At oblique to the axis of cypsela	Five resin ducts in each cotyledon
47.	<i>Leontodon crispus</i>	„	At right angle to the axis of cypsela	Six resin ducts in each cotyledon
48.	<i>Leontodon muelleri</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
49.	<i>Lactuca pseudoumbrella</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
50.	<i>Lactuce serriola</i>	„	At right angle to the axis of cypsela	Seven resin ducts in each cotyledon

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Sl. No.	Name of the taxa	Tribe	Arrangement of cotyledons	Number of resin ducts in each cotyledon
51.	<i>Lapsona communis</i>	„	At oblique to the axis of cypsela	Five resin ducts in each cotyledon
52.	<i>Hypochaeris uniflora</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
53.	<i>Hypochoeris glabra</i>	„	At right angle to the axis of cypsela	Seven resin ducts in each cotyledon
54.	<i>Hypochoeris radicata</i>	„	At right angle to the axis of cypsela	Eight resin ducts in each cotyledon
55.	<i>Hieracium racemosum</i> Fig A-5	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
56.	<i>Crepis dioscoridis</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
57.	<i>Crepis foetida</i>	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
58.	<i>Crepis neglecta</i>	„	At oblique to the axis of cypsela	Five resin ducts in each cotyledon
59.	<i>Crepis pulchra</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
60.	<i>Crepis pyrenaica</i> Fig B-14	„	At oblique to the axis of cypsela	Four resin ducts in each cotyledon
61.	<i>Crepis vesicaria</i>	„	Parallel to the axis of cypsela	Three resin ducts in each cotyledon
62.	<i>Crepis palaestina</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
63.	<i>Crepis alpina</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
64.	<i>Cichorium intybus</i>	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
65.	<i>Cicerbita cyanea</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
66.	<i>Cicerbita macrorrhiza</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
67.	<i>Cichorium endivia</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
68.	<i>Chondrilla juncea</i>	„	At oblique to the axis of cypsela	Eight resin ducts in each cotyledon
69.	<i>Arctotis venusta</i>	Arctotideae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
70.	<i>Gizania krebsiana</i> Fig A-4	„	At right angle to the axis of cypsela	Ten resin ducts in each cotyledon

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Sl. No.	Name of the taxa	Tribe	Arrangement of cotyledons	Number of resin ducts in each cotyledon
71.	<i>Senecio alpinus</i>	Senecioneae	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
72.	<i>Senecio ovatus</i>	„	At oblique to the axis of cypsela	Four resin ducts in each cotyledon
73.	<i>Ligularia dentata</i>	„	At oblique to the axis of cypsela	Four resin ducts in each cotyledon
74.	<i>Homogyne alpina</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
75.	<i>Emilia coccinea</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
76.	<i>Doronicum grandiflorum</i>	„	At oblique to the axis of cypsela	Five resin ducts in each cotyledon
77.	<i>Crassocephalum crepidioides</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
78.	<i>Crassocephalum rubens</i>	„	Parallel to the axis of cypsela	Three resin ducts in each cotyledon
79.	<i>Arnica chamissonis</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
80.	<i>Adenostyles alliariae</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
81.	<i>Calendula arvensis</i>	Calenduleae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
82.	<i>Calendula maderensis</i> Fig B-9	„	At oblique to the axis of cypsela	Nine resin ducts in each cotyledon
83.	<i>Dimorphotheca pluvialis</i> Fig A-3	„	At right angle to the axis of cypsela	Twelve resin ducts in each cotyledon
84.	<i>Podotheca angustifolia</i>	Gnaphaleae	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
85.	<i>Leptorhynchos elongatus</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
86.	<i>Aster albanicus</i>	Astereae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
87.	<i>Aster amellus</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
88.	<i>Aster thomsonii</i>	„	Parallel to the axis of cypsela	Three resin ducts in each cotyledon
89.	<i>Erigeron acer</i>	„	Parallel to the axis of cypsela	Four resin ducts in each cotyledon
90.	<i>Erigeron villarsii</i>	„	Parallel to the axis of cypsela	Four resin ducts in each cotyledon
91.	<i>Felicia heterophylla</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon



