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Comparative Morphology and Surface Microsculpture of Cypsela in Some Taxa of the Asteraceae and Their Taxonomic Significance

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MACRO- and micromorphological characteristics of cypsela in 13 species and one subspecies representing genera: *Carthamus* L., *Centaurea* L. *Cichorium* L., *Cirsium* Mill., *Crepis* L., *Lactuca* L., *Picris* L., *Reichardia* Roth and *Sonchus* L.; belonging to the two tribes Cardueae and Cichorieae of the Asteraceae, were examined under stereomicroscopy and scanning electron microscopy (SEM). The cypsela macromorphological features including; cypsela length measurements, colour, shape, surface texture and the number of ribs when present as well as the abscission scar characteristics and details of the surface microsculpture peculiarities were investigated. The cypsela length and colour presented a minor taxonomic value. However, the other remaining features were proved to be primarily diagnostic at the species level and sometimes at the genus level but not distinctive for any of the two tribes. In addition, these features were very useful in the precise technical identification of the examined cypselae. An identification key for the studied taxa, based on the investigated aspects, was presented.

Keywords: Abscission scar; Asteraceae; Cypsela morphology; SEM; Surface microsculpture.

The Asteraceae (alternatively Compositae) is the largest family of flowering plants, cosmopolitan except for Antarctica and with 1,620 genera and 23,600 species (Stevens, 2001 and Anderberg *et al*., 2007).

The fruit in Asteraceae is predominantly a dry indehiscent, unilocular, one-seeded cypsela (frequently termed an achene), but rarely the fruit is a drupe (Anderberg *et al*., 2007; Marzinek *et al*., 2008 and Schneider & Boldrini, 2011). The fruit is either crowned by the persistent pappus or the pappus is caducous or absent. The abscission scar is surrounded by a carpopodium distinguished by the form of its cells and the texture of its surface; it consists of one to many rows of cells (Anderberg *et al*., 2007).

The taxonomic treatments of many members of Asteraceae revealed that both their delineation and identification have been based mainly upon the

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morphological features of their cypselae and/or the analysis of cypsela microsculpture examined by SEM (Haque & Godward, 1984; Blanca & Guardia, 1997; Mukherjee & Sarkar, 2001; Schneider & Boldrini, 2011; Shekhar *et al*., 2011 and Talukdar & Mukherjee, 2014). However, the lack of authentic cypselae morphological data has hindered the identification of isolated fruits or cypselae, particularly when floral stages are not available (Bhar and Mukherjee, 2004).

In this study, cypselae of available 13 species and one subspecies representing nine genera of Asteraceae were examined by the stereomicroscopy and SEM. According to Anderberg *et al*. (2007) the examined three genera: *Carthamus*, *Centaurea* and *Cirsium* belong to tribe Cardueae whereas the other remainder six genera: *Cichorium*, *Crepis*, *Lactuca*, *Picris*, *Reichardia* and *Sonchus* belong to tribe Cichorieae (alternatively Lactuceae). The main objectives of this study were to gather micromorphological data via SEM concomitantly with the traditional macromorphological characters for differentiation of these taxa, to furnish new means for the precise technical identification of their isolated cypselae and to contribute to the knowledge and authentication of the macro- and micromorphological characters of the examined cypselae.

Materials and Methods

Mature dry cypselae of 13 species and one subspecies of the Asteraceae were obtained from Botanischer Garten und Botanisches Museum (BGBM) Berlin-Dahlem, Freie Universität Berlin, Germany, since June, 2012 (Table 1). The numbers on packets of the received specimens (Table 1) represent the same numbers of these specimens listed in BGBM-Index Seminum anno 2009 Collectorum from which the botanical material was requested. The packets containing the remained cypselae were carefully preserved as vouchers deposited in the herbarium of Faculty of Science, Zagazig University, Egypt. The cypselae length data are based on measurements of 10 fruits randomly chosen per taxon using a stereomicroscope equipped with an ocular micrometer. The cypselae length include the beak when present but excluding pappus when presistent. The other macromorphological features of the cypselae; including colour, shape, surface texture and number of ribs, were examined using the same microscope.

For SEM observations, at least two entire cypselae, for each taxon, were mounted on stubs, coated with a thin layer of gold in ion sputtering device (JEOL-JFC-1100 E), examined and photographed using JEOL-JSM-5300 scanning microscope at Electron Microscope Unit, Alexandria University, Alexandria, Egypt. Some SEM photomicrographs were chosen to represent the characters of more interest. The terminology for surface sculpturing patterns is based on Stearn (1983); Zhu *et al*. (2006) and Abid & Ali (2010).

