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Pollen and Seed Characters of Certain *Cuscuta* Species Growing in Egypt with a Reference to a Taxonomic Treatment of the Genus

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ABSTRACT

Thirty-four pollen and seed characters were investigated in five out of eight *Cuscuta* species growing in Egypt. The investigations pointed out to high similarity of the studied species to some other species of Convolvulaceae. Relying on the present data as well as on similar data obtained by other workers (based on pollen, seed and other parameters) on Cuscutaceae and Convolvulaceae the genus *Cuscuta* is better looked at as a derived member of Convolvulaceae rather than forming a family of its own. It was also concluded that conclusive more work on much larger number of *Cuscuta* species in particular and species from Convolvulaceae should be conducted for a precise consideration of the taxonomic treatment of this genus.

Key Words: Convolvulaceae; *Cuscuta;* Cuscutaceae; Pollen; Seed

INTRODUCTION

The genus *Cuscuta* L. is composed of approximately 150 tiny herbaceous obligatory parasitic species. Some species invade more than one host and some others are host-specific and all are detrimental. According to the conservative view the genus was classified in Convolvulaceae under the subfamily Cuscutoideae (Engelmann, 1859; Bentham & Hooker, 1862; Bessey, 1915; Core, 1955; Engler, 1964; Hutchinson & Ashton, 1979). Impressed mainly by the mode of nutrition, other authors segregated it into a family of its own viz. Cuscutaceae Dum. (Hutchinson, 1959; Cronquist, 1968; Hadać & Chrtek, 1970; Willis, 1973; Austin, 1975; Takhtajan, 1980). This segregation relied on different criteria, either on macro-floral characters especially the infrastaminal scales (Severova *et al*. 1991), on floral anatomy (Govil & Lavania, 1980) or embryological characters (Tiagi, 1951; Johri & Tiagi, 1952; Govil, 1978; Johri, 1987). The genus itself was divided by Engelmann (1859), when placed in Convolvulaceae, into three sub-genera viz. *Cuscuta, Monogyna, Grammica*. Hadać and Chrtek (1970), on the bases of floral characters, accepted the Cuscutaceae but they added one more subgenus *(Kadurias)* to Engelmann's sub-genera. However, they also stated (*op. cit.*) that embryological data do not support such division since the bisporic embryo sac is present in members of all the four subgenera.

SEM seed exomorphic characters of some *Cuscuta* species were investigated by some workers, e.g. *Cuscuta pedicellata* and *C. campestris* (Lyshede, 1992); Chinese *Cuscuta* (Huang *et al.,* 1993) and *C. chinensis* and *C. gronovii* (Hamed & Mourad, 1994). The sub-genera of *Cuscuta* viz. *Cuscuta, Monogyna, Grammica* were studied by Kim *et al.* (2000). Anatomically the seed coat of *C. hyalina* and *C. planiflora* was investigated by Tiagi (1951), *Cuscuta campestris* by Hutchinson and Ashton (1979), *C. pedicellata* and *C. campestris* by Lyshede (1984), *C. japonica* by Terekhin and Kotov (1988) and *C. chinensis* and *C. gronovii* by Hamed and Mourad (1994). So far as the author is aware, no literature can be cited on the pollen of *Cuscuta.*

The genus *Cuscuta* is represented in the flora of Egypt by a few species. Except for *C. monogyna* and *C. epilinum*, which are host-specific the former to *Citrus* and the latter to flax, each of the other species attacks more than a host. Different authors recorded different number of species and their estimates ranged between five (Montasir & Hassib, 1956) and eight species (Boulos, 2000).

The present investigation was conducted to show how far the pollen and seed characters of certain *Cuscuta* species in Egypt can contribute to the taxonomic treatment of the genus.

MATERIALS AND METHODS

Table I is a summary of the recorded *Cuscuta* species growing in Egypt; the five studied species are asterisked. The pollen characters were investigated using LM and SEM. LM investigation was applied on mature pollen released on a slide from an anther at anthesis. A drop of alcohol was added and allowed to evaporate partly. Oily and resinous substances were removed by the addition of drops of alcohol for three-four times, one drop at a time, mounted in glycerine jelly, then examined using oil immersion objective (x 100). The photographs were taken with a Leitz

Table I. *Cuscuta* species in Egypt as recorded by different authors, the studied species are asterisked