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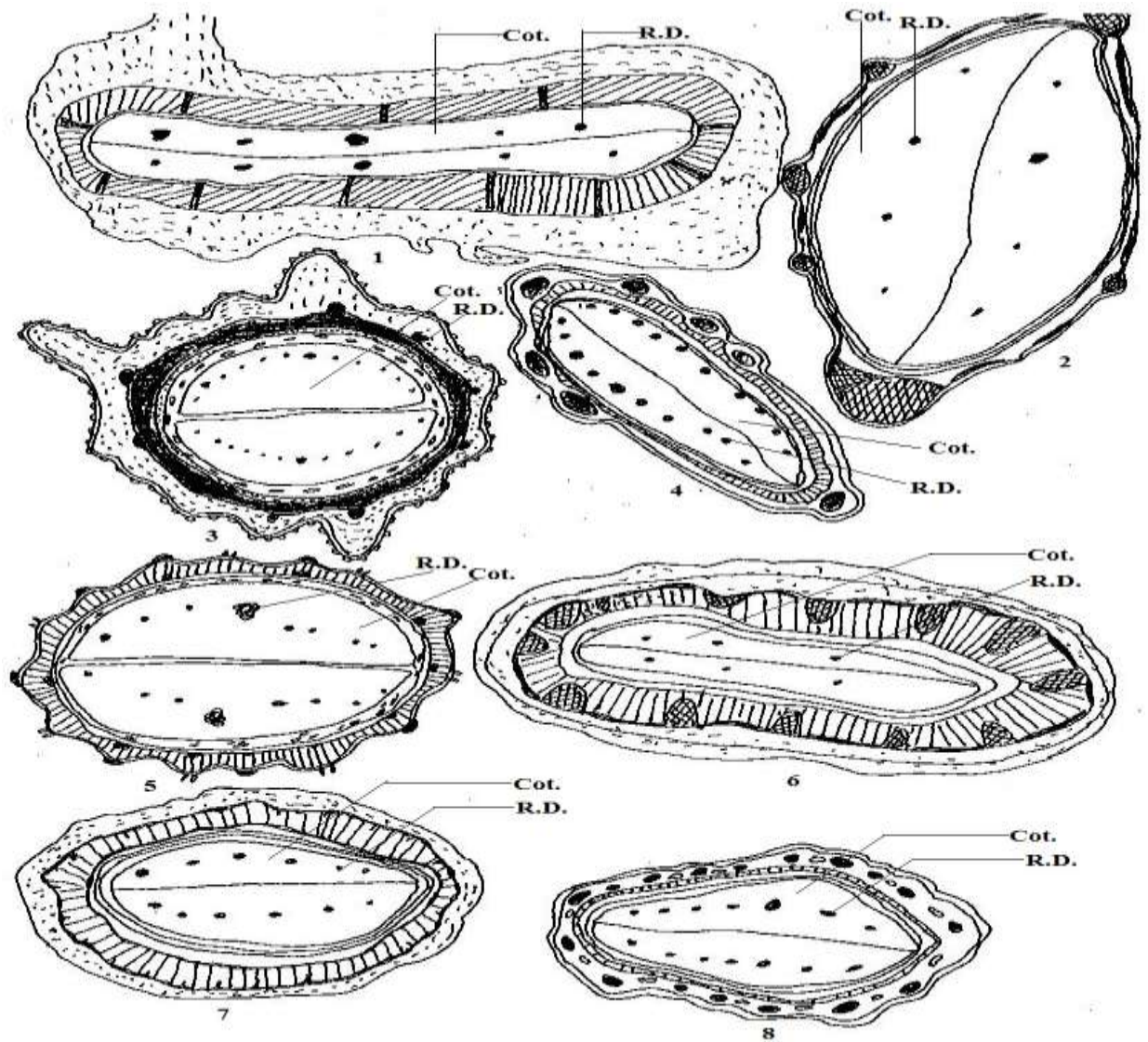
Sl. No.	Name of the taxa	Tribe	Arrangement of cotyledons	Number of resin ducts in each cotyledon
92.	<i>Felicia tenella</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
93.	<i>Grindelia camporum</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
94.	<i>Grindelia robusta</i>	„	At oblique to the axis of cypsela	Four resin ducts in each cotyledon
95.	<i>Myriactis humilis</i>	„	Parallel to the axis of cypsela	Four resin ducts in each cotyledon
96.	<i>Solidago canadensis</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
97.	<i>Solidago gigantea</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
98.	<i>Solidago virgaurea</i>	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
99.	<i>Vittadinia gracilis</i>	„	At oblique to the axis of cypsela	Five resin ducts in each cotyledon
100.	<i>Tripleurospermum inodorum</i>	Anthemideae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
101.	<i>Tripleurospermum maritimum</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
102.	<i>Tanacetum parthenium</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
103.	<i>Tanacetium vsilgare</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
104.	<i>Leucanthemum vulgare</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
105.	<i>Cladanthus arabicus</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
106.	<i>Coleostephus multicaulis</i> Fig. C-17	„	Parallel to the axis of cypsela	Four resin ducts in each cotyledon
107.	<i>Chrysanthemum weyrichii</i>	„	Parallel to the axis of cypsela	Five resin ducts in each cotyledon
108.	<i>Artemisia annua</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
109.	<i>Artemisia vulgaris</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
110.	<i>Anacyclus depressum</i>	„	At right angle to the axis of cypsela	Six resin ducts in each cotyledon
111.	<i>Anthemis maritima</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
112.	<i>Anthemis tinctoria</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon

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Sl. No.	Name of the taxa	Tribe	Arrangement of cotyledons	Number of resin ducts in each cotyledon
113.	<i>Achillea ageratifolia</i>	„	At right angle to the axis of cypsela	Six resin ducts in each cotyledon
114.	<i>Achillea macrophylla</i>	„	At right angle to the axis of cypsela	Seven resin ducts in each cotyledon
115.	<i>Carpesium cernuum</i>	Inuleae	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
116.	<i>Gnaphalium pensylvanicum</i>	„	Parallel to the axis of cypsela	Three resin ducts in each cotyledon
117.	<i>Inula ensifolia</i>	„	At oblique to the axis of cypsela	Seven resin ducts in each cotyledon
118.	<i>Inula helenium</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
119.	<i>Inula britannica</i>	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
120.	<i>Inula hirta</i>	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
121.	<i>Pulicaria dysenterica</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
122.	<i>Telekia speciosa</i>	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
123.	<i>Coreopsis tinctoria</i> Fig. B-12	Coreopsidaeae	At oblique to the axis of cypsela	Six resin ducts in each cotyledon.
124.	<i>Cosmos sulphuralis</i> Fig B-13	„	At oblique to the axis of cypsela	Eleven resin ducts in each cotyledon
125.	<i>Bidens cernua</i>	„	At oblique to the axis of cypsela	Five resin ducts in each cotyledon
126.	<i>Bidens frondosa</i>	„	At right angle to the axis of cypsela	Six resin ducts in each cotyledon
127.	<i>Bidens pilosa</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
128.	<i>Calea cymosa</i>	Neurolaeneae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
129.	<i>Tagetes lucida</i>	Tageteae	At right angle to the axis of cypsela	Six resin ducts in each cotyledon
130.	<i>Tagetes tenuifolia</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
131.	<i>Chaenactis fremontii</i>	Chaenacteeae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
132.	<i>Bahia absinthifolia</i> Fig. C-16	Bahieae	Parallel to the axis of cypsela	Three resin ducts in each cotyledon
133.	<i>Schkuhria pinnata</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon

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Sl. No.	Name of the taxa	Tribe	Arrangement of cotyledons	Number of resin ducts in each cotyledon
134.	<i>Zinnia haageana</i>	Heliantheae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
135.	<i>Tithonia diversifolia</i>	„	At right angle to the axis of cypsela	Six resin ducts in each cotyledon.
136.	<i>Tithonia rotundifolia</i>	„	At right angle to the axis of cypsela	Seven resin ducts in each cotyledon
137.	<i>Synedrella nodiflora</i>	„	At right angle to the axis of cypsela	Six resin ducts in each cotyledon
138.	<i>Lindhemera texana</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
139.	<i>Helianthus nuttallii</i>	„	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
140.	<i>Glossogyne bidens</i>	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
141.	<i>Glossogyne tenuifolia</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
142.	<i>Echinacea purpurea</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
143.	<i>Acmella oleracea</i> Fig A-2	„	At right angle to the axis of cypsela	Four resin ducts in each cotyledon
144.	<i>Acanthospermum hispidum</i> Fig A-1	Millarieae	At right angle to the axis of cypsela	Five resin ducts in each cotyledon
145.	<i>Melampodium perfoliatum</i> Fig A- 6	„	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
146.	<i>Tridax procumbens</i> Fig A-7	„	At right angle to the axis of cypsela	Six resin ducts in each cotyledon
147.	<i>Madia elegans</i>	Madieae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
148.	<i>Layia platyglossa</i>	„	At oblique to the axis of cypsela	Three resin ducts in each cotyledon
149.	<i>Villanova oppositifolia</i>	Perityleae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon
150.	<i>Eupatorium chinense</i>	Eupatorieae	At right angle to the axis of cypsela	Three resin ducts in each cotyledon

