Review
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Achene Characteristics of Some Taxa of Asteraceae from the Northwestern Mediterranean Coast of Egypt

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THIS STUDY aimed to characterize the external morphology of achenes of the 74 taxa belonging to 51 genera and four subfamilies of Asteraceae from the Northwestern Mediterranean coast of Egypt. By using light microscopy, 26 quantitative and qualitative morphological characters were recorded. Among the studied taxa, achene symmetry, hairiness, surface topography, hilum position, presence or absence of pappus and pappus type were found significant diagnostic characters for delimiting the taxa. Two main groups were identified based on the presence or absence of hardened fruiting involucre. Four types and four subtypes were recognized: (1) Achene di- or trimorphic per capitulum, (2) Achene monomorphic and lacking pappus, (3) Achene monomorphic, with coroniform or auriculate pappus, (4) Achene monomorphic, with pappus. A description, photographs and identification keys were provided to assist in identification. Despite the taxonomic significance of achene exomorphology characters on the generic and specific level for the recognition of the different studied taxa of Asteraceae, no mutual link was shown between the taxonomic division of the family into subfamilies and tribes except for few cases.

Keywords: Achene exomorphology, Achene symmetry, Asteraceae, Identification key, Pappus type.

Introduction

Asteraceae (Compositae) is one of the largest family of flowering plants, comprises approximately 1,623 genera and 24,700 species (Christenhusz & Byng, 2016), belonging to 13 subfamilies and 44 tribes (Funk et al., 2009; Panero et al., 2014). The family has a cosmopolitan distribution throughout the world in temperate and tropical regions, occupying almost all the habitats (Funk et al., 2005). Several species are edible and are used in folk medicines and as a source of many biologically active compounds like essential oils (Setzer et al., 2004; Judzentiene & Mockute, 2005) and polyphenolic compounds (Ivanescu et al., 2010).

Asteraceae shows high morphological variability between and within the taxa, distinctive in being the inflorescence a capitulum surrounded by an involucre of one or more series of phyllaries. Capitula solitary or scapiform, in cymose or corymbiform, radiate or disciform to discoid, carry one type of flowers or two types. The fruit is a 1-seeded achene (Simpson, 2010).

The taxonomic usefulness of seed and fruit morphology is variable between plant groups; however, compared with many vegetative and floral structures, seed coat and fruit morphology show very low phenotypic plasticity and less affected by environmental conditions (Barthlott 1984; Zorić et al., 2010). Achenes of Asteraceae have a variety of shape, size, pappus, ribbing pattern and surface sculpturing, representing useful taxonomic tools for classification and delimitation of various taxa from species to tribal level (Zhu et al., 2006; Kreitschitz & Vallès, 2007; Mukherjee & Nordenstam, 2008; Savadkoohi et al., 2012; Roque & Funk, 2013; Zhang et al., 2013; Akcin & Akcin, 2014; Bona, 2015; Behjou et al., 2016; Ghimire et al., 2016; Karanovic et al., 2016; Şirin et al., 2017; Ozcan & Akinci, 2019).

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In Egypt, Asteraceae contributes about 10.3% (nearly 333 taxa) of the flora of Egypt (Boulos, 2009); while it contributes 13% of the flora of the Northwestern Mediterranean coast of Egypt (126 species belong to 70 genera). Therophytes were the most represented life form (84 species), followed by hemicryptophytes (21 species) and chamaephytes (18 species), while phanerophytes (one species) and geo-helophytes (two species) were the less represented (Ahmed, 2009; Shaltout et al., 2015).

The Northwestern Mediterranean coast of Egypt extends from Sallum eastward to Alexandria westward; the coastal climate is warm, temperate, and arid, with some winter rainfall. The western coastal region can be distinguished into two main provinces: an eastern province from Alexandria to Ras El Hekma. The coastal plains are vast, with number of depressions and ridges running parallel to the coast. The western province runs from Ras El Hekma to Sallum with a narrow coastal plain (Ahmed, 2009). Thirteen major habitats were identified in this region: sand dunes, sand formations, saline depression, salt marshes, non-saline depression, inland ridges, inland plateau, wadis, cultivated land (include rainfed and irrigated farms), roadsides, summer resorts, Sallum plateau and Lake Mariut (Shaltout et al., 2015).

The main objectives of this study are to characterize the external morphology of achenes of 74 taxa of Asteraceae from the NW Mediterranean coast of Egypt, and to construct an identification key to be applied for the identification of these taxa not only for taxonomists, but also for plant breeders, archaeobotanists, pharmacologists and ecologists in the field.

Materials and Methods

The present study was based on achenes of 74 taxa belonging to 51 genera and four subfamilies of Asteraceae collected from Northwestern Mediterranean coast of Egypt (Fig. 1) in addition to Herbarium specimens of Cairo (CAI) and Tanta Universities (TANE). The identification of taxa and nomenclature was followed by Täckholm (1974), Boulos (2002), and the International Plant Name Index (IPNI, http://www.ipni.org/). The investigated taxa were arranged following the system of Jeffrey (2007) and Funk et al. (2009) (Table 1).

Fifteen to twenty fully mature achenes from at least three specimens per taxon were observed on Light Microscope (Wild, Heerbrugg) and photographs were taken with Premiere MA88-900 digital camera. However, fewer achenes were examined for some species due to lack of field material and the scarcity of achenes in herbarium specimens. Gross morphological characters of achenes (size, shape, color, outline, symmetry, hairiness, surface topography and persistence of ribs, wings and beak) and pappus (type, persistence, length and symmetry) were scored. Altogether, four quantitative and 23 qualitative morphological characters were investigated (Tables 2, 3, respectively). The terminology was followed by Stearn (2004), Bojñanský & Fargašová (2007).

Fig. 1. A map of the study sites in the Western Mediterranean coast of Egypt, showing an eastern region from Alexandria to Ras El-Hekma and western region from Ras El-Hekma to Sallum-

TABLE 1. Collection data of the investigated taxa arranged in accordance with the system of Jeffrey 2007 and Funk et al. (2009)

Examined taxa	Locality
I-Subfamily: Carduoideae Sweet **Tribe**: Cardueae Cass. **Subtribe**: Carduinae Dumort.	
1- *Carduus getulus* Pomel	- 60km from Sallum, 2-3-1996; El Garf & Soliman s.n. (CAI)- Along the seaside road, Abu sir-Hammam, 24-3-1961; Täckholm s.n. (CAI).
2- *Cynara cornigera Lindl.*	Saniet Hagg Ayyad, Wadi El Habs, between M. Matruh and Agiba; 23-3-1974; Täckholm et al. s.n. (CAI)- Wadi Naghamesh (wadi Rashid), 1-5-2005; D. A. Ahmed s.n. (TANE).
3- *Onopordum alexandrinum* Boiss.	- 24km west of Alexandria, 26-3-1954; Boulos s.n. (CAI)- Burg El Arab, 23-3-1961; Täckholm et al. s.n. (CAI).
4- *Silybum marianum* (L.) Gaertn.	- Ajeeba, Matrouh, 18-3-2004; D.A. Ahmed s.n. (TANE)- Wadi Nagamesh, Matruh, 1-5-2005; D. A. Ahmed s.n. (TANE).
Subtribe: Carlinae Dumort.	
5- *Atractylis cancellata* L.	- Wadi Hashim, 48 km before M. Matruh, April 1999; El Garf s.n. (CAI)- Burg El Arab, 22-3-1974; Täckholm et al. s.n. (CAI)- Wadi Um-Ashtan, Matruh, 1-4-2005; D. A. Ahmed s.n. (TANE).
6- *A. carduus* (Forssk.) C. Chr.	- Burg El Arab, 10-4-1971; Ibrahim *et al.* (CAI)- Ajeeba, Matrouh, 18-3-2004; D. A. Ahmed s.n. (TANE).
7- *Carlina involucrata* Poir.	- Agiba shore, 3 kilos western M. Matrouh, 16-8-1953; A. El Fadeel s.n. (CAI)- Mariut: Burg El Arab, 12-8-1929; Hassib s.n. (CAI).
Subtribe: Centaureinae Dumort.	
8- *Carthamus eriocephalus* (Boiss.) Greuter	- Maruit, Burg el Arab, 13-3-1952; A. Harhad s.n. (CAI)- Wadi Habis, Matruh, 31-3-2005; D. A. Ahmed s.n. (TANE).
9- *C. glaucus* M. Bieb. subsp. *alexandrinus* (Boiss. & Heldr.) Hanelt	- Alexandria-Rosetta road, 2-6-1961; Täckholm et al. s.n. (CAI)- Alexandria province, Alexandria, 26-4-1987; Amer 10508 (CAI)- Wadi Nagamesh, Matruh, 1-5-2005; D. A. Ahmed s.n. (TANE).
10- *C. lanatus* L.	- Siwa-M. Matruh, desert road, 15-4-1986; A Fahmy 27 (CAI)- Alexandria; Mandra, 13-8-1929; Hassib s.n. (CAI).
11- *C. mareoticus* Delile	- Burg el Arab region, Maruit, 19-3-1953; A. Abd El Fadeel s.n. (CAI)- Mariut, in the calcarious fields N of Amria station, 25-3-1927; G. Täckholm s.n. (CAI).
12- *C. tenuis* (Boiss. & Blanche) subsp. *foliosus* (Boiss.) Hanelt	- Ikinghi Mariot, 9-7-1907; Des launes s.n. (CAI)- El Gedia, Rosetta, 9-7-1976; A. Amin et al. s.n. (CAI)
13- *Centaurea calcitrapa* L.	- Ajeeba, Matrouh, 18-3-2004; D. A. Ahmed s.n. (TANE)- Sallum, 28-4-2005; D. A. Ahmed s.n. (TANE).
14- *C. dimorpha* Viv.	- Ajeeba, Matrouh, 18-3-2004; D. A. Ahmed s.n. (TANE)- Ras El-Hekma, Matruh, 30-4-2005; D. A. Ahmed s.n. (TANE).
15- *C. pumilio* L.	- Ajeeba, Matrouh, 18-3-2004; D. Ahmed s.n. (TANE)- Ras El-Hekma, Matruh, 30-4-2005; D. A. Ahmed s.n. (TANE).
16- *Volutaria crupinoides* (Desf.) Cass. ex Maire	- Wadi Habis, Matruh, 31-3-2005; D. A. Ahmed s.n. (TANE).
17- *V. lippi* (L.) Cass. ex Maire	- Wadi Um-Ashtan, Matruh, 1-4-2005; D. A. Ahmed s.n. (TANE)- 30 Km from Rossetta, 10-3-1978; Merxmüller *et al.* s.n. (CAI).
18- *V. tubuliflora* (Murb.) Sennen	- East of Alexandria not far from Abu Kir, 28-3-1957; Täckholm s.n. (CAI)- Abu Kir, 25-3-1954; Boulos s.n. (CAI)- Wadi Habis, Matruh, 31-3-2005; D. A. Ahmed s.n. (TANE).
Subtribe: Echinopsinae Dumort.	
19- *Echinops spinosissimus* Turra	- 75km from Alexandria, on the desert road to Cairo, 5-3-1976; Täckholm s.n. (CAI)- Omayed, Matruh, 19-3-2004; D. Ahmed s.n. (TANE).
II-Subfamily: Cichorioideae Chevall. **Tribe:** Cichorieae Lam. & DC. **Subtribe:** Cichoriinae Dumort.	

TABLE 1. Cont. 1

Examined taxa	Locality
20- *Cichorium pumilium* Jacq.	- Wadi Habis, 27-7-1989; El Hadidi & El Garf s.n. (CAI)- Mersa Matruh, 16-7-1959; S. Ghabbour s.n. (CAI)- Wadi Um-Ashtan, Matruh, 1-4-2005; D. A. Ahmed s.n. (TANE).
Subtribe: Hypochaeridinae Less.	
21- *Hedypnois rhagadioloides* (L.) F.W. Schmidt	- Maktala (sand dunes), Matruh, 29-4-2005; D. Ahmed s.n. (TANE)- Wadi Habis, Matruh, 31-1-2005; D. Ahmed s.n. (TANE).
22- *Leontodon tuberosus* L.	- Alexandria: Mex, 23-1-1928; G. Täckholm s.n. (CAI)- Saniet Hagg Ayyad, Wadi El Habs, Between M. Matruh & Agiba, 23-3-1974; Täckholm et al. s.n. (CAI).
23- *Picris altissima* Delile	- Ajeeba, Matrouh, 18-3-2004; D. A. Ahmed s.n. (TANE)-
24- *P. asplenioides* L.	- Ajeeba, Matrouh, 18-3-2004; D.A. Ahmed s.n. (TANE)- Ras El-Hekma, Matruh, 30-4-2005; D.A. Ahmed s.n. (TANE).
25- *Scorzoneroides hispidulus* (Delile) Greuter & Talavera	- Wadi Um-Ashtan, Matruh, 1-4-2005; D. Ahmed s.n. (TANE)- Sidi Abd el Rahman, 8-3-1978; Soliman s.n. (CAI).
26- *Urospermum picroides* (L.) Scop. ex F.W. Schmidt	- Ajeeba, 18-3-2005, D. Ahmed 106 (CAI)- Burg el Arab, 23-3-1977, Botany Department excursion s.n. (CAI)- Lake Maruit, Alexandria, 30-3-2005; D. Ahmed s.n. (TANE).
Subtribe: Hyoseridinae Less.	
27- *Hyoseris radiata* L. subsp. *graeca* Halácsy	- Omayed (Barely field), Matruh, 19-3-2004; D. Ahmed s.n. (TANE)- Wadi Agiba, M. Matruh, 20-4-1986; A. Fahmy 299 (CAI)- Burg el Arab, 20-3-1953, Täckholm s.n. (CAI).
28- *Launaea capitata* (Spreng.) Dandy	- Sallum, 31-1-2005; D. A. Ahmed s.n. (TANE)- Maktala, Matruh, 29-4-2005; D. A. Ahmed s.n. (TANE)- Cairo-Alexandria desert road, 31-5-1964; Täckholm s.n. (CAI).
29- *L. fragilis* (Asso.) Pau subsp. *fragilis*	- Ras El-Hekma, Matruh, 30-4-2005; D. A. Ahmed s.n. (TANE)- Mariut desert, 7-3-1969; Zahran s.n. (CAI).
30- *L. nudicaulis* (L.) Hook. f.	- Omayed, Matruh, 19-3-2004; D. A. Ahmed s.n. (TANE)- Lake Mariut, Alexandria, 30-3-2005; D. A. Ahmed s.n. (TANE).
31- *Reichardia tingitana* (L.) Roth	- Omayed, Matruh, 19-3-2004; D. A. Ahmed s.n. (TANE)- Burg el Arab – Alexandria, 19-3-1988; El Hadidi et al. s.n. (CAI).
32- *Sonchus asper* (L.) Hill subsp. *asper*	- Omayed, Matruh, 19-3-2004, D. A. Ahmed s.n. (TANE)- Idku, East of Alexandria, 18-4-1958; Boulos s.n. (CAI)
33- *S. macrocarpus* Boulos & C. Jeffrey	- Rosseta, 19-4-1973; Ibrahim et al. s.n. (CAI). - Omayed, Matruh, 19-3-2004; D. A. Ahmed s.n. (TANE)
34- *S. oleraceus* (L.) L.	- Burg el Arab, 24-9-1971; Imam et al. s.n. (CAI)- Agiba shores, M. Matruh, 20-4-1986; A. Fahmy 289 (CAI)- Omayed (Barely field), Matruh, 19-3-2004; D. A. Ahmed s.n. (TANE).
Subtribe: Lactucinae Dumort.	
35- *Lactuca serriola* L.	- Maruit, Abu Sir, 23-3-1961; Täckholm s.n. (CAI)- Lake Mariut, Alexandria, 30-5-2005; D. A. Ahmed s.n. (TANE).
Subtribe: Scorzonerinae Dumort.	
36- *Scorzonera undulata* Vahl	- Vicinity of M. Matruh, 1-4-1972; Täckholm et al. s.n. (CAI)- Mariut, in the calcarious fields N of Amria station, 25-3-1927; G. Täckholm s.n. (CAI)- Ajeeba, Matrouh, 18-3-2004; D. A. Ahmed s.n. (TANE)
Tribe: Vernonieae Cass. **Subtribe:** Erlangeinae H. Rob.	
37- *Ethulia conyzoides* L.fil. subsp. *conzoides*	- Porto Marina, Alexandria, 23-2007; D. A. Ahmed s.n. (TANE)- Canal bank at Abees, Alexandria, 28-8-1967; El Hadidi s.n. (CAI).
III- Subfamily: Gymnarrhenoideae Panero & V.A. Funk **Tribe:** Gymnarrheneae Panero & V.A. Funk	

