10.21608/taec.2022.118726.1036 *Taeckholmia 41 (2021): 56-69*

Taxonomic revision of genus *Oxalis* L. (Oxalidaceae) in the flora of Egypt

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Abstract

This paper provides a full taxonomic revision of the genus *Oxalis* for the flora of Egypt. The study was carried out on herbarium specimens as well as fresh materials. The study revealed the presence of five species and one variety belonging to three sections by adding *O. corymbosa* and *O. latifolia. Oxalis corniculata* is a polymorphic taxon in Egypt which led to the recognition of *O. corniculata* L. with its type var. *corniculata* and *O. corniculata* L. var. *repens* (Thunb.) Zucc. The species are mostly weed of cultivation along Mediterranean and Nile Valley with the exception of *O. anthelmintica* which is restricted to southeastern corner of Egypt. Among the studied taxa, variation in the presence or absence of stem, bulb characters, leaflets shape and color of flowers were found significant diagnostic characters for delimiting the taxa. For each taxon, update nomenclature, synonyms, type, amended descriptions, distribution (local and global), representative specimens are given. Photographs and diagnostic key to the species are provided to assist in identification.

***Key words*:** Diagnostic key, Flora of Egypt, *Oxalis*, Taxonomic revision

Introduction

Oxalis (Oxalidaceae) is a cosmopolitan genus that comprises 500 - 800 species (Oberlander et al., 2004), distributed in three principal centers of species richness (South Africa, North and South America) and fairly well represented in Europe and Asia. Most members of the genus are weeds or ornamentals in gardens. The genus is one of very few non-monocot angiosperm bulbous taxa (Judd *et al.*, 1999). The spread of many taxa, however, is made easier by bulbous reproductive mechanism which makes many taxa of S African or S American origins have become invasive in many Mediterranean countries (Young, 1968 and Pyšek *et. al*, 2017). The genus *Oxalis* is taxonomically difficult as it comprising many varieties which are extremely variable morphologically (López & Múlgura, 2011).

The first taxonomic treatment of *Oxalis* was that of Linnaeus (1753) who described 14 species of the genus classified in two main unranked groups based on the presence or absence of the stem. Reiche (1894) introduced the non-formal level of Division and subdivided the genus into four divisions: Plamatifoliae, Trifoliatae, Pteropodae and Simplicifoliae.

A monographic revision of genus *Oxalis* was provided by Knuth (1930), he recorded 791 species distributed in 37 sections with a great number of subsections and series. Delimitation of these sections was based on morphological and floral characters

The most prolific work on S African taxa of *Oxalis* is that of Salter (1944), he classified the genus into 11 sections and 13 subsections, based on morphological characters in addition to notes on its ecological responses, distribution, mode of reproduction and seed characters.

Lourteig (1994; 2000) gave a comprehensive revision of *Oxalis* with a special reference to the southern American species. She proposed a new subgeneric and sectional classification of the genus; of which four subgenera were recognized based mainly on characters of the leaf viz., *Oxalis, Thamnoxys* (Endl.) Reiche emend. Lourteig, *Monoxalis* (Small) Lourteig and *Trifidus* Lourteig. However, most of *Oxalis* species have been placed in the subgenus *Oxalis*, where 18 sections have been recognized.

Many phylogenetic studies on *Oxalis* have been carried out to elucidate the interrelationships between taxa studied (Oberlander *et al.*, 2004; 2009; 2011; Gardner *et al.*,2012; Heibl & Renner, 2012 and Vaio *et al.*, 2013; 2016). According to Oberlander *et al.* (2011); Vaio *et al.* (2013) and Jooste *et al.* (2016) the morphological and molecular diversity within *Oxalis* still limited and incongruent; moreover, the relationships among the subgenera and sections are unclear (Abreu *et al.*,2012).