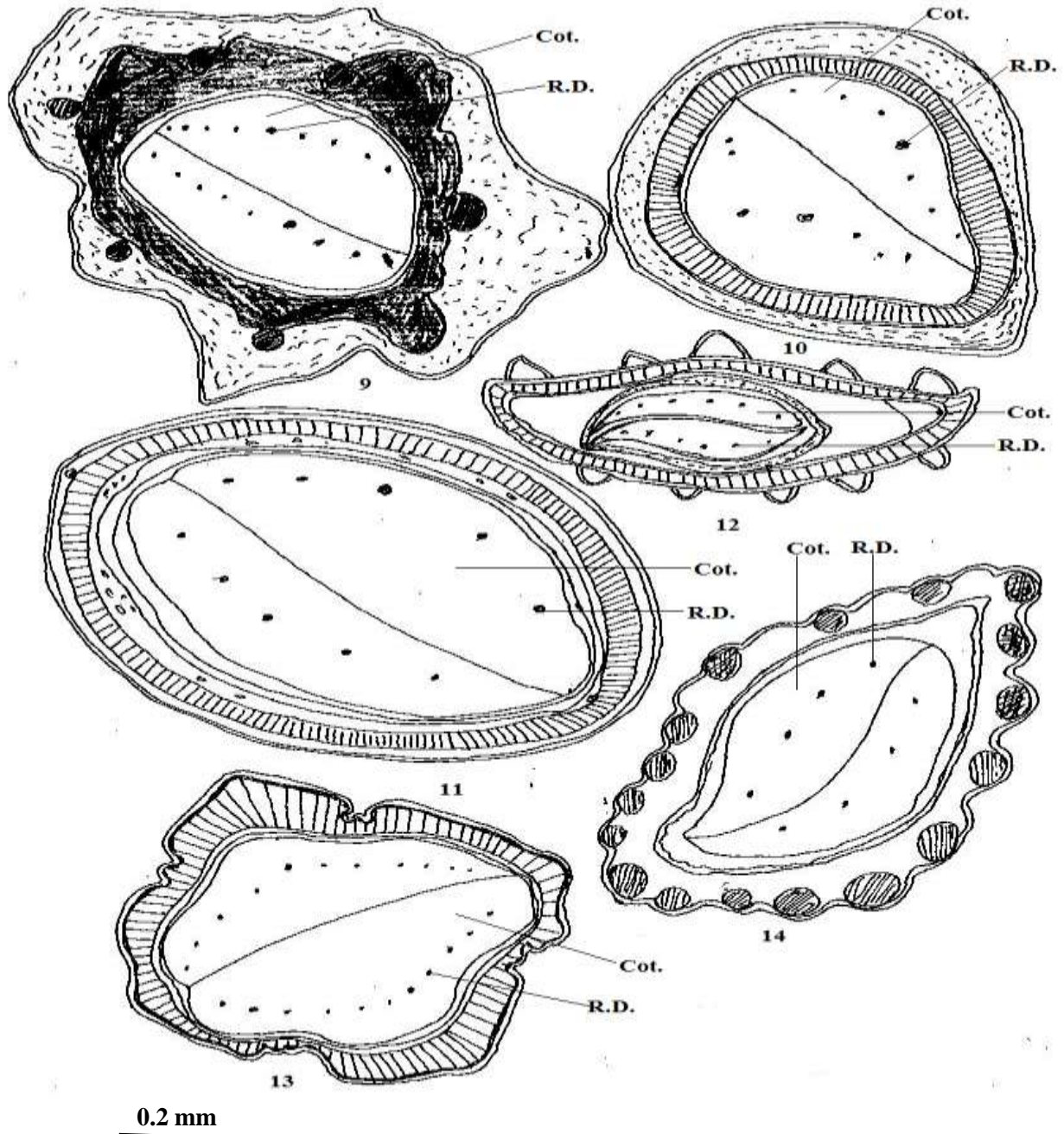


0.2 mm.

**Figure A: (1-8) Cross sections of cypselas, showing the nature of cotyledons (Right angle to the axis of cypselas), with resin duct.**

1-*Acanthospermum hispidum*, 2- *Acmella olearia*, 3- *Dimorphotheca pluvialis*, 4- *Gizania krebsiana*, 5- *Hypochoeris radicata*, 6- *Melampodium perfoliatum*, 7- *Tridax procumbens*, 8- *Xeranthemum annuum*



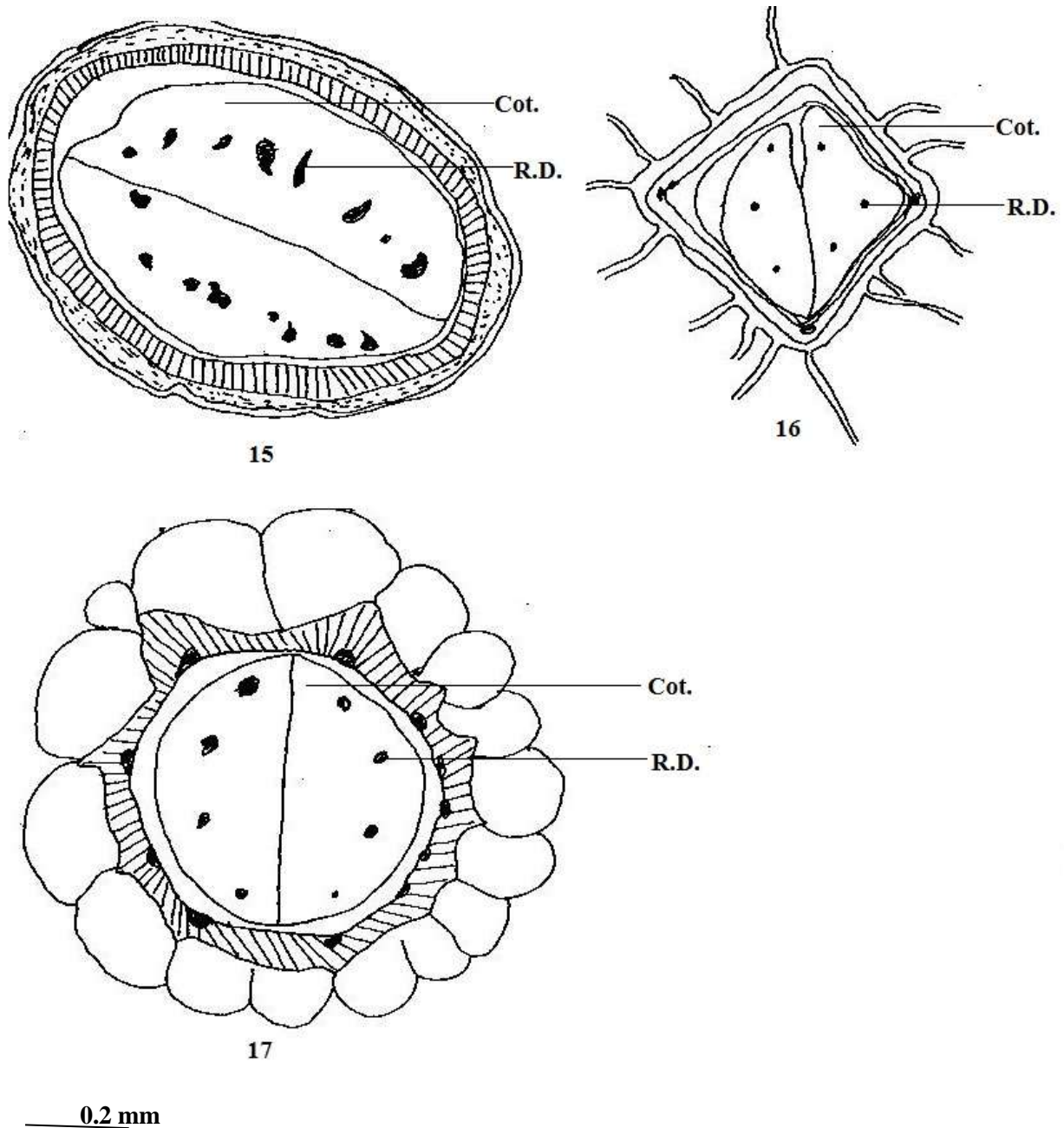


**Figure B: (9-14) Cross sections of cypselas, showing the nature of cotyledons (Oblique to the axis of cypselas), with resin duct.**