TABLE 1. Cont. 1

Examined taxa	Locality
38- *Gymnarrhena micrantha* Desf.	- Ajeeba, Matruh, 18-3-2004; D. A. Ahmed s.n. (TANE)- Wadi Hashim, 48km before M. Matruh, April 1999; I El Garf s.n. (CAI).
IV-Subfamily: Asteroideae Lindle **Tribe:** Senecioneae Cass.	
39- *Senecio aegyptius* L. var. *discoideus* Boiss.	- Lake Mariut, Alexandria, 30-3-2005; D. A. Ahmed s.n. (TANE).
40- *S. glaucus* L. subsp. *coronopifolius* (Maire) C. Alexander	- Alexandria province, 12-3-1988, Amer 1644 (CAI)- Wadi Habs, 30km before M Matruh, 21-3-1988; E. Shamso s.n. (CAI)- Lake Mariut, Alexandria, 30-3-2005; D. A. Ahmed s.n. (TANE).
41- *S. vulgaris* L.	- Ajeeba, 18-3-2004; D. A. Ahmed 45 (CAI, TANE).
Tribe: Calenduleae Cass.	
42- *Calendula arvensis* M. Bieb.	- Wadi Naghamesh, Matruh, 1-5-2005, D. A. Ahmed 71(CAI)- Sallum, on the frontier road, 24-5-1963; Täckholm et al. s.n. (CAI).
Tribe: Gnaphalieae Lecoq & Juill. **Subtribe:** Gnaphaliinae	
43- *Filago desertorum* Pomel	- 75km from Alexandria on the desert road to Cairo, 5-4-1976; El Hadidi et al. s.n. (CAI)- Mariut: in the calcarious fields N of Amria station, 25-3-1927; G. Täckholm s.n. (CAI).
44- *F. mareotica* Delile	- Omayed, Matruh, 19-3-2004; D. A. Ahmed s.n. (TANE)- Burg el Arab, 22-3-12956; El Hadidi s.n. (CAI).
45- *Ifloga spicata* (Forssk.) Schultz-Bip	- Burg el Arab, 2-4-1977; El Gazzar et al. s.n. (CAI)- 48km before Mersa Matruh, April 1999; El Garf s.n. (CAI).
46- *Laphangium luteo-album* (L.) Tzvelev	- Burg el Arab, spring 1962; Täckholm s.n. (CAI)- Ajeeba, Matruh, 18-3-2004; D. A. Ahmed s.n. (TANE).
47- *Phagnalon rupestre* (L.) DC.	- Wadi Hashim, 48km before M Matruh, 19-5-2006; El Garf & Osman 222(CAI)- Wadi Halazeen, 45 km west M Matruh, 24-4-1996; El Garf & Soliman s.n. (CAI).
Tribe: Astereae Cass. **Subtribe:** Symphyotrichinae G.L. Nesom	
48- *Symphyotrichum squamatum* (Spreng.) G. L. Nesom	- Cairo-Alexandria desert road, 167 Km from Cairo, 24-9-1971; Loutfy et al. s.n. (CAI)- Omayed, Matruh, 19-3-2004; D. A. Ahmed s.n. (TANE).
Subtribe: Conyzinae Schultz-Bip.	
49- *Erigeron aegyptiacus* L.	- Burg el Arab, 17-3-1956; Gaber s.n. (CAI).
50- *E. bonariensis* L.	- Marina, Alexandria, 27-4-2005; D. Ahmed s.n. (TANE)- Sawani Gaber, Matruh, 9-7-2005; D. Ahmed s.n. (TANE).
Tribe*:* Anthemideae Cass. **Subtribe:** Cotulinae Kitt.	
51- *Brocchia cinerea* (Delile) Vis.	- Mariut: In Calcarious fields, N of Amria station, 25-3-1927; G. Täckholm s.n. (CAI)- Ajeeba, Matruh, 18-3-2004; D. A. Ahmed s.n. (TANE).
52- *Cotula anthemoides* L.	- Wadi Halazeen, 45km west M. Matruh, 25-4-1996; El Garf & Soliman s.n. (CAI)- Mariut, Alexandria, 23-3-2006; D. Ahmed s.n. (TANE).
Subtribe: Matricariinae Willk.	
53- *Achillea tenuifolia* Lam.	- Burg el Arab, Mariut, 8-4-1955; Botany Department Excursion s.n. (CAI)- Wadi Halazeen, 45km west Mersa Matruh, 26-4-1996; El Garf & Soliman s.n. (CAI).
54-*Anacyclus monanthos* (L.) Thell. subsp. *monanthos*	- Maktala, Matruh, 29-4-2005; D. Ahmed s.n. (TANE)- El-Rasool village, Matrouh-Sallum road; 2-5-1988; A. Fahmy 943(CAI).
55- *Matricaria aurea* (Loefl.) Sch.Bip	- Cairo- Alexandria desert road, in fields west of the road, Tahrir province south of Amria,5-5-1968; Täckholm *et al.* s.n. (CAI)- Zahia, M Matruh- Sallum road, 0-3-1988; E. Shamso s.n. (CAI).
56- *M. chamomilla* L.	- Lake Mariut, Alexandria, 30-3-2005; D. A. Ahmed s.n. (TANE)- Sporting club, Alexandria, 29-11-1907; G. Maire 569 (CAI).

TABLE 1. Cont. 1

Examined taxa	Locality
57- *Otanthus maritimus* (L.) Hoffmanns & Link	- Maruit: Abu Sir, 30-5-1962; Täckholm s.n. (CAI)- El Agmi, west of Alexandria, in maritime sand, 2-4-1971; Ibrahim & Mahdi s.n. (CAI).
Subtribe: Glebionidinae Oberpr. &Vogt	
58- *Glebionis coronaria* (L.) Cass. ex Spach	- Maktala (sand dunes), 29-4-2005; D. Ahmed s.n. (TANE)- M. Matruh-Sallum road, 183 Km from Sallum, 20-3-1988; El Garf s.n. (CAI).
Subtribe: Anthemidinae (Cass.) Dumort.	
59- *Anthemis indurata* Delile	- Ajeeba, Matruh, 18-3-2004; D. Ahmed s.n. (TANE)- Burg el Arab, 8-4-1955; Täckholm s.n.(CAI).
60- *A. microsperma* Boiss. & Kotschy	- Cairo- Alexandria desert road, 180 km from Cairo, in fields west of the road, 16-4-1967; Täckholm s.n. (CAI)- Zahia, at kilo 62 before Sallum, 20-3-1988; E. Shamso s.n. (CAI).
61- *A. pseudocotula* Boiss.	- Burg el Arab, 22-3-1956; El Hadidi s.n. (CAI)- Mariut, south of Amria, 16-12-1961; Täckholm s.n. (CAI).
62- *A. retusa* Delile	- Wadi Habis, Matruh, 31—2005; D. A. Ahmed s.n. (TANE)- Ikingi Mariut, 22-1-1928; G. Täckholm s.n. (CAI).
Subtribe: Artemisiinae Less.	
63- *Artemisia monosperma* Delile	- Between El Alamein & Qattara, Libyan Desert, 25-11-1976; D. Osborn s.n. (CAI)- 50 km west of Alexandria, 27-9-1991; El Garf s.n. (CAI)- Omayed, Matruh, 19-3-2004; D.A. Ahmed s.n. (TANE).
Subtribe: Leucantheminae Bremer & Humphries	
64- *Chlamydophora tridentata* (Delile) Ehrenb. ex Less.	- Ajeeba, Matruh, 18—2004; D. Ahmed s.n. (TANE)- Maamora, East of Alexandria, 14-3-1928; M.T. Hefnawy (CAI).
Tribe: Inuleae Cass. **Subtribe:** Inulinae Dumort.	
65- *Chiliadenus candicans* (Delile) Brullo	- Wadi Halazeen, 45 km west Mersa Matrruh, 26-4-1996; El Garf & Soliman s.n. (CAI)- In the sandy dunes of Abu Sir, Spring 1949; Täckholm s.n. (CAI).
66- *Limbarda crithmoides* (L.) Dumort.	- Burg el Arab, 27-9-1991; El Garf s.n. (CAI)- Willis resort. 22-3-2007; D. Ahmed s.n. (TANE).
67- *Pallenis spinosa* (L.) Cass.	- Omayed, Matruh, 19-3-2004; D. A. Ahmed s.n. (TANE)- Plateau of Sallum, 21-4-1973; Amal Amin et al. s.n. (CAI).
Subtribe: Plucheinae Dumort.	
68- *Pluchea dioscorides* (L.) DC.	- Lake Mariut, Alexandria, 30-3-2005; D. A. Ahmed s.n. (TANE)- Busseili, west of Alexandria, 27-10-1961; Täckholm s.n. (CAI).
69- *Sphaeranthus suaveolens* (Forssk.) DC.	- Abu Kir, 28-3-1957; Boulos s.n. (CAI)- On a canal, Faculty of Agriculture farms, alexandria, 28-8-1952; Boulos s.n. (CAI).
Tribe: Heliantheae Cassini (Ambrosieae Cass.) **Subtribe:** Ambrosiinae Less.	
70- *Ambrosia maritima* L.	- Burg el Arab, Spring 1962; Täckholm s.n. (CAI)- Between Burg el Arab and Hammam, 29-11-1974; abdel Aziz & Sisi s.n. (CAI).
71- *Xanthium spinosum* L.	- In a marsh 25 Km on the road Alexandria-Amria, 19-5-1958; Täckholm s.n. (CAI) - Wadi um-Ashtan, 1-4-2005; D. A. Ahmed s.n. (TANE).
72- *X. strumarium* L.	- Bakous fields, near Alexandria, 28-8-1952; El Hadidi s.n. (CAI)- Burg el Arab, 17-3-1957; Gaber s.n. (CAI).
Subtribe: Ecliptinae Less.	
73- Eclipta *prostrata* (L.) L.	- Lake Mariut, 14-4-2005; D. A. Ahmed 308 (CAI, TANE).
Tribe: Coreopsideae Lindl. **Subtribe:** Coreopsidinae Dumort.	
74- *Bidens pilosa* L.	- Burg El-Arab, Alexandria, 3-2-2006; D. A. Ahmed 309 (CAI, TANE)

TABLE 2. Achene quantitative morphological data of the investigated taxa of Asteraceae in North western Mediterranean coast of Egypt

