

Achene Micro-morphology of Anthemis (Asteraceae) and its Allies in Iran with Emphasis on Systematics

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ABSTRACT

Anthemideae is a large tribe of Asteraceae and poses difficulties in recognizing and classifying its members based on morphological characters. This research was focused on evaluating achene peculiarities for systematic purpose. Achene micro-morphological characteristics such as size, shape, papuse, sulcuse, lacune, etc., were considered useful in species recognition. Lacunas characters in each studied taxa were specific and regarded as good separator character in the studied taxa of this tribe. Based on data, *Tanacetum kotschy* was considered as a problematic species that needs to be studied further.

Key Words: Anthemideae; Anthemis; SEM; Achene; Systematic

INTRODUCTION

Anthemideae is the seventh largest tribe of Asteraceae with about 109 genera and 1740 species worldwide (Bremer, 1994; Tahir *et al.*, 2002). The tribe shows a temperate distribution (Heywood & Humphries, 1977; Bremer & Humphries, 1993; Francisco-Ortega *et al.*, 2001). The members of this tribe have been studied by several researches (Bremer, 1994; Torrel *et al.*, 1999; Inceer *et al.*, 2004; Khokhar *et al.*, 2006). Anthemideae includes 12 genera and about 134 species in Iran; of these, *Anthemis*, *Achillea*, *Tanacetum* and *Artemisia* are the largest genera (Poljakov, 1967; Rechinger, 1986). Essential oils, secondary metabolites and medicinally important compounds with or without bioactivity, have been isolated from *Achillea*, *Anthemis*, *Artemisia*, *Balsamita*, *Chrysanthemum*, *Matricaria*, *Santolina* and *Tanacetum* genera (Heywood & Humphries, 1997; Tiexeria da Silva, 2003, 04). The principal taxonomic problems within the tribe are interrelationships amongst the genera, the circumscription of sub-tribal taxa and polymorphic species (Torrel *et al.*, 1999; Inceer *et al.*, 2004). Chromosome analysis and DNA studies (ITS) could not clear the relationship of different taxa in this tribe (Torrel *et al.*, 2001; Francisco-Ortega *et al.*, 2001; Valles *et al.*, 2003; Valles *et al.*, 2005). Recent published molecular data shows the polyphyletic ancestors of most of sub-tribes defined earlier within the tribe (Francisco-Ortega *et al.*, 2001; Watson *et al.*, 2000, 02).

The aim of this study was to compare the achene surface in selected species of Anthemideae to evaluate the application of characters in the classification of and finding some useful characters to delimit the taxa at species level.

MATERIAL AND METHODS

Achenes of 11 species representing five genera of Anthemideae were collected and dried at room temperature. A list of taxa used in this study and their voucher specimens

were deposited in Tehran University Herbarium and Bu-Ali Sina University (Table I). The achenes were coated with a thin layer of gold-paladium and studied with a JEOL-840 Scanning Electron Microscope (Japan) at Sanati Sharif University, Tehran, Iran. Achene morphological and micro-morphological characters such as size, shape, papuse, sulcuse, lacune and etc., were compared with prepared micrograph.

RESULTS

It was determined that achene's morphological and micro-morphological characters such as presence of palea, inflorescence and foliar divisions have taxonomic value. The following criteria based on the achene characters including size, shape, presence of sulcus, number of sulcus, presence of papuse, papuse type and lacuna type are the most suitable characters rearguing systematic application. These characters were determined in the 11 samples at genus and species level (Table II). These taxa belonged to 5 genera including *Achillea*, *Anthemis*, *Artemisia*, *Tanacetum* and *Tripleurospermum* (Davis, 1975; Rechinger, 1986). Data indicated that studied taxa were delineated on the following characteristics:

Length. Studied specimens were between 1.3 - 2.6 mm. Achene lengths were different in different specimens; in *Anthemis* it was longer than 2 mm, in *Achillea* about 2 mm, in *Artemisia* and *Tripleurospermum* less than 2 mm and in *Tanacetum* it was noted in a variety of sizes.

Shape. Achenes shape was also different in studied taxa. In *Artemisia* and *Achillea* were ovoid or obovoid (Fig. 1a, 2a & 3a). *Anthemis* had two different shapes, cylindrical (Fig. 4a) and compressed (Fig. 5a), that in transversal section have orbicular form (*Anthemis altissima*, *A. coleopoda* & *A. tinctoria*). Shape of achene was cylindrical in *Tanacetum* (Fig. 8a, 9a & 10a). *Tripleurospermum* had oblongate achene (Fig. 12a).

