

Taxonomic Revision of Ebenaceae in Egypt**Abd El Halim, A. Mohamed, Hafeez, R. Habeeb and Safwat, A. Azer***Flora and Phytotaxonomy Researches Department, Horticultural Research, Institute, Agricultural Research Center, Dokki, Giza, Egypt***ABSTRACTS**

This study aimed to revise Ebenaceae in Egypt. The studied species included 10 cultivated and 1 wild taxa. The cultivated taxa included: *Diospyros chloroxylon* Roxb.; *Diospyros discolor* Willd.; *Diospyros ebenum* J. Koenig, *Diospyros malabarica* (Desr.) Kostel., *Diospyros mespiliformis* Hochst.ex A. DC., *Diospyros kaki* Thunb., *Diospyros lotus* L., *Diospyros montana* Rob., *Euclea pseudebenus* E. Mey. ex A. DC. and *Euclea polyandra* (L.f.) E.Mey. ex Hiern. The wild taxon was *Euclea racemosa* subsp. *schimperi* (A.DC.) F. White. Based on morphological characters, the numerical analysis showed a considerable degree of similarity among the studied taxa. It divided the studied taxa into five clusters. First cluster included: *Diospyros chloroxylon* and *Diospyros montana*. Second cluster included: *Diospyros kaki* and *Diospyros lotus*. Third cluster included: *Diospyros ebenum* and *Diospyros mespiliformis*. Forth cluster included: *Diospyros discolor* and *Diospyros malabarica*. Fifth cluster included: *Euclea racemosa* subsp. *schimperi*; *Euclea pseudebenus* and *Euclea polyandra*. Based on the degree of similarity among the studied taxa, both (*Diospyros chloroxylon* & *Diospyros montana*); (*Diospyros kaki* & *Diospyros lotus*); (*Diospyros ebenum* & *Diospyros mespiliformis*); and (*Diospyros discolor* & *Diospyros malabarica*); had the ratios (85%); (83.3%); (82.4%) and (82%); respectively. Moreover, the highest ratio (50%) recorded between *Euclea pseudebenus* & *Euclea polyandra*, while the lowest ratio (26.7%) recorded between *Euclea racemosa* subsp. *schimperi* & *Euclea pseudebenus*. This work proved the importance of the morphological characters as a complementary tool to the taxonomy.

Key words: Taxonomy, Ebenaceae, *Diospyros*, *Euclea*, Morphology, Egypt**Introduction**

Ebenaceae Gürke in Engler & Prantl, Nat. Pflanzenfam. 4/1: 153 (1891).

Habit: trees, shrubs, usually dioecious, less frequently monoecious, sometimes polygamous; evergreen, but some deciduous; bark of tropical species often black; branchlets spine-tipped. Leaves: simple, alternate, rarely opposite to subopposite; stipules absent; lamina of leaves coriaceous; leaf margins usually entire, seldom finely crenulate, usually with strongly revolute margins at base. Inflorescences: determinate, axillary, cymose, fasciculate, pseudo-racemose usually rich-flowered. Flowers: usually unisexual, less often hermaphroditic. Male and female flowers: usually dimorphic, articulated at base, actinomorphic, 3-5 (-8)-merous. Calyx: mostly gamosepalous, less frequently polysepalous, persistent, often accrescent in fruit; lobes valvate or imbricate, often spreading or reflexed in fruit. Corolla: gamopetalous, usually isomerous with calyx, shortly to deeply lobed, tubular, campanulate or urceolate, white, or cream-colored, yellow, pink or reddish; tube usually prominent, but sometimes extremely short in male flowers; throat wide open, or restricted to a small pore. Male flowers: stamens (3-) 12 - 20 (- ca. 100), often unequal in size, commonly inserted at the base of the corolla tube or higher up in the corolla tube, episepalous, or epipetalous, hidden within the corolla tube, often in two hardly distinguishable whorls. Filaments: usually short and flattened, free or united in pairs, triads or fascicles, or sometimes even into a central cylinder. Anthers: linear or lanceolate, erect, basifixed. Pistillode: usually represented by an irregular tissue lacking style. Female flowers: staminodes episepalous or epipetalous, arranged in a single whorl, inserted at base of corolla tube often more or less rudimentary, fewer in number than stamens in male flowers of the same species, rarely absent, rudimentary. Ovary: superior, sessile, 2 - 8-carpellate, glabrous or hairy; style usually quite short; stylodia usually longer than the style, distally simple or slightly bifid; stigmas often variously lobed. Ovules: pendulous, oblong, anatropous, 4, 6, 8, 10, 12, 14 or 16 per ovary. Fruit: usually an indehiscent berry with 2-3 layered pericarp, and usually with a more or less well developed hypodermal stone-cell layer. Seeds: 1-16 per fruit, pendulous, straight, and sometimes branched (Wallnöfer, 2001).

The Ebenaceae have been traditionally placed in its own order Ebenales, together with, the following five families: Sapotaceae, Styracaceae, Sarcospermataceae, Symplocaceae and Lissocarpaceae (Cronquist, 1981). Molecular studies (Morton *et al.* 1996; Anderberg *et al.* 2002) showed that these five families are nested

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separately or in pairs within an expanded Ericales. The family represented by two subfamilies (Lissocarpoideae and Ebenoideae) and four genera (*Diospyros* L., *Euclea* Murr., *Lissocarpa* Murr. and *Royena* L.) and about 500-600 species (Wallnöfer, 2001; Senterre, 2005; Duangjai *et al.*, 2006 and 2009).