TABLE 1. The collection data of the studied taxa; taxa arranged into tribes according to Anderberg *et al*., 2007.

Tribe	Specimen number	Taxon
Cardueae	605	*Carthamus tinctorius* L.
	608	*Centaurea aspera* L.
	615	*Centaurea nervosa* Willd.
	653	*Cirsium vulgare* (Savi) Ten.
Cichorieae	633	*Cichorium intybus* L.
	664	*Crepis pyrenaica* (L.) Greuter
	743	*Lactuca perennis* L.
	744	*Lactuca viminea* J. Presl & C. Presl
	745	*Lactuca virosa* L.
	798	*Picris conyzoides* Lack & S. Holzapfel
	803	*Picris hieracioides* L. subsp. *japonica* (Thunb.) Krylov (=*Picris japonica* Thunb.)
	822	*Reichardia ligulata* (Vent.) G. Kunkel & Sunding
	862	*Sonchus palmensis* (Sch. Bip.) Boulos
	863	*Sonchus palustris* L.

Results

A. Macromorphological Characteristics

The length measurements and the other macromorphological features of cypselae of the taxa under the stereomicroscope are given in Table 2. In addition, illustrating SEM photomicrographs are presented in Fig. 1. The mean length of mature cypselae of the studied taxa ranges from 2.24 mm to 10.67 mm excluding the pappus when persistent. The smallest cypselae are recorded in *Cichorium intybus* whereas cypselae of *Lactuca viminea* are the longest ones. The colour of cypsela presented some variation. It is white or whitish mottled with dark brown spots, straw coloured, brown to brown mottled with dark brown spots or wholly dark brown. The shape of cypselae is variable among the studied taxa (Table 2 and Fig. 1). It is terete columnar, ellipsoid, oblong, ovoid, ovoid-oblong, obovoid and obovoid-oblong with 4-grooves and/or angled as well as wedge-shaped but irregularly angled. In *Picris hieracioides* subsp. *japonica* (Fig. 1K) the grooves are obviously narrower than those of *P. conyzoides* (Fig. 1J). The cypsela upper portion is obviously long- beaked in the three examined species of *Lactuca* (Figs. 1G-I). The beak is easily broken in cypselae of *Lactuca perennis* and *L. virosa* but in *L. viminea* remains intact in most cypselae and is discoid at its apex. In *Picris conyzoides* and *P. hieracioides* subsp. *japonica* (Figs. 1J & K) the cypsela apically is abruptly narrowed into a short- beak. However, the remaining species are beakless**.** Stylopodium, in some cases representing remain of the style at the centre of the top of cypsela, is observed (Fig. 1A, E & M). The body of cypsela is either straight, to slightly curved or curved**.** The cypsela surface (Table 2) shows some variations from nearly smooth, longitudinal or transverse rugulose and rugose to coarse verrucate. In addition, the cypsela surface is either ribbed or ribless. The number of ribs ranges from 4-20 ribs. In the examined cypselae of *Lactuca perennis*, *L. virosa*, and the two examined species of *Sonchus* the two lateral ribs are exaggeratedly thickened.

TABLE 2. Macro-morphological features of the studied taxa.

Taxon	Fig 1	Length (mm) Mean±SD	Colour	Cypsela shape				Cypsela surface	
				Outline	Beak	Sty	Direction	Texture	Ribs
Carthamus tinctorius	A	7.1 ±0.3	W	obovoid/obtusely 4-angled	-	+	± curved	nearly smooth	0
Centaurea aspera	B	4.29±0.3	Bm	obovoid-oblong	-	-	± curved	nearly smooth	0
C. nervosa	C	3.51±0.2	Bm	obovoid-oblong	-	-	± curved	irregular longitudinal rugulose	0
Cichorium intybus	D	2.24±0.2	Db	Wedge shape/irregularly angled	-	-	± curved	longitudinally rugose	6-10
Cirsium vulgare	E	3.46±0.3	Wm	obovoid/obtusely 3-angled	-	+	± curved	nearly smooth	0
Crepis pyrenaica	F	6.97±1.1	B	terete columnar	-	-	± curved	ribbed	20
Lactuca perennis	G	9.33±0.2	Db	ovoid-oblong	long	-	± curved	transversely rugulose	4/2*
L. viminea	H	10.67±0.8	Db	ellipsoid	long	-	± curved	transversely rugulose-ribbed	20
L. virosa	I	4.94±0.3	Db	ovoid	long	-	± curved	transversely rugulose-ribbed	14/2*
Picris conyzoides	J	4.0±0.2	Db	oblique obovoid-oblong/4-angled /4-grooved	short	-	± curved	transversely rugose	0
P. hieracioides subsp. *japonica*	K	3.82±0.4	Db	oblique obovoid-oblong/4-angled/4- obviously narrow grooved	short	-	± curved	transversely rugose	0
Reichardia ligulata	L& M	2.72±0.2	B	oblong/strongly 4-angled/4-grooved	-	+	straight	coarse verrucate-transversely rugose	0
Sonchus palmensis	N	2.93±0.1	Sc	obovoid-oblong	-	-	curved	transversely rugose	4-5/2*
S. palustris	O	3.9±0.2	Sc	oblong	-	-	± curved	transversely rugose	10-12/2*

