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THE MORPHOLOGY AND ANATOMY OF CYPSELAS IN THREE SPECIES OF THE TRIBE ARCTOTEAE (ASTERACEAE) AND THEIR TAXONOMIC SIGNIFICANCE

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The morphology and anatomy of cypselas in three species belonging to three genera (*Arctotis, Arctotheca, Barkheya*) of the tribe Arctoteae (Asteraceae) have been investigated to establish their potential usefulness in taxonomy. The most useful characters of cypselas are the number of ribs and wings, type of surface hairs, presence or absence of carpopodium, shape and size of pappus scales, the mode of orientation of epicarpic cells and distribution of tissue in mesocarpic region. The testal epidermal cells and a single layer of endosperm in mature cypselas are also useful to a limited degree. Based on diacritical characters of cypselas, an artificial key is presented.

Keywords : Arctoteae; Asteraceae-systematics; Cypselar morpho-anatomy.

Introduction

The tribe Arctoteae was established by Cassini[1] and it has been included in the subfamily Cichorioideae[2]. The tribe has 4 subtribes, 16 genera and 200 species[3]. Cypselar morphological or / and anatomical features have been elucidated as significant taxonomic parameter in many tribes of Asteraceae i.e. Anthemideae[4-6];Eupatorieae[7-9]; Astereae[10]; Inuleae[11-12]; Heliantheae[13]; Senecioneae[14-16]; Calenduleae[17,18]; Mutisieae[19,20]; Cynareae [21,22]; Lactuceae[23-27]. However, the works on the tribe Arctoteae[18, 28] have not been studied adequately from the both morphological and anatomical point of view. Hence, the present investigation is an attempt to show the usefulness of cypselar characters from systematic view point.

Materials and Methods

The present work was based on the herbarium materials obtained form three herbaria of the world. 1. State Herbarium of South Australia, Botanic Gardens, North Terrace, Adelaide, South Australia (AD) - *Arctotheca calendula* (L). Levyns; N.N. Donner 8541; subtribe-Arctotinae; 2. Centro de Botanica da Junta de Investigacoes Cientificas do Ultramar, Rua de Junqueira, Lisboa, Portugal (LISC)- *Berkheya zeyheri* (Sonder & Harvey) Olive. & Hiern ssp. *zeyheri*; A.R. Torre 6907; subtribe-Gorteriinae; 3. Botanischer Garten der Universitat Zurich, Zurich, Switzerland (Z) - *Arctotis venusta* Norlin.: Nr. 345; subtribe-Arctotinae.

For morphological studies mature cypselas were softened either by dipping in 1-5% NaOH solution or saturated chloral hydrate solution and then stained in 0.2-0.5% acqueous safranin solution. Different parts of cypselas and entire cypselas were mounted in 70% phenol glycerine. For anatomical studies, customary methods of dehydration in tertiary butyl alcohol and microtome sections (8-12μm) were stained in safranin - fastgreen combination. For SEM studies, randomly selected, cleared mature cypselas were gold coated and SEM photographs were taken in Philips SEM at RSIC, Bose Institute, Calcutta. Cypselar features were described following the terminology of different workers[29,30].

Results and Discussion

Cypselar Morphology : On the basis of present morphological studies of cypselas, the tribe Arctoteae are characterized by the following features : cypselas homomorphic, wide ribbed or winged, glabrous or pubescent; carpopodium present or absent; pappus scales

paleaceous, coroniform, biseriate, heteromorphic, 8-22 in number and usually free.

Present morphological investigation of the cypselas clearly indicate that these features can be used for the identification of the species. Cypselas are wide elliptic to elliptic with constrictions near both the ends, completely encircled by white, filiform, entangled hairs with single obtuse apex (not twin type), the pericarp reticulate and faintly horizontally straited in *Arctotheca calendula* (Fig. 1A-D, J-L), while in others these characters are absent. In *Arctotis venusta* (Fig. 2A-C; 3A1) cypselas are brownish black, 3 ribbed on anterior side and without ribs on posterior side, the surface glabrous except near the base, cypselas possess numerous white, 3.5-5mm long, tuft of twin hairs. Whereas in *Berkheya zeyheri* ssp. *zeyheri* (Fig. 2F, G,J,M; 4B1) cypselas are brown, 10 ribbed and the entire surface bears variable twin haris. Vascular tissues are easily visible in these species after clearing the cypsela wall.

