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Taxonomic studies in the *Camphorosmeae* (*Chenopodiaceae*) in Egypt. 1. Subtribe *Kochiinae* (*Bassia*, *Kochia* and *Chenolea*)

Abstract

Turki, Z., El-Shayeb, F. & Shehata, F.: Taxonomic studies in the *Camphorosmeae* (*Chenopodiaceae*) in Egypt. 1. Subtribe *Kochiinae* (*Bassia*, *Kochia* and *Chenolea*). — Fl. Medit. 16: 275-294. 2006. — ISSN 1120-4052.

The plant morphology, anatomical characters of stem, SEM of pollen and seed coat surfaces were used to reassess the taxonomic relationships between the genera *Bassia*, *Chenolea* and *Kochia*. In addition, the Egyptian species of the genus *Bassia* were revised. The results clearly indicate considerable differences between the three studied genera and support the treatment of them as different genera. *Bassia aegyptiaca* is recorded as species nova. Both *Chenolea* and *Kochia* are represented in Egyptian flora by one species for each.

Introduction

Several attempts have been made in distinguishing and identification of the extremely difficult genera *Bassia*, *Kochia*, and *Chenolea*. So far no concordance has been achieved. Many floras, such as Aellen (1961), Ball (1964), Iljin (1936), Tutin (1964), Zohary (1966) and Kug Hsien-wu & al. (1979) have treated *Kochia* and *Bassia* as separate genera. Maire (1962) proposed to include *Chenolea* to *Bassia*, and Scott (1978) proposed to submerge Eurasian species of *Kochia* and *Chenolea* with accrescent perianth with either spines or wings into *Bassia*. Watson and Dallwitz (1992) and Al-Eisawi (2004) treated *Bassia*, *Chenolea* and *Kochia* as separated genera.

As to the treatment of the genera in Egypt, Ascherson & Schweinfurth (1887) were the first to recognize *Bassia muricata* as a distinct species in Egypt. Täckholm (1956, 1974) treated *Bassia*, *Chenolea* and *Kochia* as separate genera and reported that *Bassia muricata* was represented in Egypt by two varieties, var. *brevispina* Bornm. and var. *tenuifolia* Boiss. According to Mobarak (1994) *Bassia* is represented in Egypt by three species, viz. *B. indica* (*Kochia indica*), *B. muricata* and *B. eriophora*. El-Hadidi and Fayed (1994-95) and Boulos (1995, 1999) in their working lists, treated *Chenolea arabica* and *Kochia indica* as synonyms to *Bassia arabica* and *Bassia indica*, respectively.

The utilization of SEM to study seed and pollen characters may be extremely useful to solve some taxonomic problems and may support the identification of the studied species.

The significance of seed sculpture in taxonomic and phylogenetic studies has been emphasized by many authors (Corner 1976; Rezk 1980; Barthlott 1981; Kumar & al. 1984; Khushk Vaughan 1986; Chernoff & al. 1992; Xuhan Van-Lammeren 1994; Hosny 1994; Al-Nowaihi & al. 1999; Loutfy & al. 1999; Shehata and Turki 2001).

Pollen morphology has been previously used in taxonomic treatments of the Chenopodiaceae, particularly in *Atriplex* (Frankton & Bassett 1970), *Suaeda* (Bassett & Crompton 1978; Al-Turki 1992), *Salicornia* (Fergusson 1964), *Halopeplis* (Blanch & Molero, 1987) and *Chenopodium* (Sajveroura 1988).

The present work aimed to study and revise critically the taxonomic relationships between the species of the related genera (*Bassia*, *Chenolea* and *Kochia*) in Egypt. It was found that there was no previous complete work on pollen grains and seed morphology of the studied taxa. This encouraged us for studying these taxa.

Material and methods

The present study is based on fresh materials of most of the taxa, collected from several localities in Egypt (the Mediterranean region, Eastern and western desert, Sinai) and kept in Menofyia University Herbarium (MNF) and on collections deposited in Cairo University Herbarium (CAI). *Bassia eriophora* specimens were studied from the specimens borrowed from the Kew herbarium (K).

Samples of young stems were chosen for anatomy from both herbarium specimens and fresh material (Table 1). All assessments were made on plants at similar developmental stages (fruiting stage) and in comparable positions of each plant. Stem samples were taken from the 4th internodes ca. 2-3 cm from the apex. Fresh materials were fixed in FAA. [5: 5: 90], while the dried herbarium specimens were first softened by warm water, and then fixed in FAA. after fixation samples were transformed in ethyl alcohol series, then embed-

Table 1. Specimens investigated.

Taxon	Localities
<i>Kochia indica</i>	Ras El Hekma, 24-4-2003, Turki & El Shayeb (MNF); Madinet El Sadat, 15-10-2003, Shehata. (MNF), Shebien El Koom, 20-9-2003, Shehata (MNF).
<i>Chenolea arabica</i>	Mariut, 18-4-1972, Zahran (CAI)
<i>Bassia aegyptiaca</i>	Ras El-Hekma, 22-5-2004 Turki, El shayeb and Shehata (MNF); ibid. 28-3-2005 (MNF).
<i>Bassia eriophora</i>	Wadi El-Humur, El-Ramla, Sinai, 14- 4-1973, Shabetai (K); Wadi El-Ashar, Galala Qiblya, 27-3 -1983 Hassan (K).
<i>Bassia muricata</i>	Mersa Matrouh desert road, 15-4-1986, Fahmy (CAI); Ras El-Hekma, 22-5-2004, Turki, El shayeb and Shehata (MNF); Cairo-Ismalia desert road, 9-3-1981, El-Bakry. (CAI).

ded in paraffin. The stem pieces were sectioned at 10-15 μm ; sections were dehydrated in alcohol-xytol series and stained in safranin and light green according to [Sass 1961]. The transverse sections of stems were examined and photographed by using Zeiss research microscope. A planimeter was used for estimation of the percentage of each tissue to the total section area according to Abd El-Rahman & al. (1976), Pandey (1982) and Abd El-Gawad & al. (1989).

The macromorphological characters of at least 50 specimens of pollen and 30 mature seeds for each taxon were studied by the aid of light microscope. SEM study of the investigated material was carried out by mounting dried material on brass stubs and coated with a thin layer of gold using JEOL JSM 530P SEM at electron microscopic unit, Faculty of Science, Alexandria University. Collecting localities for the examined specimens are given in table (1).

For data analysis, the macromorphological characters (53 characters) were coded and used for creating the data matrix. Phenograms illustrating the relationship between the studied taxa were then constructed by calculating the average taxonomic distance (dissimilarity) by using the NTSys. Program package for IBM-pc as described by Rohlf (1989).

Results

Macromorphological studies

Macromorphological characters used in the numerical analysis of the studied species are listed in Table (2).