Diospyros L. is the largest genus of Ebenaceae (Duangjai *et al.*, 2006) and is also one of the largest angiosperm genera (Frodin, 2004). It consists of over 500 species and is widely distributed in the tropics and subtropics. Approximately 300 species occur in Asia and the Pacific area, 98 species in Madagascar and the Comoros, 94 species in Africa, 100 species in the Americas, 15 species in Australia and 31 species in New Caledonia (White, 1980; Singh, 2005 and Duangjai, *et al.* 2009). The small genus *Euclea* is restricted to Africa and southern Arabia and contains about 19 species in Africa, 7 species of *Euclea* serve as food (Peters *et al.*, 1992; Wallnöfer, 2001).

The majority of the species are widely distributed in the tropical regions of both the eastern and western hemispheres; several species are found in the subtropical regions, especially of South Africa; very few in temperate regions, and none in the colder regions of either hemisphere. (Wallnöfer, 2001). The Ebenaceae have the source of several economically important products; the most valuable are timber (ebony) and edible fruits, e.g. *Diospyros virginiana* L (persimmons) and *D. kaki* L. (kaki) (Heinrich, 2003). They also are a conspicuous forest component of Africa and Asia, such as *D. ebenum* Hiern (Heywood, 1978; Judd *et al.*, 2002; Duangjai *et al.*, 2006). Furthermore, several species have medicinal potential, where the bark, leaves, wood, fruits, and seeds are the main sources of medicines (Mallavadhani *et al.*, 1998; Singh, 2005; Duangjai, *et al.* 2009).

In Egypt, Ebenaceae is represented by 10 cultivated and 1 wild taxon belong to 2 genera (*Diospyros* and *Euclea*). The cultivated taxa included: *Diospyros chloroxylon* Roxb., *Diospyros discolor* Willd., *Diospyros ebenum* J. Koenig, *Diospyros malabarica* (Desr.) Kostel., *Diospyros mespiliformis* Hochst.ex A. DC., *Diospyros kaki* Thunb., *Diospyros lotus* L., *Diospyros montana* Rob., *Euclea pseudebenus* E. Mey. ex A. DC. and *Euclea polyandra* (L.f.) E.Mey. ex Hiern. (Ahmad and Belal, 1990; Diwan *et al.*, 2004; Khalifa and Loutfy, 2006). The wild taxon was *Euclea racemosa* subsp. *schimperii* (A.DC.) F. White (Boulos, 2000). The objective of this study was to derive data from morphological traits to revise the taxonomic identity of the studied Ebenaceae taxa. The results were subjected to numerical analysis to clarify taxonomic relationships among the studied taxa. Moreover, taxonomic key was constructed to distinguish among studied taxa in Egypt.

Material and methods

Taxon sampling and nomenclature:

Field trips were carried out to collect the available studied taxa from different botanical gardens in Egypt during years 2013-2014. A total of 11 taxa represented 2 genera were recorded during this study. The identification of the studied taxa was based on the authentic flora and taxonomic references (White and Caveney, 1980; White, 1988; Boulos, 2000; Duangjai *et al.*, 2009; Schatz *et al.*, 2011). The updated names of the studied taxa were checked by (Angiosperm Phylogeny Group (APG III) 2009; Chase and Reveal, 2009; Haston *et al.*, 2009). Voucher specimens were kept at herbarium of Flora and Phytotaxonomy Researches Department (CAIM), Horticultural Research Institute, Agricultural Research Center, Giza, Egypt.

Morphological data:

Morphological data were gathered from collected fresh samples and deposited herbarium sheets at the herbarium of Flora and Phytotaxonomy Researches Department (CAIM), Horticultural Research Institute, Agricultural Research Center, Giza, Egypt. A total of scored 24 morphological characters were recorded (Table 1). Additional information was gathered from the literature (White, 1988). The terminology used follows (Harris and Harris, 1997; Wallnöfer 2001). Each taxon was provided with a close up view (Figures 2 and 3).

Numerical analysis:

Numerical analysis of the differential characters was based on hierarchical cluster analysis. The retrieved output was used to construct specific taxonomic relationships among the studied taxa. The substantial numbers (1 = presence and 0 = absence) of 24 characters were used for the studied taxa (Table 2). For the numerical analysis, the data were treated as a binary character in a data matrix using SPSS version 10 (SPSS, 1999). The output was plotted in the form of dendrogram (Figure 1). The dendrogram was based on average linkage (between groups) and rescaled distance cluster combine.

Results

This work was designed to study the morphological characters and clarify the taxonomic relationships among the studied taxa.

Key to the studied genera of family Ebenaceae

- 1 Calyx accrescent on fruits; staminodes present in the female flower; fruits more than one seed; inflorescence cymose-----

Diospyros

- + Calyx not accrescent on fruits; staminodes absent from the female flower; fruits 1-seeded; inflorescence racemose----- *Euclea*

Morphological characters description:

1. *Diospyros* L., Sp.Pl. 1057. (1753)

Habit: trees, shrubs or sub-shrubs, dioecious, evergreen or less frequently deciduous. Leaves: oblong, alternate; margins entire, deciduous or persistent. Inflorescences: axillary, usually cymose or fasciculate, or flowers solitary, especially females. Flowers: usually dimorphic in size and shape, males usually smaller than females. Calyx: persistent and usually accrescent on fruits, usually 3 - 8-lobed, less frequently cup-shaped. Sepals: persistent, often accrescent in fruit. Corolla: 3 - 8-lobed, very variable. Stamens: 2 to ca. 100; anthers dehiscent by longitudinal slits. Fruit: 2-16-seeded berry. Berries: yellow, orange, red, purple, brown, or black, fleshy or fibrous. Seeds: usually flattened laterally, but sometimes circular in cross-section, or often somewhat irregular in shape.