*The two lateral ribs are exaggeratedly thickened; +, present; -, absent; ± curved= Straight to slightly curved; B= Brown; Bm= Brown mottled with dark brown spots; Db= Dark brown; Sc= Straw coloured; SD= Standard deviation; Sty = Stylopodium, W= White; Wm= Whitish mottled with dark brown spots.

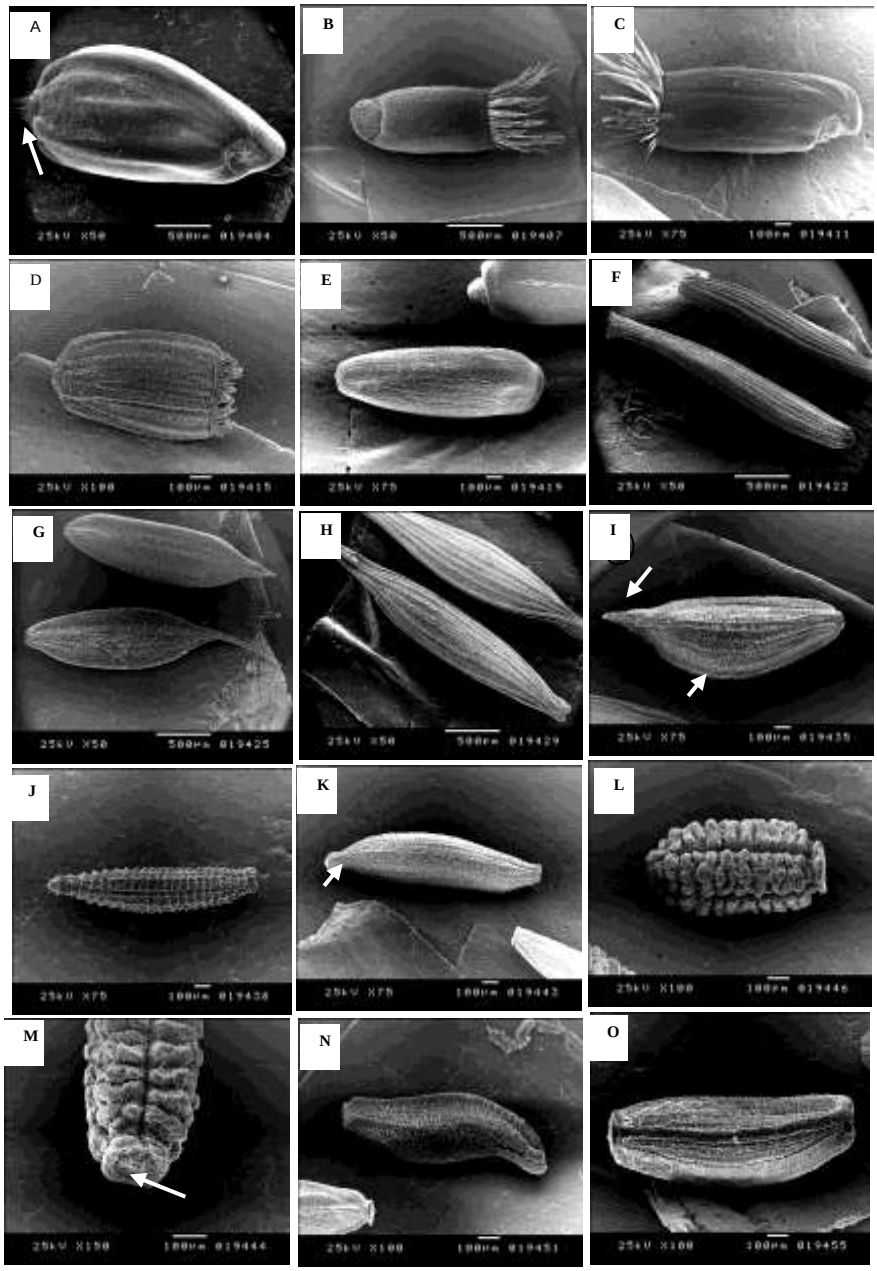

Fig. 1 (A-O). SEM photomicrographs illustrating variation in cypsela shape: A- *Carthamus tinctorius*; B- *Centaurea aspera*; C- *C. nervosa*; D- *Cichorium intybus*; E- *Cirsium vulgare*; F- *Crepis pyrenaica*; G- *Lactuca perennis*; H- *L. viminea*; I- *L. virosa*, white arrow refers to a lateral rib; J- *Picris conyzoides*; K- *P. hieracioides* subsp. *japonica*; L& M- *Reichardia ligulata*; N- *Sonchus palmensis*; O- *S. palustris*; b= beak; s= stylopodium.

