

Cleomaceae as a Distinct Family in the Flora of Egypt

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ABSTRACT

The present paper suggests separating Cleomaceae as a distinct family (with *Cleome* and *Dipterygium*) from Capparaceae. It is a more detailed revision to the Egyptian species of *Cleomaceae*, including morphological descriptions based on a large amount of herbarium material that has been checked. The geographical distribution of the studied species varies greatly. This paper recognized 10 species of *Cleome*, and also adds further evidence for the suggestion that *Cleome gynandra* is closely related to *Cleome hanburyana*.

Keywords: *Cleome*, *Dipterygium*, taxonomy

INTRODUCTION

The two major subfamilies of Capparaceae, Cleomoideae and Capparoidae, are quite distinct and have even been elevated to familial status by some authors (Airy Shaw 1965; Hutchinson 1967). Capparoidae (about 25 genera and 440 species) are typically woody (shrubs to small trees) and have dehiscent or indehiscent fruits, which are fleshy. Cleomoideae (about 8 genera and 275 species) are generally herbaceous and have dehiscent fruits with repla. The genus *Cleome* is by far the largest of almost cosmopolitan spread (Rankin 2003) with about 425 binomials listed in the database version of Index Kewensis (1997), and houses the majority of the species (200 species).

Cleomaceae is represented in the wild Egyptian flora by 2 genera and 10 species of wide ecological and geographical range of distribution (Täckholm 1974); the largest is *Cleome* with 9 species. *Gynandropsis gynandra* was included by Boissier (1867) under *Cleome pentaphylla* while Iltis (1957-1960), De Wolfe (1962), Ernst (1963), Thulin (1993), Stewart (1972), Ridly (1967) and El Hadidi and Fayed (1994-1995) gave convincing reasons for retaining this species under *Cleome* and treated it as *Cleome gynandra*. However, in the recent past, Jafri (1970), Täckholm (1974), and Boulos (1999, 2009) treated it as belonging to a separate genus, *G. gynandra*. The monotypic genera are represented by *Dipterygium*. Taking into account the new results of molecular systematics (Kubitzki 2002), it is inappropriate to maintain the two families (Capparaceae and Cleomaceae) as they are traditionally defined. Hall *et al.* (2002), who recognized that Capparaceae inclusive of Cleomoideae would be paraphyletic, recommended the recognition of smaller, monophyletic family units instead. In this work, the approach of Hall *et al.* (2002) is adopted, and will accept Cruciferae Adans., Capparaceae Adans. and Cleomaceae Horan. as separate families.

Earlier studies on Cleomaceae in Egypt focused mainly on morphology and anatomy (Al Gohary 1982; Khalifa and Al Gohary 1982), seed morphology (Al Gohary 1997) and pollen morphology (Khafagi and Al-Gohary 1998). The systematic treatment and phylogenetic affinities of the Egyptian species of *Cleome* are still obscured, and unsolved problems concerning their biology and taxonomy need further verification and confirmation. Khalifa *et al.* (1984) presumed evolutionary trends in nine *Cleome* species of Egypt, together with *Dipterygium glaucum* and *G. gynandra* by

evaluation of their macro-morphological attributes, habit and duration according to the bases of different phylogenetic systems.

The objectives of this study are to give an updated survey of the occurrence of members of the Cleomaceae in Egypt. It also tries to address the question whether *G. gynandra* must be treated as a separate genus from *Cleome* or restoring it to *Cleome* (*C. gynandra*), and to give data on local geographical distribution in order to permit easier identification of material for further investigations.

MATERIALS AND METHODS

The materials used in this study were fresh materials and herbarium specimens. The locations were accurately located using GPS. The herbarium specimens of the different species were obtained from the major herbaria in Egypt: Cairo University Herbarium (CAI), the Herbarium Section of the Ministry of Agriculture (CAIM), National Research Center (CAIRC) and Desert Research Centre (DRC). Herbaria abbreviations were according to Holmgren *et al.* (1990).

Fresh materials were recorded and collected from their natural habitats during the 2006-2008 growing seasons: Mediterranean coastal lands; Libyan, Isthmic and Arabian Deserts; Nile valley, Faiyum, Sinai, and Gebel Elba district. The specimens were examined with a Wild stereo-microscope. For every species vegetative, floral, fruit characters, and seeds, as well as nomenclatural information, details on distribution and habitat were recorded. Phytogeographical territories for the selected specimens are those proposed by El Hadidi (2000) (Fig. 1).

SYSTEMATIC TREATMENT

CLEOMACEAE (Pax) Airy-Shaw

Herbs or subshrubs. Leaves alternate, simple or digitate, glandular, flowers zygomorphic, stamens few to many, fruit a capsule with persistent replum.

Key to the studied genera

- 1.a. Fruit circular, surrounded by membranous wing, one seeded *Dipterygium*
- 1.b. Fruit linear oblong, many seeded *Cleome*