9-*Calendulla madrensis*, 10-*Centaurea spinosa*, 11-*Cirsium canadelabrum*, 12-*Coreopsis tinctoria*, 13-*Cosmos sulphures*, 14-*Crepis pyrenica*



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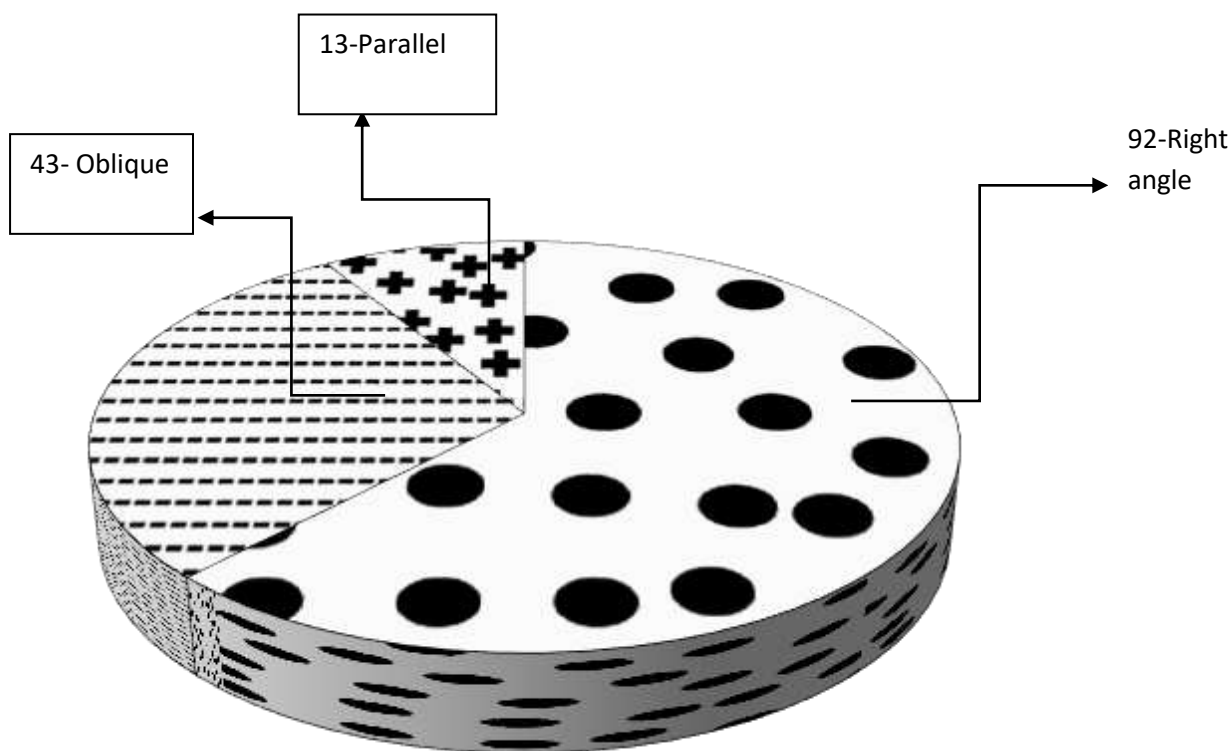


**Figure C: 15-** Cross sections of cypselas, showing the nature of cotyledons (Oblique to the axis of cypselas), with resin ducts.

**Fig. C. (16-17)-**Cross sections of cypselas, showing the nature of cotyledon (Parallel to the axis of cypselas), with resin ducts.

15- *Montisalca salmantica*, 16-*Bahia absantifolia*, 17-*Coleostephus multicaulis*

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**Figure D: Pie chart showing the mode of arrangement of cotyledons in different cypselas.**

**DISCUSSION**

On the basis of the mode of arrangements of cotyledons, the studied cypselas have been divided into following three categories (Fig. D):

**A. Cotyledons are placed in right angle to the axis of cypselas**

There are many taxa in this category:

*Acanthospermum hispidum*, *Melampodium perfoliatum*, *Tridax procumbens*, *Lindhemera texana*, *Synedrella nodiflora*, *Arctium lappa*, *Centaurea aspera*, *Centaurea scabiosa*, *Centaurea stoebe*, *Cirsium arvense*, *Cirsium eriophorum*, *Cirsium helenioides*, *Cirsium spinosissimum*, *Cousinia pterocaulos*, *Saussurea fastuosa*, *Xeranthemum annuum*, *Homogyne alpina*, *Urospermum dalechampii*, *Elephantopus carolinianus*, *Madia elegans*, *Bidens pilosa*, *Sonchus oleraceous*, *Tripleurospermum maritimum*, *Artemisia vulgaris*, *Solidago gigantea*, *Inula Britannica*, *Tagetes lucida*, *Solidago virgaurea*, *Cladanthus arabicus*, *Chaenactis fremontii*, *Schkuhria pinnata*, *Villanova oppositifolia*, *Calea cymosa*, *Inula helenium*, *Tripleurospermum inodorum*, *Bidens frondosa*, *Emilia coccinea*, *Gizania krebsiana*, *Crepis palaestina*, *Crepis dioscoridis*, *Crepis pulchra*, *Crepis foetida*, *Telekia speciosa*, *Hypochaeris uniflora*, *Tragopogon porrifolius*, *Serratula tinctoria*, *Felicia heterophylla*, *Leontodon crispus*, *Leontodon muelleri*, *Picris hieracioides*, *Cichorium endivia*, *Zinnia haageana*, *Aster albanicus*, *Inula hirta*, *Grindelia camporum*, *Felicia tenella*, *Microseris lanceolata*, *Prenanthes purpurea*, *Calendula arvensis*, *Elephantopus scaber*, *Helianthus nuttallii*, *Lactuce serriola*, *Adenostyles alliariae*, *Vernonia hymenolepis*, *Vernonia galamensis*, *Vernonia anthelmintica*, *Lactuca pseudoumbrella*, *Cichorium intybus*, *Aster amellus*, *Leptorhynchus elongates*, *Eupatorium chinense*, *Rolandra fruticosa*, *Glossogyne bidens*, *Tithonia diversifolia*, *Tithonia rotundifolia*, *Arnica chamissonis*, *Crassocephalum crepidioides*, *Achillea ageratifolia*, *Achillea macrophylla*, *Anacyclus depressum*, *Anthemis tinctoria*, *Arctotis venusta*, *Dimorphotheca pluvialis*, *Carduus*