Author species	Montasir and Hassib (1956)	Taeckholm (1974)	El Hadidi and Fayed (1994-1995)	Boulos (2000)
1	*Cuscuta monogyna* Vahl.	*Cusauta monogyna* Vahl.	*Cuscuta monogyna* Vahl.	*Cuscuta monogyna* Vahl.
2	*C. chinensis* Lam.	*C. chinensis* Lam.	*C. chinensis* Lam.	*C. chinensis* * Lam.
3	*C. arabica* Fresen.	*C. pedicellata* Ledeb. (=*C. arabica* Fresen.)	*C. pedicellata* Ledeb.	*C. pedicellata* * Ledeb. (=*C. arabica* Fresen.)
4	*C. epilinum* Weihe	*C. epilinum* Weihe	*C. epilinum* Weihe	*C. epilinum* * Weihe
5	*C. planiflora* Ten.	*C. planiflora* Ten.	*C. planiflora* Ten.	*C. planiflora* * Ten.
6		*C. campestris* Yuncker	*C. campestris* Yuncker	*C. campestris* * Yuncker
7		*C. palaestina* Boiss.	*C. palaestina* Boiss.	*C. palaestina* Boiss.
8			*C. approximata* Bab.	*C. approximata* Bab.

Wetzlar-513591 microscope. For pollen measurements, the following parameters were considered. Polar diameter (P), equatorial diameter (E) and sphericity (P/E ratio). Measurements were made on at least 20 pollen grains for every axis and the arithmetic mean was calculated for every diameter (Erdtman, 1952). For pollen size, Walker and Doyle (1975) standards were considered viz. minute grain < 10µm; small grain 10-24µm; medium grain 25-49µm; large grain 50-99 µm; very large grain 100-199µm and gigantic grain < or=200µm. For SEM investigation, the pollen was directly processed i.e unacetolyzed (Harley & Ferguson, 1990). For seeds, ten fully mature seeds of each species were investigated under LM for texture and colour. SEM of either pollen or seeds (two seeds per species) was examined by mounting the specimens on brass stubs, coated with gold (200 A^o) in sputter coating unit and scanned by a JEOL-JSM, 5300 SEM at accelerating voltage of 15 KV. For the seed coat anatomy, mature seeds were embedded, sectioned at 10-15µ and stained according to Johansen (1940) techniques.

RESULTS

General Morphology of the Flower. Flower minute, sessile or short-pedicelled, in cymose clusters; 4-, 5- merous (*Cuscuta pedicellata*) or 5-merous (*C. campestris*, *C. chinensis*, *C. epilinum, C. planiflora*); stamens as many as corolla lobes, exerted, inserted on the corolla tube; infrastaminal scales five opposite the stamens. Ovary bilocular, 4-ovuled; styles 2; stigmas capitate or linear.

LM and SEM Pollen and Seed Characters

A. The present study revealed that all the studied *Cuscuta* species share the following pollen characters (Tables II&III): isopalarity; radial symmetry; the aperture long colpus with tapering ends, more or less wide (Fig. 5); the colpus membrane granulated (Fig. 6); the apocolpium area more or less narrow (Fig. 4); the exine tectate, the tectum microechinate, perforate (Fig. 6) with the sexine more thicker than the nexine (Fig. 3). They also share some seed characters (Table IV), these are glabrous seed surface; subapical hilum (Fig. 8); elevated anticlinal walls and the concave outer periclinal walls of the epidermal cells (Fig. 11). The seed coat anatomy is also similar in the studied *Cuscuta* species: the epidermis is one layer, radially elongad, thin-walled; the subepidermis is one layer, more or less squared, thick-walled; followed by palisade-like layer (one layer) and a light line (linea lucida) running across the palisade cells and parallel to the seed surface. The palisade layer is followed by thin-walled parenchyma (2-3 layers) collapsed or not (Fig. 11).

B. Differences between the studied *Cuscuta* species are subsequently presented.

Cuscuta campestris

A-Pollen (Tables II & III)

LM characters: The pollen shape more or less circular (polar view, Fig. 1), circular-elliptic (equatorial view, Fig. 3); 3-, 4-colpate (Figs. 1 & 2 respectively); P/E=1.0, spheroidal; size 20 µm (small).