Taxa	Achene length (mm)	Achene width (mm)	Beak length (mm)	Pappus length (mm)
Carduus getulus	3.5 - 4 (3.74 ± 0.069)	1.5 - 1.8 (1.68 ±0.052)	–	9 - 13 (11.4 ±0.812)
Cynara cornigera	3 - 3.5 (3.24 ± 0.061)	1 - 1.2 (1.14 ±0.036)	–	18 - 20 (19 ±0.447)
Onopordum alexandrinum	5 - 6 (5.6 ± 0.152)	2- 3 (2.54 ±0.166)	–	10 - 15 (13 ±0.949)
Silybum marianum	6 - 7 (6.66 ± 0.169)	3 - 3.2 (3.08 ±0.044)	–	15 - 17 (16.2 ±0.489)
Atractylis cancellata	3 - 3.5 (3.22 ± 0.091)	ca. 2	–	6 - 8 (7.2 ±0.374)
A. carduus	4 - 5 (4.52 ± 0.158)	1.5 - 2 (1.76 ±0.100)	–	10 - 15 (13 ±0.949)
Carlina involucrata	2.5 - 3.5 (2.96 ± 0.221)	0.7 - 1 (0.86 ±0.061)	–	8-10 (9.2 ±0.374)
Carthamus eriocephalus	6 - 8 (7 ± 0.316)	1.5 - 2 (1.84 ±0.083)	–	10 - 13 (11.8 ±0.583)
Carthamus glaucus subsp. *alexandrinus*	5.5- 6 (5.8 ± 0.085)	3.5 - 4 (3.76 ±0.100)	–	4 - 8 (6 ±0.894)
C. lanatus	4 - 4.5 (4.24 ± 0.100)	1.8 - 2 (1.88 ±0.044)	–	6-7 (6.4 ±0.245)
C. mareoticus	3 - 4 (3.52 ± 0.158)	1.7-2 (1.86 ±0.061)	–	5 - 6 (5.6 ±0.245)
C. tenuis subsp. *foliosus*	4 - 5 (4.5 ± 0.165)	2 - 2.5 (2.34 ±0.083)	–	8-10 (9.2 ±0.489)
Centaurea calcitrapa	2.7-3.5 (3.1 ± 0.123)	1.3-1.5 (1.4 ±0.04)	–	–
C. dimorpha	5-5.5 (5.22 ± 0.091)	2.5-3 (2.74 ±0.092)	–	OP: 1-1.5 (1.28±0.116)
				IP: 4 - 4.5 (4.24 ±0.112)
C. pumilio	2.5-3 (2.76 ± 0.100)	1-1.2 (1.12 ±0.044)	–	8-10 (9.4 ±0.4)
Volutaria crupinoides	4-4.5 (4.24 ± 0.092)	1.6-1.8 (1.68 ±0.033)	–	3-3.5 (3.3 ±0.122)
Volutaria lippi	2-2.5 (2.22 ± 0.087)	1-1.2 (1.06 ±0.036)	–	1.1-1.5 (1.34 ±0.075)
V. tubuliflora	2.7-3.5 (3.1 ± 0.123)	1-1.3 (1.16 ±0.061)	–	2-2.5 (2.24 ±0.103)
Echinops spinosissimus	0.8 – 1.5 (1.18 ±0.115)	1 - 1.1 (1.04 ±0.022)	–	0.5-0.8 (0.7 ±0.063)
Cichorium pumilium	2-2.5 (2.22 ± 0.091)	1.2-1.5 (1.34 ±0.054)	–	Up to 0.3
Hedypnois rhagadioloides	MA: 6-8 (7 ± 0.316)	MA: 0.5-0.8 (0.68 ±0.052)	–	MA: up to 1
	IA: 5-7 (6 ± 0.316)	IA: ca. 1	–	IA: 4-5 (4.54±0.245)
Leontodon tuberosus	MA: 5-6 (5.66 ± 0.169)	MA: 0.8-1 (0.9±0.04)	–	MA: 1.5-2 (1.82 ±0.092)
	IA: 3-3.5 (3.22 ± 0.091)	IA: 0.4-0.5 (0.48±0.018)	4.5-5 (4.78±0.091)	IA: 6-7 (6.6 ±0.245)
Picris altissima	MA: 3-4 (3.5 ± 0.165)	MA: 0.8-1 (0.92±0.044)	–	MA: 1.5-3 (2.2 ±0.339)
	IA: 2.5-3.5 (3 ± 0.152)	IA: 0.8-1 (0.88 ±0.033)	–	IA: 5-6 (5.4 ±0.244)
P. asplenioides	MA: 3-4 (3.54 ± 0.154)	MA: 0.5-1 (0.82±0.087)	–	MA: 1-1.5 (1.2 ±0.095)
	IA: 2-2.5 (2.22 ± 0.091)	IA: 0.8-1 (0.88±0.044)	–	IA: 5-6 (5.5 ±0.224)
Scorzoneroides hispidulus	4 – 5 (4.58 ± 0.151)	0.3 - 0.4 (0.36 ±0.022)	2-3 (2.62±0.158)	5-6 (5.4±0.245)

TABLE 2. Cont.

Taxa	Achene length (mm)	Achene width (mm)	Beak length (mm)	Pappus length (mm)
Urospermum picroides	3.5-4 (3.7 ±0.085)	1.2 – 1.5 (1.32 ±0.052)	8-9 (8.56 ±0.146)	9-10 (9.6 ±0.245)
Hyoseris radiata subsp. *graeca*	MA: 9-15 (12 ±0.979)	MA: 1.5-2.5 (2.14 ±0.161)	–	MA: 1-1.5 (1.28 ±0.086)
	MdA: 8-12 (10 ±0.632)	MdA: 2.5-3.5 (3 ±0.152)	–	MdA: 8-10 (9 ±0.447)
	IA: 9-12 (10.2 ±0.522)	IA: 0.8-1 (0.94 ±0.036)	–	IA: 10-12 (10.8 ±0.374)
Launaea capitata	MA: 3-3.5 (3.24 ±0.092)	MA: 1.5-2 (1.68 ±0.118)	–	MA: 5-6 (5.4 ±0.245)
	IA: 3-4 (3.54 ±0.154)	IA: 1.2-1.5 (1.4 ±0.057)	–	IA: 5-6 (5.6 ±0.245)
L. fragilis subsp. *fragilis*	MA: 4-6 (5.06 ±0.339)	MA: 0.3-0.5 (0.46 ±0.036)	–	MA: 10-12 (11.2 ±0.374)
	IA: 5-6 (5.5 ±0.165)	IA: 0.3-0.4 (0.36 ±0.022)	–	IA: 10-12 (11.2 ±0.374)
L. nudicaulis	MA: 2.5-3 (2.8 ±0.085)	MA: 0.5	–	MA: 7-8 (7.4 ±0.245)
	IA: ca. 3	IA: 0.5	–	IA: 7-8 (7.6 ±0.145)
Reichardia tingitana	MA: 2-2.2 (2.06 ±0.036)	MA: 0.8-1 (0.92 ±0.044)	–	MA: 7-9 (8 ±0.447)
	IA: 2-3 (2.66 ±0.169)	IA: 0.5-1 (0. ±0.085)	–	IA: 7-9 (8 ±0.447)
Sonchus asper subsp. *asper*	2.5-3 (2.72 ±0.087)	1-1.2 (1.12 ±0.045)	–	6-9 (7.8 ±0.583)
S. macrocarpus	4-5 (4.54 ±0.166)	1.5-1.7 (1.58 ±0.043)	–	7-8 (7.5 ±0.224)
S. oleraceus	2.8-3 (2.92 ±0.044)	0.8-1 (0.92 ±0.033)	–	5-7 (6 ±0.365)
Lactuca serriola	2.5 – 3 (2.8 ±0.085)	1 - 1.5 (1.24 ±0.073)	4.5-5 (4.78 ±0.091)	4-5 (4.7 ±0.218)
Scorzonera undulata	10-13 (11.2 ±0.522)	1-1.5 (1.38 ±0.086)	–	13-15 (14.2 ±0.401)
Ethulia conyzoides subsp. *conyzoides*	1.5-2 (1.82 ±0.082)	1-1.3 (1.08 ±0.052)	–	–
Gymnarrhena micrantha	1-1.5 (1.3 ±0.085)	ca. 0.5	–	3-4 (3.5 ±0.224)
Senecio aegyptius var. *discoideus*	1.7-2 (1.88 ±0.052)	0.4-0.5 (0.48 ±0.018)	–	3-3.5 (3.3 ±0.1)
S. glaucus subsp. *coronopifolius*	1.7-2 (1.86 ±0.054)	0.2-0.3 (0.26 ±0.022)	–	6-7 (6.5 ±0.224)
S. vulgaris	2.2-2.5 (2.38 ±0.052)	0.4-0.5 (0.46 ±0.022)	–	4.5-6 (5.2 ±0.279)
Calendula arvensis	MA: 15-20 (17.6 ±0.829)	MA: 2-2.5 (2.32 ±0.082)	MA: ca. 10	–
	IA: 5-6 (5.58 ±0.150)	IA: 2-3 (2.5 ±0.152)	–	–
Filago desertorum	0.5-0.7 (0.6 ±0.04)	0.2-0.3 (0.22 ±0.018)	–	1.7-2 (1.85 ±0.056)
F. mareotica	0.6-0.8 (0.68 ±0.033)	ca. 0.3	–	–
Ifloga spicata	0.6-0.7 (0.64 ±0.022)	0.2-0.3 (0.26 ±0.022)	–	1.5-1.7 (1.6 ±0.040)
Laphangium luteo-album	0.5-0.7 (0.6 ±0.04)	0.2-0.3 (0.25 ±0.025)	–	2-2.5 (2.3 ±0.079)
Phagnalon rupestre	0.9-1 (0.96 ±0.022)	ca. 0.2	–	5-6 (5.5 ±0.224)
Symphyotrichum squamatum	2-2.5 (2.28 ±0.077)	0.3-0.4 (0.35 ±0.02)	–	5-6 (5.3 ±0.211)

TABLE 2. Cont.

Taxa	Achene length (mm)	Achene width (mm)	Beak length (mm)	Pappus length (mm)
Erigeron aegyptiacus	ca. 1	0.2-0.3 (0.24 ±0.017)	–	3-3.5 (3.3 ±0.086)
Erigeron bonariensis	1.5-1.7 (1.62 ±0.033)	0.2-0.3 (0.26 ±0.017)	–	4-4.5 (4.27 ±0.084)
Brocchia cinerea	1-1.2 (1.1 ±0.04)	0.5-0.6 (0.55 ±0.02)	–	–
Cotula anthemoides	MA: 1-1.2 (1.08 ±0.044)	MA: -0.7-0.8 (0.73 ±0.018)	–	–
	IA: 0.7-1 (0.88 ±0.052)	IA: 0.5-0.6 (0.54 ±0.022)	–	–
Achillea tenuifolia	1.2-1.5 (1.38 ±0.052)	0.5-0.7 (0.62 ±0.033)	–	–
Anacyclus monanthos	2-2.5 (2.24 ±0.092)	1.5-2 (1.72 ±0.091)	–	–
Matricaria aurea	0.6-0.8 (0.7 ±0.04)	0.3-0.4 (0.34 ±0.022)	–	1 - 1.5 (1.3 ±0.77)
M. chamomilla	0.9-1 (0.96 ±0.022)	0.3-0.4 (0.36 ±0.022)	–	–
Otanthus maritimus	1.8-2 (1.9 ±0.04)	1-1.2 (1.1 ± 0.04)	–	–
Glebionis coronaria	MA: 2-2.2 (2.1 ±0.04)	MA: 1-1.5 (1.28 ±0.088)	–	–
	IA: 2.5-3 (2.82 ±0.087)	IA: 1.5-2 (1.82 ±0.086)	–	–
Anthemis indurata	1.5-2 (1.8 ±0.085)	0.7-1 (0.8 ±0.055)	–	0.3-0.5 (0.42 ±0.037)
A. microsperma	1-1.1 (1.04 ±0.022)	0.5-0.6 (0.54 ±0.024)	–	–
A. Pseudocotula	1.2-1.5 (1.34 ±0.061)	0.6-0.8 (0.7 ±0.045)	–	ca. 0.5
A. retusa	1.3-1.5 (1.4 ±0.04)	0.4-0.5 (0.48 ±0.02)	–	–
Artemisia monosperma	1.5-2 (1.76 ±0.100)	0.5-0.6 (0.54 ±0.024)	–	–
Chlamydophora tridentata	1.2-1.5 (1.34 ±0.061)	ca. 0.3	–	1.5-1.8 (1.64 ±0.678)
Chiliadenus candicans	1.2-2 (1.7 ±0.139)	0.3-0.4 (0.36 ±0.024)	–	OP: - 0.5-1 (0.7 ±0.095)
				IP: - 5-5.5 (5.2 ±0.095)
Limbarda crithmoides	1.7-2 (1.846 ±0.054)	0.3-0.4 (0.38 ±0.02)	–	4-5 (4.4 ±0.245)
Pallenis spinosa	MA: 2.2-2.5 (2.38 ±0.052)	MA: 1.7-2 (1.88 ± 0.058)	–	MA: 0.5-0.6 (0.54 ±0.0245)
	IA: 1.5-2 (1.68 ±0.087)	IA: ca. 1	–	IA: 0.5-0.7 (0.58 ±0.037)
Pluchea dioscorides	0.9-1 (0.94 ±0.022)	0.1-0.2 (0.16 ±0.024)	–	2.5-3 (2.76 ±0.112)
Sphaeranthus suaveolens	1-1.5 (1.28 ±0.077)	0.2-0.3 (0.256 ±0.024)	–	–
Ambrosia maritima	4 -5 (4.62 ±0.158)	3-3.5 (3.24 ±0.103)	ca. 1	–
Xanthium spinosum	10– 15 (12.8 ±0.769)	5 -8 (6.8 ±0.583)	4-5 (4.58 ±0.150)	–
X. strumarium	15 – 20 (17.6 ±0.779)	8 -10 (9 ±0.447)	2-3 (2.54 ±0.154)	–
Eclipta prostrata	2.5-3 (2.8 ±0.085)	1-1.2 (1.08 ±0.049)	–	–
Bidens pilosa	8-10 (9.2 ±0.335)	0.8-1 (0.92 ±0.049)	–	2-3 (2.64 ±0.181)

MA= Marginal achene; MdA= Median achene; IA= Inner achene; OP= Outer series of pappus; IP= Inner series of pappus

TABLE 3. Achene qualitative morphological data of the investigated taxa of Asteraceae in North western Mediterranean coast of Egypt

Character	Taxa							
	Carduus getulus	*Cynara cornigera*	*Onopordum alexandrinum*	*Silybum marianum*	*Atractylis cancellata*	*A. carduus*	*Carlina involucrata*	*Carthamus eriocephalus*
Achene-bur	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Achene symmetry	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic
Achene colour	Yellowish brown	Yellowish brown	Blackish brown	Pale brown with dark brown streaks	Dark brown	Dark brown	Brown	Pale brown
Hilum position	Sub-basal	Basal	Basal	Sub-basal	Basal	Basal	Basal	Sub-lateral
Achene shape	Ellipsoid to oblong	Obovoid-oblong	Oblong	Obovoid-oblong	Obovoid	Obovoid-oblong	Fusiform to oblong	Elongated oblong
Achene –surface	Glabrous	Glabrous	Glabrous	Glabrous	Densely hairy	Densely hairy	Densely hairy	Glabrous
Hair types	Absent	Absent	Absent	Absent	Brown, curly and silky hairs	Golden-yellow silky hairs	Appressed brownish hairs	Absent
Achene-outline	Slightly compressed	4- angled	4- angled	Slightly compressed	Compressed	Compressed	Compressed	4- angled
Wing-prescence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
No. of wings	–	–	–	–	–	–	–	4-narrowly scarious wings
Ribs prescence	present	Absent	Present	Absent	Absent	Absent	Absent	Absent
No. of ribs	Multi-ribbed	–	Multi-ribbed	–	–	–	–	–
Ribs appearance	Slightly distinct	–	± Distinct	–	–	–	–	–
Beak presence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Beak surface	–	–	–	–	–	–	–	–
Beak base	–	–	–	–	–	–	–	–
Pappus presence	Present	Present	Present	Present	Present	Present	Present	Present
Pappus type	Yellowish-white barbellate bristles	Yellowish plumose bristles	Golden-yellow plumose bristles	Yellowish-white scabrid bristle-like scales	Yellowish-white plumose bristles	Yellowish-white plumose bristles	Setiform scales dissected into plumose bristles-like segments	Setose pappus of yellowish-white plumose bristles surrounded by brownish denticulate margin (rim)
Pappus persistence	Deciduous	Deciduous	Deciduous	Deciduous	Persistent	Persistent	Persistent	Persistent
Pappus series	Multiseriate	Multiseriate	Multiseriate	Multiseriate	Uniseriate	Multiseriate	Uniseriate	Multiseriate
No. of pappus	Many	Many	Many	Many	Many	Many	10	Many
Pappus symmetry	Homomorphic	Homomorphic	Homomorphic	Homomorphic	Homomorphic	Homomorphic	Homomorphic	Homomorphic
Surface topography	Shallow Longitudinal rugulose	Smooth	Transversely rugose	Smooth	Indistinct	Indistinct	Indistinct	Smooth

TABLE 3. Cont.