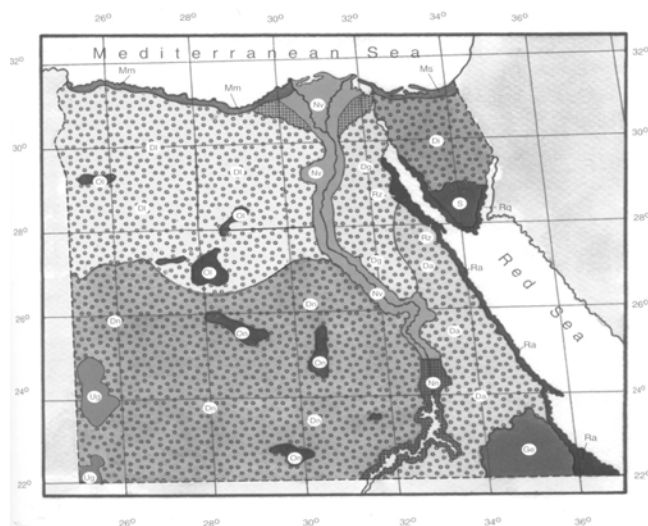


Fig. 1 Phytogeographical territories of Egypt. M: Mediterranean coastal Land, Mm: Mareotis sector, Ms: Sinatic sector, DI: Libyan desert, Dn: Nubian desert, Di: Isthmic desert, Dg: Galala desert, Da: Arabian desert, Nv: Nile Valley sector of the Nile land, Nn: Nubian sector of the Nile land, O: Oasis of DI & Dn (OI, On), S: Southern mountainous Sinai, R: Red Sea coastal plains (Ra, Rz, Rq), Ge: Gebel Elba district; Ug: Gebel Uweinat area. After El Hadidi (2000).

1. *Dipterygium Dene*

Small shrublets; leaves simple, small, short petioled; flowers small, bisexual in lax raceme, actinomorphic; sepals 4; petals 4; stamens 6, equal; fruit nutlike, indehiscent, 1-seeded, surrounded by a scarious wing. One species distributed in Egypt, East Africa, Arabia to Pakistan.

1.1. *Dipterygium glaucum* Dene., Ann. Sci. Nat. Bot., sér.2, 4: 67 (1835). (Fig. 3C, 4C, 5D)

Perennial herbs or subshrubs, 30–60 cm, straight rigid divaricate, much branched, glandular; leaves small mostly deciduous, simple, Inflorescence terminal, lax raceme; pedicel short (1–2 mm), glandular erect; flower, 3–4 mm, bracteate; sepals 4, connate at base, glandular; petals 4, short claw; stamens 6, filament shorter than petals fruit pedicel 2–2.5 mm; fruit dry, indehiscent or schizocarpic, 3.5–5 × 2–3.5 mm, one-seeded; seeds smooth, glabrous, brown, obovate, 1.5–2 × 1 mm.

Representative specimens: (Ra) Wadi Lahmi, Red Sea coast, 11.2.1961, *Täckholm & Kassas* s.n. (CAI); Red Sea coast, 11.2.1961, *Täckholm & Kassas* s.n. (CAI); (Da) Little gully, Wadi el Allaqi, 27.1.1963, *Täckholm & Kassas* s.n. (CAI); (Ge) Wadi hodein, 14.1. 1930, *Täckholm, V.* s.n. (CAI); Wadi Muqs at the foot of Gebel Elba, 21.1.1963, *Kassas* s.n. (CAI); Shalateen, Wadi Hodeen, 13.01.2005, 22:39:54 N, and 35:20:29 E, *Kadry El-Sayed* s.n. (Suez Canal Univ. Herb.); Shalateen, Wadi Abu Girfan, 11.01.2005, 22:34:01 N, and 35:41:82 E, *Kadry El-Sayed* s.n. (Suez Canal Univ. Herb.).

Distribution in Egypt: Ra, Da, Ge sandy and gravely deserts.

General distribution: Egypt, Sudan, Ethiopia, Somalia, Djibouti, Saudi Arabia, Iran.

2. *Cleome L.*

Annual or perennial herbs or half-shrubs, glandular or glabrous. Leaves simple or composed of 3–7 leaflets. Flowers bisexual, solitary or in racemes, actinomorphic or zygomorphic, white, yellow or purple. Sepals 4, free or connate, sometimes caduceus. Petals 4, with or without claw. Stamens 4 to numerous, inserted on a torus or a short androphore. Ovary more or less short stipitate, 2-carpelled, 1-loculed with a replum, ovary many, on two parietal placentae; style very short or absent. Fruit a capsule, opening by 2

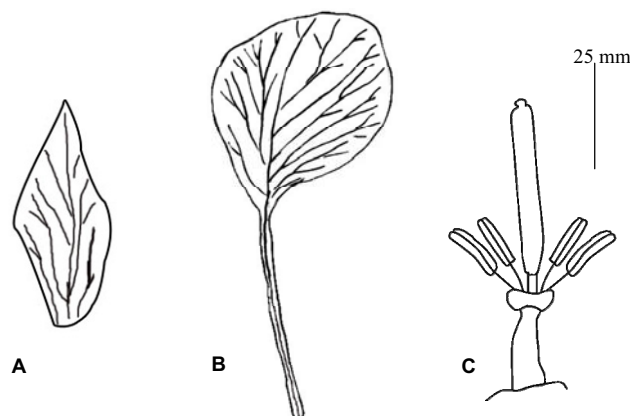


Fig. 2 Flower parts of *Cleome gynandra*. (A) Calyx; (B) long clawed petal; (C) stamens and ovary with androgynophore.

membranous valves separating from replum. Seeds reniform, asperulous or wooly. 150 species in tropical and warm regions.