Key to the studied *Diospyros* species in Egypt

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|---|--|-------------------------|
| 1 | Leaf deciduous; inflorescence greenish-yellow; fissures absent---- | <i>D. montana</i> |
| + | Leaf persistent; inflorescence yellowish-white; fissures present---- | 2 |
| 2 | Corolla of male flowers urceolate; leaf base narrowed----- | <i>D. mespiliformis</i> |
| + | Corolla of male flowers funnel-shaped; leaf base rounded----- | 3 |
| 3 | Female flowers clusters; stamens 24-64----- | <i>D. malabarica</i> |
| + | Female flowers solitary; stamens 20----- | 4 |
| 4 | Stamens glabrous; fruit surface hairy----- | <i>D. discolor</i> |
| + | Stamens hairy; fruit surface glabrous----- | 5 |
| 5 | Calyx of male flowers campanulate; bark scabrous, yellowish ---- | <i>D. chloroxylon</i> |
| + | Calyx of male flowers funnel-shaped; bark glabrous, darkish ---- | 6 |
| 6 | Leaf non-membranous, green; staminodes 16----- | <i>D. ebenum</i> |
| + | Leaf sub-membranous, glaucous; staminodes 8----- | 7 |
| 7 | Inflorescence sessile; fruits yellowish; fissures absent----- | <i>D. lotus</i> |
| + | Inflorescence pedicellate; fruits reddish; fissures present----- | <i>D. kaki</i> |

1.1 *Diospyros montana* Roxb. Pl. Coromandel 1: 37 (1795).

Synonyms: *Diospyros orixensis* Klein ex Willd. Sp. Pl. 4: 407 (1805).

Diospyros heterophylla Wall. ex G. Don Gen. Hist. 4: 41 (1837).

Diospyros auriculata Wight ex Hiern Trans. Cambridge Philos. Soc. 12: 188 (1873).

Diospyros calcarea Fletcher Bull. Misc. Inform. Kew 1937: 383 (1937).

Habit: tree up to 15 m tall; trunk with scattered spines; twig pubescent, spreading; bark darkish, fissures absent. Leaves: green, pubescent, deciduous, oval, oblong, obovate, or ovate-oblong, alternate, thinly coriaceous, apex mucronate, base cordate. Inflorescence: greenish-yellow, cymose, scentless, dioecious. Male flowers: many, 4 (-5)-merous. Calyx: campanulate, deeply 4-fid, pubescent on both sides or nearly glabrous. Corolla: urceolate, glabrous, 4-lobed. Stamens: 16 united at base in 8 pairs and inserted at base of corolla, hairy. Female flowers: solitary, on re-curved peduncles. Calyx: campanulate, puberulous, deeply 4-fid. Corolla: urceolate, exceeding the calyx, glabrous, 4-fid. Stamines: 4, 8, 12, glabrous. Ovary: glabrous, globular, 8-celled; styles 4. Fruit: poisonous, globose, glabrous, yellowish, 2-6 seeded; fruit calyx accrescent.

1.2 *Diospyros mespiliformis* Hochst. ex A. DC. Prodr. 8: 672 (1844).

Synonyms: *Diospyros bicolor* Klotzsch Naturw. Reise Mossambique 6: 184 (1861).

Diospyros corylicarpa Gürke Bot. Jahrb. Syst. 46: 156 (1911).

Habit: tree up to 30m; twig spreading, glabrescent; bark darkish with long vertical fissures. Leaves: green, glabrous, persistent, alternate, oblong or elliptical, somewhat narrowed or rounded at either end, thinly coriaceous. Inflorescence: cymose, yellowish-white, dioecious. Male flower: few, ferruginous-tomentose, pentamerous. Calyx: campanulate, 4-fid, hairy on both sides. Corolla: urceolate, glabrous inside. Stamens: 10-16, often in pairs, hairy. Female flowers: solitary, pentamerous or tetramerous. Calyx: campanulate, hairy on both sides. Corolla: bell-shaped, pubescent outside, glabrous inside, exceeding the calyx. Stamines: 6-8, in one row, inserted at base of the corolla, glabrous. Ovary: glabrous, terminated by 2 short styles. Fruit: glabrate, globose, edible, yellowish when ripe, 4-5 seeded; fruit calyx accrescent.

1.3 *Diospyros malabarica* (Desr.) Kostel. Allg. Med.-Pharm. Fl. 3: 1099 (1834).

Synonyms: *Diospyros glutinifera* (Roxb.) Wall. Numer. List 4123 B (1831).

Diospyros biflora Blanco Fl. Filip. 303 (1837).

Diospyros citrifolia Wall. ex A.DC. Prodr. 8: 285 (1844).

Diospyros peregrina (Gaertn.) Gürke Nat. Pflanzenfam. 4(1): 164 (1891).

Habit: large evergreen tree; twig glabrescent, spreading; bark darkish, fissures absent; Leaves: green, glabrous, oblong or narrowly oval, alternate, rounded at base, acuminate or obtuse at apex, coriaceous, persistent. Inflorescence: yellowish-white, cymose, dioecious. Male flower: many, puberulous, tetramerous or pentamerous. Calyx: campanulate, 4-fid; lobes pubescent inside. Corolla: funnel-shaped, glabrous inside. Stamens: indefinite, 24-64 or more, hairy. Female flowers: clusters, subsessile, tetramerous, glabrescent or pubescent. Calyx: campanulate, pubescent, lobes dilatate-subcordate at base. Corolla: bell-shaped. Staminodes: 1-12, hairy, hypogynous. Ovary: glabrous, glandular; styles 4, hairy at base, dilated and lobed at apex. Fruit: edible, solitary, globular, glabrate, yellowish, 4-6-seeded; fruit calyx accrescent.

1.4 *Diospyros discolor* Willd. Sp. Pl. 4: 1108 (1806).

Synonyms: *Diospyros blancoi* A.DC. Prodr. 8: 237 (1844).