Characters	Taxa							
	Carthamus glaucus* subsp. *alexandrinus	***C. lanatus***	***C. mareoticus***	***C. tenuis* subsp. *foliosus***	***Centaurea calcitrapa***	***C. dimorpha***	***C. pumilio***	***Volutaria crupinoides***
Achene-bur	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Achene symmetry	Monomorphic	Dimorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic
Achene colour	Whitish brown	**MA**: Dark brown **IA:** Greenish brown	Glossy whitish with dark brown spots or not	Whitish - yellow	grayish	Yellowish-brown	Brown	Dull brown
Hilum position	Lateral	Lateral	Sub-lateral	Lateral	lateral	Lateral	Sub-lateral	Lateral
Achene shape	Obpyramidal	**MA**: Obconical **IA:** Oblong	Narrowly obpyramidal	Obconical	Ellipsoid	Ellipsoid	Obconical	Ellipsoid
Achene –surface	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Sparsely hairy	Densely hairy	Densely hairy
Hair types	–	–	-	–	–	Silky hairs	Silky hairys	silky hairs
Achene-outline	4- angled	**MA**: 4 anglad **IA:** 4 obscure angles	4- angled	±terete	Terete	Obcompressed	Obcompressed	Sub-compressed
Wing-prescence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
No. of wings	–	–	–	–	–	–	–	–
Ribs prescence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
No. of ribs	–	–	–	–	–	–	–	Multi-ribbed
Ribs appearance	–	–	–	–	–	–	–	Distinct
Beak presence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Beak surface	–	–	–	–	–	–	–	–
Beak base	–	–	–	–	–	–	–	–
Pappus presence	Present	MA: Absent IA: Present	Present	Present	Absent	Present	Present	Present
Pappus type	Paleaceous pappus of unequall, golden scales, the shorter pappus with emaginate apex & the longer with acut apex,and violet scarbidulous hairs	Paleaceous pappus of unequal golden scales, with purplish scarbidulous hairs	Whitish scabrid bristles	Paleaceous pappus of unequal golden scales, the shorter emaginate apex & the longer acute apex, with violet scarbidulous hairs	–	Short Scale-like bristles in the outer, barbellate bristles toward the center	Plumose bristles	Paleacous pappus of unequall, serrately apex, golden scales, surrounded by denticulate rim
Pappus persistence	Persistent	Persistent	Deciduous	Persistent	–	Persistent	Persistent	Persistent
Pappus series	Multiseriate	Multiseriate	Multiseriate	Multiseriate	–	Multiseriate	Multiseriate	Multiseriate
No. of pappus	Many	Many	Many	Many	–	Many	Many	Many
Pappus symmetry	Heteromorphic	Heteromorphic	Homomorphic	Heteromorphic	–	Heteromorphic	Homomorphic	Heteromorphic
Surface topography	Wrinkled or rugose at upper half	**MA**: Rugose **IA:** Smooth	Smooth	Smooth	Smooth	Smooth	Indistinct	transversely pitted between ribs

TABLE 3. Cont.

Characters	Taxa							
	Volutaria lippi	*V. tubuliflora*	*Echinops spinosissimus*	*Cichorium pumilium*	*Hedypnois rhagadioloides*	*Leontodon tuberosus*	*Picris altissima*	*P. asplenioides*
Achene-bur	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Achene symmetry	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Dimorphic	Dimorphic	Dimorphic	Dimorphic
Achene colour	Grayish brown	Grayish brown	Brown	yellowish with dark brown streaks	Dark brown	**MA**: pale brown **IA:** brown	Brown	Brown
Hilum position	Lateral	Lateral	Basal	Basal	Basal	Basal	Basal	Basal
Achene shape	Cylindrical	Cylindrical	Narrowly cylindrical	Obconical	-Cylindrical	**MA**: Elongated ovoid **IA:** Fusiform	-Fusiform	**MA**: Fusiform **IA:** Oblong
Achene –surface	Hairy	Hairy	Densely Hairy	Glabrous	-Glabrous	Glabrous	-Glabrous	**MA**: Hairy **IA:** Glabrous
Hair types	Silky hairs	Silky hairs	Pilose	–	Strigose along the ribs only	–	–	**MA**: Puberulent
Achene-outline	Slightly compressed	Slightly compressed	Terete	3-5 sided prismatic	Terete	±Terete	Terete	±Terete
Wing-prescence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
No. of wings	–	–	–	–	–	–	–	–
Ribs prescence	present	Present	Absent	Absent	Present	Present	present	Present
No. of ribs	Multi-ribbed	Multi-ribbed	–	–	Multi-ribbed	**MA**: 4 ribs (furrows) **IA:** multi-ribbed	4 ribs	4 ribs
Ribs appearance	faint	Faint	–	–	Distinct	**MA**: distinct **IA:** faintly	Distinct	Faintly
Beak presence	Absent	Absent	Absent	Absent	Absent	**MA**: Absent **IA:** Present	Absent	Absent
Beak surface	–	–	–	–	–	Glabrous	–	–
Beak base	–	–	–	–	–	Normal	–	–
Pappus presence	Present	Present	Present	Present	Present	Present	Present	Present
Pappus type	Paleaceous pappus of unequall, serrately apex. whitish scales, surrounded by denticulate rim	Paleaceous pappus of unequall, serrately apex, whitish scales, surrounded by denticulate rim	Coroniform dentate scales	Crown of minute whitish scales	**MA**: Coroniform of erose scales **IA:** Subulate scales with scabrid awns	**MA**: yellowish scales **IA:** yellowish plumose bristles	**MA**: Unequal plumose bristles **IA:** Plumose bristles	- **MA**: short Barbellate bristles **IA:** plumose bristles
Pappus persistence	Persistent	Persistent	Persistent	Persistent	Persistent	Persistent	Deciduous	Deciduous
Pappus series	Multiseriate	Multiseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate
No. of pappus	Many	Many	Many	Many	**MA**: Many **IA:** 4-6 scales	Many	Many	Many
Pappus symmetry	Heteromorphic	Heteromorphic	Homomorphic	Homomorphic	Heteromorphic	Heteromorphic	Heteromorphic	Heteromorphic
Surface topography	Minutely pitted between ribs	Minutely pitted between ribs	indistinct	Verruculose	Smooth	Obscure to distinct transversely rugose	Longitudinal striate with transversely rugose	Longitudinal striate with transversely rugose to muricate

TABLE 3. Cont.

Characters	Taxa								
	Scorzoneroides hispidulus	***Urospermum picroides***	***Hyoseris radiata*** subsp. ***graeca***	***Launaea capitata***	***L. fragilis*** subsp. ***fragilis***	***L. nudicaulis***	***Reichardia tingitana***	***Sonchus asper*** subsp. ***asper***	***S. macrocarpus***
Achene-bur	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Achene symmetry	Monomorphic	Monomorphic	Trimorphic	Dimorphic	Dimorphic	Dimorphic	Dimorphic	Monomorphic	Monomorphic
Achene colour	Brown	Greenish yellow	Pale brown	Whitish	**MA:** Brown **IA:** Grayish brown	**MA:** Blackish **IA:** Whitish	**MA:** Grayish brown **IA:** Whitish	Whitish brown	Brown to dark brown
Hilum position	Basal	Basal	Basal	Basal	Basal	Basal	Basal	Basal	Basal
Achene shape	Fusiform	Obovoid	**MA:** Elongated ovoid **MdA:** Ellipsoid **IA:** Oblong	Ellipsoid	Cylindrical	**MA:** ± Fusiform **IA:** Oblong	Oblong	Claviform	Ellipsoid
Achene-surface	Glabrous	Glabrous	**MA:** Hairy **MdA & IA:** Glabrous	-Glabrous	**MA:** Hairy **IA:** Glabrous	Glabrous with spinulose at ribs	Glabrous	hairy at ribs and wings only	Glabrous
Hair types	–	–	-Scabrous at ribs & margins or puberulent	–	Densely strigulose	–	–	Retrose spinulose	–
Achene-outline	Slightly compressed	Obcompressed	**MA:** Dorsally compressed **MdA:** Compressed **IA:** ±Terete	Terete to slightly compressed	Terete	±Terete	Tetragonal with 4-sulcate	compressed	compressed
Wing-prescence	Absent	Absent	Present only in the intermediate achene	Present	Absent	Absent	Absent	Present	Present
No. of wings	–	–	bi-winged	**MA:** 3-eroding wings **IA:** 2-narrow eroding wings	–	–	–	2-narrow wings	2-narrow wings
Ribs prescence	Present	Absent	Present	Present	Present	Present	Absent	Present	Present
No. of ribs	Multi-ribbed	–	**MA:** Dorsally grooved **MdA:** 3-ribs at dorsal face **IA:** 5-6 ribs	**MA:** 5-ribs **IA:** 4-ribs	**MA:** 5-ribs **IA:** 4-ribs	**MA:** 5- ribs **IA:** 4-ribs	–	3- median ribs on each surface	3- median ribs on each surface
Ribs appearance	faintly	–	Distinct	Distinct	Distinct	Distinct	–	Distinct	Distinct
Beak presence	Present	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Beak surface	Scabrous	Scabrous	–	–	–	–	–	–	–
Beak base	Normal	Fistulose gibbous	–	–	–	–	–	–	–
Pappus presence	Present	Present	Present	present	Present	present	Present	Present	Present
Pappus type	Barbellate bristles	White plumose bristles	**MA:** Coroniform bristle-like scales **MdA & IA:** Barbellate Bristles	Smooth bristles	Mixed of Soft and setaceous bristles	Smooth bristles	Smooth to barbellate bristles	Whitish smooth silky bristles	Whitish smooth silky bristles
Pappus persistence	Persistent	Deciduous	Persistent	Deciduous	Persistent	Persistent	Deciduous	± Deciduous	Deciduous
Pappus series	Uniseriate	Uniseriate	Uniseriate	Multiseriae	Multiseriate	Multiseriae	Multiseriate	Fascicles in uniseriate	Fascicles in uniseriate
No. of pappus	10	Many	Many	Many	Many	Many	Many	Many	Many
Pappus symmetry	Homomorphic	Homomorphic	Heteromorphic	Homomorphic	Heteromorphic	Homomorphic	Homomorphic	Homomorphic	Homomorphic
Surface topography	Transversely muricate	Transversely muricate-lamellate	Smooth	Minutely tuberculate-rugulose at ribs	Smooth	Smooth	**MA:** transversely Rugose -verrucose **IA:** slightly rugose	Faint scalariform between ribs	Smooth

TABLE 3. Cont.

Characters	Taxa							
	S. oleraceus	***Lactuca serriola***	***Scorzonera undulata***	***Ethulia conyzoides*** subsp. ***conyzoides***	***Gymnarrhena micrantha***	***Senecio aegyptius*** var. **discoideus**	***S. glaucus*** subsp. ***coronopifolius***	***S. vulgaris***
Achene-bur	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Achene symmetry	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic
Achene colour	Bright brown	Pale brown	Whitish- brown	Straw yellow	Dark brown	Dark brown	Grayish	Dull brown to grayish brown
Hilum position	Basal	Basal	Basal	Basal	Basal	Basal	Basal	Basal
Achene shape	claviform	Prolonged obovoid	Cylindrical	Obpyramidal-prismatic	Obovoid	Cylindrical	Ellipsoid-oblong	Fusiform
Achene –surface	Glabrous	Hairy	Hairy	Glabrous	Densely hairy	Densely hairy	Densely hairy	Densely hairy
Hair types	–	Hispidulous near the apex	Puberulent with scabrid to squamate at ribs	–	Brownish villous	Whitish strigulose	Whitish appressed strigose	Whitish, appressed hirtellous
Achene-outline	compressed	Obcompressed	Terete	4-6 sided	Compressed	Subterete	Subterete	Subterete
Wing-prescence	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent
No. of wings	2-narrow wings	–	–	–	–	–	–	–
Ribs prescence	Present	Present	Present	Absent	Absent	Present	Present	Present
No. of ribs	3- median ribs on each surface	6-8 on each surface	Multi-ribbed	–	–	Multi-ribbed	Multi-ribbed	Multi-ribbed
Ribs appearance	Distinct	Distinct	±Distinct	–	–	Faint	Distinct	Faint
Beak presence	Absent	Present	Absent	Absent	Absent	Absent	Absent	Absent
Beak surface	–	Glabrous	–	–	–	–	–	–
Beak base	–	Normal	–	–	–	–	–	–
Pappus presence	Present	Present	Present	Absent	Present	Present	Present	Present
Pappus type	Whitish smooth silky bristles	Barbellate bristles	Yellowish-white plumose bristles	–	Barbellate bristels with 5- linear, acuminate scales in the innermost	White silky barbellate bristles	White silky barbellate bristles	White silky barbellate bristles
Pappus persistence	Deciduous	Deciduous	Persistent	–	Persistent	Deciduous	Deciduous	Deciduous
Pappus series	Fascicles in uniseriate	Uniseriate	Multiseriate	–	Multiseriate	Multiseriate	Multiseriate	Multiseriate
No. of pappus	Many	Many	Many	–	Many	Many	Many	Many
Pappus symmetry	Homomorphic	Homomorphic	Homomorphic	–	Heteromorphic	Homomorphic	Homomorphic	Homomorphic
Surface topography	Smooth with minutely rugose at ribs	Smooth	Smooth with Squamate at ribs	Yellowish glandular punctuate	Indistinct	Indistinct	Indistinct	Indistinct

TABLE 3. Cont.