Key to the species of *Cleome*

- 1.a Stamens born on conspicuous androgynophore ... *C. gynandra*
- 1.b. Stamens not born on androgynophore 2
- 2.a. Leaves simple 3
- 2.b. Leaves digitate (1-) 3–5 foliate..... 4
- 3.a. Inflorescence terminal; stamens 6 *C. scaposa*
- 3.b. Inflorescence axillary, stamens otherwise 5
- 4.a. Plant glabrous *C. paradoxa*
- 4.b. Plant glandular or viscid 6
- 5.a. Fruit pedicel erect; stamens 4 *C. droserifolia*
- 5.b. Fruit pedicel curved; stamens (8–10) *C. chrysantha*
- 6.a. Petals clawed; seeds lanate 7
- 6.b. Petals not clawed; seeds glabrous 8
- 7.a. Leaves narrowly oblong; fruit with longitudinal veins *C. amblyocarpa*
- 7.b. Leaves ovate; fruit without veins..... *C. arabica*
- 8.a. Stamens 6 *C. brachycarpa*
- 8.b. Stamens 8–10 9
- 9.a. Gynophore absent, fruit longitudinal nerved..... *C. viscosa*
- 9.b. Gynophore present, fruit obliquely striated nerved *C. hanburyana*

2.1. *Cleome gynandra* L., Sp. Pl., ed. 1, 671 (1753). (Fig. 2, 3D, 4B)

Syns.: *Cleome pentaphyla* L., Sp. Pl., ed. 2, 938 (1763). *Gynandropsis gynandra* (L.) Briq. Conserv. Jard. Bot. Genève 17: 382 (1941).

Type: Habitat in Asia, Africa, America Callidissimis. Annual herbs, 15–60 (90) cm, glandular pubescent to glabrous, erect or ascending, widely branched from base; leaves, 3–5 foliate, unequal; leaflets thinly glandular puberulous, obovate or elliptic, 0.2–0.4 (7) × 1–3.5 cm, obtuse or acuminate, denticulate to ciliate; inflorescence terminal, corymbose raceme; flower 1–2 cm, petals white or pinkish yellow, orbicular above, attenuate to long claw, 6–12 mm with 3–7 mm claw, obtuse; stamens 6 (10), 2–2.5 mm, small filament 0.5 mm, androphore present, shorter than petals; gynophore glabrous, 4–10 mm long; ovary 5–7 mm, oblong elliptic; fruits dry capsule, valves with longitudinal, centripetal veins. As weed cultivation.

Representative specimens: (Dg) Ismailia, Abu Soweir, in cultivated land of Mango and vegetables, 12.09.2004, *Abd El-Hameid, H* s.n. (Suez Canal Univ. Herb.); (Da) Nag Kassab, Abu Simbel, east of the Nile, 26.12.1963, *Ramadan, A* (DRC).

Distribution in Egypt: Dg, Da, as weed of cultivation.

General distribution: Widely distributed as weed of cultivation

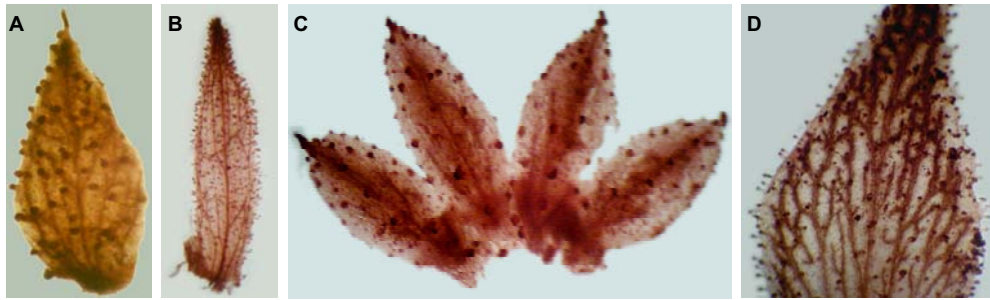


Fig. 3 Calyx forms of some studied species (X25). (A) *Cleome brachycarpa* with glandular ovate sepals; (B) *Cleome hanburyana* with glandular, oblong, slightly connate at base sepals; (C) *Dipterygium glaucum* with sepals connate at base; (D) *Cleome gynandra* with glandular puberulous, lanceolate oblong sepals.

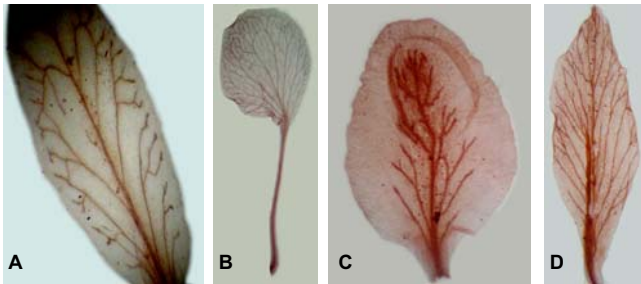


Fig. 4 Petal forms (X25). (A) *Cleome amblyocarpa*; (B) *Cleome gynandra*; (C) *Dipterygium glaucum*; (D) *Cleome brachycarpa*.

in tropical and subtropical regions of the world.

2.2. *Cleome scaposa* DC., Prodr. 1: 239 (1824).

Syn.: *Cleome papillosa* T. Anderson, J. Proc. Linn. Soc. Bot. 5, Suppl. 1: 3 (1860), nom. illeg. Steud., Nomencl. Bot. (2nd Edn), 1: 382 (1840).

Type: In Aegypto Coll. Ign. (G).

Annual or perennial herbs, 10–30 cm, erect, slightly branched from base villous and glandular hairy; leaf simple, scabrous or papillose, suborbical to ovate elliptic, 1–2.5 × 0.5–1.8 cm, margin glandular hairy, acute, attenuate at base with 0.3–0.5 cm petiole; inflorescence terminal, lax raceme; flower minute 3–5 mm; sepals 4, basely connate, equal 1.5–2 mm long; petals 4, white or pinkish turning pale yellow, 3–4 × 1.5–2 mm; stamens 6, 2–3.5 × 0.05–0.15 cm; capsule linear, slightly curved, dehiscent by 2 valves, 1.2 cm long pedicel, glabrous to slightly glandular, peak present; seeds many, minutely granulate.