1- *KOCHIA*

Herb or shrub, flowers solitary, rarely 2 or 3, hermaphrodite, or by abortion pistillate, bractless. Perigonium urn-shaped, fruiting lobes connivent into a disk, stamen 5, inserted at bottom of perigonium, style divided into 2, filiform lobes. Utricle depressed, included in the perigonium; pericarp membranous. Seed horizontal; testa membranous. Embryo nearly circular, surrounding the albumen.

About 80 species, mainly in temperate zones of the old world and also in N America and Australia. Only *Kochia indica* known in Egypt.

Kochia indica Wight, Icon. Pl. Ind, Orient. no. 1791 (1852).

Syn. *Bassia indica* (Wight) A. J. Scott, Feddes Repert. 89: 108 (1978); *Kochia scoparia* (L.) Schard. subsp. *indica* (Wight) Aellen, Mitt. Basler Bot. Ges. 2: 15 (1954).

Type: Described from India, Coimatore, Wight 2479 (K).

Annual undershrub densely branched at base, forming cushion, 50-200 cm diameter and up to 250 cm high. Leaves lanceolate with acute tips, 10-40 \times 3-10 mm. Inflorescence spicate, mostly with 1-3 sessile flowers in axils of leaf like bracts. Fruiting perianth winged with membranous wings. Seeds wide elliptic, black.

Representative specimens:

M: Ras El-Hekma, spring 1955, El-Hadidi s.n. (CAI); ibid, 20.7.1959, Ghabbour s.n. (CAI); ibid, 24.4.2003. Turki & El Shayeb s.n. (MNF); Alexandria, 24.8.1952, Boulos s.n.

Table 2. Morphological features of the studied taxa. (Measures in mm if not otherwise indicated).

Taxon \ Character	<i>K. indica</i>	<i>C. arabica</i>	<i>B. aegyptiaca</i>	<i>B. muricata</i>	<i>B. eriophorae</i>
Plant height (cm)	200-250	50-70	40-70	60-70	10-30
Plant diameter (cm)	50-200	20-30	20-40	30-50	7-25
Plant colour	Yellow-blue green	Yellow green	Yellow green	Blue green	olive
Internodes	9-20	(2)3-7	4-8(10)	4-7(10)	4-6(9)
Leaf shape	Lanceolate	Oblong-narrowly ovate	Lorate-narrowly oblong	Linear-elliptic	Linear
Blade length	10-30(40)	18-25(32)	(11)14-20(23)	(8)10-16(20)	8-15(20)
Blade width	3-7(10)	1.5-2.5(3)	1-2	1.6-2.0	15-20(25)
Number of flowers	1-3	1	2	1-3	1-2
Tepal apex	acut	Incurved acute	Obtuse-acute	acute-acuminat	Acute incurved
Tepal length	0.9-1.2(1.5)	2.5-3	0.8-1.0	(0.6)1.2-1.5	0.3-0.4
Tepal width	0.4-0.6(0.8)	1.3-1.6	0.4-0.5	(0.3)0.4-0.6	0.2-0.3
Anther shape	oblong	ovate	Oblong-ovate	oblong	Oblong
Anther length	0.5-0.6	0.7-0.8	0.6-0.7	0.4-0.6	0.5-0.6
Appendage	Triangular	Semicircular	Triangular	Tri-oblong	Triangular
Length μ m	30-40	100	450-500	500	400-500
Width μ m	70-85(90)	950	50-90	450	300-400
Ovary diam	0.3-0.4(4.5)	1.2-1.8	0.4-0.6	0.4-0.5	0.4-0.5
Style	0.3-0.5	0.8-1.2	0.1-0.3(0.4)	0.2-0.3	0.3-0.4
Stigma	1-1.2	2.3-2.8(3.1)	0.6-0.9	0.7-0.9(1.1)	2-4

(CAI); *ibid*, 30.8.1928, Mustafa & Sabet s.n. (CAI); *ibid*, 23.3.1956, Täckholm & El-Hadidi s.n. (CAI).

Di: On Cairo-Alexandria road, a little south of Amria, 2.4.1961, Täckholm s.n. (CAI); Cairo-Alexandria desert road, 110 km south Alexandria (N of Wadi Natroun, 21.9-.967, El Hadidi, El Sayed & Mahdi s.n. (CAI); Madinet El Sadat 15.10.2003, Shehata s.n. (MNF).

Nv: Tewfikia, Mansoura, 3.9.1975, Gazzar & Abdel Aziz s.n. (CAI); Mitghamer area, 6.8.1954, El Hadidi s.n. (CAI); Newly reclaimed farmland 6 km west of Katattba, 11.8.1985, Soliman s.n.(CAI);

Di: Cairo-Ismailia desert road, 12.5.1980, El-Bakry s.n. (CAI); EL-Bassayla (Arab Tufeila); Ismailia, 26.8.1981, Amer s.n. (CAI); Suez, 21.9.002, Turki & El-Shayeb s.n. (MNF).

Fruiting: August-September.

Grows preferably in saline alkali conditions, very common in Egypt (Mediterranean, Libyan Desert, Nile Valley and isthmie desert)

Distribution: N Africa (Libya, Egypt), Sudan, Palestine, SW Asia to Pakistan and India.

2- *CHENOLEA*

Small fleecy - a crescent shrub. Flowers hermaphrodite, or by abortion, polygamous. Perigonium urn-shaped, with 5, short, fleshy, somewhat keeled, woolly lobes, becoming indurate. Stamen 5, inserted at the bottom of the perigonium, anthers exerted. Ovary ovate, style divided into 2, filiform lobes. Utricles depressed, included in the unchanged but closed perigonium, pericarp membranous. Seed horizontal, testa membranous, embryo peripheral, albumen little or 0. About 3 species in S Africa and in the Sahara – Arabian region. Only *Chenolea arabica* known in Egypt.

Chenolea arabica (Boiss.) Diagn. Pl. Orient 12: 97 (1853).

Syn: *Bassia arabica* (Boiss) Maire & Weiller in Maire, Fl. Afr. Nord 8: 54 (1962); *Chenoleoides arabica* (Boiss.) Botsch., Bot. Zhurn. 61: 1409 (1976).

Type: Hab. in desertis jugi Tih Arabia petrea, Boissier.

Perennial undershrub densely branched. 50-70 cm high, 20-30 cm diameter, lower branches decumbent. Leaves pseudopetiolate, oblong-narrow ovate with obtuse tips, 18-30x1.2-2.5 mm. Inflorescence spicate with only one sessile flower in the axil of leaf like bract. Fruiting perianth slightly enlarged with the lobes membranous. Seeds wide ovate, pale to dark brown.

Representative specimens:

M: Sollum on the seashore, 22-25-9-1963, Täckholm, Boulos, Girgis, Zahran and El sayed s.n. (CAI); ibid, 4 mile south of the town, Osbon & Helmy, s.n. (CAI); El-Alamein 27-2-1963, Romee. s.n. (CAI); Burg El-Arab, 15-3-1928, Täckholm s.n. (CAI); Mariut, 25-3-1949, Täckholm s.n (CAI); Wadi Maged, Mariut 18-4-1972, Zahran s.n (CAI).