SEM characters: The tectum perforations more or less circular, relatively large, regularly distributed all over the

Table II. LM pollen morphological characters of the studied *Cuscuta* species

Characters / Species	Polarity	Symmetry	Pollen shape (outline) Polar view	Equatorial view	Pollen class	Dimensions (µm) P	E	P/E	Shape class	Pollen size (µm)	Exin thickness Sexine	Nexine
Cuscuta campestris	Isopolar	Radially symmetrical	± Circular	Circular to elliptic	3-,4-Colpate	20	20	1.0	Spheroidal	20 (small)	Thick	Thin
C. chinensis	Isopolar	Radially symmetrical	± Circular	Elliptic	3-,4-Colpate	24	20	1.20	Subprolate	24 (small)	Thick	Thin
C. epilinum	Isopolar	Radially symmetrical	Circular to lobed	Elliptic	3-,4-Colpate	22.5	20	1.1	Prolate	22.5 (small)	Thick	Thin
C. pedicellata	Isopolar	Radially symmetrical	Circular to lobed	Elliptic	3-Colpate	25	20	1.25	Subprolate	23-25 small to medium	Thick	Thin
C. planiflora	Isopolar	Radially symmetrical	Circular to lobed	± Circular	3-Colpate	16.5	18.75	0.9	Oblate-spheroidal	16.5 (small)	Thick	Thin

±, more or less; E, width of grain in the equatorial axis; P length of grain in the polar axis; P/E, ratio between polar axis P and equatorial axis E

Table III. SEM pollen characters of the studied *Cuscuta* species

Characters	Aperture					Tectum					Sculpture		
	Type	Length	Width	Apex	Membrane	Perforated	Pore shape	Pore size	Pore distribution	Micro-echinate	Echinae		
Species						(+)				(+)	Occurrence	Apex	Distribution
Cuscuta campestris	Colpate	Long	Wide	Tapering	Granulated	(+)	Circular	Coarse	Regular	(+)	Single / grouped	Blunt	Regular
C. chinensis	Colpate	Long	Wide	Tapering	Granulated	(+)	Irregular	Fine	Irregular	(+)	Single	Acute / Blunt	Regular
C. epilinum	Colpate	Long	Wide	Tapering	Granulated	(+)	Irregular	Fine	Regular	(+)	Single / grouped	Acute / Blunt	Regular
C. pedicellata	Colpate	Long	Wide	Tapering	Granulated	(+)	Circular	Fine	Regular	(+)	Single / grouped	Acute	Regular
C. planiflora	Colpate	Long	Wide	Tapering	Granulated	(+)	Circular	Fine	Regular	(+)	Single / grouped	Acute / Blunt	Regular

(+), Present

Table IV. LM and SEM morphological seed characters of the studied *Cuscuta* species

Characters	LM			SEM							
	Seed		Seed shape	Hilum					Spermoderm		
Species	Texture	Colour		Topography	Shape	Leveling	Rim (-,+)	Cells surrounding hilum	Sculpture	Anticlinal walls	Outer periclinal walls
Cuscuta campestris	Glabrous	Brown	Globose	Subapical	Slit-like	Leveled	(-)	Radiating	Rugulate micro-reticulate	More or less elevated	Concave
C. chinensis	Glabrous	Orange	Oval	Subapical	Slit-like	Leveled	(+)	Radiating	Irregular reticulate	Elevated	Deeply concave
C. epilinum	Glabrous	Greenish brown	Pyramidal	Subapical	Slit-like	Leveled	(+)	Radiating	Reticulate	Highly elevated	Deeply concave
C. pedicellata	Glabrous	Brown	Globose	Subapical	Slit-like	Sunken	(-)	Irregularly arranged	Rugulate	Elevated	Deeply concave
C. planiflora	Glabrous	Yellowish brown	Globose	Subapical	Rounded	Sunken	(-)	Irregularly arranged	Rugulate	Elevated	Concave

(-), absent; (+), present

exine surface (Fig. 6); the echinae regularly distributed, arising singular with acute or blunt apices (Fig.6).

B-Seed (Table IV). Colour brown (LM)

SEM characters: Seed globose (Fig. 7); hilum leveled, rimless, with the surrounding cells radiating (Fig.9); sculpture rugulate microreticulate (Fig.10).

Cuscuta chinensis

A- Pollen (Tables II & III).

LM characters: The pollen shape more or less circular (Polar view, Fig.12), elliptic (equatorial view, Fig.14); 3-,4-colpate (Figs. 12 & 13 respectively); P/E=1.20, subprolate; size 24 µm (small).