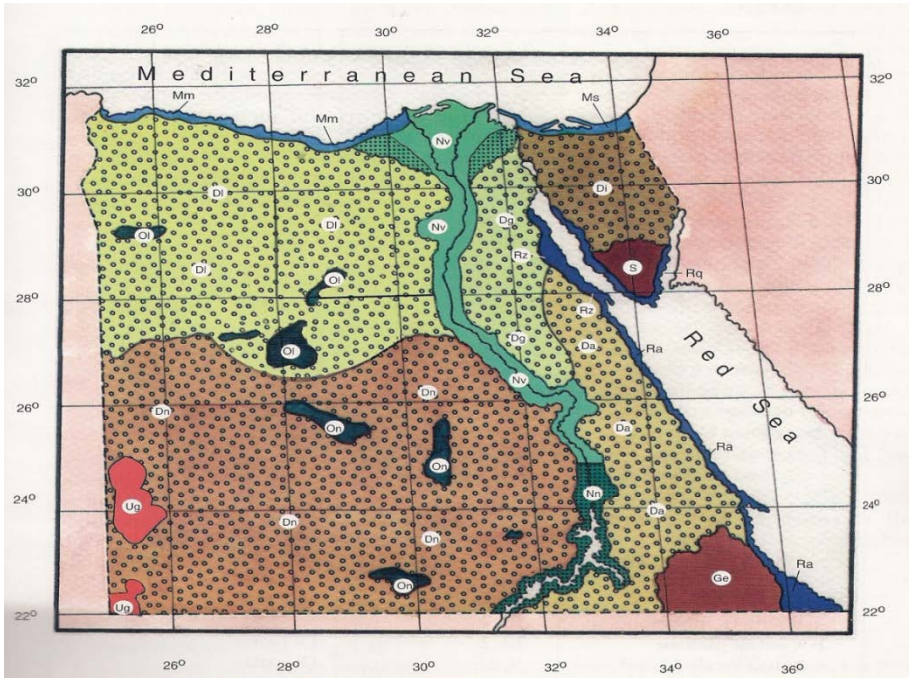
Received on 28/01/2022 and accepted on 04/04/2022 Edited by Dr. Ashraf Soliman

In Egypt, Täckholm (1956; 1974) enumerated three species of *Oxalis* with one variety namely: *Oxalis pes-caprae* (naturalized weed), *O. anthelmintica* (very rare species from Gebel Elba), *O. corniculata* var. *corniculata* (common weed) and var. *repens* (very rare from Mediterranean coast). A recent revision of the genus in Egypt by El Hadidi & Fayed (1994/95) and Boulos (1999, 2009) recorded only three species without any infraspecific taxa, they included *O. corniculata* var. *repens* within *O. corniculata* as a synonym. In 2005, El Khanagry added two more species from Nile Valley as a weed of cultivation viz.: *O. latifolia* and *O. corymbosa*.

The objective of this study is to provide an update taxonomic revision of genus *Oxalis* in Egypt and to provide a diagnostic key to distinguish the taxa examined.

Materials and Methods

The present study was based on examination of specimens kept in the major Egyptian herbaria: Cairo University (CAI), the Agriculture Museum, flora and phytotaxonomy researches (CAIM), National Research Centre (CAIRC)and Tanta University (TANE); (Herbaria acronyms according to Thiers, 2021; continuously updated). In addition to fresh specimens collected from different localities. The identification of the collected specimens was confirmed by referring to various regional floras (Täckholm, 1974; Boulos, 1999; Zohary, 1972; Cullen, 1967; Meikle, 1977; Ali, 1977; Stace, 1997;Chaudhary, 2001) and comparing them with herbarium specimens and images available in virtual herbaria [Kew Herbarium Catalogue (http://apps.kew.org/herbcat/navigator.do), African Plant Database (www.tropicos.org) and JSTOR Global Plants (https:// Plants.jstor.org/)] as well as collections housed at the Herbarium of Cairo University. Nomenclature of all taxa has been updated according to several websites (www.theplantlist.org; www.ipni.org). For each taxon, the revised specimens were geographically arranged according to the phytogeographical territories of Egypt proposed by El Hadidi, 2000 (Map 1). Within each phytogeographical territory specimens are arranged according to the date of collection and the sequence of location from East to West and from North to South. Photographs showing the habit, inflorescence, leaves, flowers and bulbs of each taxon are provided (if available) using HUAWEI Y6-Pro mobile camera (not in scale). For SEM study, seeds were mounted onto stubs with double sided adhesive tape, coated with gold, then were examined and photographed by a field emission scanning electron microscope (FE-SEM) QUANTA FEG250Y at accelerating voltage 20 KV, at Electron Microscopy Unit, NRC, Dokki. Voucher specimens of the studied taxa are deposited in the herbaria of Cairo University (CAI) and National Research Centre (CAIRC).



Map (1): Phyto-geographical territories of Egypt (El Hadidi, 2000)

Da: Arabian Desert, the southern province of the desert east of the Nile. **Dg**: Galala Desert, the northern province of the desert east of the Nile. **Di**: Isthmic Desert, the northern part of Sinai Peninsula, south of the Mediterranean Coastal land and its extension westward to the Nile Delta. **Dl**: Libyan Desert, the northern province of the desert west of the Nile. **Dn**: Nubian Desert, the southern province of the desert west of the Nile. **Ge**: Gebel Elba district, at the SE corner of the Arabian Desert. **Mm**: Mareotis sector of the Mediterranean coastal land extending between Egypt-Libyan border, eastward to Rosetta. **Ms**: Sinaitic sector of the Mediterranean coastal land extending between Port Said eastward to Rafah at the Egyptian-Palestinian border. **Nn**: Nubian sector of Nile land, extending from Sudanese.