Fruiting: February - March.

Very rare in sandy soils in Egypt.

Distribution: Sahara-Arabian region, N Africa, Libya, Egypt, Syrian Desert in El-Tih and eastward to Mesopotamia.

3- *BASSIA*

Annual, rarely perennial herbs with herbaceous stem, leaves alternate, thin or succulent, sessile or with short petiole, linear, lanceolate, ovate, covered with simple hairs, obtuse, acute to acuminate tips. Bracts leaf like, lanceolate, oblong, ovate, entire, with obtuse to acuminate tips, covered with simple hairs. Flowers sessile, bisexual or rarely unisexual pistillate, solitary, or 2-4 in clusters in axil of bracts, in spicate inflorescence, perianth segments 5, membranous, glabrous, or tomentose - woolly, free or slightly connate, fruiting perianth accrescent, chartaceous, with horizontal spines; stamens 5, anther oblong - ovate; stigma 2-3, exerted, style short, ovule subsessile. Pericarp membranous free. Seed horizontal or vertical in a few bisexual flowers with hard testa, embryo annular or subannular, endosperm abundant or absent, meally. About 10 species mainly in Sahara-Arabian and the Irano-Turanian regions. Three species are known in Egypt.

1- *Bassia aegyptiaca* Turki, El Shayeb & Shehata sp. nova.

Type: Egypt, Mediterranean coastal land, Ras El-Hekma, (225 km west of Alexandria, long. 27° 51'), 22.5.2004, Turki, El-Shayeb & Shehata s.n. (MNF, holo- and isotypes).

Planta perennis, suffrutices. Caulibus suberectis, 40-70 cm longis. Folia vulgo angusta

oblongo alterna sessiles, 14-20 mm longo, 1-2 mm lato, acuta glauca. Pilis longis rectis. Flores plerumque 2, sessiles. Segmenta perianthii 5, membranacea, elliptica, basi affixa, 0.8-1.0 mm longus, stamina 5, stigmata 2. pericarpium accrescens, induratum hardened spinae provisae. Pollen isopolare, polyporatum.

Perennial, loosely branched undershrub, 40-70 cm high, 20-40 cm in diameter, branches alternate, blue green, lower branches decumbent, upper branches erect, internodes (3) 4-8 (10) mm long, hairy with more condensed hairs at upper parts. Leaves sessile, lorate-narrow oblong with acute tips, (11) 14-20 (23) mm long, 1-2 mm wide, hairy, with hairs multicellular, uniseriate, smooth or papillate. Bracts leaf-like, lorate, with obtuse to acute tips (4) 6-12 (16) mm long, 2-2.5 (3) mm wide, hairy. Inflorescence spicate, mostly with 2 flowers in the axile of each bract. Flowers sessile, bisexual or unisexual. Tepals 5, membranous, elliptic with entire margins and obtuse - acute tips, 8-9.5 (10) mm long, 0.4-0.5 mm wide, triangular, green blotch in upper 1/3-1/2 of the tepal, each tepal with one vein, outer surface covered with hairs. Stamens 5, exerted; filament white, linear, 1.2-1.4 mm long; anther oblong - ovate, 0.6-0.7 mm long, 0.4-0.5 mm wide including a 0.015-0.02 mm long, 0.05-0.09 mm wide, triangular appendage. Ovary ovoid, 0.4-0.5 x 0.4-0.6 mm; style cylindrical 0.1-0.3 (0.4) mm long; stigma 2, filiform, papillate, 0.6-0.9 mm long. Fruit achene, 1.3-1.4 (1.5) mm in diameter, fruiting perianth with radiating spines, spines longer than the disc 1.4 -1.7 (1.8) mm long. Seeds horizontal, oval, pale - dark brown, 0.9-1.2 x 0.5 - 0.7 mm.(Fig. 1).

Representative specimens:

M: Ras El-Hekma, 22-5-2004 Turki, El shayeb and Shehata s.n. (MNF); ibid. 28-3-2005 (MNF).

Fruiting: April - Mai.

Collected from sandy soils at the margins of a desert road.

2- *Bassia eriophora* (Schrad.) Asch. in Schweinf., Beitr. Fl. Aethiop. 187 (1867).

Syn: *Kochia eriophora* Shrad., Neues J. Bot.3 (3-4): 86 (1809).

Kochia latifolia Fresen., Mus. Senckenb. 1: 179 (1834); *Bassia latifolia* (Fresen) Asch. in Schweinf., Beitr. Fl. Aethiop.187 (1867).

Type: ad reu pestribus et arabiae petraeae ad ovadi Herbran

Annual small herb, 10-30 cm high, densely hairy with woolly hairs. Leaves sessile, linear, 15-20 mm long and 8-15 mm wide, with acute tips. Inflorescence spicate with only one sessile flower (rarely two) in dense fluffy woolly hairs in the axil of leaf like bracts. Fruiting perianth with radiating stout, incurved tips spines. Spines shorter than the disc. Seeds ovate, pale to dark brown.

Representative specimens:

Di: Wadi El-Humur, El-Ramla, Sinai, 14- 4-1973, Shabetai (K).

Dg: Om Ruthi, E Galala Qiblya 3/7-5-1887, Schweinfurth.(K); Wadi El-Ashar, Galala Qiblya, 27-3 -1983 Hassan (K).

Fruiting: March - Mai

Grows in the dry mountainous habitats.

Distribution: Egypt (mountainous habitats in Southern Sinai), Sudanian and Saharo - Sindian regions extending into Irano-Turanian territories.