SEM characters: The tectum perforations irregular in shape, relatively small and randomly distributed; the echinae regularly distributed and arising singular with acute or blunt apices (Fig. 17).

B- Seed (Table IV). Colour orange (LM)

SEM characters: Seed oval (Fig.18); hilum slit-like, leveled, rimmed, with the surrounding cells radiating (Fig. 19); sculpture regular reticulate (Fig.20).

Cuscuta epilinum

A- Pollen (Tables II & III)

LM characters: The pollen shape circular to lobed (polar view, Fig.22), elliptic (equatorial view, Fig.23); 3-,4-colpate (Figs.21&22 respectively); P/E=1.1, prolate; size 24µm (small).

SEM characters: The tectum perforations irregular in shape, relatively small, regularly distributed (Fig.27); the echinae regularly distributed, arising singular or in groups of two's or three's with acute apices (Fig. 27).

B- Seed (Table IV). Colour brown (LM)

SEM characters: Seed pyramidal (Fig. 28); hilum leveled, rimmed, with the surrounding cells radiating (Fig.30); sculpture reticulate (Fig. 31).

Cuscuta pedicellata

A- Pollen (Tables II & III).

LM characters: The pollen shape circular to lobed (polar view, Fig. 32), elliptic (equatorial view, Fig. 33); 3-colpate (Fig.32); P/E=1.25, subprolate; size 23-25µm (small to medium).

SEM characters: The tectum perforations more or less circular, relatively small, regularly distributed (Fig. 36); the echinae regularly distributed, arising singular or in groups of three's or four's with acute apices (Fig. 36).

B- Seed (Table IV). Colour brown (LM)

SEM characters: Seed globose or oval (Fig. 37); the hilum slit-like, sunken, rimless, (Fig.38), with the surrounding cells irregularly arranged (Fig.38); sculpture rugulate (Fig. 39).

Cuscuta planiflora

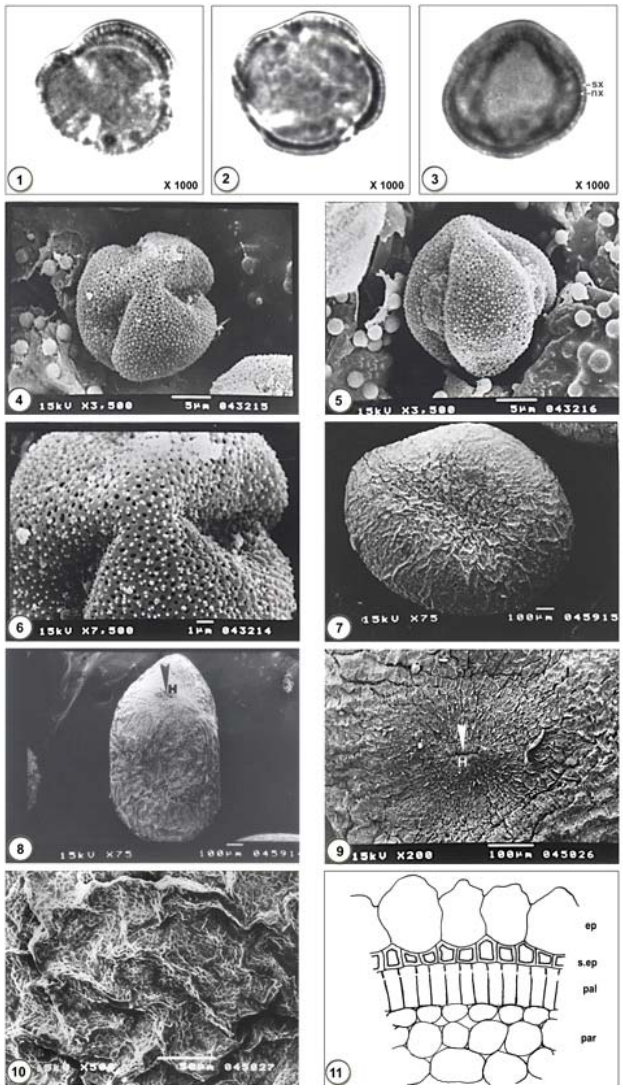
A- Pollen (Tables II & III)

LM characters: The pollen shape circular to lobed (polar view, Fig.40), more or less circular (equatorial view, Fig.41); 3-colpate (Fig.40); P/E=0.9, subspheroidal; size 16.5µm (small).