Table I. List of studied taxa and their localities

Species	Locality	Herbarium Number
<i>Achillea talagonica</i>	Iran, Zandjan, Ijrroud, South of Sultanieh	3182
<i>Artemisia incana</i>	Iran, Zandjan, Gheydar, Gheydar mt.	1950
<i>A. sieberi</i>	Iran, Zandjan, Tarum, Dahneh	71
<i>Anthemis tinctoria</i>	Iran, Zandjan, Tarum, Yahza Abad	23
<i>A. altissima</i>	Iran, Zandjan, Tarum, Gilan-Kosheh	41
<i>A. coleopoda</i>	Iran, Zandjan, Tarum, Chaftan	4243
<i>A. hausknechtii</i>	Iran, Zandjan, Paiin Kuh, Chereh Nou	53
<i>Tanacetum kotschyi</i>	Iran, Zandjan, Tarum, Ebrahim Abad	74
<i>T. polycephalum</i>	Iran, Zandjan, Gheydar, Zarrin Abad	1865
<i>T. parthenium</i>	Iran, Zandjan, Tarum, Chal village	1531
<i>Tripleurospermum disciforme</i>	Iran, Zandjan, Tarum, S Khanchaii	1840

Papuse. Papuse were seen in different forms; entire in *A. altissima* (Fig. 4b), *A. coleopoda* (Fig. 5b), *A. tinctoria* (Fig. 6b), *Tanacetum polycephalum* (Fig. 10b) and *T. parthenium* (Fig. 8b); unilateral in *A. haussknechtii* (Fig. 7b). *Tanacetum kotschyi* (Fig. 9b) was different regarding shape of papuse. It had unilateral papuse that was divided into two lobes with fission. Other studied species had no papuse.

Sulcus. It was a variable character in studied specimens. *Artemisia* and *Achillea* had no sulcus on their surfaces but *A. sieberi* had thin ribs on both sides. All of *Tanacetum* and *Anthemis* had thin and considerable sulcus on both sides. Only *T. disciforme* was different on its two sides, on adaxial side had no rib or sulcus but on abaxial side there were two thin grooves by a conspicuous middle line.

Tubercule. Our observation showed that *T. parthenium* and *T. polycephalum* had large gland on the sulcus along the achene but there were no glands on the achene of *T. kotschyi*. On adaxial side of *T. disciforme* there were glands that had certain forms.

Wart. It was very rare in the studied specimens. It was seen only in *A. hausknechtii*. In this case, warts were distributed on the both sides of achene.

Lacuna. It was a valuable character in our samples. All taxa were specific in shape and size of lacuna that apparently could help in recognition and classification of taxa even at the species level. *A. talagonica* had irregular achene without lacuna; only some interweave folds could be seen. *A. sieberi* had very thin ribs but these ribs in *A. incana* were irregular without certain lacuna. In *Anthemis* species lacunae were more regular than the past. Lacuna in *A. altissima*, were hexagonal and in center of each lacuna a convex was

visible. This structure was very regular in shape and size. *A. coleopoda* had concave lacunae without any convex. In *A. tinctoria*, lacunae were more or less irregular with uncertain shape or even hard to distinguish. In *A. hausknechtii* besides its wart, there was a group of lacuna. *T. parthenium* is also similar to *A. altissima* but lacuna shape is more or less lozenge-elliptic and smallish. In *T. polycephalum*, lacuna are concave with irregular shape. *T. kotschyi* had lacuna with uncertain shape but visible on both surfaces. In *Tripleurospermum* two surfaces of achene were different in structure. On adaxial side there was no lacuna, but on the abaxial side oblong lacuna with some nodes were seen.

DISCUSSION

From the results of this study the micro-morphological character of achene showed some similarities and differences compared to others. All characters showed that these five genera can be distinguished by achene characters (Fig. 1 - 12). Many morphological properties were common between genera and species but micromorphological characters such as lacuna were specific for each species (Table II). Our observations showed that by using micro-morphological characters, species were identified even if only achene characters were used. Lacuna was a highly variable character in the studied taxa, which emerged as a suitable character for separating of species. *Achillea sp.* has achenes with different characters; regular shape and sculpturing absences on surface of achenes are very clear in its species. Molecular research showed that this genus was monophyletic and had clear boundaries (Francisco-Ortega *et al.*, 2001; Guo *et al.*, 2004). Studied species of *Anthemis* showed differences regarding some characters such as, lacuna shape; number of sulcus and papuse form but in the case of presence of sulcus and papuse, their size was more or less common. *Achillea* and *Anthemis* are relatively homogenous genera regarding morphology and are considered monophyletic with well circumscribed generic boundaries. This genus has few similarities with *Tripleurospermum*, but Oberprieler (2001) showed it as polyphyletic. *Tanacetum* species were different in some characters such as presence of glands along sulcus and papuse shape (glands were not seen in *T. kotschyi*). *Tanacetum* is a polyphyletic complex and interpretation based on the placement of one representative species is un-