The pappus is noticed in the cypselae of the three species: *Centaurea aspera*, *C. nervosa* and *Cichorium intybus* (Figs. 1B-D) but it is lacking in cypselae of the remaining taxa.

B. Micromorphological Characteristics

The abscission scar as seen under SEM (Table 3; Fig. 2) is basal- lateral in *Carthamus tinctorius*, *Centaurea aspera* (Figs. 2A & H) and in *C. nervosa* and is basal in the remaining taxa (Figs. 2B-G & I-L). The shape of the abscission scar is variable. It is pyriform in *Carthamus tinctorius* (Fig. 2A), ring-shaped in *Picris conyzoides* and *P. hieracioides* subsp. *japonica* (Figs. 2B & C), angular ring in *Cichorium intybus* (Fig. 2D), triangular in *Cirsium vulgare* (Fig. 2E), rectangular in *Sonchus palustris* (Fig. 2F), rhombic in *Lactuca virosa* (Fig. 2G), irregular with a callus-like protuberance in the two examined species of *Centaurea* (Fig. 2H), more or less rounded in the remaining five species (Figs. 2I-L). The abscission scar of cypselae is sometimes with carpopodium. The carpopodium is obvious in *Carthamus tinctorius* (Fig. 2A), or poorly- developed in the three examined species of *Lactuca* (Figs. 2G, J & K) and *Crepis pyrenaica* (Fig. 2I) and undeveloped in the remaining nine taxa (Figs. 2B-F, H & L).

According to the type of cell arrangement, on the surface of cypselae, the following epidermal patterns were recognized (Table 3; Fig. 3):

Type 1: Longitudinally parallel to the long axis of the cypsela in *Cichorium intybus* (Fig. 3A), the three examined species of *Lactuca* and in *Picris conyzoides* and *P. hieracioides* subsp. *japonica* (Figs. 3B-D). In *Centaurea nervosa* (Fig. 3E) such pattern is scrobiculate but in *Cirsium vulgare* (Fig. 3F) it is irregularly compact striate.

Type 2: Reticulate in *Carthamus tinctorius* (Fig. 3G).

Type 3: Reticulate to scalariform in *Centaurea aspera* (Fig. 3H).

Type 4: Irregularly reticulate to ill-defined in *Crepis pyrenaica* (Fig. 3I).

Type 5: Irregularly wavy reticulate in *Sonchus palmensis* and *S. palustris* (Figs. 3J & K). In *S. palmensis* some verrucae are prominent (Fig. 3J).

Type 6: Verrucate and tuberculate inbetween in *Reichardia ligulata* (Fig. 3L).

The shape of epidermal cells is more or less ellipsoidal with acute walls in *Cichorium intybus* (Fig. 3A), more or less rectangular with acute-caudate end walls in the examined cypselae of the three species of *Lactuca* (Figs. 3B & C), rod-shaped in *Picris conyzoides*, *P. hieracioides* subsp. *japonica* (Fig. 3D) and in *Cirsium vulgare* (Fig. 3F), penta- to hexagonal and frequently elongated in one direction in *Carthamus tinctorius* (Fig. 3G), *Centaurea aspera* and *C. nervosa*; where the epidermal cells are much elongated (Figs. 3E & H). The epidermal cells are more or less rectangular in *Sonchus palustris* (Fig. 3K), more or less rectangular to ill-defined in *Crepis pyrenaica* and *Sonchus palmensis* (Figs. 3I & J), but in *Reichardia ligulata* (Fig. 3L) they are in the form of irregular tubercles frequently aggregated in large verrucae.

TABLE 3. Abscission scar characteristics and surface scan details in the studied taxa.