SEM characters: The tectum perforations more or less circular, relatively small, regularly distributed (Fig. 44); the echinae regularly distributed, arising singular or in groups of

Fig. 1-11. Pollen (Figs 1-3, LM; Figs 4-6, SEM) and seed (Figs 7-10, SEM; Fig 11,) characters of *Cuscuta campestris*: 1, 2, 4, polar view; 3, 5, equartorial view; 6, tectum perforate, sculpture microechinate; 7, seed shape; 8, hilum (H) topography; 9, hilum shape and leveling; 10, sculpture rugulate microreticulate; 11, line illustration (T.S) for seed coat anatomy. ep., epidermis; nx, nexine; pal., palisade-like cells; par., parenchyma; s.ep., sub-epidermis; sx, sexine

Fig. 12-20. Pollen (Figs 12-14, LM; Figs 15-17, SEM) and seed (Figs 18-20 SEM) characters of *Cuscuta chinensis*: 12, 13, 15, polar view; 14, 16, equatorial view; 17, tectum perforate, sculpture microechinate; 18, seed shape and hilum (H) topography; 19, hilum shape, leveling and rim (R); 20, sculpture irregular reticulate



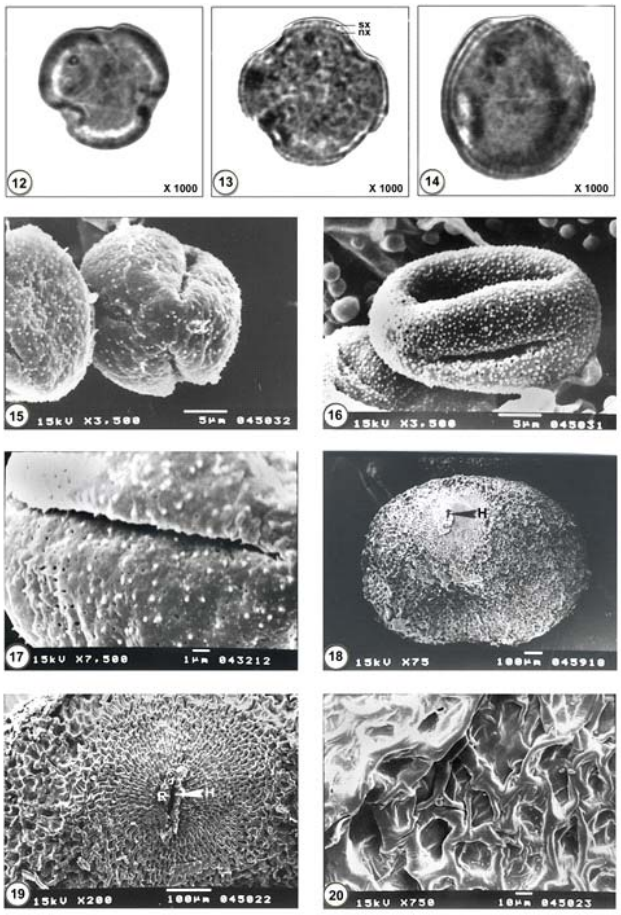
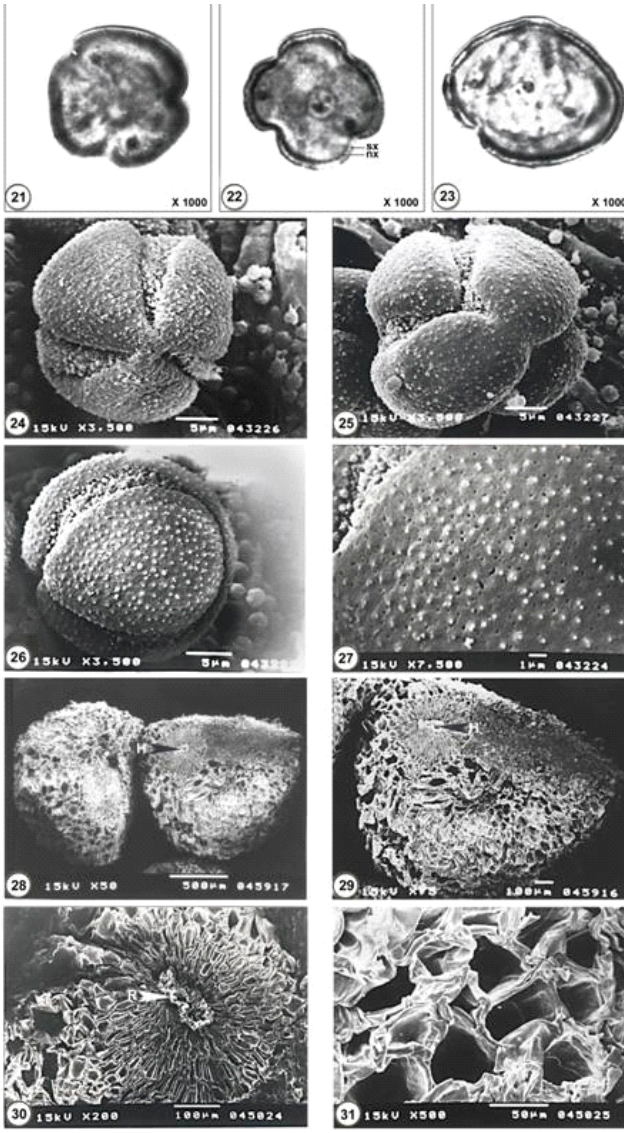
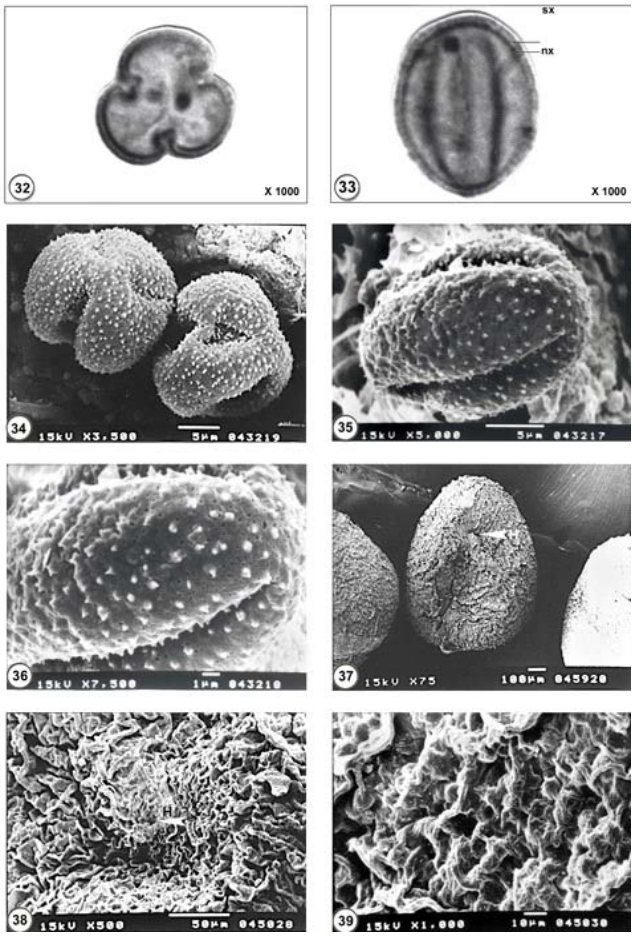