Diospyros utilis Hemsl. Ann. Bot. (Oxford) 9: 154 (1895).

Diospyros merrillii Elmer Leaf. Philipp. Bot. 5: 1775 (1913).

Habit: tree up to 50-80m height; trunk regular; twig spreading, glabrescent; bark glabrous, darkish; fissures absent. Leaves: green, oblong, alternate, coriaceous, glabrous, persistent, acuminate at apex, rounded at base. Inflorescence: yellowish-white, dioecious, cymose. Male flowers: many, sub-sessile, tetramerous or pentamerous. Calyx: campanulate, coriaceous, deeply lobed, lobes, silky outside, glabrous inside. Corolla: silky outside, glabrous inside, coriaceous, funnel-shaped, spreading. Stamens: 20, in pairs, equal, glabrous, hypogynous. Female flowers: solitary, axillary, bracteate at base, tetramerous or pentamerous, sessile. Calyx: open, coriaceous, campanulate, appressedly silky outside, glabrous, imbricated. Corolla: bell-shaped, contracted about middle, silky outside except near base, glabrous inside, spreading. Staminodes: 4 -10, much shorter than the corolla. Ovary: glabrous. Fruit: thick, fleshy, globose, hairy, reddish, edible after removing the hairs and skin, 4-6-seeded; fruit calyx accrescent.

1.5 *Diospyros chloroxylon* Roxb. Pl. Coromandel 1: 38 (1795).

Synonyms: *Diospyros tomentosa* Poir. Encycl. 5: 436 (1804).

Diospyros insculpta Buch. Ham Trans. Linn. Soc. London 15: 112 (1827).

Diospyros capitulata Wight Icon. Pl. Ind. Orient. 4: t. 1224 (1848).

Habit: tree of medium size; twig pubescent, spreading; bark yellowish, scabrous, fissures absent. Leaves: green on upper side, alternate, oval or oval-oblong, usually rounded at base and mucronate at apex, pubescent, persistent. Inflorescence: yellowish-white, dioecious, cymose, densely pubescent. Male flowers: many, tetramerous, with very short pedicels. Calyx: campanulate, densely tawny-pubescent, deeply 4-fid, glabrous inside. Corolla: 4-fid, glabrous, urceolate. Stamens: 16 in 2 rows, nearly equal, hairy. Female flowers: solitary, sessile, tetramerous. Calyx: campanulate, brownish-yellow, densely pubescent. Corolla: urceolate, glabrous. Staminodes: 7-9, glabrous, hypogynous. Ovary: glabrous, surmounted by 4 erect glabrous styles. Fruit: edible, globose, glabrous, cherry-like, reddish, 2-8- seeded; fruit calyx accrescent.

1.6 *Diospyros ebenum* J.Koenig ex Retz. Physiogr. Sölsk. Handl. 1: 176 (1781).

Synonyms: *Diospyros ebenaster* Retz. Observ. Bot. 5: 31 (1788).

Diospyros membranacea A.DC. Prodr. 8: 227 (1844).

Diospyros laurifolia A.Rich. Hist. Fis. Cuba, Bot. 11(2): 86 (1850).

Habit: trees, up to 20-30m; twig glabrous, spreading; bark darkish, fissures present. Leaves: non-membranous, green, glabrous, alternate, elliptic-lanceolate to ovate, persistent, retuse at apex, somewhat narrowed at base. Inflorescence: yellowish-white, dioecious, cymose. Male flowers: many, subsessile, on short pubescent cymes. Calyx: funnel-shaped, shortly 4-lobed, glabrous outside, hairy inside. Corolla: urceolate constricted at middle, glabrous, 4-fid, with imbricated lobes. Stamens: 16, unequal, in pairs, hairy, inserted at base of corolla. Female flowers: solitary, with 2 bracts at base, shortly stalked. Calyx: funnel-shaped, much longer than in the male flower, deeply 4-fid. Corolla: urceolate, thick and fleshy. Staminodes: 16, in pairs; style: 1; stigmas 4; ovary glabrous. Fruit: edible, globose, glabrous, berries blackish, 4-seeded; fruit calyx accrescent.

1.7 *Diospyros lotus* L. Sp. Pl. 1057 (1753).

Synonyms: *Diospyros mediterranea* Oken Allg. Naturgesch. 3(2): 935 (1841).

Diospyros microcarpa Siebold Ann. Soc. Hort. Pays-Bas 1844: 28 (1844).

Diospyros calycina Dippel Handb. Laubholz. 1: 306 (1889).

Habit: small tree; twig pubescent, spreading; bark darkish, rough, fissures absent. Leaves: alternate, pubescent, deciduous, glaucous, elliptic or ovate-oblong, submembranous, apex acuminate, base rounded. Inflorescence: sessile, yellowish-white, cymose, dioecious. Male flowers: many, axillary. Calyx: campanulate, shortly 4-lobed; lobes ovate. Corolla: pale yellow, urceolate, glabrous. Stamens: 16, combined by their glabrous filaments in 8 pairs, equal. Female flowers: solitary, sessile, wider than in the male flowers. Calyx: ultimately spreading. Corolla: often remaining at apex of the young fruit, urceolate. Stamines: 8, in one row inserted at the base of the corolla, hairy. Ovary: glabrous, 8-celled. Fruit: edible, glabrous, subglobose; flesh of the fruit astringent, yellowish, more than 1-seeded; fruit calyx accrescent.

1.8 *Diospyros kaki* L.f. Suppl. Pl. 439 (1782).

Synonyms: *Diospyros amara* Perrier Mém. Soc. Linn. Paris 3: 112 (1825).

Diospyros costata Carrière Rev. Hort. 42: 134 (1870).

Diospyros lycopersicon Carrière Rev. Hort. 50: 470 (1878).