Characters	Taxa							
	Calendula arvensis	*Filago desertorum*	*F. mareotica*	*Ifloga spicata*	*Laphangium luteo-album*	*Phagnalon rupestre*	*Symphyotrichum squamatum*	*Erigeron aegyptiacus*
Achene-bur	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Achene symmetry	Dimorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic
Achene colour	**MA:** Yellowish **IA:** pale brown	Grayish- brown	Pale brown	Grayish - brown	Brown	Greenish brown	Pale brown	Yellow
Hilum position	Basal	Basal	Basal	Basal	Basal	Basal	Basal	Basal
Achene shape	**MA:** Cymbiform **IA:** Annulate	Ellipsoid	Ellipsoid	Obovoid	Oblong to cylindrical	Oblong	Fusiform	Obconical
Achene –surface	Glabrous to sparsely hairy	Glabrous	Glabrous	Glabrous	Glabrous	Densely hairy	Densely hairy	Sparsely hairs
Hair types	–	–	–	–	–	Whitish appressed hairs	Appressed pilose	Pubescent
Achene-outline	±Terete	Subcompressed	Obcompressed	Subcompressed	Terete	Terete	subcompressed	Lateral compressed
Wing-prescence	Present in the Inner achene	Absent	Absent	Absent	Absent	Absent	Absent	Absent
No. of wings	bi-winged	–	–	–	–	–	–	–
Ribs prescence	Absent	Absent	Absent	Absent	Absent	Absent	Present	Absent
No. of ribs	–	–	–	–	–	–	5- ribs	–
Ribs appearance	–	–	–	–	–	–	Faint	–
Beak presence	Present in the marginal achene	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Beak surface	Glabrous	–	–	–	–	–	–	–
Beak base	Normal	–	–	–	–	–	–	–
Pappus presence	Absent	Present	Absent	Present	Present	Present	present	Present
Pappus type	–	Whitish barbellate bristles	–	Whitish barbellate bristles ended with plumose	Barbellate bristles with patent cilia at base	White brittle bristles	Yellowish- White barbellate bristles	Whitish finely barbellate bristles
Pappus persistence	–	Deciduous	–	Deciduous	Deciduous	Persistent	Persistent	Deciduous
Pappus series	–	Uniseriate	–	Uniseriate	Uniseriate	Uniseriate	uniseriate	Uniseriate
No. of pappus	–	Ca. 10 bristles	–	10 bristles	10-15 bristles	5 bristles	Many	Many
Pappus symmetry	–	Homomorphic	–	Homomorphic	Homomorphic	Homomorphic	Homomorphic	Homomorphic
Surface topography	Aculeate at back	Glossy papillulate	Minute papillulate	Smooth	Yellowish papillulate	Indistinct	Indistinct	Smooth

TABLE 3. Cont.

Characters	Taxa								
	Erigeron bonariensis	***Brocchia cinerea***	***Cotula anthemoides***	***Achillea tenuifolia***	***Anacyclus monanthos***	***Matricaria aurea***	***M. chamomilla***	***Otanthus maritimus***	***Glebionis coronaria***
Achene-bur	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Achene symmetry	Monomorphic	Monomorphic	Dimorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Dimorphic
Achene colour	Pale brown	Grayish	Brown	Yellowish – brown	Pale brown	brown	Brown	Pale brown	Brown
Hilum position	Basal	Basal	Basal	Basal	Basal	Obliquely basal	Obliquely basal	Basal	Basal
Achene shape	Oblong	Narrowly cylindrical	**MA:** Obovoid **IA:** Oblong	Narrowly obovoid	Broadly obovoid	Obliquely oblong	Slightly recurved oblong	Fusiform	**MA:** Triquetrous **IA:** Obpyramidal
Achene –surface	Sparsely hairy	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous
Hair types	Appressed silky hairs	–	–	–	–	–	–	–	–
Achene-outline	Lateral compressed	Terete	Obcompressed	Obcompressed	Obcompressed	terete	terete	Obcompressed	Angular
Wing-prescence	Absent	Absent	**MA:** Present **IA:** Often absent	Absent	Present	Absent	Absent	Absent	Present
No. of wings	–	–	**MA:** yellowish bi-winged **IA:** Slightly brownish uni-winged if present	–	2- scarious toothed wings	–	–	–	**MA:** Narrowly winged angles **IA:** Obliquely wing on the adaxile face
Ribs prescence	Absent	Absent	Absent	Present	Absent	Present	Present	present	**MA:** Absent **IA:** Present
No. of ribs	–	–	–	2- whitish ribs	–	3-brownish ribs at ventral face and faint striat at the dorsal face	5-whitish ribs at ventral face faint striate at the dorsal face	4-5 whitish ribs	3 ribs at lateral faces
Ribs appearance	–	–	–	Distinct	–	Distinct	Distinct	Distinct	Distinct
Beak presence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Beak surface	–	–	–	–	–	–	–	–	–
Beak base	–	–	–	–	–	–	–	–	–
Pappus presence	Present	Absent	Absent	Absent	Absent	Present	Absent	Absent	Absent
Pappus type	Whitish finely barbellate bristles	–	–	–	–	Unilateral white membranous auricle	–	–	–
Pappus persistence	Deciduous	–	–	–	–	Persistent	–	–	–
Pappus series	Uniseriate	–	–	–	–	Absent	–	–	–
No. of pappus	Many	–	–	–	–	One	–	–	–
Pappus symmetry	Homomorphic	–	–	–	–	Homomorphic	–	–	–
Surface topography	Smooth	Striate-scalariform with sparsely brownish glandular punctuate	Smooth with glandular punctate	Finely Striate	Finely striate and granules	Yellowish glandular punctate on ventral face	Yellowish glandular punctate on ventral face	Smooth with golden glandular punctate between ribs	Smooth with sparsely glandular punctate

TABLE 3. Cont.

Characters	Taxa								
	Anthemis indurata	*A. microsperma*	*A. pseudocotula*	*A. retusa*	*Artemisia monosperma*	*Chlamydophora tridentata*	*Chiliadenus candicans*	*Limbarda crithmoides*	*Pallenis spinosa*
Achene-bur	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Achene symmetry	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Dimorphic
Achene colour	Dull white	Grayish to dark brown	Pale brown	Pale brown	Dark brown	Dark brown	Dark brown	Dark brown	MA: Grayish brown IA: Dark brown
Hilum position	Basal	Basal	Basal	Basal	Sub-basal	Obliquely basal	Basal	Basal	Basal
Achene shape	Obconical	Obconical	Obovoid- Oblong	Turbinate - obpyramidal	Claviform to obovoid	Slightly recurved Fusiform,	Oblong	Ellipsoid	MA: MA: Oblong-orbicular IA: Triquetrous to turbinate
Achene –surface	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Densely hairy	Densely hairy	MA: Subglabrous IA: Hairy
Hair types	–	–	–	–	–	–	Yellowish hairs with glossy glandular punctate	Whitish appressed hairs	MA: Scabrous at margin IA: Appressed hairs
Achene-outline	Sub-terete	Terete	± Tetragonal	Terete	Terete	Terete	Subcompressed	Terete	MA: Dorsally compressed IA: Slightly angular
Wing-prescence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	MA: Present IA: Absent
No. of wings	–	–	–	–	–	–	–	–	Bi-winged
Ribs prescence	Present	Present	Present	present	Present	Present	Absent	Absent	Absent
No. of ribs	Multi-ribbed	Multi-ribbed	Multi-ribbed	Multi-ribbed	Whitish Multi-ribbed	10-yellowish ribs	–	–	–
Ribs appearance	Faintly	Distinct	Distinct	Distinct	Distinct	Distinct	–	–	–
Beak presence	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Beak surface	–	–	–	–	–	–	–	–	–
Beak base	–	–	–	–	–	–	–	–	–
Pappus presence	Present	Absent	Present or absent	Absent	Absent	Present	Present	Present	Present
Pappus type	Coronalate	–	Unilateral membranous auricle	–	–	Unilateral membranous auricle	Bristle –like scales in the outer and golden barbellate bristles in the inner	Yellowish barbellate bristles	MA: coroniform fringed scales IA: fimbriate scales
Pappus persistence	Persistent	–	Persistent	–	–	Persistent	Persistent	Persistent	Persistent
Pappus series	uniseriate	–	Absent	–	–	Absent	Biseriate	Multiseriate	Uniseriate
No. of pappus	Many	–	One	–	–	One	Many	Many	Many
Pappus symmetry	Homomorphic	–	–	–	–	–	Heteromorphic	Homomorphic	Heteromorphic
Surface topography	Areolate-scalariform	Scalariform with tubercles at ribs	Smooth	Smooth	Smooth between the ribs	Smooth	Indistinct, with glossy glandular punctate	Indistinct	Smooth

TABLE 3. Cont.

Characters	Taxa						
	Pluchea dioscorides	*Sphaeranthus suaveolens*	*Ambrosia maritima*	*Xanthium spinosum*	*X. strumarium*	*Eclipta prostrata*	*Bidens pilosa*
Achene-bur	Absent	Absent	present	present	Present	Absent	Absent
Achene symmetry	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic	Monomorphic
Achene colour	Dark brown	Brown	Grayish brown	Brown	Dark brown	Pale brown	Blackish brown
Hilum position	Basal	Basal	Basal	Basal	Basal	Basal	Sub-basal
Achene shape	Ellipsoid to oblong	Oblong	Broadly obovoid	Ellipsoid	Ovoid to oblong	Obconical	Narrowly fusiform
Achene –surface	Hairy at ribs	Hairy	Hairy	Hairy	Hairy	Glabrous	hairy at ribs
Hair types	Sparsely appressed hairs	Pilose with anchor-shaped hairs	Pubescent with 7-8 horn - like processes	Arachnoid hairy armed with hooked spines	Glandular scabrous armed with hooked spines	–	Few srtrigose on the ribs & near the apex
Achene-outline	± angular	Terete to slightly anglur	Terete	Terete	Terete	Trigonous to laterally compressed	Slightly angled
Wing-prescence	Absent	Absent	Absent	Absent	Absent	Absent	Absent
No. of wings	–	–	–	–	–	–	–
Ribs prescence	Present	Absent	Absent	Absent	Absent	Absent	Present
No. of ribs	4- pale brown ribs	–	–	–	–	–	4-ribs
Ribs appearance	distinct	–	–	–	–	–	Distinct
Beak presence	Absent	Absent	Present	Present	Present	Absent	Absent
Beak surface	–	–	Glabrous	Glabrous	Glabrous	–	–
Beak base	–	–	Normal	Normal	Normal	–	–
Pappus presence	Present	Absent	Absent	Absent	Absent	Absent	Present
Pappus type	Barbellate bristles	–	–	–	–	–	2-3 retrosely barbed awns surrounded by scarious brownish corona
Pappus persistence	Persistent	–	–	–	–	–	Persistent
Pappus series	Uniseriate to biseriate	–	–	–	–	–	Uniseriate
No. of pappus	10-15 bristles	–	–	–	–	–	2-3 awns
Pappus symmetry	Homomorphic	–	–	–	–	–	Homomorphic
Surface topography	Smooth	Smooth	Reticulate- nerved	Smooth with prickles	Smooth with prickles	Tuberculate	Dense verruculose or fine granules

- MA= Marginal achene; MdA= Median achene; IA= Inner achene).
- Taxa are arranged according to the system of Jeffrey (2007) and Funk et al. (2009).

Results

Seventy-four taxa with eight subspecies and one variety belonging to 51 genera were examined (Table 1). Of which, *Anthemis microsperma* Boiss. & Kotschy and *Sonchus macrocarpus* Boulos & C. Jeffrey are endemic to Egypt (Boulos 2009; Hosni et al., 2013). The main features of the investigated achenes are summarized in Tables 2 and 3 and they are shown in Figs. 2-9. The achenes of the studied taxa are variable in terms of shape, color, symmetry, hairiness, presence or absence of ribs, and pappus characters. Among the taxa examined, two basic morphological groups were distinguished. Achenes were closely enveloped by a hardened fruiting involucre (bur), woody and covered with hooked prickles, this pattern is recorded in *Xanthium spinosum* and *X. stramonium* or rigid with 7-8 horn-like processes restricted to the upper half in *Ambrosia maritima* (Fig. 2, a-d). The rest of the studied taxa possess achenes without fruiting involucre. Four different achene morphological types were recognized within this group, based on achene symmetry, hairiness, hilum position, presence or absence of pappus and pappus type.