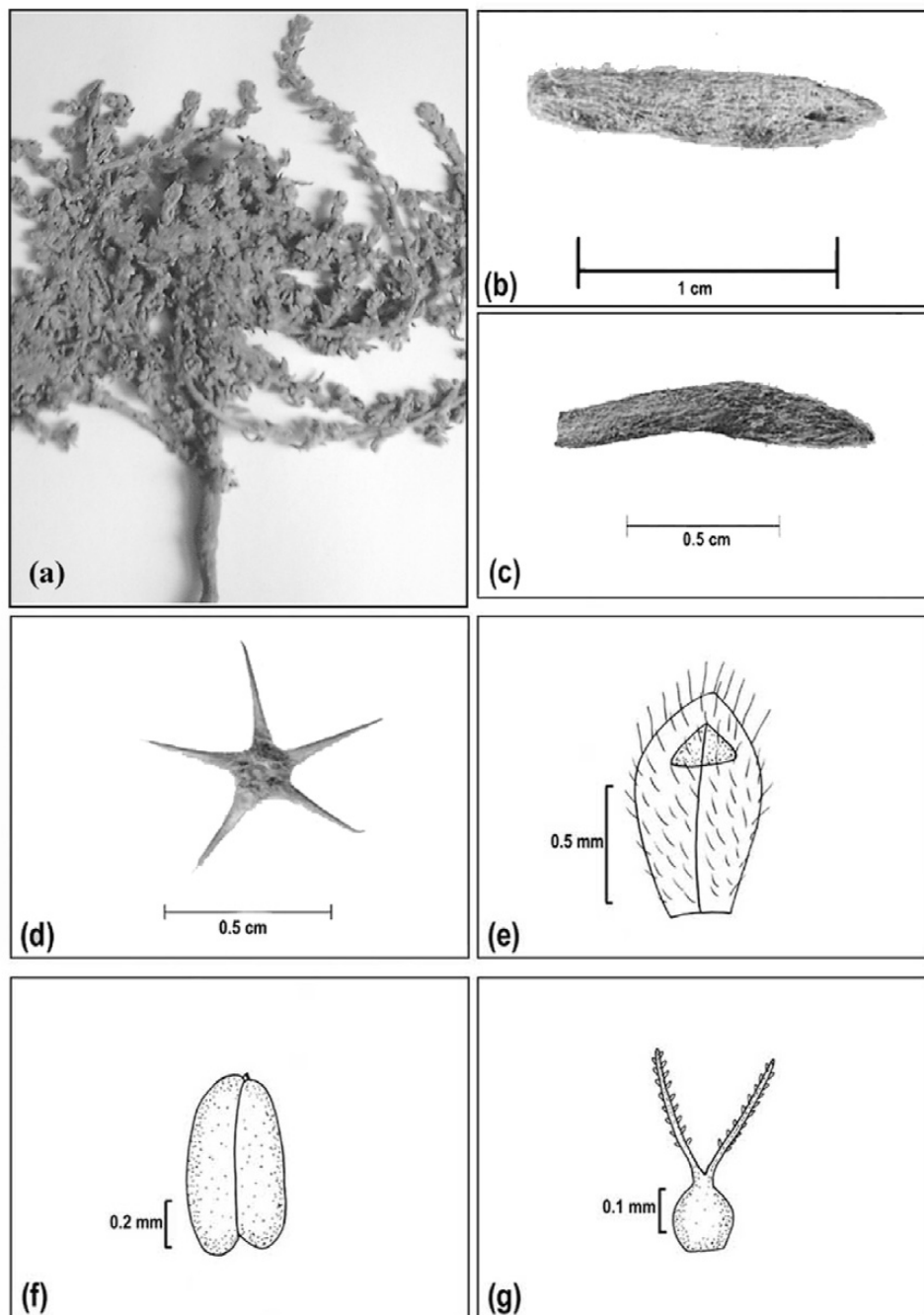


Fig. 1. *Bassia aegyptiaca*, photographs of: a. habit; b. leaf; c. bract; d. fruit; drawings of: e. tepal; f. anther; g. pistil.

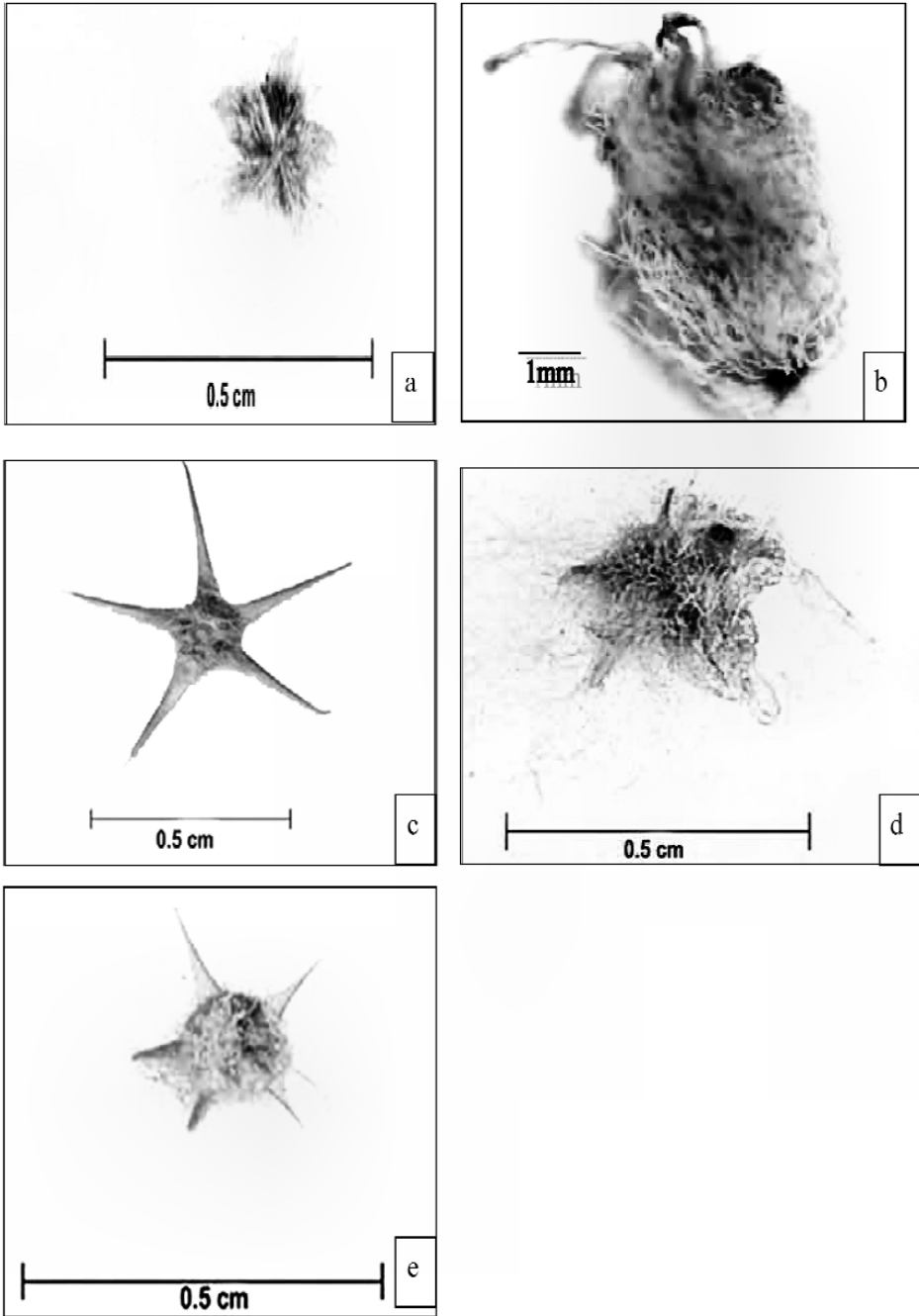


Fig. 2. Photographs of the fruits of the taxa studied: **a.** *Kochia indica*; **b.** *Chenolea arabica*; **c.** *Bassia aegyptiaca*; **d.** *Bassia eriophora*; **e.** *Bassia muricata*.