Diospyros argyi H.Lév. Mem. Real Acad. Ci. Barcelona 12(22): 10 (1916).

Diospyros trichocarpa R.H.Miao Acta Sci. Nat. Univ. Sunyatseni 32(4): 63 (1993).

Habit: small tree; twig densely pubescent, spreading; bark darkish, fissures present. Leaves: glaucous, alternate, submembranous, ovate, apex acuminate, base rounded, glabrous, deciduous. Inflorescence: pedicellate, yellowish, cymose, dioecious. Male flowers: many, axillary, drooping. Calyx: Campanulate, shorter than the corolla. Corolla: hairy outside, urceolate. Stamens: 16 in pairs, equal, hairy. Female flowers: solitary, axillary. Calyx: large, hairy on both sides, deeply 4-fid with widely ovate spreading lobes. Corolla: puberulous, 4-fid, bell-shaped. Stamines: 8. Ovary: glabrous, 8-10 celled. Fruit: edible, glabrous, globular, reddish, 8-celled, more than 1-seeded; fruit calyx accrescent.

2. *Euclea* Murr., Syst. Veg., ed. 13: 747 (1774)

Habit: trees, shrubs or sub-shrubs, and usually evergreen. Leaves: alternate, opposite to sub-opposite, or in pseudo-whorls, entire. Inflorescences: dioecious, axillary, or less frequently in branched pseudo-racemes, or flowers occasionally solitary. Calyx: 4-5-lobed, usually polysepalous, not accrescent on fruits. Corolla: urceolate to subglobose, 5-8-lobed or campanulate and deeply 4-5-lobed. Stamens: 10-30; anthers dehiscing by large ellipsoidal apical pores, hairy or glabrous, oblong or lanceolate, 2-celled; filaments short, usually slender and glabrous. Stamines: usually absent, glabrous; styles 2 (or 1, bifid), usually glabrous; stigmas bifid at apex. Ovary: ovoid or globular, hairy or glabrous, usually 4-celled; ovules 4, pendulous. Fruit: usually globose, 1-seeded berry, edible.

Key to the studied *Euclea* species in Egypt

- | | | |
|---|---|---------------------------|
| 1 | Leaves obovate, apex rounded, base cuneate; fruit with short appressed scale-like hairs----- | <i>Euclea racemosa</i> |
| + | Leaves linear; apex mucronate; base narrowed; fruit without short appressed scale-like hairs----- | 2 |
| 2 | Stamens 12-20; leaves linear; apex mucronate----- | <i>Euclea pseudebenus</i> |
| + | Stamens 21-30; leaves rounded; apex obtuse----- | <i>Euclea polyandra</i> |

2.1 *Euclea racemosa* subsp. *schimperi* (A.DC.) F. White, Bull. Jard. Bot. Natl. Belg. 50: 399 (1980).

Synonyms: *Kellaua schimperi* A.DC. Ann. Sci. Nat. Bot. II, 18: 209 (1842).

Euclea kellau Hochst. Flora 26: 83 (1843).

Euclea bilocularis Hiern Trans. Cambridge Philos. Soc. 12: 102 (1873).

Euclea microcarpa Gürke Pflanzenw. Ost-Afrikas C: 305 (1895).

Euclea schimperi (A.DC.) Dandy Fl. Pl. Sudan 2: 370 (1952).

Habit: small tree; twig glabrescent, drooping; bark darkish, minutely fissured. Leaves: dark green, coriaceous, glabrous, obovate or oblong-obovate, shortly petiolate, subopposite, persistent, shining, glossy, coriaceous, apex rounded, base cuneate. Inflorescences: yellowish-white, dioecious, racemose with lanceolate bracts at base of pedicels. Male flower: many, racemes, spreading. Calyx: short, 4-fid, with apiculate deltoid erect lobes. Corolla: erect, funnel-shaped, 4-lobed. Stamens: 10-20, mostly in pairs, glabrous. Female flower: clusters, racemes, glabrous. Calyx: with 4 or 5 deeply divided erect deltoid acuminate lobes, persistent. Corolla: bell-shaped, twice the height of the calyx, with 4-5 lobes. Stamines: absent. Ovary: glabrous, 4-celled, cells 1-ovuled. Fruit: edible, globose, reddish, glabrous, 1-celled, 1-seeded with short appressed scale-like hairs; fruit calyx non accrescent.

2.2 *Euclea pseudebenus* E.Mey. ex A.DC. Prodr. 8: 217 (1844).

Synonyms: *Euclea angustifolia* Benth. Niger Fl. 441 (1849).

Diospyros pseudebenum (E.Mey. ex A.DC.) Parm. Histol. Ébén. 29 (1892).

Habit: tall shrub; twig drooping, glabrescent; bark yellowish, densely glandular, hairy, fissures absent. Leaves: glaucous, glabrous, linear-lanceolate, alternate, persistent, thickly coriaceous; apex mucronate; base narrowed. Inflorescence: greenish-yellow, deciduous, racemose, glandular, hairy. Male flowers: many, racemose, hairy, erect; pedicels slender. Calyx: funnel-shaped, 4-5-lobed. Corolla: urceolate 5 - 8-lobed. Stamens: 12-20, two rows, the inner and outer opposing each other, hairy. Female flowers: solitary, borne in 2-3 flowered slightly smaller than the males. Calyx: funnel-shaped, lobes 5-6. Corolla: urceolate, densely villous outside. Ovary: pubescent, ovoid; styles 2. Staminodes: absent. Fruit: edible, globose, without short appressed scale-like hairs, fleshy and blackish when ripe, glabrescent, one-seeded.

2.3 *Euclea polyandra* (L.f.) E.Mey. ex Hiern Trans. Cambridge Philos. Soc. 12: 92 (1873).