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*defloratus*, *Centaurea cyanus*, *Centaurea maculosa* Lam. Ssp. *maculosa*, *Ptilostemon diacantha*, *Cirsium japonicum*, *Cirsium vulgare*, *Cicerbita cyanea*, *Cicerbita macrorrhiza*, *Hypochoeris radicata*, *Hypochoeris glabra*, *Sonchus megalocarpus*

**B. Cotyledons are placed in oblique to the axis of cypselas**

*Dicoma sessiliflora* Harv. In Harv. & Sond. ssp. *sessiliflora*, *Echinops sphaerocephalus*, *Carlina acanthifolia*, *Ligularia dentata*, *Glossogyne tenuifolia*, *Echinacea purpurea*, *Coreopsis tinctoria*, *Vittadinia gracilis*, *Vernonia stenolepis*, *Anthemis maritime*, *Senecio ovatus*, *Tagetes tenuifolia*, *Carduus acanthoides*, *Grindelia robusta*, *Calendula maderensis*, *Osteospermum vaillantii*, *Podotheca angustifolia*, *Cosmos sulphuralis*, *Pulicaria dysenterica*, *Inula ensifolia*, *Hieracium racemosum*, *Centaurea spinosa*, *Crepis pyrenaica*, *Crepis neglecta*, *Crepis alpina*, *Vernonia ceneria*, *Leontodon aisternnalis*, *Leucanthemum vulgare*, *Layia platyglossa*, *Artemisia annua*, *Senecio alpines*, *Bidens cernua*, *Tanacetum parthenium*, *Solidago Canadensis*, *Chondrilla juncea*, *Tanacetium vsilgare*, *Lapsana communis*, *Sonchus wightianus*, *Doronicum grandiflorum*, *Carpesium cernuum*, *Montisalca salmantica*, *Cirsium canadelabrum*, *Acmella oleracea*

**C. Cotyledons are placed in parallel to the axis of cypselas**

*Crepis vesicaria*, *Chrysanthemum weyrichii*, *Crassocephalum rubens*, *Gnaphalium pensylvanicum*, *Myriactis humilis*, *Erigeron villarsii*, *Erigeron acer*, *Aster thomsonii*, *Vernonia poskeana*, *Vernonia melleri*, *Coleostephus multicaulis*, *Tragopogon pratensis*, *Bahia absinthifolia*

Number of resin ducts is more or less fixed in each species, because, it has been controlled by genetic composition. On the basis of the number of resin ducts in each cotyledon, cypselas can be divided into following categories:-

**1. Each cotyledon has three resin ducts ( 80 species)**

*Sonchus megalocarpus*, *Crepis vesicaria*, *Cicerbita cyanea*, *Dicoma sessiliflora* Harv. In Harv. & Sond. ssp. *sessiliflora*, *Echinops sphaerocephalus*, *Cirsium vulgare*, *Cirsium japonicum*, *Ptilostemon diacantha*, *Arctotis venusta*, *Anthemis tinctoria*, *Crassocephalum rubens*, *Crassocephalum crepidioides*, *Arnica chamissonis*, *Glossogyne tenuifolia*, *Glossogyne bidens*, *Echinacea purpurea*, *Gnaphalium pensylvanicum*, *Aster thomsonii*, *Vernonia poskeana*, *Vernonia melleri*, *Rolandra fruticosa*, *Eupatorium chinense*, *Aster amellus*, *Lactuca pseudoumbrella*, *Vernonia galamensis*, *Vernonia stenolepis*, *Anthemis maritime*, *Adenostyles alliariae*, *Tragopogon pratensis*, *Elephantopus scaber*, *Calendula arvensis*, *Podotheca angustifolia*, *Microseris lanceolata*, *Pulicaria dysenterica*, *Felicia tenella*, *Grindelia camporum*, *Aster albanicus*, *Zinnia haageana*, *Cichorium endivia*, *Leontodon muelleri*, *Hieracium racemosum*, *Hypochaeris uniflora*, *Crepis alpina*, *Crepis palaestina*, *Vernonia ceneria*, *Tripleurospermum inodorum*, *Leucanthemum vulgare*, *Layia platyglossa*, *Calea cymosa*, *Villanova oppositifolia*, *Schkuhria pinnata*, *Chaenactis fremontii*, *Bahia absinthifolia*, *Artemisia annua*, *Cladanthus arabicus*, *Senecio alpines*, *Solidago gigantean*, *Artemisia vulgaris*, *Tanacetum parthenium*, *Solidago Canadensis*, *Tripleurospermum maritimum*, *Tanacetium vsilgare*, *Sonchus wightianus*, *Bidens pilosa*, *Madia elegans*, *Elephantopus carolinianus*, *Homogyne alpina*, *Carpesium cernuum*, *Saussurea fastuosa*, *Cousinia pterocaulos*, *Cirsium spinosissimum*, *Cirsium helenioides*, *Cirsium eriophorum*, *Cirsium arvense*, *Centaurea stoebe*, *Centaurea scabiosa*, *Centaurea aspera*, *Arctium lappa*, *Lindhemera texana*, *Melampodium perfoliatum*