3- *Bassia muricata* (L.) Asch. in Schweinf., Beitr. Fl. Aethiop. 1:187 (1867).

Syns: *Salsola muricata* L. Mant. 54 (1767); *Kochia muricata* (L.) Schrad., Neues. J. Bot. 3 (3-4):86 (1809).

Type: Heb. Linn. 315/22 (Linn.).

Annual densely branched herb, differ widely in habit, lower branches decumbent. Leaves sessile, linear-narrow elliptic, 10-20 mm long and 1.5-2.0 mm wide, with acute-acuminate tips. Inflorescence spicate, with 1-3 sessile flowers in the axils of leaf like bracts. Fruiting perianth with radiating spines, spines longer than the disc. Seeds orbicular, pale-dark brown.

Representative specimens:

M: 25 km East Marsa Matrouh, 1-4-1972, Täckholm s.n. (CAI); Ras El-Hekma, 25-5-1954, Migahid and Abd El Shafey s.n. (CAI); *ibid*, 22-5-2004 Turki, El shayeb and Shehata s.n. (MNF); On the way of Burg El-Arab - El Alamein, 1-6-1964, Täckholm, Boulos, and Mahdi s.n. (CAI); Burge El-Arab, 1-4-1960, El-Batanouny s.n.(CAI); El-Arish, 12-7-1955, Diab s.n. (CAI); *ibid*, 3-2-1956, Boulos s.n. (CAI).

DL: Siwa - Mersa Matrouh desert road, 15-4-1986, Fahmy s.n. (CAI).

Nv: Between Giza Pyramid and the village Kirdasa, 10-11-1926, Täckholm s.n. (CAI); N. of the Giza Pyramid, 5-11-1926, Täckholm s.n. (CAI); Gebel Asfar NE of Cairo, 5-11-1926, Täckholm s.n. (CAI); Madinet Naser, Cairo, May 1973, El-Gazzar s.n. (CAI).

Di: Cairo-Ismalia desert road, 9-3-1981, El-Bakry s.n. (CAI); Seuz road, Kilo 22, April 1955, El-Hadidi s.n. (CAI); Cairo-Seuz road, 87km from Cairo, 12-1-1978, Kassas *et al* s.n. (CAI).

Fruiting: March - Mai

Common herb in sandy soils and at the margins of desert roads.

Distribution: Egypt, Saharo-Arabian and Irano-Turanian territories.

Stem anatomy (Fig. 3)

1- *Kochia indica*

In young stem, the outline in cross section is terete with slightly ridged margins 2.0-2.3 mm in diameter, hairy; hairs multicellular, uniseriate, papillate and smooth, with swollen basal cell and acute apical cell. Epidermis consists of one layer, covered with wavy cutine with cells more or less pentagonal in shape. Cortex is wide, consists of 2-3 outer layers of collenchyma, which are of pentagonal-hexagonal cells, followed by 3-4 layers of irregularly, flattened parenchyma with well defined sand crystals; endodermis is well defined, pericycle is in the form of sclerenchymatous patches facing vascular bundles; vascular cylinder is composed of 16-18 vascular bundles; the vascular bundles are equidistant from the centre of stem; vascular bundles separated by medullary rays; phloem 2-4 layers, cambium 1-3 layers; xylem vessels angular, arranged in rows; pith 1200 µm in wide, consists of pentagonal - polygonal thick walled parenchyma, with well represented sand crystals.

2- *Chenolea arabica*

In young stem the outline of stem in cross section is wavy terete, 0.9-1 mm diameter, hairy; hairs, multicellular, uniseriate, papillate covered with wavy cutine with swollen

basal cell and acute apical cell. Epidermis consists of one layer with more or less pentagonal cell. Cortex consists of 1-2 layers of collenchyma which are pentagonal to hexagonal cell followed by 1-2 layers of irregularly shaped parenchyma; pericycle in the form of sclerenchymatous patches facing vascular bundles; vascular cylinder composed of 9-10 vascular bundles, the vascular bundles are equidistant from the centre of stem vascular bundles separated by medullary rays; phloem 3-4 layers; cambium 1-2 layers; angular xylem vessels are arranged in rows, pith 440µm, consists of polygonal thin-walled parenchyma with well represented sand crystals.

3- *Bassia*

3.1- *Bassia aegyptiaca*

The anatomical feature is built on the same plan as that of *Chenolea arabica* except in the following:

1-Epidermis is wider with tangentially elongated cells. 2- Cortex twice as wide as *C. arabica*, with collenchyma more or less isodiametric. 3- Druses in pith absent. 4-Number of vessels is less than in *C. arabica*. 5-Vessel diameter is wider. 6-Pith is wider and consisting of hexagonal thin-walled parenchyma.

3.2- *Bassia muricata*

The anatomical feature is built on the same plan as that of *Chenolea arabica* except in the following:

1-Epidermis with more or less tetragonal cell, cell more widely. 2-Cortex more than twice as wide as in *C. arabica*, with collenchyma cells semicircular and parenchyma polygonal with well defined sand crystals. 3-Number of vessels is more than that in *C. arabica* ranging from 10-13. 4-Veselle diameter is wider up to 40 µm. 5-Pith is very wide, up to 1050 µm.

Table 3. Anatomical characters and measurements of the stem of the studied taxa (+ present; - absent).

Characters Species	Epidermis Width µm	Cortex			Pith		No. of bundles	Vessel diam. µm
		Width	Sand in coll	Sand in paren	Sand & Druses	Width in µm		
<i>Kochia indica</i>	15	125	-	+	Druses	120	16-18	40
<i>Chenolea arabica</i>	15	60	-	+	+	440	9-10	15
<i>Bassia aegyptiaca</i>	18	120	-	+	-	700	7-8	25
<i>Bassia muricata</i> ,	19	150	-	+	-	1050	10-13	40
<i>Bassia eriophora</i>	20	40	-	+	+	950	10-11	15