Border northwards to Kom Ombo. **Nv**: Nile Valley sector of Nile land, extending from Kom Ombo northwards to include the Nile-fed Faiyum area and the Nile Delta with its extensions of reclaimed lands of Tahrir Province to the west and Salhyiya District to the east. **Ol**: Oases of the Libyan Desert province. **On**: Oases of the Nubian Desert province. **Ra**: Arabian sector of the Red Sea coastal plains extending between 22˚-28˚ N. **Rq**: Aqaba Gulf sector of the Red Sea coastal plains which extends along the Western coast of Aqaba Gulf between 28˚-29˚.30′ N. **Rz**: Suez Gulf sector of the Red Sea coastal plains in the Eastern Desert and Sinai between 28˚-30˚ N. **S**: mountainous southern Sinai. **Ug**: Gebel Uweinat massive on Egypt's border with Libya and Sudan and the northerly situated El Gilf El Kebir.

Results and discussion

Taxonomic treatment:

Oxalis L. (1753: 433, 1754: 198)

Type species: *Oxalis acetosella* L.

Annual or perennial herbs or subshrubs, caulescent or acaulescent, usually with bulbous- rooted or rhizome. Leaves basal in fascicled-like or cauline, alternate, mostly 3-foliolate, digitate or pinnate, petiolate, sometimes with or without membranous stipules adnate to the petiole; leaflets obcordate to obdeltoid, emarginated or bilobed, cuneate at the base, glabrous or hairy, sometimes with impressi-punctate (i.e., large epidermal cells become pitted when dry) and brown dots or streaks (calli). Inflorescence axillary or on long erect scape-like peduncles, cymose or pseudo-umbel, sometimes flowers solitary. Flowers actinomorphic, pentamerous, pedicellate and bracteate. Sepals distinct, imbricate mostly with apical calli; petals yellow, pink, purple red or white, convolute, sometimes slightly connate at base. Stamens 10, biseriate, connate at base, the series of 5 short external stamens opposite the petals (alternisepalous), the internal series (alternipetalous) longer and sometimes with an abaxial appendage, usually all stamens fertile. Pistils usually heterostylous, bi-, tri-morphic or mono-morphic, ovary of 5 fused carpels, with 1-many ovules in each locule, styles 5, filiform, free ending with capitate stigma. Fruit loculicidal capsule; seeds one to many, brown, with fleshy aril, explosively ejected.

The present study revealed the presence of five species and one variety. According to the systems proposed by Salter (1944) and Lourteig (2000), members of *Oxalis* in Egypt distributed in three sections of subgenus *Oxalis*, viz.: section *Corniculatae* DC. includes *O. corniculata* var. *corniculata* and var. *repens*, section *Cernuae* Knuth includes *O. pes-caprae* and *O. Anthelmintica* and section *Ionoxalis* (Small) Knuth includes *O. corymbosa* and *O. Latifolia*.

Key to Oxalis taxa in Egypt

1.a. Herb with branched stems, non-bulbous……...…...***O. corniculata***

b. Herb without stem, bulbous…….…… (2)

2.a. Plant with vertical rhizome. ……...……...……...……..… (3)
b. Plant without vertical rhizome…….……...……...……...……... (4)

3.a. Flowers yellow; rhizome whitish; leaflets broadly obcordate, asymmetric bi-lobed with wide sinus, 10-15mm apart. Long stamens with appendage.……...……...……...……. ***O. pes-caprae***

b. Flowers purple; rhizome brownish; leaflets subcircular to obovate, symmetric bilobed with emarginate at apex. Long stamens without appendage……..……...….....…. ***O. anthelmintica***

4.a. Bulb solitary with contractile and fibrous roots; leaflets obdeltoid or obtriangular without brownish calli at the margin, bilobed divergent.…….…….... ***O. latifolia***
b. Bulb composed of numerous, sessile, uniform in size bulbils, with translucent tuberous root; leaflets obcordate, with brownish calli near the margin, bilobed with narrow sinus 1 - 2 mm apart……. ***O. corymbosa***

Section: *Corniculatae* DC.

1. ***Oxalis corniculata*** L., Sp. Pl. ed.1:435 (1753).