Representative specimens: (Ge) Gebel Elba; Wadi Haiteim, 27.1.1962, *El Hadidi* s.n. (CAI).

Distribution in Egypt: (Ge); sandy and rocky soils.

General Distribution: North Africa, Saudi Arabia, Pakistan.

2.3. *Cleome droserifolia* (Forssk.) Delile, Descr. Egypte. Hist. Nat. 250 (1814).

Syn. *Rodularia droserifolia* Forssk., Fl. Aegypt.-Arab. 35 (1775). Half shrubs, 20–60 cm, ascending, profusely and intricately branched, densely glandular hispid; leaf simple, thick, yellowish green, densely covered with short simple hairs and long stipitate glands, orbicular or broadly ovate, 0.5–1.5 × 0.7–1.7 cm acute or mucronate, 3 nerved; flower 10–12 mm long; sepals ± symmetric, dimorphic densely glandular; petals, yellow, unequal, anterior petals oblong ovate 8–10 × 3 mm, posterior petals oblong, 7–7.5 × 1–1.5 mm, acute to acuminate, appendiculate with scale-like appendages; capsule siliquiform, glandular, dehiscent by 2 valves, with 2 mm peak, replum present; seeds many, glabrous, minutely granulate.



Fig. 5 Different forms of gynoeceum (X25). (A) *Cleome amblyocarpa* with gynophore and short style; (B) *Cleome brachycarpa* with distinct long style; (C) *Cleome paradoxa* with oblong ovary and short gynophore; (D) *Dipterygium glaucum* with distinct style and capitate stigma.

Representative specimens: (Dg) Wadi Aber, Gebel Ataqa, Suez, 8.4.1967, *Täckholm* s.n. (CAI); Wadi Hagoul, 86 km of Cairo–Suez road, 5.2.1982, *Hassan* s.n. (CAI); (Ra) Bir Um Einaba of Gebel El shayeb, Red Sea, 11.2.1966, *Täckholm & Kassas* s.n. (CAI); (S) Sinai, Nuaiba-Dahab Road, on rocks, 09.10.2004, N:28:29:04, and E:34:29:41, *Kamel & El-Bous* s.n. (Suez Canal Univ. Herb.); Sinai, Wadi Maier, 18.09.2004, rock crevices, *Moustafa* s.n. (Suez Canal Univ. Herb.); Sinai, Dahab–Sharm El-Sheikh road, 09.10.2004, N:23:26:20& E: 34:23:33, *Kamel & El-Bous* s.n. (Suez Canal Univ. Herb.); Sinai, 100 km Dahab-Sharm El-Sheikh road, 09.10.2004, N:28:31:04, and E: 34:26:47, *Kamel & El-Bous* s.n. (Suez Canal Univ. Herb.); (Da) Luxor-Kosseir road, Wadi El Beda, 16.4.1993, *Rukewitz* s.n. (CAI); (Ge) Gebel Elba, 1.10.1932, *Drar* s.n. (CAI); Wadi Maerafawi, Gebel Freid, Shalatein, 09.01.2005, N:23:23:51 and E: 35:21:91, *El Sayed* s.n. (Suez Canal Univ. Herb.).

Distribution in Egypt: Da, Dg, Ra, S,Ge stony and sandy wadis and plains.

General distribution: Libya, Egypt, Palestine, Syria, and Aratri.

2.4. *Cleome chrysantha* Decne., Ann. Sci. Nat. Bot., ser. 2, 3:274 (1835).

Type: Sinai, entre El Tor et le Sinai. *Bove* 227 (P, K)

Perennial herbs or subshrubs, villous to wooly, glandular, (6) 15–20 (50) cm, flexuous or ascending; leaf broad ovate to broad elliptic, 10–15 × 10–20 mm, obtuse, densely glandular hairy, scabrous or sparsely pilose; petiole (6) 8–14 mm long, villous; flower solitary, (4) 7–9 mm; pedicel (3) 4–10 (12) mm; sepals equal, densely glandular; anterior petal 4–8 × 4–8 mm, posterior petals 4–8 × 2.5–5 mm, obtuse, with or without scales; capsule 5–6 mm round and coiled, dehiscent by 2 valves, with 2–3 mm peak; seeds many, reniform, glabrous.

Representative specimens: (Da) Eastern desert, Rest house, desert road from Idfu to Mersa Alam, 12.3.1981, *Boulos* s.n. (CAI); Eastern desert, wadi El-Jidami, Febr. 1985, *Hassan* s.n. (CAI);

(Ra) Gebel El Faraied, Red Sea coast, 12.2.1961, *Täckholm & Kassas* s.n. (CAI); Gebel Um Gurdi, Red Sea coast, 11.2.1961, *Täckholm* (CAI); **(Ge)** Wadi Haiteem, Gebel Elba, 27.1.1962, *Hassan* s.n. (CAI); Shalateen, Wadi Am Sheleem, 13.01.2005, N:23:03:69 and E:35:23:35, *El Sayed* s.n. (Suez Canal Univ. Herb.).

Distribution in Egypt: Da, Ra, Ge rocky and sandy desert wadis and plains.

General Distribution: Egypt, Libya Sudan, Ethiopia, Saudi Arabia, Iran.

2.5. *Cleome paradoxa* R.Br.ex DC., Prodr. 1:241 (1824).

Type: Described from Abyssinia (now Ethiopia).

Ozenda (l.c.) and Keith l.c.) reported in from Tibesti.