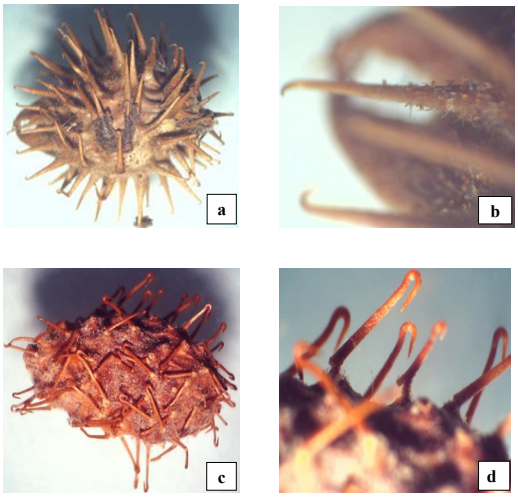

Fig. 2. Achenes closely enveloped by hardened fruiting involucre (bur), woody and covered with hooked spines [*Xanthium stramarium* (a= 1.5X & b=4X) showing glandular scabrous armed with hooked spines; *Xanthium spinosum* (c= 1.25X & d= 2.5X) showing arachnoid hairy armed with hooked spines]

Description of Achene morphological types and subtypes

Type I: This group readily recognize by the presence of two or three different kinds of achenes per capitulum (the marginal and inner achenes). Achenes mostly glabrous, rarely hairy; beakless or beaked, winged or not, 4-5 (-6) or multi-ribbed, sometimes without ribs. Achenes with paleaceous or setose pappus, rarely without pappus (Fig. 3, a-i). This group comprises *Calendula arvensis, Leontodon tuberosus, Hedypnois rhagadioloides, Picris altissima*, *Picris asplenioides, Reichardia tingitana, Hyoseries radiata* subsp. *graeca, Launaea nudicaulis, L. capitata, L. fragilis* subsp. *fragilis, Carthamus lanatus, Pallenis spinosa, Glebionis coronaria* and *Cotula anthemoides*

Fig. 3. Type I: Show the two shapes of achenes per capitulum [marginal achene (left) and inner achene (right)] [*Calendula arvensis* (a=1.25X & b= 1.5X) show aculeate surface, epappus achenes; *Launaea nudicaulis* (c=2.5X & d=2.5X) showing ribbed achene with smooth, bristly pappus; *Pallenis spinosus* (e= 3.5X & f= 3.75X) showing biwinged achenes, no ribs, coroniform and fimbriate scales pappus]

Fig. 3. Cont. Type I: Show the two shapes of achenes per capitulum [marginal achene (left) and inner achene (right)] [*Hedypnois rhagadioloides* (g=1.5X, h= 1.25X & I= 3X magnified part of inner achene) showing marginal achene enfolded by the inner phylaries with coronoiform pappus and 4-6 subulate scales pappus in inner achenes; *Glebionis coronaria* (j= 4X) showing ribed achenes with glandular punctate; *Carthamus lanatus* (k= 2.5X & i= 1.25X) showing 4-angelled, epappose outer achene and Paleaceous pappus of unequal golden scales]

Type II: Includes taxa with capitulum bearing one kind of achene (monomorphic) and lacking pappus. The mature achenes are straight to slightly curved in *Matricaria chamomilla*; terete or obcompressed, sometimes angular or with two scarious-toothed wings in *Anacyclus monanthos* subsp. *monanthos*). Glabrous; however, anchor-shaped hairs were observed in *Sphaeranthus suaveolens* (Fig. 4c) ribbed or not. Surface smooth or finely striate to scalariform, sometimes with golden glandular punctate or tubercules (Fig. 4, a-f). Taxa included are: *Eclipta prostrata, Achillea tenuifolia, Otanthus maritimus*, *Matricaria chamomilla*, *Artemisia monosperma, Anthemis microsperma, A. retusa, Centaurea calcitrapa, Sphaeranthus suaveolens, Anacyclus monanthos* subsp. *monanthos, Ethulia conzoides* subsp. *conzoides, Filago mareotica* and *Brocchia cinerea.*

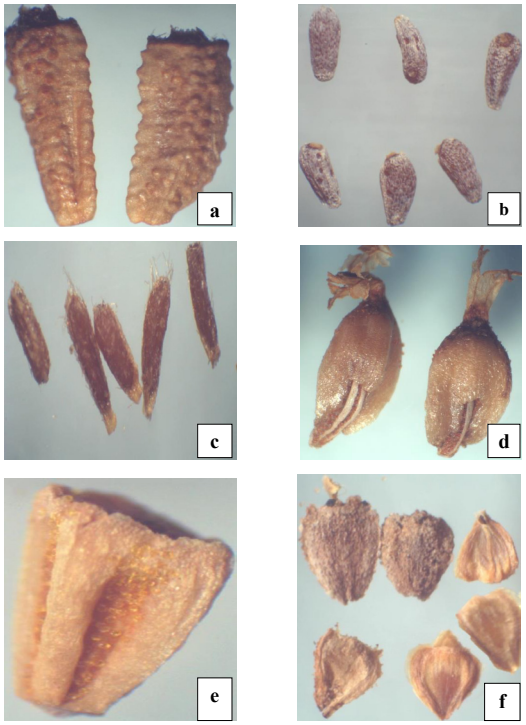

Fig. 4. Type II: Show the achenes without pappus [*Eclipta prostrata* (a= 4X) showing tuberculate surface; *Brocchia cinerea* (b= 3.75X) showing striate-scalariform with sparsely brownish glandular punctuate surface; *Sphaeranthus suaveolens* (c= 3.75X) showing hairy achene with distinct carpopodium; *Otanthus maritimus* (d= 2X) showing achene-apex included in accrescent spongy base of corolla and smooth surface with golden glandular punctate between whitish ribs; *Ethulia conzoides* subsp.*conzoides* (e= 3.75X) showing prismatic achene with yellowish glandular punctuate surface between 4-6 sides; *Anacyclus monanthos* subsp. *monanthos* (f= 2.5X) showing obovate achene with 2- scarious toothed wings and longitudinal striate surface]

Type III: Includes taxa with capitulum bearing one kind of achene, with minute scales, coroniform or auriculate pappus. Achene is straight or slightly curved, terete or angular, glabrous or densely hairy. Ribbed or not ribbed, ribs either 3- brownish restricted to the ventral face as in *Matricaria aurea*), 10- yellowish in *Chlamydophora tridentata* or multi-ribbed. Achene surface smooth or areolate-scalariform to verruculose. Pappus very short, 0.3-1.8mm long,

either coroniform scales or unilateral membranous auricle (Fig. 5, a, b). Taxa included are *Matricaria aurea, Cichorium pumilium, Chlamydophora tridentata, Echinops spinosissimus, Anthemis pseudocotula* and *A. indurata,*

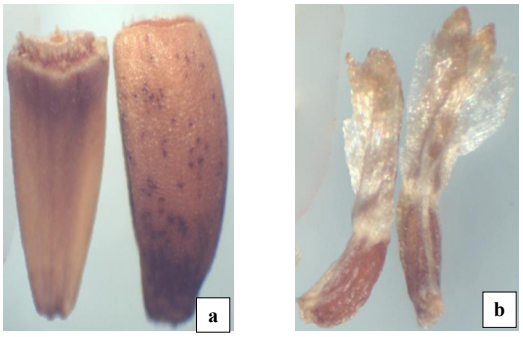

Fig. 5. Type III. show monomorphic achenes with coroniform or auriculate pappus [*Cichorium pumilium* (a= 3.5X) showing pappus crown of minute whitish scales and yellowish with dark brown streaks surface-- *Matricaria aurea* (b= 3.5X) showing achene with obliquely hilum and white membranous auriculate pappus and the 3 brownish ribs]

Type IV: Includes taxa with capitulum bearing one kind of achene with pappus. This group exhibit a high variation in the morphological characters. On the basis of the presence or absence of beak, position of hilum, type of the pappus, and hairiness, four subtypes were recognized:

Subtype A: Characterized by the presence of scabrous or glabrous beak, fistulose-gibbose at the base. Achene body obcompressed, glabrous or hispidulous near the apex, ribbed or not. Pappus–setose of barbellate or plumose bristles (Fig. 6, a-g). Taxa included are: *Lactuca serriola, Urospermum picroides* and *Scorzoneroides hispidulus*

Subtype B: Characterized by achenes with lateral hilum, glabrous or silky hairy, slightly compressed, absence of ribs and smooth ornamentation. Pappus persistent rarely deciduous, paleaceous of whitish to golden scales or setose of barbellate or plumose bristles surrounded with a rim (Fig. 7, a-f). Taxa included are *Centaurea dimorpha, C. pumilio*, *Volutaria tubuliflora, V. lippii, V. crupinoides, Carthamus glaucus* subsp. *alexandrinus, C. tenuis* subsp. *foliosus, C. eriocephalus* and *C. mareoticus*.

Fig. 6. Type IV (subtype A) Achenes monomorphic, with beak and pappus present [*Urospermum picroides* (a= 1.25 X & b= 2X) showing scabrous beak, fistulose-gibbous at base and pappus white plumose, deciduous; *Lactuca serriola* (c= 1.5X, d & e= 3X) showing distinct ribs with hispidulous near apex, glabrous beak and pappus barbellate bristles, deciduous; *Scorzoneroides hispidulus* (f= 1.5X & g= 3X) showing multi-ribbed with transversal muricate in between, scabrous beak and 10- barbellate persistent pappus]

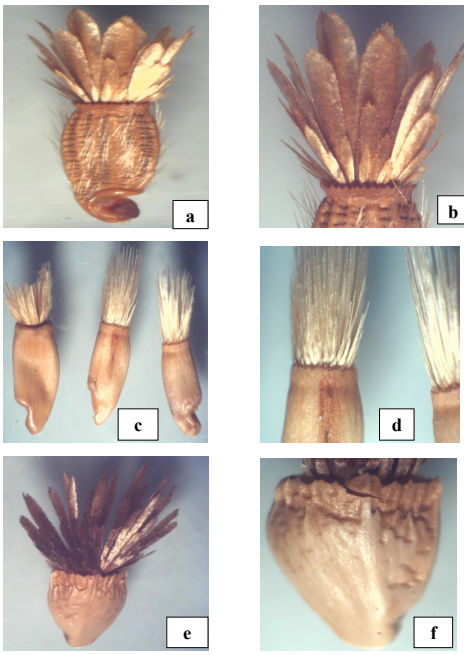

Fig. 7. Type IV (subtype B) Achenes with lateral hilum [*Volutaria crupinoides* (a= 1.5 X & b= 2.5

X) showing densely silky hairy achene, multi-ribbed with transversely pitted between them and denticulate rim surrounding the paleaceous pappus of unequal golden serrately scales; *Centaurea dimorpha* (c= 1.5 X & d= 3X) showing sparsely hairy achene and pappus with short scale-like bristles in the outer and barbellate bristles toward the center; *Carthamus glaucus* subsp. *alexandrines* (e= 1.25 X & f= 2X) showing glabrous achene with paleaceous pappus of unequal golden scales with acute-acuminate apex and violet scarbidulous hairs]

Subtype C: Characterized by glabrous achenes, sometimes rugulose or papillose. Pappus-setose silky bristles, plumose bristly, barbellate, or with 2-3 aristate awns and scabrid-like scales, (Fig. 8, a-g). Taxa included are: *Laphangium luteo-album, Carduus getulus, Filago desertorum, Ifloga spicata, Onopordum alexandrinum*, *Cynara cornigera, Sonchus asper* subsp. *asper, S. macrocarpus, S. oleraceous, Bidens pilosa* and *Silybum marianum.*

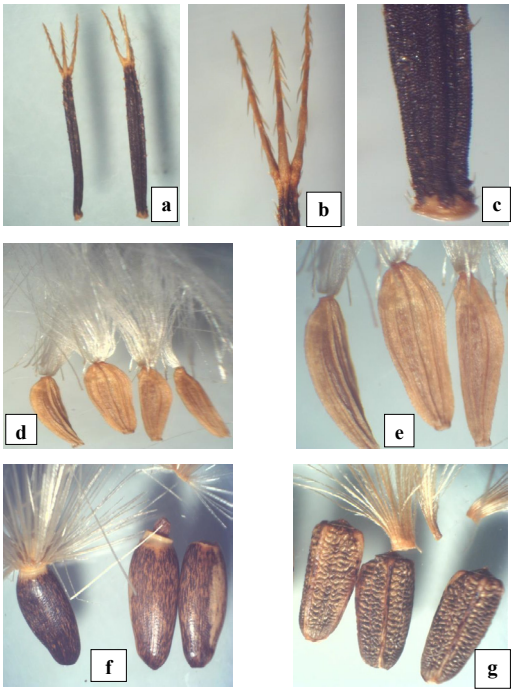

Fig. 8. Type IV (subtype C) achene-surface glabrous [*Bidens pilosa* (a= 1.5X, b= 3X & c= 3X) showing achene with 4 strigose ribs, disctinct carpopodium and aristate pappus of 2-3 retrosely barbed awns surrounded by scarious brownish corona; *Sonchus asper* (d= 1.75 X & e= 3.5X) showing 2-narrow wings and 3-midian ribs, pappus whitish smooth silky bristles, deciduous; *Silybum marianum* (f= 1.5X) showing achene pale brown with dark brown streaks, no ribs, apex with annular margin surrounding the umbo and pappus yellowish-white scabrid bristle-like scales, deciduous; *Onopordum alexandrinum* (g= 1.5X) showing multi-ribbed achene with transversely rugose in between and pappus golden-yellow plumose bristles, deciduous]

Subtype D: Monomorphic achenes readily recognize this group with sparsely to densely hairy surface, hairs appressed, mostly villous to hirsute, or strigose (Fig. 9, a-e). Taxa included are: *Erigeron bonariensis*, *E. aegyptiacus, Pluchea dioscorides*, *Symphyotrichum squamatum, Senecio aegyptius* var. *discoideus, S. vulgaris, S. glaucus* subsp. *coronopifolius, Scorzonera undulata, Atractylis carduus*, *A. cancellata, Chiliadenus candicans, Phagnalon rupestre, Carlina involucrata, Gymnarrhena micrantha* and *Limbarda crithmoides.*