In true sense the carpopodia are absent in *Arctotheca* and *Arctotis*, since the basal cells of the cypselas are not distinct morphologically from the cells of the cypselar wall. Haque and Godward[35] have also reported the absence of carpopodium in *Arctotis stoechadifolia*. In *Berkheya* (Fig. 2F, G;5C) the carpopodium is very uncommon type. Here it exists in two sections or two lobes. The nature of carpopodium is a significant parameter for the delimitation of these taxa.

In general the pappus scales are paleaceous, coroniform, biseriate and heteromorphic[3]. In addition to the above characters the shape and size of the pappus are taxonomically useful[31]. In all the observed species inner pappus scales are comparatively larger than outer scales. In *Arctotheca* (Fig. 1 F-I), pappus scales are 8-10, about 0.5-0.8 mm x 0.15-0.3mm, obtuse at apex, serrulate in margin, oblong to narrow obovate and free. In *Arctotis* (Fig. 2A,D,E), pappus scales are 8, about 4-4.5mm x 1.25-2.0mm, acute at apex, undulate at the apical margin and nearly

Fig. 1 A - L - *Arctotheca calendula* (L). Levyns, A-Cypsela covered by surface hairs; B - Cypsela after removing surface hairs; C-Cypsela after clearing and removing surface hairs; D - Cypselar surface configuration; E - Cypselar basal part; F - Cypselar apical part; G - Outer pappus scale; H - Inner pappus scale; I - Marginal cells of pappus scales; J - Cypselar surface after removing hairs partially; K - Cypselar wall after clearing; L - Cypselar hair.

Fig. 2 A - E - *Arctotis venusta* Norlin. A - Cypsela; B - anterior side of cypsela (pappus and hairs detached); C - Posterior side of cypsela (pappus and hairs detached); D - Marginal part of pappus scale; E-Basal part of pappus scale. F-M *Berkheya zeyheri* (Sond. & Harv.) Oliv. & Hiern ssp. *zeyheri*, F.G. - Cypselas; H - Inner pappus scale; I - Outer pappus scale; J - Cypselar hair; K - Epicarpic cells in furrows; L - Carpopodial cells; M - Cypselar wall after clearing.

Fig. 3 Cross section of cypsela.
A1 - A4 - *Arctotis venusta* Norlin. A1 - Diagrammatic; A2 - A part of cypselar wall; A3 - A part of parenchymatous zone of pericarp at the terminal region of wing; A4 - Inner part of mesocarpic zone.

Fig. 4 Cross section of cypselas.
A1 - A3 - *Arctotheca calendula* (L.) Levyns, A1, A2 - Diagrammatic; A3 - A part of cypselar wall at the lobe. B1, B2 - *Berkheya zeyheri* (Sond. & Harv.) Oliv. & Hiern ssp. *zeyheri*, B1 - Diagrammatic; B2 - A part of cypselar wall.