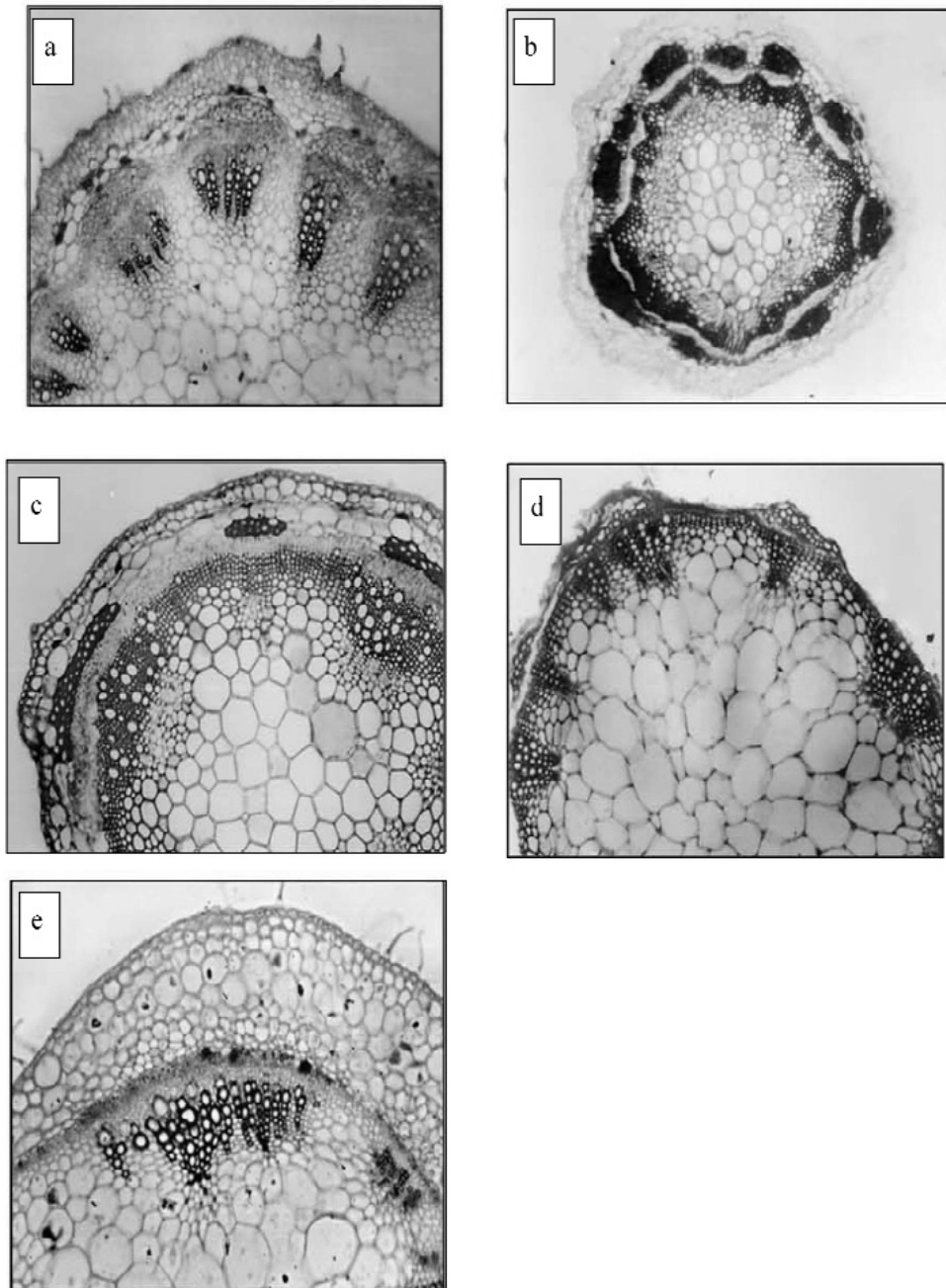


Fig. 3. Photographs of the anatomical structure of young stems of the taxa studied: **a.** *Kochia indica*; **b.** *Chenolea arabica*; **c.** *Bassia aegyptiaca*; **d.** *Bassia eriophora*; **e.** *Bassia muricata*.

3.3- *Bassia eriophora*

In young stem, the outline of stem in cross section is terete with slightly ridged margins about 1.4 mm in diameter, pericycle in the form of sclerenchymatous patches facing vascular bundles. Vascular cylinder composed of 10-11 vascular bundles; the vascular bundles are equidistant from the centre of stem. Vascular bundle separated by medullary rays in young stem, phloem 1-2 layers, cambium 1-2 layers, angular xylem vessels arranged in rows; pith 950 μm wide, consists of polygonal, thin-walled parenchyma, with well represented sand crystals.

SEM of the pollen grains

Cumulative tables and plates showing similarities and dissimilarities among the taxa studied were designed (Tables 4 & Fig. 4).

The pollen grains in all studied taxa appeared to be relatively uniform in shape, all are pantoporate, spinulose. The species have been grouped in two groups according to the pollen size:

- (1) Small pollen (up to 22 μm) in *K. indica*, *B. aegyptiaca*, and *B. muricata*.
- (2) Medium-sized pollen (25-27 μm) in *Chenolea arabica* and *B. eriophora*.

Table 4. Pollen characters of the studied taxa (S: Smooth; P: Punctate).

<i>Taxon</i>		<i>Kochia indica</i>	<i>Chenolea arabica</i>	<i>Bassia aegyptiaca</i>	<i>Bassia muricata</i>	<i>Bassia eriophora</i>
Characters						
Diameter (μm)		21	25	22	16	25
Aperture/pollen diameter		0.058	0.055	0.0514	0.085	0.063
Spines on the tectum	Many					+
	Medium	+	+		+	
	Few			+		
Aperture level	Raised					
	Sunken	Slightly	+	+	+	+
Spines inside the aperture	Many	+				+
	Medium				+	
	Few		+	+		
Exine		S	P	P	S	P
No of Aperture		43	33	36	28	32
Width of aperture (μm)		1.25	1.38	1.0	1.25	1.5