Fig. 21-31. Pollen (Figs 21-23, LM; Figs 24-27, SEM) and seed (Fig 28-31, SEM) characters of *Cuscuta epilinum*: 21, 22, 24, 25, polar view; 22, 26, equatorial view; 27, tectum perforate, sculpture microechinate; 28, seed shape; 29, hilum (H) topography; 30, hilum shape, leveling and rim (R); 31, sculpture reticulate.

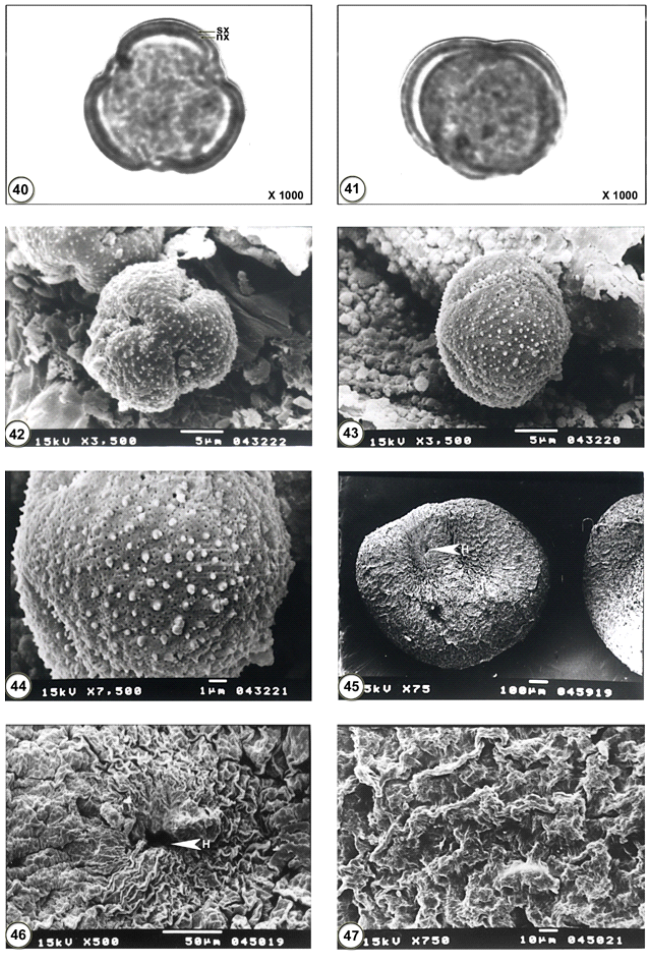
Fig. 32-39. Pollen (Figs 32, 33, LM; Figs 34-36, SEM) and seed (Figs 37-39, SEM) characters of *Cuscuta pedicellata*: 32, 34, polar view; 33, 35, equatorial view; 36, tectum perforate, sculpture microechinate; 37, seed shape and hilum (H) topography; 38, hilum shape and leveling; 39, sculpture rugulate reticulate.





three's or four's with acute or blunt apices (Fig. 44).
B- Seed (Table IV). Colour yellowish brown (LM)

Fig. 40-47. Pollen (Figs 40, 41, LM; Figs 42-44, SEM) and seed (Figs 45-47, SEM) characters of *Cuscuta planiflora*: 40, 42, polar view; 41, 43, equatorial view; 44, tectum perforate, sculpture microechinate; 45, seed shape and hilum (H) topography; 46, hilum shape and leveling; 47, sculpture rugulate.



SEM characters: Seed globose (Fig. 45); the hilum more or less rounded, sunken, rimless (Fig. 46), with the cells surrounding the hilum irregularly arranged (Fig.46); sculpture rugulate (Fig. 47).

DISCUSSION

Pollen of all the herein studied species share the same isopolarity, radial symmetry, long colpate aperture with tapering ends, granulated colpus membrane and microechinate perforated tectum with the sexine thicker than the nexine. These characters had been recorded by El Ghazaly (1991) for *Cuscuta chinensis, Convolvulus arvensis, C. cephalopodus, C. pilosellifolius* and *C. prostratus.* More pollen similarities between the studied *Cuscuta* species and certain other taxa of Convolvulaceae cited in comparable studies might be stated. The colpus characters and the perforated tectum (with thick sexine) are similar to those mentioned for genus *Convolvulus* (Saad, 1967), the echinate tectum was recorded in *Ipomoea* species by Hsiao and Kuoh (1995) and the granulated colpus membrane in *Porana* by Zhang *et al.* (2003).

Some other characters, though not constant among the studied *Cuscuta* species they can refer to a similarity to other Convolvulaceae. Pollen shape, pollen shape class and the relative size of pores of tectum are among these characters. Pollen of many *Ipomoea* species (Anjum & Qaiser, 1998), *Convolvulus arvensis, C. cantabrica, C. dryadum, C. humilis, C. pitardii, C. sabatius, C. supinus, C. trabutianus* and *C. valentinus* (Menemen & Jury, 2002) and *Porana* species (Zhang *et al.,* 2003) show similarity to the studied *Cuscuta* species. The echinae of the tectum that arise in groups (recorded in *Cuscuta epilinum*, *C. pedicellata* & *C. planiflora*) are similar to those of *Cressa cretica* as investigated by El Ghazaly (1991) to be in groups of two's or three's.

However, some pollen characters that were previously recorded in Convolvulaceae and not recorded in the present work such as the pantoporate pollen (in *Ipomoea* species by Hsiao & Kuoh, 1991), reticulate to punctuate-scabrate sculpture (in some *Convolvulus* species by Anjum & Qaiser, 1998), large-sized pollen (in *Convolvulus arvensis* & *C. cephalopodus* by El Ghazaly, 1991), tricolporate pollen and the tuberculate colpus membrane (in genus *Porana* by Zhang *et al.,* 2003). Despite of this dissimilarity the shared pollen characters between the studied *Cuscuta* species and some other convolvulaceous species may support the retention of *Cuscuta* within Convolvulaceae.