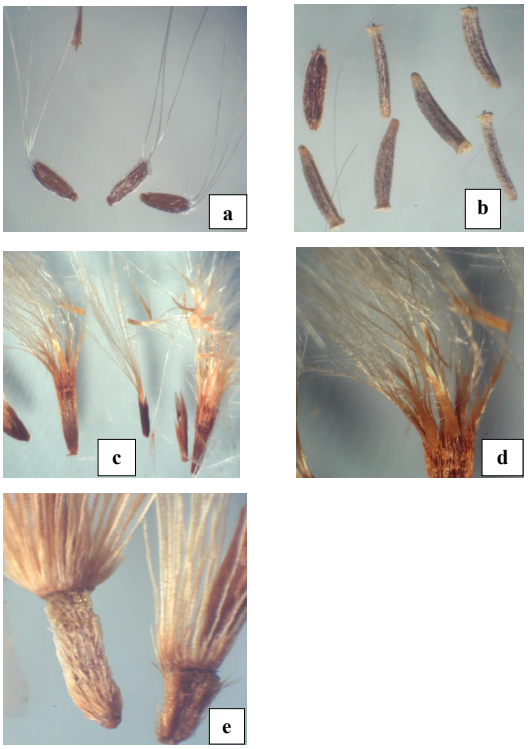

Fig. 9. Type IV (subtype D) Achene-surface sparsely to densely hairy [*Phagnalon rupestre* (a= 3.75X) showing achene not ribbed, surface with whitish appressed silky hairs and Pappus 5-white brittle bristles; *Senecio glaucus* subsp. *coronopifolium* (b= 2X) showing achene ribbed with distinct rim at apex, surface with whitish appressed strigose and Pappus deciduous, white silky barbellate bristles; *Carlina involucrate* (c=1.25 X & d= 2X) showing pappus 10-setiform scales dissected into plumose bristles-like segments; *Chiliadenus candicans* (e=

3.5X) showing surface densely yellowish appressed hairy and glossy glandular punctuate with Pappus numerous, bristle –like scales in the outer and golden barbellate bristles in the inner]

Discussion

This investigation is considered the first work that deals with the external morphology of mature achenes for 74 taxa belonging to 11 tribes and four subfamilies of Asteraceae from the Northwestern coast of Egypt by using a light microscope. This work is in support of the previous studies on various species of Asteraceae in using the achene characters as diagnostic features for distinguishing taxa and resolving many taxonomic problems, especially at generic and specific levels (Das & Mukherjee, 2008; Aksoy et al., 2010; Shabestari et al., 2013; Bona, 2014; Behjou et al., 2016; Candan et al., 2016; Das et al., 2018).

Among the 74 species investigated, the studied taxa of tribe Cardueae-subtribe: Ambrosiinae (namely *Ambrosia maritime, Xanthium spinosum* and *X. strumarium)* characterized by achenes closely enveloped by a hardened fruiting involucre (bur). Achenes of other taxa vary greatly in symmetry, shape of achenes, hairiness, color, presence or absence of beaks, ribs, hilum position and pappus characteristics. The most remarkable is the symmetry of achenes where the monomorphic achenes were recorded in 57 taxa. Di- or trimorphic achenes per capitulum were also recorded; this feature was present in 14 taxa belonging to five tribes Cichorieae (ten species), Cardueae, Calenduleae, Anthemideae and Inuleae (one species each). Our results, however, correlate with the results recorded by Das & Mukherjee (2008) and Jana & Mukherjee (2012, 2014).

Morphological data from the pappus are taxonomically useful for assessing relationships among species and have helped to reveal evolutionary relationships among and within genera of Asteraceae (Mukherjee & Sarkar, 2001; Semple & Hood, 2003 & 2005; Semple, 2006; Abid & Zehra, 2007; Abid & Qaiser, 2007, 2009; Mukherjee & Nordenstam, 2008; Bona, 2015; Şirin et al., 2017). It may also contribute to the wind-dispersal of the seeds (Azuma, 2006; Stille et al., 2016). In the present study, the presence or absence of pappus and pappus features are variable and support in the delimitation of the studied taxa. The presence or absence of pappus was found useful to recognized three types: Achenes lacking pappus (type II), Achenes with coroniform or unilateral auriculate pappus (type III) and Achenes with bristles or paleaceous pappus (type IV). The last type shows a wide range of variation in achene characteristics and is subdivided according to the hairiness, position of hilum and presence or absence of beak into four achene subtypes.

According to the results, discussed achene morphological characters can be of great value at the generic and specific level and their taxonomic value increases when they are considered together with other morphological characters. The key to identifying achene types and examined taxa given in the present investigation can be an additional taxonomic identification tool.

Identification keys of the achene types and the studied taxa based on achene exomorphology

Achene closely enveloped by bur (hardened fruiting involucre)

1. Achene-bur broadly obovoid, 4–5 x 3-3.5mm, hard with 7–8 horn-like processes restricted to the upper half and one prickly beak….....***Ambrosia maritima***
– Achene-bur ellipsoid or ovoid, 10–20 x 5–10mm, woody with hooked spines along the surface and 1 or 2-pricklbeaks.....….(2)
2. Achene-bur ellipsoid, 10–15 x 5–8mm, with 1- pointed, acicular prickle at apex, 4–5 mm long. Surface arachnoid hairy armed with hooked spines…..... ***Xanthium spinosum***
– Achene-bur ovoid to oblong, 15–20 x 8–10mm, with 2- divergent curved prickles at apex, 2–3 mm long. Surface glandular scabrous, armed with hooked spines….....***Xanthium stramarium***

Achene not enveloped by bur (hardened fruiting involucre)

1.Achene di- or trimorphic (i.e. two or three different kinds of achene per capitulum) ……..... **Type 1**
– Achene monomorphic (i.e. one kind of achene per capitulum) ..... (**2**)
2.Achene epappose …..... **Type 2**
– Achene with pappus or pappus-like ….....(**3**)

3. Achene with coroniform or auriculate pappus ….....**Type 3**
– Achene with bristles or paleaceous pappus ….....**Type 4**

Type (1): Achene di- or trimorphic per capitulum

1.Achene epappose…..... (**2**)
– Achene pappose…..... (**4**)
2.Marginal achene cymbiform, 15 – 20mm long, beaked, and inner achene annulate, beakless. Both achenes aculeate at back.....***Calendula arvensis***
–Marginal achene obcompressed or triquetrous, 1 – 2.2mm long, and inner achene not annulate. Both achenes beakless and smooth with glandular ..... (**3**)
3.Marginal achene obcompressed, obovoid, 1–1.2 x 0.7–0.8mm, with lateral yellowish 2-wings. Inner achene slightly compressed, obovoid-oblong, 0.7–1 x 0.5–0.6mm, unwinged….....…***Cotula anthemoides***
–Marginal achene triquetrous, 2 –2.2 x 1–1.5mm, narrowly winged angles. Inner achene ob-pyramidal, 2.5 –3 x 1.5 –2mm, with obliquely wing on the adaxial face and 3-ribbed at lateral faces …***Glebionis coronaria***
4.Marginal achene enfolded by the inner phylaries, slightly curved…..... (**5**)
–Marginal achene not enfolded by the inner phyllaries, straight…..... (**8**)
5.Inner achene beaked, beak slender, 4.5–5mm long ….....…..... ***Leontodon tuberosus***
–Inner achene without beak…..... (**6**)
6.Marginal achene elongated- cylindrical, 6 –8 x 0.5 –0.8mm, multi-ribbed, strigose along the ribs. Pappus coroniform of erose scales, up to 1 mm long. Inner achene with persistent, paleaceous pappus of 4–6 awn-tipped subulate scales, 4–5mm long ….....***Hedypnois rhagadioloides***
–Marginal achene fusiform, 3 –4 x 0.5–1mm, 4- striate to ribbed, glabrous along the ribs. Pappus barbellate or unequal plumose bristles, 1–3mm long. Inner achene with deciduous, setose pappus of plumose bristles, 5–6mm long .....(**7**)
7.Marginal achene with 4- striate, puberulent and smooth in between. Pappus short barbellate bristles, 1–1.5mm long .....… ***Picris asplenoides***
–Marginal achene with 4- ribbed, glabrous and transversely rugose in between. Pappus unequal plumose bristles, 1.5–3mm long ….....***Picris altissima***
8.Achene trimorphic (the marginal achene dorsally compressed with coroniform pappus, the median achene compressed with 2-wings and central one ±terete). Pappus barbellate bristles…..***Hyoseries radiata* subsp. *graeca***
–Achene dimorphic. Pappus smooth bristles or scales…..... (**9**)
9.The marginal achene winged…..(**10**)
–The marginal achene unwinged…..... (**11**)
10.The marginal achene grayish-brown, dorsally compressed, oblong-orbicular, 2.2–2.5 x 1.5–2mm, glabrous, bi-winged. Pappus of fringed scales, up to 0.6mm long. Inner achene dark brown, slightly compressed triquetrous to turbinate, 1.5–2 x 1mm, appressed hairy. Pappus of fimbriate scales 0.5–0.7mm long; persistent in both achenes….....***Pallenis spinosa***
–The marginal achene whitish, ± terete, ellipsoid, 3–3.5 x1.5–2mm, glabrous, with 3-conspicuous eroding wings and 5-ribs. Inner achene whitish, ± terete, ellipsoid, 3–4 x 1.2 –1.5mm, glabrous, with 2-narrow eroding wings and 4-ribs. Ribs with minutely tuberculate-rugulose. Pappus of smooth bristles 5–6mm long and deciduous in both achenes.....…***Launaea capitata***
11.Hilum lateral, marginal achene epappose and the inner with paleaceous pappus of purplish scabrous scales ….....… ***Carthamus lanatus***
–Hilum basal, both achenes with setose pappus of smooth bristles …..... (**12**)
12.Both achene tetragonal, oblong, 2–3 x 0.5–1mm, with 4-sulcate and transversely rugose-verrucose. Pappus deciduous.....….***Reichardia tingitana***
–Both achene fusiform to cylindrical, (2.5) 3–6mm long, with 4 - 5 main ribs, smooth between ribs. Pappus persistent ….....(**13**)
13.Marginal achene ± fusiform, 2.5–3 x 0.5mm, blackish, with spinulose at ribs. Inner achene whitish, ca. 3 x 0.5mm, with minutely spinulose at ribs, not horned at base. Pappus monomorphic of smooth bristles, 7–8 mm long.....…… ***Launaea nudicaulis***
–Marginal achene cylindrical, 4–6 x 0.3–0.5mm, brown, densely strigulose along the surface. Inner achene grayish-brown, 5–6 x 0.3–0.4mm, glabrous with 4-horned at base. Pappus dimorphic of soft and setaceous

bristles, 10–12mm long.....***Launaea fragilis* subsp. *fragilis***

Type (II): Achene monomorphic and lacking pappus

1.Achene - surface pilose with anchor - shaped hairs...…….....***Sphaeranthus suaveolens***
–Achene - surface sub-glabrous to glabrous …..... (**2**)
2.Achene -length 2.5 – 3mm long…..…… (**3**)
– Achene -length less than 2.5mm long ….....…….(**4**)
3.Achene ± ellipsoid, terete, grayish; surface smooth. Hilum lateral….....***Centaurea calcitrapa***
–Achene obconical, trigonus to lateral compressed, pale brown; surface tuberculate. Hilum basal…….***Eclipta prostrata***
4.Achene obcompressed …..... (**5**)
–Achene terete or prismatic …..... (**8**)
5.Achene 0.6 – 0.8mm long, surface with minute papillae ……..……..….....…***Filago mareotica***
–Achene more than 1mm long, surface longitudinal striate or smooth…..... (**6**)
6.Achene - apex included in accrecent spongy base of corolla, 4-5 whitish ribs. Surface smooth with golden glandular punctate between ribs .....… ***Otanthus maritimus***
–Achene - apex not included in accrescent spongy base of corolla, 2- wings or 2- ribs. Surface longitudinal striate…..…… (**7**)
7.Achene broadly obovoid, 2 – 2.5 x 1.5– 2mm, pale brown, with 2- scarious and toothed wings. Surface finely striate with scattered granules ….....***Anacyclus monanthos* subsp. *monanthos***
–Achene narrowly obovoid, 1.2– 1.5 x 0.5– 0.7mm, yellowish-brown, lustrous, with 2-whitish ribs. Surface finely striate….....…***Achillea tenuifolia***
8.Achene prismatic with 4-6 sided ….....…***Ethulia conzoides* subsp. *conzoides***
– Achene terete ribbed or striate……..... (**9**)
9.Achene finely striate. Surface scalariform with sparsely brownish glandular punctate.....***Brocchia cinerea***
–Achene ribbed. Surface smooth or with yellowish glandular punctate between the ribs…..... (**10**)
10.Achene slightly curved, with 5-whitish ribs restricted to the ventral face, with yellowish glandular punctate between the ribs.....… ***Matricaria chamomilla***
–Achene straight, multi-ribbed and smooth surfaces...…..... (**11**)
11.One achene per capitulum, achene claviform to obovoid, 1.5– 2 x 0.5– 0.6mm, ribs whitish. Apex with platform, hilum sub-basal…….....……***Artemisia monosperma***
–Many Achenes per capitulum, achene obconical or obpyramidal 1– 1.5 x 0.4– 0.6mm, ribs brownish. Apex without platform (truncate or rounded), hilum basal…..... (**12**)
12.Achene obconical, 1– 1.1x 0.5 – 0.6mm, grayish to dark brown, ribs with tubercles. Apex rounded……..... ***Anthemis microsperma***
–Achene turbinate-obpyramidal, 1.3–1.5 x 0.4 – 0.5mm, pale brown, ribs smooth. Apex truncate ……..... .....***Anthemis retusa***

Type (III): Achene monomorphic, with coroniform or auriculate pappus

1.Achene with coroniform pappus..... (**2**)
–Achene with an auricle.....… (**4**)
2.Achene 3- 5 sided prismatic, yellowish with dark brown streaks….....…***Cichorium pumilium***
–Achene sub-terete to terete, the color otherwise.....… (**3**)
3.Achene obconical, 1.5–2 x 0.7–1mm, sub-terete, dull white. Surface glabrous, striate to faintly ribbed, with areolate-scalariform sculpture ….....***Anthemis indurata***
–Achene narrowly cylindrical, 0.8– 1.5 x 1mm, terete, brown. Surface pilose, not ribbed, with indistinct sculpture…..... ***Echinops spinosissimus***
4.Achenes obovoid-oblong, 1.2– 1.5 x 0.6– 0.8mm, ± tetragonal, multiribbed. Hilum basal without proximal stipe (carpopodium). Auricle less than 1mm long …….....…***Anthemis pseudocotula***
–Achene fusiform or oblong, 0.6 –1.5 x 0.3mm long, slightly curved, terete, 5- 10 ribbed. Hilum obliquely basal with proximal stipe (carpopodium). Auricles 1– 1.8mm long..... (**5**)
5.Achene fusiform, 1.2–1.5 x 0.3mm, dark brown, with 10-yellowish ribs along the surface, smooth in between. Auricles 1.5– 1.8mm long.....***Chlamydophora tridentata***
–Achene oblong, 0.6– 0.8 x 0.3mm, brown, with 3- brownish ribs restricted to the ventral face, with yellowish

glandular punctate between the ribs. Auricles 1–1.5mm long.....*Matricaria aurea*