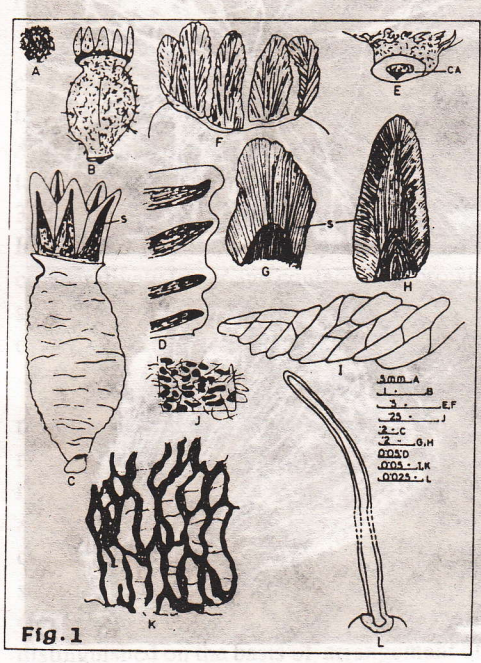

Fig.1

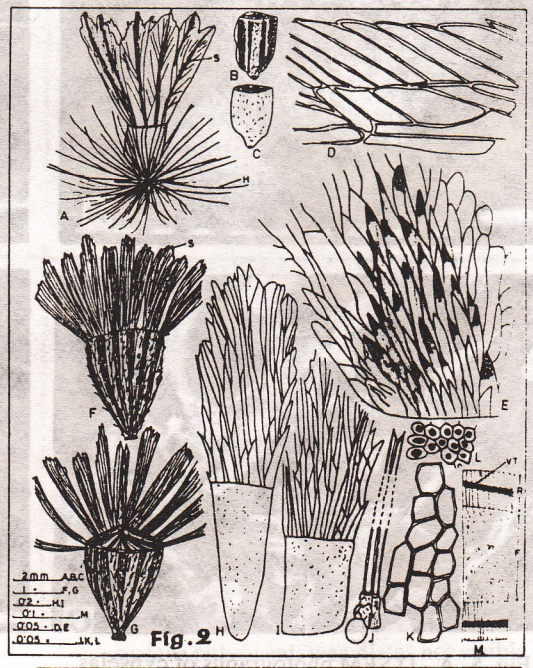

Fig.2

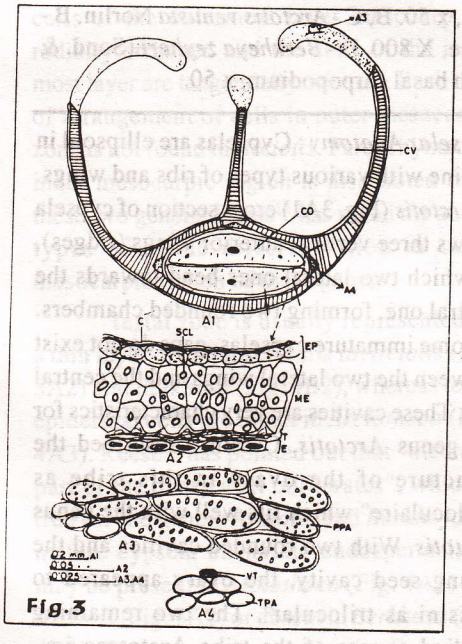

Fig.3

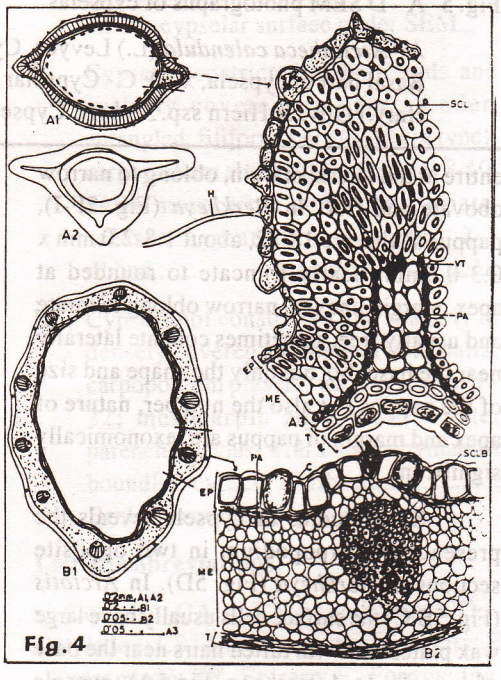

Fig.4

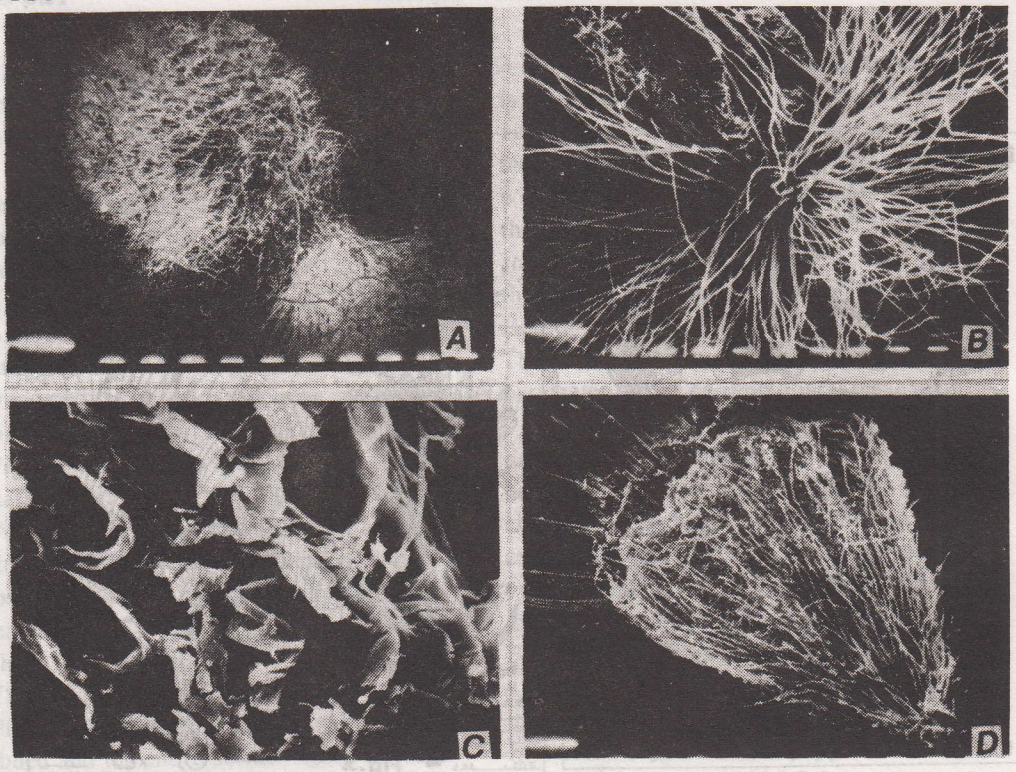

Fig. 5 A - D SEM photographs of cypselas.

A - *Arctotheca calendula* (L.) Levyns, Cypsela, x 50. B, C - *Arctotis venusta* Norlin. B - Basal part of cypsela, x 50; C - Cypselar surface, X 800. D - *Berkheya zeyheri* (Sond. & Harv.) Oliv. & Hiern ssp. *zeyheri*. Cypsela with basal carpopodium, x 50.

entire at the lateral margin, oblong to narrow obovate and free. In *Berkheya* (Fig. 2F-I), pappus scales are 18-22, about 1.8-2.0 mm x 0.3-0.5mm, nearly truncate to rounded at apex, margin uneven, narrow oblong to lorate and usually free, sometimes connate laterally near the base. So not only the shape and size of the pappus but also the number, nature of apex and margin of pappus are taxonomically significant.

SEM studies of cypsela reveals the presence of carpopodium in two opposite sections in *Berkheya* (Fig. 5D). In *Arctotis* (Fig. 5B,C) the surface cells usually have large wax plates and with tufted hairs near the base of cypsela. In *Arctotheca* (Fig.5A), cypsela wholly covered by numerous, very fine, slender, wooly hairs and basal end of cypsela bears tail like tufted hairs.

Cypselar Anatomy : Cypselas are ellipsoid in outline with various types of ribs and wings. In *Arctotis* (Fig, 3A1) cross section of cypsela shows three vertical anterior wings (ridges), of which two lateral ones bend towards the central one, forming two rounded chambers. In some immature cypselas, gaps do not exist between the two lateral wings and the central one. These cavities are very characteristics for the genus *Arctotis*. Cassini[1] described the structure of the ovary in this tribe as "triloculaire" which fits well with the genus *Arctotis*. With two rounded cavities and the young seed cavity, the ovary appeared to Cassini as trilocular[3]. The two remaining studied genera of the tribe Arctoteae i.e., *Arctotheca* and *Berkheya*, are easily distinguished from the *Arctotis* by lack of cavities and wings in their cypselas. In

Arctotheca (Fig.4A1, A2) cypsela is 2-3 ribbed whereas *Berkheya* (Fig. 4B1) is 10 ribbed.