Annual or short perennials herbs, 40–200 cm, erect, branched, glabrous; leaves compound, digitate, (1-) 3–5 foliate; inflorescence terminal, lax raceme; flower 2–4 cm; sepals unequal, 2 broad, 2 narrow; petals yellow with reddish veins and margin, unequal, glandular, dimorphic, scales appediculate; stamens 6, 10–20 mm long; capsule glabrous, with longitudinal nerves, linear oblong, 90–150 × 2–3 mm, with 9–15 mm peak, dehiscent by 2 valves; seeds many, reticulate, densely hairy on maturity.

Representative specimens: **(Ge)** Gebel Elba, Wadi Kansisrob, 24.1.1933, *G. Täckholm* s.n. (CAI); Shalateen, Wadi Baaneed, 9.01.2005, N: 22:40:77 and E: 35:22:01, 300 m high, *El Said, K.* s.n. (Suez Canal Univ. Herb.).

Distribution in Egypt: Stony Wadis, slopes and waste ground.

General distribution: Southeast Egypt, Sudan, Ethiopia, Saudi Arabia.

2.6. *Cleome amblyocarpa* Barratte & Murb., Acta Univ. Lund, ser. 2, 1(4):25 (1905).

Syns.: *Cleome africana* Botsch., Nov. Sist. Vyss. Rast.1:130 (1964). *Cleome arabica*, acut. Non L., Cent. Pl. 1:120 (1755). *Siliquaria glandulosa* Forssk., Fl. Aegypt.-Arab.:78 (1775).

Type: Morocco, Akka Oasis, 1873, Mar dochee.

Annual or short lived perennials with offensive odour, 10–40 (150) cm, stem erect, simple or branched in the lower part, glandular pubescent; upper leaf simple, lower leaf trifoliate, scabrid, densely glandular, narrowly oblong or narrowly obovate; raceme; flower 0.4–0.7 (1) cm long; sepals 4, equal, densely glandular; petals 4, yellow with purple veined and violet ting at the apices; stamens six; Siliqua dehiscent by 2 valves, longitudinally netted veins, glandular, compressed, 1–2 mm peak; seeds 10–20, lanate, covered with white long hairs.

Representative specimens: **(OI)** Siwa Oasis, 40 km on the road to Siwa Oasis, Um-el saghier, 17.4.1986, *El Hadidi & Fahmy* s.n. (CAI); **(Nv)** In the desert at the North side of Giza Pyramids, 10.4.1926, *G. Täckholm* (CAI); Helwan, 24.8.1967, *Boulos* s.n. (CAI); **(Ms)** Al-Arish–Rafah Road, Al-Shalak Village, 3 km before El-Sheikh Zoweid, 29.08.2004, *Kamel & El-Bous* s.n. (Suez Canal Univ. Herb.); Abu Shenar Village, on the Rafah Borders, 19.08.2004, *Kamel & El-Bous* s.n. (Suez Canal Univ. Herb.); **(Dg)** Cairo-Suez desert road, 20.4.1967, *El Hadidi* s.n. (CAI); Suez–Ismailia Road, Amer Village, 02.09.2004, N:30:03:24 and E: 32:33:04, *Kamel & El-Bous* s.n. (Suez Canal Univ. Herb.); Wadi Leblab (Gebel Ahmer), 6.3.1953, *M. Fawzi* (CAI); **(Nn)** Wadi Khashab, Kom Ombo desert, 6.2.1964, *Täckholm & Kassas* s.n. (CAI); **(Ge)** Mersa Haleib, at the shore of the Red Sea, 20.1.1929, *G. Täckholm* s.n. (CAI); Gebel Hamra Doom–Shalateen–Abu Ramad, 11.01.2005, N: 22:39:70 and E: 35:38:31, *EL Said* s.n. (Suez Canal Univ. Herb.).

Distribution in Egypt: OI, Ms, Nv, Nn, Ge sandy coastal dunes, waste ground, desert wadis and plains.

General distribution: North and east Africa; Sinai; Sudan, Ethiopia; Palestine, Saudi Arabia; Iraq; Iran.

2.7. *Cleome arabica* L., Cent. Pl. 1:20 (1775).

Syn.: *Cleome trinervia* Fresen., Mus. Senkenb. 1:177 (1834).

Type: Arabia, Hasselquist, SBT.

Perennial aromatic herbs, glandular; leaves simple; densely glandular; lower one may be 3-lobed or trifoliate; 3 nerved, inflorescence terminal, lax raceme; flower 6–8 (10) mm; sepals equals; petals brown with red veins, clawed; fruit siliqua, glandular, not netted, with replum, dehiscent by 2 valves; seeds many, lanate.

Representative specimens: **(Nv)** As weed among *Ricinus* plants in the desert sand north of the Giza Pyramids, 5.11.1926, *G. Täckholm* s.n. (CAI); Wadi Gibbu of the Helwan desert, 15.8.1960, *Täckholm* s.n. (CAI); Wadi Hof, 13.5.1959, *Ghabbour & Imam* s.n. (CAI); **(Ms)** W. El Arish-Rafah, 18.5.1955, *Boulos* s.n. (CAI); W. El Mizéirie, near G. El Maghara, N. Sinai, 24.4.1959, *Boulos* s.n. (CAI); **(Dg)** Wadi Aber, near Suez, 15.2.1956, *El Hadidi* s.n. (CAI); Wadi Aber, Gebel Ataqa, 15.2.1956, *Imam & Fadeel* s.n. (CAI); Cairo-Suez road, at km 116-119 from Cairo, 10.1.1961, *Täckholm & Kassas* s.n. (CAI); Gebel Ataqa, 10.2.1965, *Boulos & Täckholm* s.n. (CAI); **(S)** The area of St.Catherine Monastery, Sinai, 1.3.1985, *Darwish Al Far* s.n. (CAI); Sinai Peninsula, Wadi Feiran, 4 km East of Feiran Oasis, 660 m; Sandy Wadi, 27.04.1991, *Gamal El-Din* s.n. (Suez Canal Univ. Herb.); Wadi Isla, 29.8.1994, *Zaghloul* s.n. (Suez Canal Univ. Herb.); **(Nn)** Wadi Sheit, 69 Km E. of Kom Ombo, 3.3. 1961, *Täckholm* s.n. (CAI); Wadi Khashab, Kom Ombo desert, 6.2.1964, *Täckholm & Kassas* s.n. (CAI); **(Ra)** Mouth of Wadi Ranga, Red Sea coast, 7.2.1961, *Täckholm & Kassas* (CAI); Wadi Gemal, Red Sea coast, 7.3.1967, *Osborn & Helmy* s.n. (CAI).