Taxon	Abscission scar				Surface microsculpture details			
	Position	Shape	Carpd.	[1]Calluse	Cell arrangement (Pattern)	Epidermal cell shape	Anticlinal boundaries	Periclinal walls
Carthamus tinctorius	basal-lateral	pyriform	+	-	reticulate	5-6-gonal, elongate in one-direction	raised	Cv -F/G
Centaurea aspera	basal-lateral	irregular	-	+	reticulate-scalariform	5-6-gonal, elongate in one-direction	raised	Cv-F/G
C. nervosa	basal-lateral	irregular	-	+	scrobiculate	5-6-gonal, elongate in one-direction	channelled	Cx/S
Cichorium intybus	basal	angular ring	-	-	longitudinally parallel to long axis of cypsela	± ellipsoidal with acute walls	channelled	Cx-F/S
Cirsium vulgare	basal	triangular	-	-	irregularly compact striate	rod-shaped	channelled	Cx/S
Crepis pyrenaica	basal	± rounded	+	-	irregularly reticulate to ill-defined	± rectangular to ill-defined	raised	Cv-F/G
Lactuca perennis	basal	± rounded	+	-	longitudinally parallel to long axis of cypsela	± rectangular with acute-caudate walls	channelled	Cx/DMSH
L. viminea	basal	± rounded	+	-	longitudinally parallel to long axis of cypsela	± rectangular with acute-caudate walls	channelled	Cx/DMSH
L. virosa	basal	rhombic	+	-	longitudinally parallel to long axis of cypsela	± rectangular with acute-caudate walls	channelled	Cx/DMSH
Picris conyzoides	basal	ring-shaped	-	-	longitudinally parallel to long axis of cypsela	rod-shaped	channelled	Cx/G
P. hieracioides subsp. *japonica*	basal	ring-shaped	-	-	longitudinally parallel to long axis of cypsela	rod-shaped	channelled	Cx/G
Reichardia ligulata	basal	± rounded	-	-	verrucate and tuberculate inbetween	irregular tubercles aggregated in large verrucae	unclear	Cx/S
Sonchus palmensis	basal	± rounded	-	-	irregularly wavy reticulate-verrucate	± rectangular to ill-defined	raised	Cv/St
S. palustris	basal	rectangular	-	-	irregularly wavy reticulate	± rectangular	raised	Cv/St

[1]Callus -like protuberance in the abscission scar; +, present; -, absent; ±, more or less; Carpod.= Carpopodium; Cv= Concave; Cx= Convex; DMSH= Densely microstriated with hair like projections; G= Granular; F= Flat; S= Smooth; St= Sometimes striated.