Synonyms: *Royena polyandra* L.f. Suppl. Pl. 240 (1782).

Euclea elliptica (G.Don) A.DC. Prodr. 8: 216 (1844).

Euclea pubescens Eckl. & Zeyh. Linnaea 20: 192 (1847).

Habit: shrub; twig drooping, glabrescent; bark darkish, fissures absent. Inflorescence: yellowish-white, dioecious, racemose. Leaves: green, alternate or subopposite, glabrous, coriaceous, persistent; apex obtuse; base rounded or cordate. Male flower: many, racemose, axillary, pubescent, usually drooping. Calyx: glabrous inside; lobes lanceolate or deltoid. Corolla: urceolate, lobed only near apex. Stamens: 21-30, united at base in pairs, hairy. Female flowers: cymes, clusters, axillary, pubescent, usually drooping; pedicels short. Calyx: shorter than the corolla, 5-7-fid; lobes ovate or deltoid. Corolla: urceolate, shortly lobed at apex. Staminodes: absent. Ovary: ovoid-conical, pubescent, 4-celled, 4-ovuled. Fruit: edible, solitary, blackish, hairy, globular, 1-celled, 1-seeded; fruit calyx non accrescent.

UPGMA dendrogram among the studied taxa:

The dendrogram (Figure 1) showed that, the studied taxa separated into five clusters (Table 3). First cluster included: *Diospyros chloroxylon* and *Diospyros montana*. Second cluster included: *Diospyros kaki* and *Diospyros lotus*. Third cluster included: *Diospyros ebenum* and *Diospyros mespiliformis*. Fourth cluster included: *Diospyros discolor* and *Diospyros malabarica*. Fifth cluster included: *Euclea racemosa* subsp. *schimperi*; *Euclea pseudebenus* and *Euclea polyandra*. On the whole, the plants of clusters one and two had closed relationship to each other. Moreover, the wild taxa (*Euclea racemosa* subsp. *schimperi*) had a closed relationship to the cultivated taxa of genus *Euclea* (Figure 1).

Intraspecific variation among the Diospyros taxa:

According to data of similarity matrix (Table 2), *Diospyros chloroxylon* and *Diospyros montana* had the highest value of similarity (0.850), followed by (0.833) between *Diospyros kaki* and *Diospyros lotus* and (0.824) between *Diospyros ebenum* and *Diospyros mespiliformis*. On the other hand, the lowest value of similarity 0.550 was recorded between *Diospyros lotus* and *Diospyros mespiliformis* followed by 0.656 between *Diospyros malabarica* and *Diospyros lotus*.

Intraspecific variation among the Euclea taxa:

According to data of similarity matrix (Table 2), *Euclea pseudebenus* and *Euclea polyandra* had the highest value of similarity (0.500), followed by (0.455) between *Euclea racemosa* subsp. *schimperi* and *Euclea polyandra*. On the other hand, the lowest value of similarity (0.267) was recorded between *Euclea racemosa* subsp. *schimperi* and *Euclea pseudebenus*.

Interspecific variation between Diospyros and Euclea taxa:

According to data of similarity matrix (Table 2), *Diospyros discolor* and *Euclea racemosa* subsp. *schimperi* had the highest value of similarity (0.471), followed by (0.455) between *Diospyros chloroxylon* and *Euclea polyandra* and (0.450) between *Diospyros ebenum* and *Euclea polyandra*. On the other hand, the lowest value of similarity (0.158) was recorded between *Diospyros discolor* and *Euclea pseudebenus* followed by (0.190) between *Diospyros malabarica* and *Euclea pseudebenus* and (0.200) between *Diospyros lotus* and *Euclea pseudebenus*.

Table 1. Summary and coding of 24 morphological characters among the studied Ebenaceae taxa: with their code for numerical analysis (1=presence and 0=absence).

SPECIES	<i>Diospyros discolor</i>	<i>Diospyros malabarica</i>	<i>Diospyros chloroxylon</i>	<i>Diospyros montana</i>	<i>Diospyros kaki</i>	<i>Diospyros lotus</i>
HABIT						
1.shape	tree (1)	tree (1)	tree (1)	tree (1)	tree (1)	tree (1)
TWIG						
2.surface	glabrescent (0)	Glabrescent (0)	pubescent (1)	pubescent (1)	pubescent (1)	pubescent (1)
3.branched	spreading (0)	spreading (0)	spreading (0)	spreading (0)	Spreading (0)	spreading (0)
BARK						
4.color	darkish (1)	darkish (1)	yellowish(0)	darkish (1)	darkish (1)	darkish (1)
5.fissure	absent (0)	absent (0)	absent (0)	absent (0)	present (1)	absent (0)
LEAF						
6.color	green(1)	green (1)	green (1)	green (1)	Glaucous(0)	glaucous (0)
7.surface	glabrous (0)	glabrous (0)	pubescent (1)	pubescent (1)	glabrous (0)	pubescent (1)
8.presence	persistent (1)	persistent (1)	persistent(1)	deciduous (0)	deciduous (0)	deciduous (0)
INFLORESCENCE						
9.color	yellowish- white(1)	yellowish- white (1)	yellowish- white (1)	greenish- yellow(0)	Yellowish (1)	yellowish- white (1)
10.type	cymose (1)	cymose (1)	cymose (1)	cymose (1)	cymose (1)	cymose (1)
11.sex	dioecious (1)	dioecious (1)	dioecious (1)	dioecious(1)	dioecious (1)	dioecious (1)
MALE FLOWER						
12.number	many (1)	many (1)	many (1)	many (1)	many (1)	many (1)
13.corolla	funnel-shaped (0)	funnel-shaped (0)	Urceolate (1)	Urceolate (1)	Urceolate (1)	Urceolate (1)
14.stamens no.	20 (0)	24-64 (1)	16 (0)	16 (0)	16 (0)	16 (0)
15.stamen surface	glabrous (0)	hairy(1)	hairy(1)	hairy(1)	hairy(1)	glabrous (0)
FEMALE FLOWER						
16.number	solitary (0)	clusters (1)	solitary (0)	solitary (0)	solitary (0)	solitary (0)
17.corolla	bell-shaped(0)	bell-shaped(0)	urceolate(1)	urceolate(1)	bell-shaped(0)	urceolate(1)
18.staminode	present (1)	present (1)	present (1)	present (1)	present (1)	present (1)
19.ovary	glabrous (1)	glabrous (1)	glabrous (1)	glabrous (1)	glabrous (1)	glabrous (1)
FRUIT						
20.calyx	accrescent (1)	accrescent(1)	accrescent (1)	accrescent (1)	accrescent (1)	accrescent (1)
21. seeds no.	many (1)	many (1)	many (1)	many (1)	many (1)	many (1)
22.color	reddish (1)	yellowish (1)	reddish (1)	yellowish (1)	reddish (1)	yellowish (1)
23.surface	hairy (0)	glabrous (1)	glabrous (1)	glabrous (1)	glabrous (1)	glabrous (1)
24.palatability	edible (1)	edible (1)	edible (1)	edible (1)	edible (1)	edible (1)