Distribution in Egypt: Nv, Nn, Dg, Ra, S; rocky wadis and sandy plains.

General distribution: Egypt; Lower Jordan Valley, Dead Sea area, Saudi Arabia, southern Iran.

2.8. *Cleome brachycarpa* Vahl ex DC., Prodr.1:240 (1824).

Type: Arabia, Yemen, Loioe ot (C, BM).

Annual or perennial herbs, 10–40 cm, ascending, branched from base, pubescent with short glands; leaves compound, (1-) 3–5 unequal foliate; leaflets obovate or elliptic, 9–15 × 3–10 mm, acute, rarely obtuse, glandular pubescent; raceme terminal, lax; flower 4–8 mm, bracteate; sepals 4, glandular; petals 4, equal yellow, elliptic oblong; stamens 6 shorter than petal; capsule siliquiform glandular, netted veined with irregular wrinkles, tapering at ends, 5–12 × 2–3 mm, with 2–3 mm peak, dehiscent by 2 valves; seeds many, glabrous, finely tuberculate.

Representative specimens: **(Ra)** Red Sea district, 1.12.1986, *Kassas* s.n. (CAI); **(Ge)** Gebel Elba, 7.2.1962, *Kassas & Täckholm* s.n. (CAI); North west and west slope of Gebel Elba, 28.1.1962, *Täckholm* (CAI); Gebel Elba, Wadi Mawaw, 28.1.1962, *Täckholm & Kassas* s.n. (CAI); Gebel Elba, Upstream part of wadi Sarentai, 7.2. 1962, *Kadry El-Sayed & Khodeir* s.n. (CAI).

Distribution in Egypt: Ra, Ge stony wadis and sandy plains.

General distribution: Tropical and Northeast Africa, Sinai, Saudi Arabia to Northwest India.

2.9. *Cleome viscosa* L., Sp. Pl. (1st Edn), 672 (1753).

Syn. *Cleome icosandra* L., Sp.Pl. 672 (1753)

Polanisia viscosa (L.) DC., Prodr. 1:242 (1842).

Type: Habitat in Zeylona, Malabar.

Annual herbs, up to 100 cm, simple or much branched from base; stem grooved, glandular viscid; leaves compound 3–5 foliate, flowers solitary, axillary or in terminal lax raceme; sepals sym-

metric densely glandular, oblong, 4–8 × 2–3 mm; petals yellow and purplish at base; capsule linear dehiscent by 2 valves with distinct centripetal nerves, obliquely striate, glandular hairy; seeds many, glabrous with strong cross ribs and faint concentric ribs.

Representative specimens: (Mm) Burg El Arab, Mariut, 24.9.1971, *El Hadidi* s.n. (CAI).

Distribution in Egypt: Mm; stony ground.

General Distribution: Egypt, Saudi Arabia, W. Pakistan, Afghanistan, India, Malaysia, N. Australia, tropical Africa.

2.10. *Cleome hanburyana* Penz., Atti.Congr. Bot. Genova 330 (1893).

Annual or perennial herbs, 15–40 cm, erect branched from base, young shoot velutinous, old one villous; leaves compound, (3)–5 foliate unequal, petiole 30–60 mm, villous; inflorescence terminal raceme; sepals united below (**Fig. 3B**), glandular; petals pink or purple; stamens 8–10, capsule siliquiform, dehiscent by 2 valves, 6–8 mm pedicel; seeds many, glabrous with parallel transverse striations, brown, circular, 1.5–1.7 mm diameter.

Representative specimens: (Ge) Gebel Elba, 23.1.1933, *G. Täckholm* s.n. (CAI).

Distribution in Egypt: Ge, stony wadis.

General distribution: Tropical Northeast Africa, from South Egypt to Northeast Kenya, Saudi Arabia.

DISCUSSION

A taxonomic study of the Cleomaceae family in Egypt revealed that Cleomaceae is represented by two genera: *Cleome* (10 species), and *Dipterygium* (one monotypic genus). The Egyptian taxa (11) of Cleomaceae belong to the xerophytic communities (Zahran and Willis 1992; Abd El-Ghani and Marei 2006), except for *C. gynandra* which is common among the weed flora of the arable fields (Boulos and El Hadidi 1984).

The geographical distribution and occurrence of the studied taxa in the wild flora of Egypt vary greatly among species. Some are very rare and under immediate threat, while others show a certain degree of consistency to a certain phytogeographical territory, e.g., *C. hanburyana* is confined to Gebel Elba. Some other *Cleome* species e.g. *C. amblyocarpa* and *C. arabica* are widespread in the Mediterranean, Nile Delta, Sinai, along the Red Sea coast, and Oases while *C. brachycarpa*, *C. scaposa*, *C. paradoxa* and *Dipterygium glaucum* are distributed only in the Western desert, Red Sea coast and Gebel Elba region. They occupy a wide range of habitats from sandy coastal dunes, waste ground to desert wadis and plains.