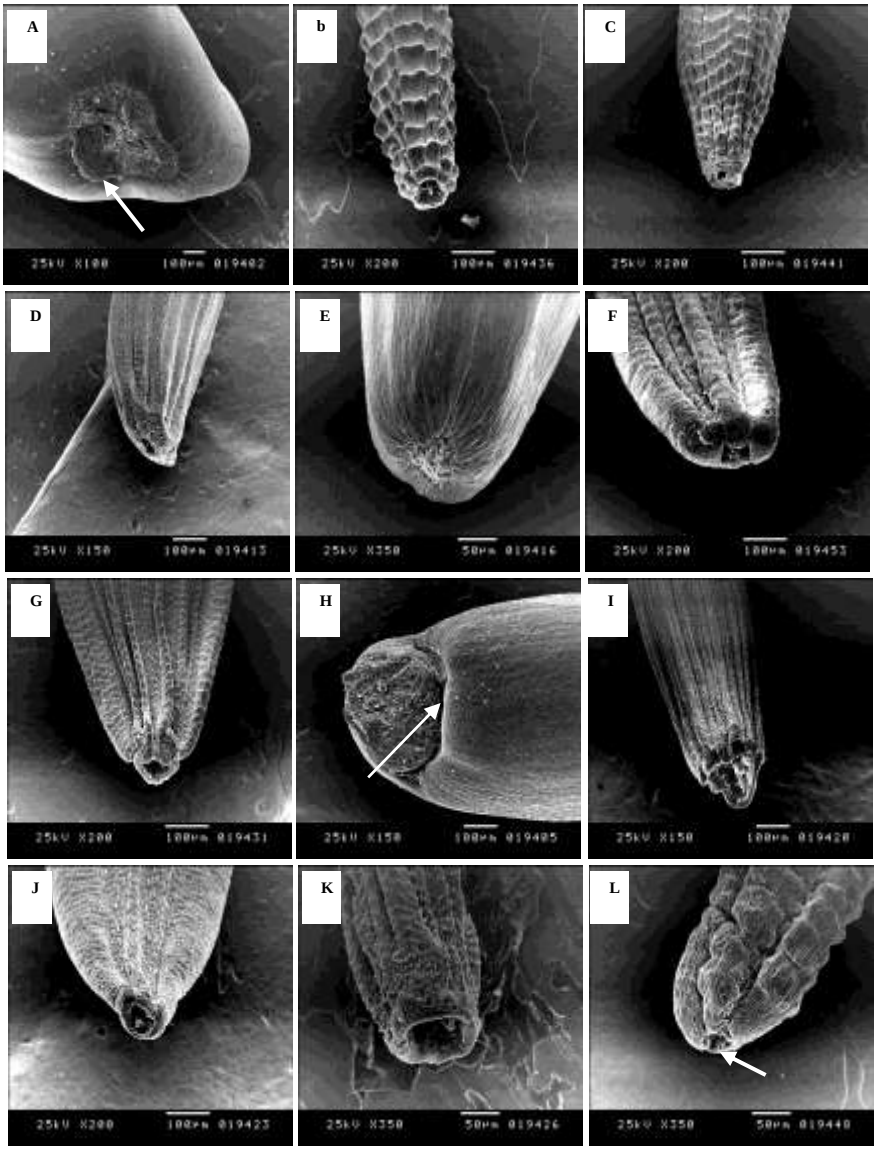

Fig. 2 (A-L). SEM photomicrographs illustrating variation in the abscission scar of cypsela: A- *Carthamus tinctorius*; B- *Picris conyzoides*; C- *P. hieracioides* subsp. *japonica*; D- *Cichorium intybus*; E- *Cirsium vulgare*; F- *Sonchus palustris*; G- *Lactuca virosa*; H- *Centaurea aspera*; I- *Crepis pyrenaica*; J- *Lactuca perennis*; K- *L. viminea*; L- *Sonchus palmensis*; as= abscission scar.