**2. Each cotyledon has four resin ducts (18 species)**

*Ligularia dentata*, *Myriactis humilis*, *Erigeron villarsii*, *Erigeron acer*, *Cichorium intybus*, *Vernonia anthelmintica*, *Senecio ovatus*, *Coleostephus multicaulis*, *Grindelia robusta*, *Carduus acanthoides*, *Inula hirta*, *Serratula tinctoria*, *Crepis pyrenaica*, *Telekia speciosa*, *Crepis foetida*, *Solidago virgaurea*, *Inula Britannica*, *Acmella oleracea*

**3. Each cotyledon has five resin ducts (24 species)**

*Cicerbita macrorrhiza*, *Centaurea maculosa* Lam. Ssp. *maculosa*, *Centaurea cyanus*, *Carduus defloratus*, *Chrysanthemum weyrichii*, *Vittadinia gracilis*, *Leptorhynchus elongates*, *Vernonia*

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*hymenolepis, Helianthus nuttallii, Prenanthes purpurea, Picris hieracioides, Felicia heterophylla, Crepis neglecta, Crepis pulchra, Crepis dioscoridis, Emilia coccinea, Leontodon aisterminalis, Inula helenium, Bidens cernua, Lapsona communis, Sonchus oleraceous, Doronicum grandiflorum, Cirsium canadellabrum, Acanthospermum hispidum*

**4. Each cotyledon has six resin ducts (9 species)**

*Tridax procumbens, Synedrella nodiflora, Tagetes lucida, Bidens frondosa, Leontodon crispus, Coreopsis tinctoria, Tithonia diversifolia, Achillea ageratifolia, Anacyclus depressum*

**5. Each cotyledon has seven resin ducts (10 species)**

*Hypochoeris glabra, Carlina acanthifolia, Achillea macrophylla, Tithonia rotundifolia, Lactuca serriola, Inula ensifolia, Centaurea spinosa, Tragopogon porrifolius, Urospermum dalechampii, Xeranthemum annuum*

**6. Each cotyledon has eight resin ducts (4 species)**

*Hypochoeris radicata, Osteospermum vaillantii, Chondrilla juncea, Montisalca salmantica*

**7. Each cotyledon has nine resin ducts (1 species)**

*Calendula maderensis*

**8. Each cotyledon has ten resin ducts (1 species)**

*Gizania krebsiana*

**9. Each cotyledon has eleven resin ducts (1 species)**

*Cosmos sulphuralis*

**10. Each cotyledon has twelve resin ducts (1 species)**

*Dimorphotheca pluvialis*

Among the studied cypselas (150 taxa), 61.3 % cypselas have right angled oriented cotyledons, 28.6 % cypselas have obliquely placed cotyledons and only 8.6 % cypselas have parallelly placed cotyledons.

Among the studied cypselas (150 species), 54 % taxa have three resin ducts in each cotyledon, 6.6 % taxa bear seven resin ducts in each cotyledon, 2.6 % taxa having eight resin ducts in each cotyledon, 16 % taxa contains five resin ducts in each cotyledon, 6 % taxa bear six resin ducts in each cotyledon, 12 % taxa possess four resin ducts in each cotyledon, 0.6 % taxa containing ten, nine, eleven and twelve resin ducts in each cotyledon.

Highest number of resin ducts (12) are present in *Dimorphotheca pluvialis*. Among 150 studied cypselas, minimum number of resin ducts (3) are noted in 81 species.

In majority of the studied cypselas (61.3%, 92 species), cotyledons, are oriented in right angle to the axis of cypselas, whereas, (28.6 %, 43 species) cypselas possess obliquely arranged cotyledons and 8.6% (13 species), bear parallelly placed cotyledons. From the above study, it is observed that each cotyledon has eight resin ducts representing about 2.6 % of taxa. Similarly 0.6 % taxa of each category contains nine, ten, eleven & twelve number of resin ducts. Generally, cotyledons are arranged in three ways, such as right angle to the axis of cypselas, oblique to the axis of cypselas and parallel to the axis of cypselas.