Table 1. Continued

SPECIES	<i>Diospyros ebenum</i>	<i>Diospyros mespiliformis</i>	<i>Euclea racemosa</i> subsp. <i>schimper</i>	<i>Euclea pseudebenus</i>	<i>Euclea polyandra</i>
HABIT					
1.shape	tree (1)	tree (1)	tree (1)	shrub (0)	shrub (0)
TWIG					
2.surface	glabrescent (0)	glabrescent (0)	glabrescent (0)	glabrescent (0)	glabrescent (0)
3.branched	spreading (0)	spreading (0)	drooping (1)	drooping (1)	drooping (1)
BARK					
4.color	darkish (1)	darkish (1)	darkish (1)	yellowish 0	darkish (1)
5.fissure	present (1)	present (1)	present (1)	absent (0)	absent (0)
LEAF					
6.color	green (1)	green (1)	green (1)	glaucous(0)	green (1)
7.surface	glabrous (0)	glabrous (0)	glabrous (0)	glabrous (0)	glabrous (0)
8.presence	persistent (1)	persistent (1)	persistent (1)	persistent (1)	persistent (1)
INFLORESCENCE					
9.color	yellowish- white (1)	yellowish-white (1)	yellowish-white (1)	greenish-yellow 0	yellowish-white (1)
10.type	cymose (1)	cymose (1)	racemose (0)	racemose (0)	racemose (0)
11.sex	dioecious (1)	dioecious (1)	dioecious (1)	dioecious (1)	dioecious (1)
MALE FLOWER					
12.number	many (1)	few (0)	many (1)	many (1)	many (1)
13.corolla	urceolate (1)	urceolate (1)	funnel-shaped (0)	urceolate (1)	urceolate (1)
14.stamen no.	16 (0)	10-16 (0)	10-20 (0)	12-20 (0)	20-30 (0)
15.stamen surface	hairy (1)	hairy (1)	glabrous (0)	hairy (1)	hairy (1)
FEMALE FLOWER					
16.number	solitary (0)	solitary (0)	clusters (1)	solitary (0)	clusters (1)
17.corolla	urceolate (1)	bell-shaped (0)	bell-shaped (0)	urceolate (1)	urceolate (1)
18.staminode	present (1)	present (1)	absent (0)	absent (0)	absent (0)
19.ovary	glabrous (1)	glabrous (1)	glabrous (1)	pubescent (0)	pubescent (0)
FRUIT					
20.calyx	accrescent (1)	accrescent (1)	non (0)	non (0)	non (0)
21. seeds no.	many (1)	many (1)	one (0)	one (0)	one (0)
22.color	blackish (0)	yellowish (1)	reddish (1)	blackish (0)	blackish (0)
23.surface	glabrous (1)	glabrous (1)	glabrous (1)	glabrous (1)	hairy (0)
24.palatability	edible (1)	edible (1)	edible (1)	edible (1)	edible (1)

Table 2. Similarity matrix showed the degree of similarity among the studied Ebenaceae taxa: *Diospyros discolor* (SP1), *Diospyros malabarica* (SP2), *Diospyros chloroxylon* (SP3), *Diospyros montana* (SP4), *Diospyros kaki* (SP5), *Diospyros lotus* (SP6), *Diospyros ebenum* (SP7), *Diospyros mespiliformis* (SP8), *Euclea racemosa* subsp. *schimperi* (SP9), *Euclea pseudebenus* (SP10) and *Euclea polyandra* (SP11) in Egypt.

Similarity Matrix											
Taxa	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	SP11
SP1	1.000										
SP2	0.820	1.000									
SP3	0.650	0.636	1.000								
SP4	0.600	0.591	0.850	1.000							
SP5	0.632	0.619	0.714	0.750	1.000						
SP6	0.667	0.565	0.750	0.789	0.833	1.000					
SP7	0.667	0.650	0.667	0.619	0.737	0.600	1.000				
SP8	0.706	0.684	0.619	0.571	0.684	0.550	0.824	1.000			
SP9	0.471	0.474	0.304	0.261	0.333	0.286	0.500	0.444	1.000		
SP10	0.158	0.190	0.350	0.300	0.250	0.200	0.333	0.211	0.267	1.000	
SP11	0.350	0.429	0.455	0.409	0.429	0.381	0.450	0.333	0.455	0.500	1.000

Table 3. Clustering of the studied Ebenaceae taxa based on the numerical analysis of 24 morphological characters.