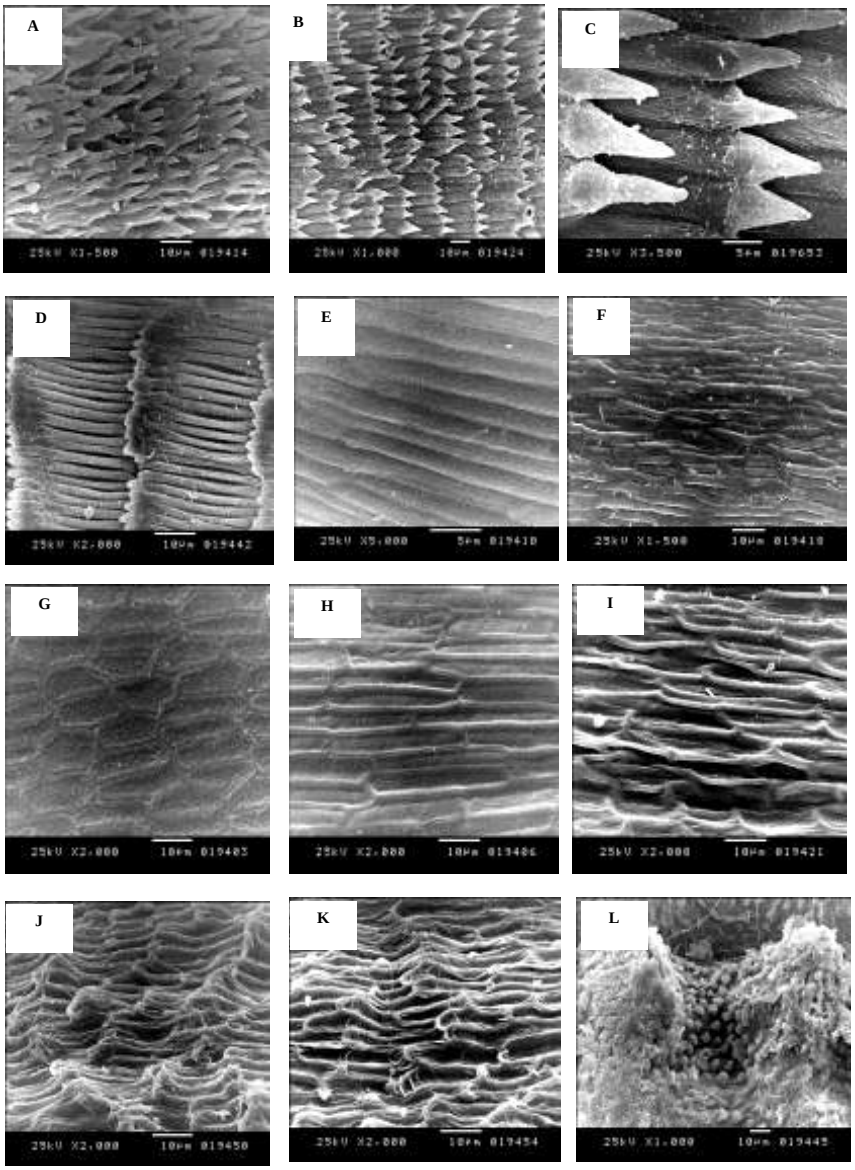

Fig.3(A-L). SEM photomicrographs illustrating details of cypsela surface microsculpture: A- *Cichorium intybus*; B & C- *Lactuca perennis*; D- *Picris hieracioides* subsp. *japonica*; E- *Centaurea nervosa*; F- *Cirsium vulgare*. G- *Carthamus tinctorius*; H- *Centaurea aspera*; I- *Crepis pyrenaica*; J- *Sonchus palmensis*; K- *S. palustris*; L- *Reichardia ligulata*.

The anticlinal cell wall boundaries are raised in five species (Figs 3G-K) channelled in eight taxa (Figs. 3A-F) but unclear in *Reichardia ligulata* (Fig. 3L). The outstanding feature of the periclinal walls (Table 3) is that observed in the three examined species of *Lactuca* where they are densely microstriated and with numerous hair-like projections (Figs. 3B & C).

The waxy deposition is generally either rudimentary (Figs. 3E, G-K) or sometimes it is sparse variable granules in *Cichorium intybus* and *Cirsium vulgare* (Figs. 3A & F). In addition, the waxy deposition is continuous and superimposed on the ends of cells in the three examined species of *Lactuca*, *Picris* conyzoides and *P. hieracioides* subsp. *japonica* (Figs. 3B-D) but in *Reichardia ligulata* appears as flakes over the verrucae (Fig. 3L).

Discussion

The taxonomic status of many genera and species of Asteraceae has been clarified in the light of their cypselae morphological features especially when they are studied under SEM (Chehregani & Mahanfar, 2007; Abid & Qaiser, 2009 and Abid & Ali, 2010). Observation of cypselae characteristics of the examined taxa under stereomicroscopy and SEM has revealed many valuable characters which can be useful for separation and identification of these taxa as well as the precise technical identification of their cypselae.

The mean length of the examined mature cypselae can be useful to differentiate cypselae of *Lactuca viminea* and *Cichorium intybus*. The colour of cypsela seems clearly distinctive to cypselae of *Carthamus tinctorius* having white colour and also to those of *Sonchus palmensis* and *S. palustris* having straw colour. Bhar & Mukherjee (2004) reported that the colour of cypsela is not reliable distinguishing character because it changes with the degree of maturity of cypselae.

The cypsela shape appeared unique in *Crepis pyrenaica*; being terete columnar. In addition, the cypsela shape seems to be clearly diagnostic for some of the examined taxa viz., *Carthamus tinctorius*, *Cichorium intybus*, *Cirsium vulgare* and *Reichardia ligulata*. The presence of beaked cypselae is diagnostic for the three examined species of *Lactuca* having obviously long-beaked cypselae and also for *Picris conyzoides* and *P. hieracioides* subsp. *japonica* with short-beaked ones.

The stylopodium is a structure attached to the top of the cypsela and composed of the style base and associated nectaries (Wetter, 1983 and Mukherjee, 2005). Mukherjee (2005) pointed out that actually the stylopodium is commonly found in young cypsela and may not be very clear in the mature state.

He added that the stylopodium micro-characters are not sufficient either for generic or specific segregation. The stylopodium is detected, here, to be of negligible importance as it is just clear in cypselae of *Carthamus tinctorius*, *Cirsium vulgare* and minute in cypselae of *Reichardia ligulata*.

The examined cypselae are either ribbed or ribless. Marzinek *et al*. (2010) stated that some species in Eupatorieae (Asteraceae) demonstrate variations in rib numbers making the use of this trait controversial. However, the use of number of ribs as an attribute for differentiation of species from Asteraceae in the identification keys has been adopted (Bahar & Mukherjee, 2004 and Abid & Qaiser 2009).

Our observation of cypselae under SEM has revealed the presence of the abscission scar in all the studied taxa either at a basal or a basal-lateral position but the carpopodium is developed in *Carthamus tinctorius*, poorly developed in *Crepis pyrenaica* and the three species of *Lactuca* and undeveloped in the rest of examined taxa. This observation coincides with that formerly reported by Anderberg *et al*., (2007). The shape of the abscission scar may seem to be a reliable character for generic separation as observed in the two studied species of *Centaurea*. Also it appears a suitable feature for separation of some of the studied taxa.