Among the 92 cypselas, where the cotyledons are positioned at right angles, highest number of resin ducts (12) are noted in *Dimorphotheca pluvialis*, in each cotyledon, whereas in the cypselas of *Melampodium perfoliatum, Lindhemera texana, Arctium lappa, Centaurea aspera, Centaurea scabiosa, Centaurea stoebe, Cirsium arvense, Cirsium eriophorum, Cirsium helenioides, Cirsium spinosissimum, Cousinia pterocaulos, Saussurea fastuosa, Homogyne alpina, Elephantopus carolinianus, Madia elegans, Bidens pilosa, Tripleurospermum maritimum, Artemisia vulgaris, Solidago gigantea, Cladanthus arabicus, Chaenactis fremontii, Schkuhria pinnata, Villonova oppositifolia, Calea cymosa, Tripleurospermum inodorum, Crepis palaestina, Hypochaeris uniflora, Leontodon muelleri, Cichorium endivia, Zinnia haageana, Aster albanicus, Grindelia camporum, Felicia tenella, Microseris lanceolata, Calendula arvensis, Elephantopus scaber, Adenostyles alliariae, Vernonia galamensis, Lactuca pseudoumbrella, Aster amellus, Eupatorium chinense, Rolandra fruticosa, Glossogyne bidens, Arnica*



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*chamissonis*, *Crassocephalum crepidioides*, *Anthemis tinctoria*, *Arctotis venusta*, *Ptilostemon diacantha*, *Cirsium japonicum*, *Cirsium vulgare*, *Cicerbita cyanea* and *Sonchus megalocarpus*, each cotyledon has 3 resin ducts.

Among 43 cypselas with oblique placed cotyledons, highest number of resin ducts (11) are present in *Cosmos sulphuralis*, whereas low number of resin ducts (3) are found in *Carpesium cernuum*, *Sonchus wightianus*, *Tanacetum vulgare*, *Solidago Canadensis*, *Tanacetum parthenium*, *Senecio alpinus*, *Artemisia annua*, *Layia platyglossa*, *Leucanthemum vulgare*, *Vernonia ceneria*, *Crepis alpine*, *Hieracium racemosum*, *Pulicaria dysentrica*, *Podotheca angustifolia*, *Tagewtes tenuifolia*, *Anthemis maritime*, *Vernonia stenolepis*, *Echinacea purpurea*, *Glossogyne tenuifolia*, *Echinops sphaerocephalus* and *Dicoma sessiliflora*, from each cotyledon.

Among 13 cypselas with parallelly placed cotyledons, highest number of resin ducts (5) are present in *Chrysanthemum weyrichii*, whereas minimum number of resin ducts (3) are present in *Crepis vesicaria*, *Crassocephalum rubens*, *Vernonia melleri*, *Vernonia poskeana*, *Aster thomsonii*, *Gnaphalium pennsylvanicum*, *Tragopogon pratensis* and *Bahia absinthifolia*, from each cotyledon.

Cron (1993), has done a detailed study regarding cypselar anatomy and has noted about the information regarding the number of resin ducts in each cotyledon. He has not mention regarding the plane of arrangements of cotyledons. Horvatic (1963), has worked the anatomical study of cypselas. From his study, the information regarding the plane of arrangements of cotyledons in relation to vascular traces. He has not mentioned regarding the plane of arrangement of cotyledons in his paper. Present study is clearly fulfils with the study of Cron (1993), regarding the number of resin ducts in each cotyledon. Pak and Kawano (1990), have investigated the fruit structure of 18 species of the tribe Lactuceae and have given an idea regarding the plane of arrangement of cotyledons through anatomical study. Generally, each cotyledon has 3 resin ducts. It is the basic type. The number of resin duct is also variable. In our study, highest number of resin duct is recorded in *Dimorphotheca pluvialis*, where each cotyledon has twelve resin duct. The presence of fixed number of resin ducts in cotyledon has been reported by Pandey and Sing (1982) and Corn (1993). Presence of 3 resin ducts in each cotyledon is not prevalent type.

**Notes on the evolution of cypselas, on the basis of the mode of the arrangements of number of resin ducts in each cotyledon**

There is no relation among the studied taxa as well as the tribes of Compositae on the basis of the plane of arrangements of cotyledon and number of resin ducts in each cotyledon. Both the arrangements of cotyledons and number of resin ducts in each cotyledon are variable among the different species of the same tribe or among the different tribes. It is also variable among the different species of a same genus. The plane of arrangements of cotyledons and number of resin ducts in each cotyledon are very characteristic for each species, because it is probably may be a genetic character. Pandey and Sing (1982), have provided a deta regarding the intergeneric differentiation of the number of resin ducts. The present study is clearly fits with the observation of Pandey and Sing (1982).

From the evolutionary point of view, cypselas containing 3 resin ducts in each cotyledon is probably most primitive. Among the total number of studied cypselas (150), in 54% cypselas have 3 resin ducts in each cotyledon. Corn (1993), in his observation regarding the anatomy of the cypselae of species of *Cineraria* L., has given the idea that three resin canals are found in many of the studied species and this number may be extended. In the present observation, the number of resin ducts in each cotyledon may be extended up to 12. So, according to his (Corn, 1993) observation, the number of resin ducts are also variable. So, from this observation, it may be happen that cypselas with 3 resin ducts in each cotyledon is probably most primitive type, whereas each cotyledon containing 12 resin ducts bearing taxa may be advanced one.



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**Probable evolution of cypselas on the basis of the number of resin ducts in each cotyledon**

12 resin ducts in each cotyledon  
11 resin ducts in each cotyledon  
10 resin ducts in each cotyledon  
9 resin ducts in each cotyledon  
8 resin ducts in each cotyledon  
7 resin ducts in each cotyledon  
6 resin ducts in each cotyledon  
5 resin ducts in each cotyledon  
4 resin ducts in each cotyledon  
3 resin ducts in each cotyledon  
(Most primitive)



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