Studied taxa	Clusters
<i>Diospyros chloroxylon</i> (SP3) <i>Diospyros montana</i> (SP4)	C 1
<i>Diospyros kaki</i> (SP5) <i>Diospyros lotus</i> (SP6)	C 2
<i>Diospyros ebenum</i> (SP7) <i>Diospyros mespiliformis</i> (SP8)	C 3
<i>Diospyros discolor</i> (SP1) <i>Diospyros malabarica</i> (SP2)	C4
<i>Euclea racemosa</i> subsp. <i>schimperi</i> (SP9) <i>Euclea pseudebenus</i> (SP10) <i>Euclea polyandra</i> (SP11)	C 5

Dendrogram using Average Linkage (Between Groups)

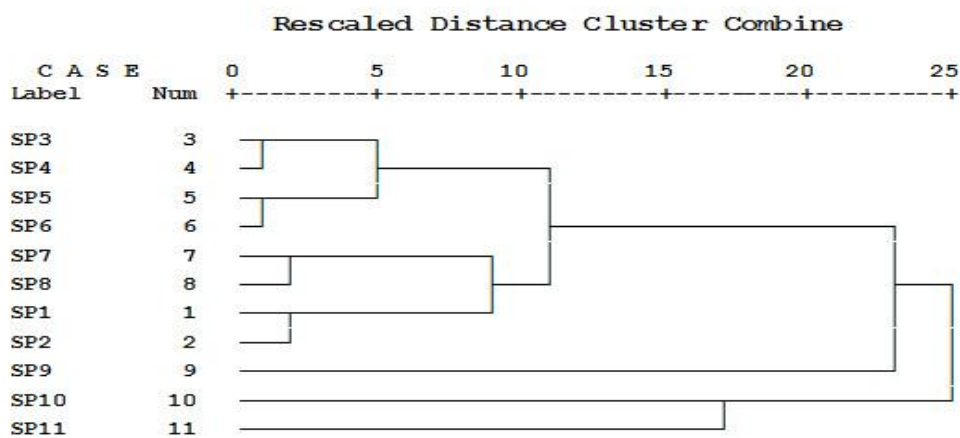


Fig. 1. UPGMA Dendrogram showed the studied Ebenaceae species: *Diospyros chloroxylon* (SP3), *Diospyros montana* (SP4), *Diospyros kaki* (SP5), *Diospyros lotus* (SP6); *Diospyros ebenum* (SP7), *Diospyros mespiliformis* (SP8), *Diospyros discolor* (SP1), *Diospyros malabarica* (SP2), *Euclea racemosa* subsp. *schimperi* (SP9), *Euclea pseudebenus* (SP10) and *Euclea polyandra* (SP11) in Egypt.



(SP1)



(SP2)



(SP3)



(SP5)



(SP4)



(SP6)

Fig. 2. Showing the studied Ebenaceae taxa: *Diospyros discolor* (SP1), *Diospyros malabarica* (SP2), *Diospyros chloroxylon* (SP3), *Diospyros montana* (SP4), *Diospyros kaki* (SP5) and *Diospyros lotus* (SP6) in Egypt.



(SP7)



(SP8)



(SP9)



(SP10)



(SP11)

Fig. 3. Showing the studied Ebenaceae taxa: *Diospyros ebenum* (SP7), *Diospyros mespiliformis* (SP8), *Euclea racemosa* subsp. *schimperi* (SP9), *Euclea pseudebenus* (SP10) and *Euclea polyandra* (SP11) in Egypt.

Discussion

The analysis of the Ebenaceae species allowed the observation of important taxonomic characters for the studied species. It is worth high lighting that researchers have long sought the importance of external morphology to aid in species identification (Metcalf and Chalk 1979; Almeida-Jr. *et al.* 2012).

In this study, on the basis of morphological characters, both (*Diospyros chloroxylon* and *Diospyros montana*) and (*Diospyros kaki* and *Diospyros lotus*) were closed to each other and ranked together in clusters one and two, respectively (Figure 1 and Table 3). This was due to the similarities in some morphological traits (Table 1). The current results were in agreements with the investigations that exhibited more or less similar results by (Hiern, 1873; Berry *et al.*, 2001; Wallnöfer, 2001; Duangjai *et al.*, 2006 and 2009).

In the same way, both (*Diospyros ebenum* & *Diospyros mespiliformis*) and (*Diospyros discolor* & *Diospyros malabarica*) were closed to each other and ranked together in clusters three and four, respectively (Figure 1 and Table 3). This was due to the similarities in some morphological traits (Table 1). The current results were in agreements with those reported by (Hiern, 1873; Wallnöfer, 2001; Duangjai *et al.*, 2006 and 2009).

Similarly, *Euclea racemosa* subsp. *schimperii*, *Euclea pseudebenus* and *Euclea polyandra* placed separately in a single cluster (Figure 1 and Table 3). This was due to the similarities in some morphological characters (Table 1). These findings were in agreements with those stated by (Hiern, 1873; Morton *et al.*, 1996; Wallnöfer 2001; Duangjai *et al.*, 2006 and 2009). The studied taxa showed differences that indicated the importance of morphological tools for taxonomic evaluation among the studied taxa.

Conclusions

The current taxonomic study based on morphological characters revealed that, the position of following studied taxa: (*Diospyros chloroxylon* and *Diospyros montana*), (*Diospyros kaki* and *Diospyros lotus*), (*Diospyros ebenum* and *Diospyros mespiliformis*), (*Diospyros discolor* and *Diospyros malabarica*) and (*Euclea racemosa* subsp. *schimperii*, *Euclea pseudebenus*, *Euclea polyandra*) in different five clusters respectively, confirmed its closed relationship.

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