Moreover the investigated seed characters (LM & SEM) refer to a consistency of four characters among all the studied species. These are seed texture, hilum topography, anticlinal wall leveling and the concave outer periclinal walls of the epidermal cells. The former two characters reflect a similarity to *Cuscuta gronovii*, *Ipomoea bona-nox, I. leari* and *Quamoclit coccinea* investigated by Hamed and Mourad (1994). It has been also noticed that there is a similarity in the seed shape of the studied *Cuscuta* species to that of *Calystegia sepium, Convolvulus arvensis, C. tricolor, Ipomoea bona-nox, I. hederacea, I. leari, I. purpurea, I. fistulosa* and *Quamoclit coccinea* as recorded by Hamed and Mourad (1994). The slit-like hilum that recorded in the studied *Cuscuta* species was recorded in *Cuscuta gronovii* by Hamed and Mourad (1994). The sunken hilum recorded in the studied *Cuscuta* species have been recorded also in *Convolvulus arvensis, C. tricolor, Ipomoea bona-nox, I. hederacea, I. leari, I. purpurea, I. fistulosa* and *Quamoclit coccinea* by the same authors (op.cit.). More similarities which indicate evident

relationship between the studied *Cuscuta* species and other Convolvulaceae can be sated. These include reticulate sculpture in *Ipomoea fistulosa*, *I. leari* and *I. purpurea* (Hamed and Mourad, 1994), in *Ipomoea aquatica, I. chryseides, I. fistulosa, I. hederifolia, I. hispida, I. nil, I. obscura, I. pes-caprae, I. quamoclit, I. sepiaria, I. tigridis, I. triloba* (Das *et al*., 1995) and in two subgenera of *Cuscuta* viz. *Cuscuta* and *Grammica* (Kim *et al*., 2000). Reticulate or rugulate sculpture in *Ipomoea eriocarpa, I. hederifolia, I. nil, I. obscura, I. pes-caprae, I. pes-tigridis, I. purpurea, I. quamoclit* and *I. tuberosa* (Shanmukha & Leela, 1993).

However, some seed characters were previously recorded in Convolvulcaeae but were not recorded in the present work. These are the tuberculate texture which was recorded in *Convolvulus arvensis* and *C. tricolor*. (Hamed & Mourad, 1994) and the striate sculpture in the Chinese *Cuscuta* (Huang *et al.,* 1993).

Anatomically, the seed coat of *Cuscuta* showed a similar structure in all the studied species in accordance with the claim of Corner (1976). Lyshede (1992) referred to the same structure in *Cuscuta campestris* and *C. pedicellata* and Hamed & Mourad (1994) in *Cuscuta gronovii.*

Anatomical similarity of the seeds of the studied *Cuscuta* species to other members of Convolvulaceae was early reported by Corner (1976) with no reference to particular species. On the other hand Lopez *et al.* (1990) recorded the presence of 3-4 layers of sclerenchyma internal to the subepidermis and a double linea lucida in *Ipomoea leucantha*.

As mentioned for the pollen characters, the shared seed characters between the studied *Cuscuta* species and other Convolvulaceae may justify the retention of *Cuscuta* within the Convolvulaceae.

Irrespective of the heterotrophic behaviour of *Cuscuta* species and the infrastaminal scales the investigated characters which reflect similarities with other Convolvulaceae are much more consistent than other morphological, anatomical, or floral characters taken as criteria for the separation of this genus to form Cuscutaceae. Relying on the present data the author is in favour of retention of *Cuscuta* in Convolvulaceae. Additional support to this was the work of Hamed and Hassan (1990) on floral morphology and Hamed and Mourad (1994) on seed morpho-anatomy on some species of Convolvulaceae (including *Cuscuta*). That *Cuscuta* is best considered as a derived member of Convolvulaceae rather than a family by itself is also supported by molecular studies in the work of Downie *et al.* (1991), Bommer *et al.* (1993), Perez *et al.* (1996), and Neyland (2001). However, more studies should be conducted on much larger number of species of *Cuscuta* and of Convolvulaceae before the final settlement of this issue.

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