The different species of *C.* vary also in their growth forms: from perennial herbaceous to woody perennials (*C. chrysantha*, *C. droserifolia* and *C. paradoxa*). Leaves are simple in *C. chrysantha*, *C. droserifolia* and *C. scaposa*, while it is compound in the remaining studied species. Leaf texture varies from densely glandular as in *C. droserifolia* to pilose as in *C. hanburyana*. Flowers in terminal inflorescence in all examined species of *C.* except in *C. chrysantha* where flower solitary and axillary; however in *C. viscosa* flowers are both axillary and solitary or in terminal raceme. Flower actinomorphic in most examined species, whereas zygomorphic flower present in four species, namely *C. paradoxa*, *C. amblyocarpa*, *C. droserifolia* (due to presence of dimorphic petals), and *C. viscosa* (due to unequal stamens). The shape of petal also varies between different species, where petal with claw in *C. amblyocarpa* and *C. arabica* and without claw in the remaining species; whereas petal of *C. droserifolia* is apendiculate with scale-like appendages. *C. droserifolia* has 4 stamens, while in *C. chrysantha* and *C. hanburyana* stamens vary from 8 to 11 stamens; however *C. viscosa* characterized by 10 to 20 un-

equal stamens. Gynophore is present only in *C. paradoxa* and *C. hanburyana* and absent in the remaining studied *C.* species. Most species have conspicuous style with different lengths; however style is absent in *C. hanburyana* and inconspicuous in *C. arabica*. Fruit with replum in three species (*C. droserifolia*, *C. arabica* and *C. amblyocarpa*) while replum is absent in the remaining studied *Cleome* species.

Khalifa *et al.* (1984) concluded that *Dipterygium glaucum* shares most of the characteristic morphological features of *C. paradoxa*. The results of this study disagree with this conclusion, and showed that *Dipterygium glaucum* is closely related to *C. scaposa* where both taxa have simple leaves, basely connate sepals, 6 stamens and absence of gynophore. Iltis (1960), De Wolf (1962), Ernst (1963), Jafri (1970), Täckholm (1974) Al-Gohary (1997) and Boulos (2009) adopted the treatment of *Gynandropsis* as separate genus. This study supported the concept adopted by some authors as El Hadidi and Fayed (1994/95) who retained *Gynandropsis gynandra* as *C. gynandra* of the family Cleomaceae. Corner (1976) also reported that the seeds of some *Cleome* species seem to resemble those of *Gynandropsis* e.g. *C. chelidonii*. The results of macro and micro-morphology showed also that *C. gynandra* and *C. hanburyana* share some characters, e.g., 5-foliate compound leaf, obovate leaflets, flowers terminal, actinomorphic, in racemose inflorescence, gynophore present, fruit with longitudinal veins, with no or reduced style, no replum, and dehiscent by valves. However, *C. gynandra* differ in having denticulate leaflets, androgynophore, 6 stamens, glabrous gynophore. Accordingly, the results of macro- and micromorphological characters favor to treat *Gynandropsis* as *C. gynandra*. The results of this study also added further evidence for the suggestion of Pax and Hoffman (1936), Ernst (1963) and Khafagi and Al-Gohary (1998) that *Gynandropsis gynandra* is closely related to *C. hanburyana*. Our result confirmed the occurrence of 10 *Cleome* species namely: *C. scaposa*, *C. droserifolia*, *C. chrysantha*, *C. paradoxa*, *C. amblyocarpa*, *C. arabica*, *C. brachycarpa*, *C. viscosa*, *C. hanburyana* and *C. gynandra*.

The monotypic genus *Dipterygium* has been placed by some authors in Cruciferae (Täckholm 1974), while Montasir and Hassib (1956) and Boulos (1999-2009) included it within Capparaceae. Hedge *et al.* (1980) discussed the history of its family assignment and pointed out that phytochemical data strongly reinforce its inclusion in the Capparaceae rather than in the Cruciferae. The placement of this genus in some lineage of Capparaceae is supported by the presence of methyl-glucosinolate, a compound that is known from Capparaceae but not Brassicaceae (Hedge *et al.* 1980; Lünig *et al.* 1992).

Based on molecular and morphological data, Hall *et al.* (2002) also demonstrated a strong relationship within the clade including *Cleome* spp., *Dipterygium glaucum* and *Gynandropsis gynandra*, and they concluded that the floral characteristic that ally *Dipterygium* in Cleomoideae include six stamens of equal length (not tetradynamous). Khalifa *et al.* (1984) considered that this species shares most of the characteristic morphological features of *C. paradoxa*, while the results of this study disagree with this statement and showed that *Dipterygium glaucum* is closely related to *C. scaposa* where both taxa have simple leaves, basely connate sepals, 6 stamens and absence of gynophore. In this context, it agrees with Hall *et al.* (2002), in the fact that *Dipterygium glaucum* must ally in the Cleomaceae not in Capparaceae.