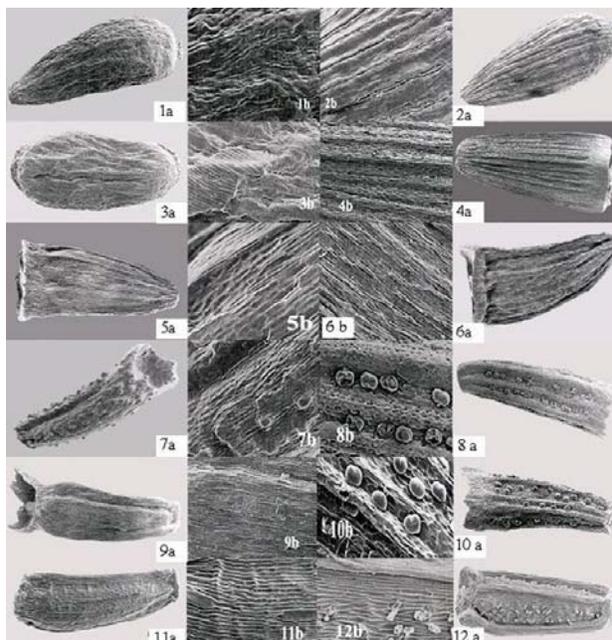
Table II. Characters studied in members of the tribe Anthemideae

Taxon character	Shape	Length mm	Pappuse	Sulcus	Wart	Gland	Lacuna	Lacuna size μm
<i>Anthemis altissima</i>	obconical-compressed	2.4	entire	10-12	absent	absent	**concave	60-70
<i>A. coleopoda</i>	obconical -compressed	2.1	entire	1-3	absent	absent	concave	60
<i>A. hausknechtii</i>	cylindrical	2.6	unilateral	2	present	absent	convex	40
<i>A. tinctoria</i>	Obconical -Compressed	2.1	entire	5-6	absent	absent	amorphous	60-70
<i>Achillea talagonica</i>	Obovoid	2.1	absent	0	absent	absent	amorphous	-
<i>Artemisia incana</i>	Obovoid	1.3	Absent	0	absent	absent	amorphous	-
<i>Artemisia sieberi</i>	Obovoid	1.8	absent	Ribbed	absent	absent	amorphous	-
<i>Tanacetum kotschyi</i>	obconical-cylindrical	2.4		2	Absent	absent	amorphous	-
<i>T. parthenium</i>	Cylindrical	1.6	entire	4-5	absent	present	**concave	20-30
<i>T. polycephalum</i>	cylindrical	2.3	entire	5-6	absent	present	concave	70
<i>Tripleurospermum disciforme</i>	oblong	1.3	absent	2	absent	present	concave	*70

*only in abaxial side.

** In middle part is convex

Fig. 1-12. Achene properties of studied taxa from Anthemideae tribe. (1)- *Achillea talagonica* (a, $\times 20$; b, $\times 60$). (2)- *Artemisia sieberi* (a, $\times 26$; b, $\times 60$). (3)- *Artemisia incana* (a, $\times 34$; b, $\times 83$). (4)- *Anthemis altissima* (a, $\times 19$; b, $\times 51$). (5)- *Anthemis coleopoda* (a, $\times 21$; b, $\times 50$). (6)- *Anthemis tinctoria* (a, $\times 20$; b, $\times 70$). (7)- *Anthemis hausknechtii* (a, $\times 17$; b, $\times 40$). (8)- *Tanacetum parthenium* (a, $\times 30$; b, $\times 75$). (9)- *Tanacetum kotschyi* (a, $\times 19$; b, $\times 50$). (10)- *Tanacetum polycephalum* (a, $\times 19$; b, $\times 50$). (11)- *Tanacetum parthenium* (a, $\times 33$; b, $\times 54$). (12)- *Tripleurospermum disciforme* (a, $\times 20$; b, $\times 60$)



warranted (Judd *et al.*, 1999; Watson *et al.*, 2000, 02; Valles *et al.*, 2003).

These data suggested some similarities between *Anthemis* and *Tanacetum* species regarding achene structure such as papuse, absence of glands and lacuna shape. In other vegetative properties they had more similarities such as foliar shape, inflorescence, capitule character and ligulate flowers presence (Rechinger, 1986). Watson *et al.* (2002) with molecular data showed that *Tanacetum* is a problematic genus and our data indicate *T. kotschyi* is heterogeneous that needs to further investigation.

To conclude, achene micro-morphological characters are important and could be helpful in the identification species and genera. Studies on the other taxa of this tribe may further invoke that micro-morphological characters of achene are truly valuable characters to classify the species.

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