Type (IV): Achene monomorphic, with pappus

1.Achene with beak ……**Subtype A**
–Achene without beak ……. **(2)**
2.Achene with lateral hilum……**Subtype B**
–Achene with basal hilum…. **(3)**
3.Achene –surface glabrous……**Subtype C**
–Achene-surface hairy……**Subtype D**

Subtype A: Achene with beak

1.Beak 8–9 mm long, oblique, fistulose and gibbous at base, articulate with the achene, scabrous. Pappus of plumose bristles….*Urospermum picroides*
–Beak 2–5mm long, terminal and normal (not gibbous) at base, not articulate with the achene, glabrous or scabrous. Pappus of barbellate bristles……. (**2**)
2.Beak 4.5– 5mm long, glabrous. Pappus more than 10, deciduous. Achene prolonged obovoid, 2.5– 3 x 1– 1.5mm, hispidulous near apex. Surface with 6-8 ribs on each side, smooth in between …*Lactuca serriola*
–Beak 2-3mm long, scabrous. Pappus 10, persistent. Achene fusiform, 4– 5 x 0 .3– 0.4mm, glabrous. Surface longitudinal striate with transversal muricate in between……. *Scorzoneroides hispidulus*

Subtype B: Achene with lateral hilum

1.Achene – surface sparsely to densely silky hairs ..... (**2**)
–Achene – surface glabrous ..... (**6**)
2.Achene – apex with coroniform denticulate rim surrounding the paleaceous pappus of unequal serrately scales.(**3**)
–Achene – apex without rim surrounding the setose pappus of barbellate or plumose bristles ……..……(**5**)
3.Achene ellipsoid, 4– 4.5 x 1.6– 1.8mm, multi-ribbed with transversely pitted between them. Pappus golden-yellow, 3– 3.5mm long….*Volutaria crupinoides*
–Achene cylindrical, 2– 3.5 x1– 1.3mm, obscure ribs with minutely pitted between them. Pappus whitish, 1.1–2.5mm long…. (**4**)
4.Achene 2.7 – 3.5mm long, pappus 2– 2.5mm long.....*Volutaria tubuliflora*
–Achene 2– 2.5mm long, pappus 1.1– 1.5mm long ..... *Volutaria lippii*
5.Achene ellipsoid, 5–5.5 x 2.5–3mm, yellowish-brown, sparsely silky hairy. Pappus multi-seriate of barbellate bristles, 4– 4.5mm long, the outer series short, scale-like bristles, 1 – 1.5mm long…*Centaurea dimorpha*
–Achene obconical, 2– 3 x 1mm, brown, densely silky hairy. Pappus multi-seriate of plumose bristles, 8–10mm long.....*Centaurea pumilio*
6.Paleaceous pappus of unequal scales. Scales golden yellow with violet scarbidulous hairs along the surface and the margin..... (**7**)
–Setose pappus of barbellate or plumose bristles. Bristles whitish to yellowish white……..... (**8**)
7.Achene obpyramidal, 5.5– 6 x 3.5– 4mm, 4- angled, wrinkled at the upper half. Apex truncate with dentate margin, pappus 4–8mm long ….*Carthamus glaucus* **subsp.** *alexandrinus*
–Achene obconical, 4 – 5 x 2 – 2.5 mm, ± terete, smooth. Apex truncate with sub-entire margin, pappus 8–10mm long……..…. *Carthamus tenuis* **subsp.** *foliosus*
8.Achene elongated oblong, 6– 8 x 1.5 – 2mm, with 4- narrowly scarious wings, pale brown; apex denticulate margin (rim). Pappus plumose bristles 10– 13mm long, yellowish-white, persistent…*Carthamus eriocephalus*
–Achene narrowly obpyramidal, 3– 4 x 1.7– 2mm, with 4- angled, whitish with dark brown spots or not; apex entire margin and dark brown. Pappus barbellate bristles, 5– 6mm long, whitish, deciduous …*Carthamus mareoticus*

Subtype C: Achene – surface glabrous

1.Aristate pappus of 2-3 retrosely barbed awns ... .*Bidens pilosa*
–Setose pappus of smooth, barbellate or plumose bristles ..... (**2**)
2.Pappus of smooth silky bristles. Achene compressed with narrow winged at margins and 3- median ribs

on each surface ..... (**3**)
–Pappus of barbellate or plumose bristles. Achene terete or angular, no ribs nor wings.....(**5**)
3.Achene – wings and ribs with retrose spinulose .....***Sonchus asper* subsp. *asper***
–Achene – wings and ribs glabrous ..... (**4**)
4.Achene ellipsoid, 4 –5 x 1.5– 1.7mm, brown to dark brown, smooth; apex without a collar. Pappus 7– 8mm long ….....***Sonchus macrocarpus***
– Achene claviform, 2.8–3 x 0.8–1mm, bright brown, rugose especially at the ribs; apex with a short collar. Pappus 5– 7mm long .....***Sonchus oleraceous***
5.Pappus of plumose bristles, achene with 4- angles ..... (**6**)
–Pappus of barbellate bristles, achene terete to sub-compressed..... (**7**)
6.Achene oblong, 5– 6 x 2– 3mm, blackish-brown, ribbed, surface with transversely rugose between ribs. Pappus 10– 15mm long….....***Onopordum alexandrinum***
–Achene obovoid-oblong, 3– 3.5 x 1– 1.2mm, yellowish brown, not ribbed, surface smooth. Pappus 18–20mm long.....***Cynara cornigera***
7.Achenes 3.5– 7 x 1.5–3.2mm, apex with annular margin surrounding the umbo. Hilum sub-basal .....(**8**)
–Achene 0.5–0.7 x 0.2–0.3mm, apex without annular margin, hilum basal….....(**9**)
8.Achene obovoid-oblong, 6– 7 x 3– 3.2mm, pale brown with dark brown streaks. Pappus of scabrid bristle-like scales, 15–17mm long ….....***Silybum marianum***
–Achene ellipsoid to oblong, 3.5– 4 x 1.5– 1.8mm, yellowish-brown with brown striate. Pappus of barbellate bristles, 9– 13mm long ..... ***Carduus getulus***
9.Achene-surface smooth. Pappus of barbellate bristles ended by plumose .....***Ifloga spicata***
–Achene -surface glossy papillulate. Pappus of barbellate bristles..... (**10**)
10.Achene oblong to cylindrical, 0.5– 0.7 x 0.2– 0.3mm, terete, base with proximal stipe (carpopodium). Pappus-bristles 10 -15, with patent cilia at the base, 2– 2.5mm long, ... ***Laphangium luteo-album***
–Achene ellipsoid, 0.5– 0.7 x 0.2– 0.3mm, sub-compressed, base without proximal stipe (carpopodium). Pappus - bristles ca. 10, 1.7– 2mm long…….....***Filago desertorum***

Subtype D: Achene – surface hairy

1.Pappus setae of plumose bristles …..... (**2**)
–Pappus setae of barbellate bristles …..... (**5**)
2.Achene cylindrical, 10–13 x 1– 1.5mm, terete, ribbed, scabrid to squamate at ribs, puberulent in between….....***Scorzonera undulata***
–Achene obovoid or fusiform, 2.5– 5 x 0.7– 2 mm, compressed, not ribbed, surface densely silky hairs …(**3**)
3.Achene 4–5mm long, pappus setae multi-seriate, 10–15mm long ….....***Atractylis carduus***
–Achene 2.5– 3.5mm long, pappus setae uniseriate, 6– 10mm long…..... (**4**)
4.Achene fusiform to oblong, 2.5– 3.5 x 0.7– 1mm, basal hilum with proximal stipe. Pappus of 10- setiform scales, dissected into plumose bristle- like segments, 8–10mm long…….....***Carlina involucrata***
–Achenes obovoid, 3– 3.5 x 2mm, basal hilum without proximal stipe. Pappus more than 10- plumose bristles, 6– 8mm long ..... ***Atractylis cancellata***
5.Pappus setae 5-15 bristles …..... (**6**)
–Pappus setae more than 15 bristles……..... (**7**)
6.Achene terete, greenish-brown, not ribbed. Surface with whitish appressed hairs. Pappus 5-brittle bristles, 5–6mm long .....***Phagnalon rupestre***
–Achene ± angular, dark brown, with 4- ribs. Surface with sparsely appressed hairs along the ribs. Pappus 10-15 barbellate bristles, 2.5–3mm long ……..….....***Pluchea dioscorides***
7.Pappus persistent, achene with two types of setae…..... (**8**)
–Pappus persistent or deciduous, achene with one type of setae ……..... (**9**)
8.Pappus setae biseriate, the outer of short bristle-like scales and the inner of barbellate bristles. Achene-surface densely yellowish appressed hairy and glossy glandular punctuate.....……***Chiliadenus candicans***
–Pappus setae multi-seriate of barbellate bristles, the innermost series with 5- linear acuminate scales. Achene-surface densely brownish villous.....***Gymnarrhena micrantha***
9.Pappus persistent ..... (**10**)
–Pappus deciduous ……..……..... (**11**)
10.Achene ellipsoid, 1.7– 2 x 0.3 – 0.4mm, dark brown, terete, not ribbed. Pappus multi-seriate of yellowish

bristles, not connect at the base, 4–5 mm long ……..... ***Limbarada crithmoides***
–Achene fusiform, 2– 2.5 x 0.3– 0.4mm, pale brown, sub-compressed, with 5- shallow ribs. Pappus uniseriate of yellowish-white bristles, connect into ring, 5–6mm long….....….***Symphotrichum squamatum***
11.Achene laterally compressed, not ribbed, apex without rim. Surface with appressed silky hairy or pubescent..... (**12**)
–Achene sub-terete, ribbed, apex with distinct rim. Surface with whitish strigose…..... (**13**)
12.Achene oblong, 1.5– 1.7 x 0.2– 0.3mm, pale brown, not attenuate at base, hilum with proximal stipe. Surface with appressed silky hairy…..... ***Erigeron bonariensis***
–Achene obconical, ca. 1 x 0.2– 0.3mm, yellow, attenuate at base, hilum with obscure proximal stipe. Surface pubescent…….....….***Erigeron aegyptiacus***
13.Achene fusiform, 2.2–2.5 x 0.4–0.5mm, both apex and base attenuated ….....….***Senecio vulgaris***
–Achene cylindrical or ellipsoid, 1.7– 2 x 0.2– 0.5mm, not attenuated…..... (**14**)
14.Achene ± cylindrical, 1.7– 2 x 0.4– 0.5mm, dark brown, whitish strigulose, inconspicuous ribbed. Pappus 3– 3.5mm long …..... ***Senecio aegyptius* var**. ***discoideus***
–Achene ellipsoid, 1.7– 2 x 0.2– 0.3mm, grayish, appressed white strigose, conspicuous ribbed. Pappus 6–7mm long.....….***Senecio glaucus* subsp**. ***Coronopifolius***

Conclusion

The analysis of achene characters of 74 taxa belonging to family Asteraceae were evaluated, and two main groups with four types and four subtypes were recognized. Despite the taxonomic significance of achene characters on the generic and specific level for the recognition of the different taxa of Asteraceae, no mutual link was shown between the taxonomic division of the family into subfamilies and tribes. The authors hope that this work will encourage future studies on achene morphology to elucidate the complex taxonomy of the family. Using this study as a monograph in association with other morphological characters will increase the taxonomic value of achene characters to facilitate the identification of taxa in the field.

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الصفات المورفولوجية للفقيرات لبعض أنواع الفصيلة المركبة (Asteraceae) من الساحل الشمالي الغربي للبحر المتوسط لمصر

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تهدف هذه الدراسة إلى اظهار القيمة التصنيفية للصفات المورفولوجية الخارجية للفقيرات الناضجة لأربعة وسبعين نوعا تمثل احدى وخمسون جنسا وأربعة تحت الفصائل من الفصيلة المركبة (Asteraceae) والذي تمثل جزءا من الغطاء النباتي للساحل الشمالي الغربي للبحر المتوسط لمصر. باستخدام المجهر الضوئي، أسفرت هذه الدراسة عن تسجيل ستة و عشرون صفة مورفولوجية كمية ونوعية و من ضمن أهم الصفات ذات القيمة التصنيفية بين الأنواع المدروسة هي التماثل للفقيرات والشعر و تضاريس السطح وموضع السرة و وجود أو عدم وجود الزغب (Pappus) وأنواعه و خلصت هذه الدراسة إلى تحديد مجموعتين رئيستين على اساس وجود أو عدم وجود bur وأيضا تمييز أربعة أنماط رئيسية مع أربعة تحت نمطية و هم: 1) نوعين أو ثلاثة من الفقيرات في النورة الرأسية الواحدة. 2) نوع واحد من الفقيرات بدون زغب. 3) نوع واحد من الفقيرات مع وجود زغب على شكل تاج أو أذين. 4) نوع واحد من الفقيرات مع وجود زغب على شكل شعيرات. كما تضمن البحث وصف لكل نمط وصور فوتوغرافية بالمجهر الضوئي ومفاتيح تعريفية لسهولة الفصل بين الأنماط والأنواع قيد الدراسة. وقد أوضحت هذه الدراسة عن الأهمية التصنيفية للفقيرات في الفصل بين الأنواع المدروسة على مستوى النوع والجنس ولم تظهر أي دور في التقسيم التصنيفي للفصيلة المركبة على مستوى تحت الفصيلة أو القبائل الا في حالات قليلة.