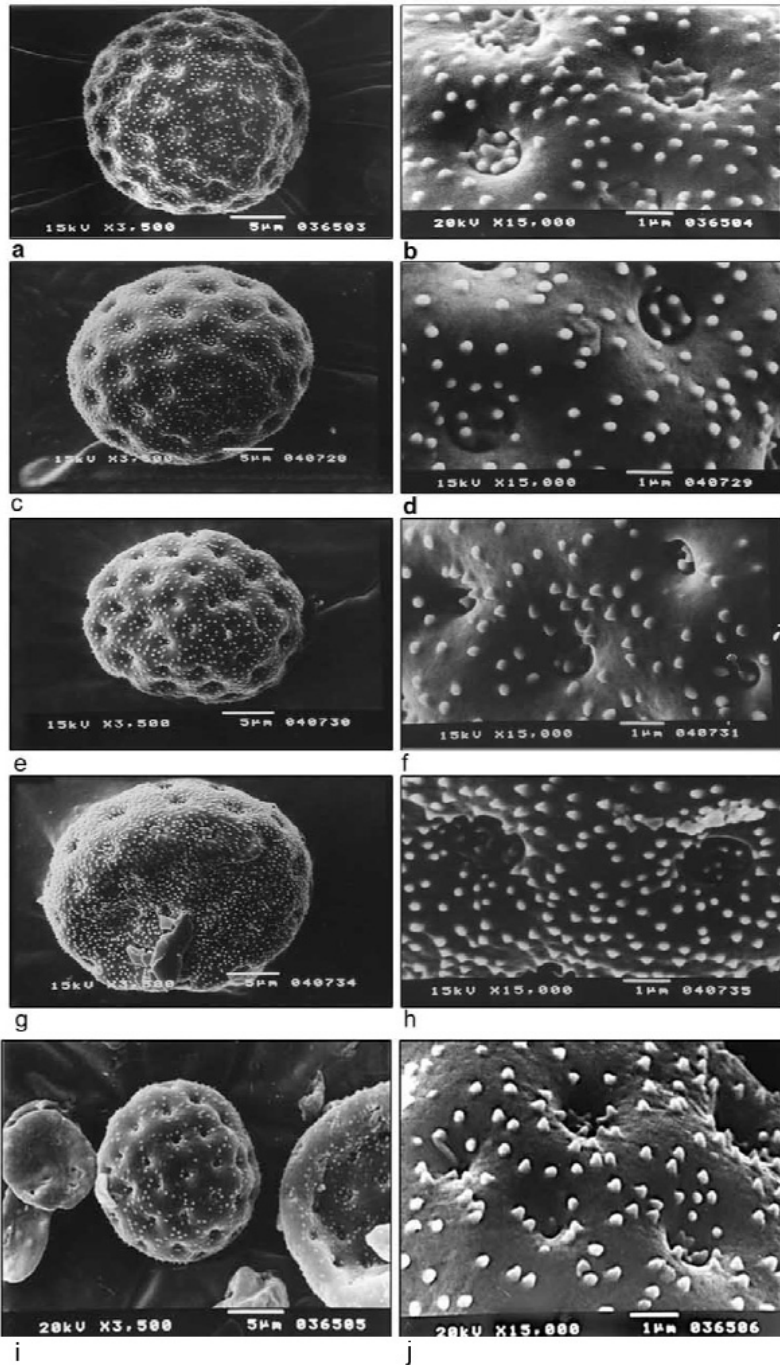


Fig. 4. SEM micrographs of pollen grains of the taxa studied: **a-b.** *Kochia indica*; **c-d.** *Chenolea arabica*; **e-f.** *Bassia aegyptiaca*; **g-h.** *Bassia eriophora*; **i-j.** *Bassia muricata*.

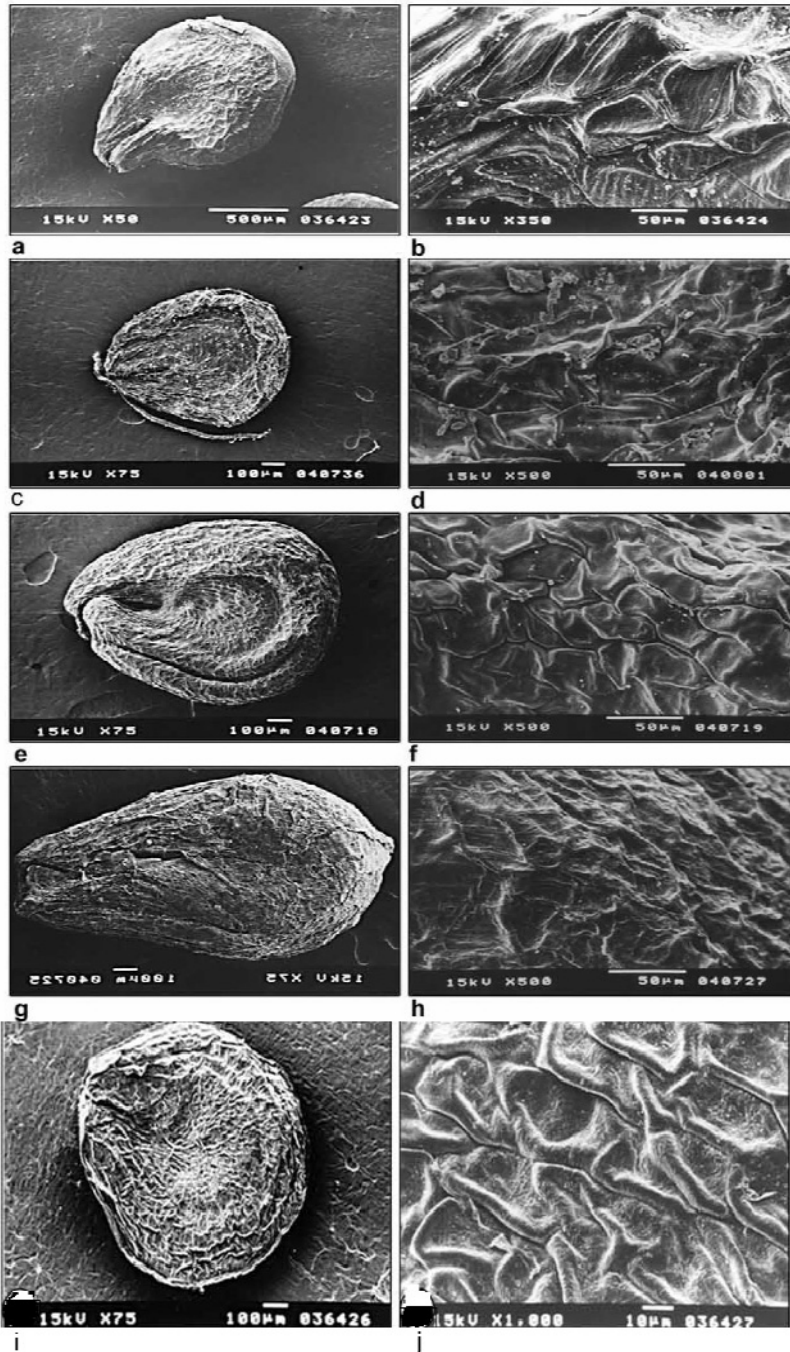


Fig. 5. SEM micrographs of pollen grains of the taxa studied: **a-b.** *Kochia indica*; **c-d.** *Chenolea arabica*; **e-f.** *Bassia aegyptiaca*; **g-h.** *Bassia eriophora*; **i-j.** *Bassia muricata*.

Spinules are homogeneously distributed over all the grains except in *Bassia muricata*, they are concentrated around the pores. Species can be differentiated into two groups according to the pollen tectum; punctate in *Chenolea arabica*, *Bassia aegyptiaca*, *B. eriophora* and *B. muricata* and smooth in *Kochia indica*.

As to mesoporial exine level, pollen grains were distinguished into: sunken (*Bassia muricata*, *Chenolea arabica* and *Kochia indica*), deeply sunken (*Bassia aegyptiaca*) and the same level (*Bassia eriophora*). In addition, there were some differences in the number of mesoporial exine spinules ranging from 3-4 in pollen grains of perennial taxa (*Chenolea arabica* and *Bassia aegyptiaca*); 5-6 in *Bassia muricata* and 8-10 in *Kochia indica* and *Bassia eriophora*.