Details of the cypsela microsculpture under SEM have been found very useful in identifying many of the examined cypselae and also in the separation of their corresponding species. In addition, the two studied taxa of *Picris*: *P. conyzoides* and *P. hieracioides* subsp. *japonica* as well as the three examined species of *Lactuca* could be easily delimited at the generic level via their cypsela surface microsculpture.

Based on the recorded characters of the examined cypselae, the following key to the studied taxa was constructed:

1a. Abscission scar basal-lateral……..2
1b. Abscission scar basal…….....4
2a. Cypsela obovoid; abscission scar pyriform……..*Carthamus tinctorius*
2b. Cypsela obovoid-oblong; abscission scar irregular with a callus-like projection…3
3a. Cellular pattern reticulate-scalariform…….....….....*Centaurea aspera*
3b. Cellular pattern scrobiculate…….....….....*Centaurea nervosa*
4a. Cypsela beakless…….....……5
4b. Cypsela beaked…….....……10
5a. Cypsela ribbed…….....……...6
5b. Cypsela ribless…….....……..9
6a. The two lateral ribs exaggeratedly thickened…….....……7
6b. The two lateral ribs not so……..……..8
7a. Cypsela obovoid-oblong; abscission scar more or less rounded; cellular pattern irregularly wavy reticulate-verrucate……*Sonchus palmensis*
7b. Cypsela oblong; abscission scar rectangular; cellular pattern irregularly reticulate…….……*Sonchus palustris*
8a. Cypsela wedge-shaped; cellular pattern longitudinally parallel to the long axis of cypsela……...*Cichorium intybus*

8b. Cypsela terete columnar; cellular pattern irregularly reticulate to ill-defined……..…..*Crepis pyrenaica*
9a. Cypsela obovoid; cellular pattern irregularly compact striate....*Cirsium vulgare*
9b. Cypsela oblong; cellular pattern verrucate-tuberculate……. *Reichardia ligulata*
10a. Cypsela apically abruptly narrowed into a short beak…….....…….11
10b. Cypsela obviously long-beaked…….....…….....12
11a. Cypsela 4-angled alternating with 4-grooves; grooves obviously narrow……..**.....**……*Picris hieracioides* subsp. *japonica*

11b. Cypsela 4-angled alternating with 4- grooves; grooves relatively wider…… *Picris conyzoides*
12a. Abscission scar rhombic…….**.....***Lactuca virosa*
12b. Abscission scar more or less rounded…….**.....**13
13a. Cypsela ovoid-oblong; Ribs 4……**....**……..*Lactuca perennis*
13b. Cypsela elliptic; Ribs 20…….*Lactuca viminea*

In conclusion, combination of cypselae characteristics including some salient macromorphological features viz. cypsela shape, presence or absence of beak, ribbed or ribless cypsela surface, the number of ribs if present concomitantly with the position and shape of the abscission scar as well as the surface microsculpture peculiarities can be considered crucial clues for the precise identification of the isolated cypselae of the studied taxa. In addition, such characteristics can be useful for designation primarily at the species level and sometimes at the genus level. However, no of such characteristics could be stated as criteria for separation at the tribal level.

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الشكل الظاهرى المقارن وزركشة السطح فى سبسلاء بعض الوحدات التصنيفية من الفصيلة المركبة وأهميتهم التصنيفية

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يتناول البحث دراسة الخصائص المورفولوجية وزركشة السطح فى سبسلاء ثلاثة عشر نوعا إضافة إلى تحت نوع من نباتات الفصيلة المركبة جلبت من الحديقة النباتية والمتحف النباتى بجامعة برلين بألمانيا باستخدام كلا من المجهر الضوئى المجسم والمجهر الإلكترونى الماسح. وتهدف الدراسة إلى تقييم أهمية تلك الخصائص فى إيضاح المزيد من العلاقات التصنيفية بين هذه الأنواع، وكذلك التعرف الدقيق على سبسلائها.

أوضحت الدراسة وجود اختلافات فى صفات طول ولون وشكل السبسلاء، وكذلك فى ملمسها وعدد العروق على أسطحها، كما تباينت صفات الندبة (موضع اتصال السبسلاء بتخت النورة) فى شكلها، و أيضا من وجود أو غياب النسيج الذى يحيط بها، وموقع اتصالها سواء أكان قاعديا أو قاعديا إلى جانبيا، كما تنوعت أنماط زركشة سطح السبسلاء تحت المجهر الإلكترونى الماسح مما أمكن معه التعريف الدقيق للأنواع، وكذلك تمييز البعض منها عند مستوى الجنس، كما أسهمت نتائج الدراسة فى عمل مفتاح اصطناعى يميز الأنواع المدروسة، وكذلك يمكن من التعرف الدقيق على سبسلائها.