The mode of orientation of epicarpic cells and their structures are useful taxonomically. In *Arctotis* (Fig. 3A2) and *Arctotheca* (Fig. 4A3) epicarpic cells are tangentially placed while in *Berkheya* (Fig. 3B2) these are more of less radially arranged. In *Berkheya* few epicarpic cells are comparatively larger and contain deep brown substances. Few epicarpic cells are papillate or vesciculate in *Arctotheca*.

The distribution of tissues in mesocarpic region is important. Mesocarpic region or outer mesocarpic region is represented by sclerenchymatous tissue in *Arctotis* (Fig. 3A2) or *Arctotheca* (Fig. 4A3) or parenchymatous tissue with ten sclerenchymatous bundles in *Berkheya* (Fg. 4B2). *Arctotis* and *Arctotheca* again could be distinguished on the basis of arrangement of sclerenchymatous tissue. In *Arctotheca* the cells of the outermost layer mesocarp are radially arranged and the cells of the inner most layer are tangentially oriented. Such type of arrangement of cells in outer mesocarpic zone is not found in *Arctotis*. Parenchymatous inner mesocarpic region is also noted from these two genera. Reese[18] has noted the above types of tissue differentiation in outer mesocarpic region of these genera.

Testal zone is usually represented by a thin layer of collapsed cells in *Arctotis* (Fig. 3A2) and *Berkheya* (Fig. 4B2), whereas testal epidermal cells are intact in *Arctotheca* (Fig. 4A3). Reese[18] has pointed out that "the inner part of the ovary wall obliterates"; which is true for the genera *Arctotis* and *Berkheya*. In mature cypsela uniseriate endosperm layer may be present in *Arctotheca* (Fig. 4A3) and *Arctotis* (Fig. 3A2) or absent in *Berkheya* (Fig. 4B2). Endosperm is usually single layer in mature seeds[29].

Amongst the studied genera *Arctotis*, *Arctotheca* and *Berkheya*, the former two are closely related in cypselar morphology and anatomy as also expressed by placing them under the subtribe Arctotinae. The *Berkheya* is quite distinct from the former two and is placed under subtribe Gorteriinae. Thus the previous morphological opinion is similar or rather supporting to present morpho-anatomical study of cypsela.

An Artificial Key to The Genera Based On Cypselar Characters

A. Cypsela with three vertical, anteriour wings, of which two lateral ones bend towards the central one, forming two longitudinal or rounded chambers in CS; cypsela surface glabrous and bears truft of long, distinct, white, fine, silky, twin hairs only at the base; wax plates visible in the cypselar surface under SEM.....*Arctotis venusta*.

AA. Cypsela not winged or chambered; surface pubescent; wax plates not visible on the cypselar surface under SEM.

B. Cypsela constricted at both ends and entirely covered by very slender, entangled, filiform hairs (not twin type); carpopodium absent; pappus scales 8-10; outer mesocarpic zone multiseriate, sclerenchymatous; cypsela 2-3 ribbed.....*Arctotheca calendula*.

BB. Cypsela not constricted and sparsely to densely covered by unequal twin hairs; carpopodium present; pappus scales 18-22; mesocarpic zone multiseriate, parenchymatous, with sclerenchymatous boundles; cypsela 10-ribbed..... *Berkheya zeyheri* ssp. *zeyheri*.

List of Abbreviations

C-Cuticle; CA - Carpopodium; CO - Cotyledon; CS - Cross section; CV-Cavity; E - Endosperrm; EP - Epicarp; F - Furrow; Fig. - Figure; H - Hair; ME - Mesocarp; PA - Parenchyma; PPA - Pitted parenchyma; R-

Ridge or rib; S-Scale; SCL-Sclerenchyma; SCLB-Sclerenchyma trace or bundle; T-Testa; TPA-Thick-walled parenchyma; VT-Vascular trace or tissue.

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