SEM of the spermoderm

Reticulation of the anticlinal walls

The seed surface reticulation is simple, with tetragonal – pentagonal epidermal cells having straight anticlinal walls with normal thickening (Table 5 & Fig. 5). This pattern is considered here as the basic type and is recorded in *Kochia indica*. Such aspect is disturbed to various degrees in the anticlinal walls, their thickening and undulation in the remainder taxa. Epidermal cell irregular, having anticlinal walls straight and thick (*Chenolea arabica*, *Bassia muricata*), slightly undulate and wavy (*Bassia aegyptiaca* and *Bassia eriophora*).

Outer periclinal walls

The outer cell wall, as regards its shape in the surface view, may be flat (*Kochia indica*), concave (*Bassia aegyptiaca*, *B. eriophora* & *B. muricata*) and convex (*Chenolea arabica*)

Table 5. The seed testa characters of the studied taxa.

Species /Characters	1	2	3	4	5
Length (mm)	1.4	0.83	1.1	1.5	1.1
Wide (mm)	1.1	0.7	0.91	0.95	0.95
Shape	Wide elliptic	Wide ovate	Wide ovate	Narrow ovate	Suborbiculate
Hilum/Seed	0.3	0.4	0.34	2.8	0.3
Outline of cell boundary	Tetragonal - pentagonal	Irregularly shaped	Irregularly shaped	Reticulate	Irregularly shaped
Relief of cell boundary	Channeled	Raised	Channeled	Raised	At the same level
Curvature of outer periclinal wall	Flat	Convex	Concave	Slightly concave	Flat
Texture	Striated	Smooth	Smooth	Reticulate	Granulated
Anticlinal wall	Straight, thick	Straight, thick	Slightly wavy	Wavy, slightly raised, slightly thick	Slightly wavy, thin, At the same level

Discussion

Several attempts have been made in distinguishing and identification of the genera *Bassia*, *Chenolea* and *Kochia*. Boissier (1879) and Post (1883) united *Bassia*, *Kochia* under the name *Kochia*. Maire (1962) proposed to include *Chenolea* to *Bassia*. However many recent floras have retained *Bassia*, *Chenolea* and *Kochia* as separate genera. Scott (1978), on the bases of morphological characters, proposed to submerge species of *Chenolea* and *Kochia* into *Bassia*.

The different morphological characteristics of the studied taxa revealed that they varied from each other and can be distinguished in the field depending on the habit of the stem, length and width of basal leaves and fruit appendages (Fig. 2).

The use of anatomical method in taxonomic investigation is becoming of increasing interest. Anatomical structure is most likely providing evidence helping to establish the affinities of genera of uncertain taxonomic status, yet in the same time proves very helpful for individual identification (Welkie & al. 1970 and Osmond & al. 1980). Denford (1980) reported that differences in epidermal characters of comparable organs seem always to reflect genetic differences in the plants. Zaki & al. (1991) proved that the characters of the epidermal cells, the cortical zone and vascular cylinder of the young stem provided reliable characters for the distinction of closely allied species of section *Tamarix*. Waly (1999) proved that wood anatomical characters were found useful for the identification of *Tamarix* species.

The studied taxa displayed remarkable differences in the anatomical investigations of their stems. Comparison of the internal structure of the stems revealed differences in thickness of epidermis, cortex, number of vascular bundles, and xylem and pith diameter. Table (3) & Fig. (3).

Kasetsinsombat & al. (2000) reported that pollen morphology has a taxonomic value and can be used as supporting evidence to the morphological and phylogenetic studies.

Study of pollen grains by SEM indicated the presence of differences represented in: density and distribution of spinules on the pollen surface, number of apertures, pollen exine punctate or smooth, and number of mesoporial spinules.

Table 6. The proposed treatment of the Egyptian taxa, based on numerical analysis.

Genus	Group	Taxon	Cluster	Serie
<i>Kochia</i>	GR ₁	<i>Kochia indica</i>	→ C ₁	S ₁
<i>Bassia</i>	GR ₂	<i>Bassia aegyptiaca</i>	→ C ₂	
	GR ₃	<i>Bassia muricata</i>		
	GR ₄	<i>Bassia eriophora</i>		
<i>Chenolea</i>	GR ₅	<i>Chenolea arabica</i>	→ C ₃	S ₂

Anticlinal undulations and characters of cell boundaries in the seed exine are of high taxonomic significance and often characterize between the species and genus level (Barthlott & Voit 1979; Barthlott 1981).

The results of spermoderm SEM revealed differences in relief of cell boundaries and characteristics of both periclinal and anticlinal walls.

The relationships between the studied taxa based on morphological data as based on the average taxonomic distance (dissimilarity) is represented in table (6). The phenogram constructed according to analysis of 53 macromorphological characters revealed the delimiting of the studied taxa into three major phenetic lines which largely correspond to the three genera of subtribe Kochiinae represented in Egypt. In the first line at a distance of about 1.72 the studied taxa are separated into two series. The first series included *Chenolea arabica* which was delimited from the other taxa and characterized by its perennial habit and unchanged fruiting perianth. The second series was distinguished at a distance of about 1.56 into two clusters including the genera *Kochia* and *Bassia*. The first cluster included *Kochia indica* which was characterized by winged fruiting perianth and large seeds which are black with brownish dots. In the second cluster the three studied species of the genus *Bassia* are grouped together. *B. eriophora* is distinguished from the other two at a distance level of 1.39. *B. aegyptiaca* is distinguished from *B. muricata* at a distance level 1.25.

The present study, depending on the results of macromorphological and anatomical investigations, SEM studies on pollen grains and seeds clearly indicates considerably differences between the three studied genera *Bassia*, *Chenolea* and *Kochia*, and support the treatment of them as different genera. The results contradict the grouping of them in one genus as done by Scott (1978).

Key to the genera:

1. - Fruiting perianth winged, seeds 1.5-1.8 mm long, elliptic, testa black with brownish dots, cell boundary tetragonal to pentagonal, texture striated..... ***Kochia***
1. - Fruiting perianth spiny or unchanged, seeds 0.9-1.3 mm long, narrowly -widely ovate, testa pale to dark brown; cell boundary neither tetragonal nor pentagonal, texture not striated **2**
2. - Perennial undershrub, fruiting perianth unspiny, anther with a semicircular appendage, hairs papillate, outer periclinal wall of spermoderm convex..... ***Chenolea***
- 2.- Annual or perennial herb, fruiting perianth spiny, anther with a triangular -oblong appendage, hairs smooth and papillate, outer periclinal wall of spermoderm concave ***Bassia***

Key to the *Bassia* species

- 1a. - Perennial, pollen aperture up to 1.0 μm wide..... ***B. aegyptiaca***
- 1b. - Annual, pollen aperture 1.3-2.4 μm wide..... **2**
- 2a. - Flowers in dense fluffy woolly hairs, stigma 2-3.5 mm, hilum/seed ratio more than 0.4 ***B. eriophora***
- 2b. - Flowers exposed with loose hairs, stigma 1-1.8 mm, hilum/seed ratio less than 0.4..... ***B. muricata***

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