REFERENCES

- Abd El-Ghani MM, Marei AH (2006) Vegetation associates of the endangered *Randonia africana* Coss. and its soil characteristics in an arid desert ecosystems of western Egypt. *Acta Botanica Croatica* **65** (1), 83-99
- Airy Shaw HK (1965) Diagnoses of new families, new names, etc. for the 7th edition of Willi's (Dictionary). *Kew Bulletin* **18**, 249-273
- Al-Gohary IH (1982) Morphological studies on the Capparidaceae in Egypt. MSc thesis, Botany Department, Faculty of Science, Ain Shams University, Egypt, 175 pp
- Al-Gohary IH (1997) Biosystematic studied of Cleomaceae in Egypt. 1. The

- seed morphology and its taxonomic significance. *Desert Institute Bulletin d'Egypt* **47** (2), 423-440
- Boissier PE** (1867) *Flora Orientalis* (Vol 1), Basel and Geneva, pp 419-420
- Boulos L** (1999) *Flora of Egypt (Azollaceae-Oxalidaceae)* (Vol 1), Al Hadra Publishing, Cairo, pp 176-181
- Boulos L** (2009) *Flora of Egypt* (Checklist Revised Annotated Edn), Al Hadra Publishing, Cairo, pp 68-69
- Boulos L, El Hadidi MN** (1984) The Weed Flora of Egypt. The American University in Cairo Press, pp 20
- Corner EJH** (1976) Centrifugal stamens. *Journal of Arnold Arboretum* **27**, 423-437
- De Wolf GP** (1962) Notes on African Capparidaceae, III. *Kew Bulletin* **16**(1), 75-83
- El Hadidi MN** (2000) *Flora Aegyptiaca* (1st Edn), The Palm Press, Cairo, pp 1-22
- El Hadidi MN, Fayed AA** (1994-1995) Materials for Excursion. Flora of Egypt (EFE) *Taeckholmia* **15**, 38-39
- Ernst WR** (1963) The genera of Capparaceae and Moringaceae in the southeastern United States. Harvard University. *Journal of Arnold Arboretum* **44**, 1-81
- Hall JC, Sytsma KJ, Iltis HH** (2002) Phylogeny of Capparaceae and Brassicaceae based on chloroplast sequence data. *American Journal of Botany* **89**, 1826-1842
- Hedge IC, Kaejer A, Malver O** (1980) *Dipterygium*: Cruciferae or Capparaceae. *Notes from the Royal Botanical Gardens of Edinburgh* **38** (2), 247
- Holmgren PK, Holmgren NH, Barnett LC** (1990) *Index Herbariorum 1. The Herbaria of the World. Regnum Vegetabile 1, 120*, New York Botanical Garden, 551 pp
- Hutchinson J** (1967) *The Genera of Flowering Plants* (Vol 2), Clarendon Press, Oxford, UK, pp 303-317
- Iltis HH** (1957) Studies in the Capparidaceae III: Evolution and phylogeny of the western North America Cleomoideae. *Annals of the Missouri Botanical Garden* **44**, 77-119
- Iltis HH** (1960) Studies in Capparidaceae VII. Old World Cleomes adventure in New World. *Brittonia* **12**, 283-290
- Index Kewensis on CD-Rom**, Version 2.0, Oxford
- Jafri SM** (1977) *Flora Libya* (Vol 12), Al-Faateh University, Tripoli, pp 1-20
- Khafagi A, Al-Gohary IH** (1998) Biosystematic studies of Cleomaceae in Egypt. II. Taxonomic significance of some micromorphological characters of the leaf and pollen grains. *Al-Azhar Bulletin of Science* **19** (2), 1027-1036
- Khalifa SF, Al-Gohary IH** (1982) Studies on the Capparidaceae. II: Taxonomic significance of micromorphological attributes of the *Cleome* species of Egypt. *Research Bulletin Faculty of Agriculture, Ain Shams University, Cairo, Egypt* **1959**, 1-13
- Khalifa SF, Yousef MM, Al-Gohary IH** (1984) Morphological trends in Capparidaceae: II. Studies on taxa of *Cleome*, *Dipterygium* and *Gynandropsis* in Egypt and Saudi Arabia. *Journal of College of Science King Saud Univ.*, **15** (1), 27-40
- Kubitzki K** (2002) Introduction to Capparales. In: Kubitzki K (Ed) *The Families and Genera of Vascular Plants. 5. Flowering Plants, Dicotyledons: Malvales, Capparales, and Non Betalin: Caryophyllales*, Springer, Berlin, pp 7-11
- Lüning KB, Seffers P** (1992) Methyl glycosinolate confirmed in *Puccinia* and *Dhofaria* (Capparidaceae). *Biochemical Systematics and Ecology* **20**, 394-400
- Montasir AH, Hassib M** (1956) *Illustrated Manual Flora of Egypt. Bulletin of the Faculty of Science, Ain Shams University* (Part I, 1st Edn), Cairo, 615 pp
- Pax F, Hoffmann K** (1936) Capparidaceae. In: Engler A, Prantl K (Eds) *Die Natürlichen Pflanzenfamilien* (2nd Edn, 17 b), Engelmann, Leipzig, Germany, pp 146-233
- Rankin R** (2003) *Cleome* sect. *Physostemon* (Cleomaceae) in Cuba. *Willdenowia* **33**, 439-444
- Ridly HN** (1967) *The Flora of Malay Peninsula*, A. Asher & Co. Amsterdam, The Netherlands, 183 pp
- Stewart RR** (1972) An annotated catalogue of West Pakistan and Kashmir. In: Nasir E, Ali S (Eds) *Flora of West Pakistan*, Fakhri Press, Karachi, 1028 pp
- Täckholm V** (1974) *Students' Flora of Egypt* (2nd Edn), Cairo University, Cairo, Egypt. Coop. Ca, Beirut, p 167-169
- Thulin M** (1993) *Flora of Somalia* (Vol 1), Kew Royal Botanical Garden, on behalf of the National Herbarium, NRA, Mogadishu, Somalia, 501 pp
- Zahrn MA, Willis AJ** (1992) *The Vegetation of Egypt*, Chapman and Hall, London, UK, 424 pp