General description

Annual or perennial, procumbent to ascending herb, with a rigid root stock, 8–50cm tall, much branched; bulbs absent. **Stems** often freely rooting at nodes, sparsely to densely pubescent or hirsute; internodes variable in length, 1.1 – 7 cm long. **Leaves** alternate or pseudo-verticillate. **Petiole** 1.2-6.5 cm long, with dense curled hairs. **Stipules** broadly oblong, 2-3.3 x 0.6-1mm, truncate or auriculate at apex and ciliate margin. **Leaflets** subequal, green or glaucous, obcordate, cuneate, 2-14 x 3-22 mm, sessile, symmetric bilobed with narrow sinus,1-4 mm apart, glabrous to subglabrous above, hairy below. **Inflorescence**

axillary,1-6 flowers per peduncle in umbelliform cymes. **Peduncle** ascending, 2-6 cm long, pilose. **Bracts** 2, subequal, scarious, linear-lanceolate to subulate,1.5-3.2 x 0.2-0.5 mm, hairy at lower surface. **Flowers** yellow, pedicellate, pedicels 6-15 mm long, deflexed in fruit, pilose. **Sepals** subequal, oblong-lanceolate, 3-4.2 x 0.9-1.2 mm, pubescent, ecallose, with acute apex and ciliate margin, persistent in fruit. **Petals** spathulate to oblong-obovate, 5-6 x 2-2.2 mm, clawed at the base, glabrous. **Stamens** 10, unequal; long stamens 3-3.5 mm long and short stamens c. 2 mm long, glabrous. **Ovary** oblong to ellipsoid, 1.5-1.8 x 0.8-1 mm, hairy; styles 5, adpressed hairy, 1-1.5 mm long, including the capitate stigma. **Fruit** 5-angled capsule, cylindric or narrowly ovoid, 6-15 x 1-3 mm, gradually attenuated at apex, strigose with simple hairs and a few septate hairs along the sutures. **Seeds** 8-10 per locule, glossy brown, broadly ovoid to ellipsoid, 1.4-1.6 x 0.9-1 mm, flattened dorsiventral, enclosed by a smooth, turgid aril (i.e., exo- & mesotesta layers) which splits at maturation; hilum basal and slightly raised. Testa transversely ridged, ridges thin or thick and interrupted; channels ± wide and deep. SEM of seed surface sculpture showed reticulate pattern with thin, straight anticlinal walls and periclinal walls with central cubic crystals.

Flowering period*:* April – December.

Habitat: growing among rocks in rocky slopes and as a weed in cultivated terraces, waste ground and lawn sand roadsides.

Global distribution*:* Its native range is Mexico to Venezuela and Peru. Introduced and naturalized in Africa, most Asia, Australia and many parts of the Americas.

Taxonomic notes:

A polymorphic species, its taxonomy is complicated by the description of many subspecific taxa and other species now considered to be synonyms (Lourteig, 1979). In Egypt, *Oxalis corniculata* is a polymorphic taxon which led to the recognition of *O. corniculata* L. with its type var. *corniculate* and *O. corniculata* L. var. *repens* (Thunb.) Zucc. *Oxalis repens* was firstly described by Thunberg (1781), later, Zuccarini (1831) lowered it to varietal level viz. *Oxalis corniculata* var. *repens* (Nesom, 2009; Groom *et al.* 2019), a concept accepted by Kabuye (1971), while Lourteig (1979) treated this taxon as synonym to *O. corniculata*. Täckholm (1974) recognized two varieties from Egypt, the type variety and var. *repens* both can be distinguished through the characters of stem, leaves, capsule and seeds. The later variety was treated by El Hadidi & Fayed (1994/95) and Boulos (1999, 2009) as conspecific to var. *corniculata*. The present investigation confirms the opinion of Täckholm in treating var. *repens* as a distinct taxon and the morphological differences of both varieties are constructed in the following key:

- Plant 10 - 50 cm tall. Leaflets green, 5-14 x 9-22 mm, punctuate at abaxial surface. Capsule cylindrical, 8 - 15 x 1-3 mm. Seeds broadly ovoid to ellipsoid outline, Seed-ridges thick and interrupted……***O. corniculata* var. *corniculata***
- Plant up to 8 cm tall. Leaflets glaucous, 2-5 x 3-8 mm, Punctuate at both surfaces. Capsule narrowly ovoid, 6-8 x 2-2.2 mm. Seeds narrowly ovoid outline, Seed-ridges thin and ± discrete.…..…. ***O. corniculata* var. *repens***

1.a. *O. corniculata* L. var. ***corniculata*** Sp. Pl. ed. 1:435 (1753). **(Plate 1)**

Type: "Habitat in Italia, Sicilia"
Lectotype: Herb. Linn. No. 600.31 (LINN)

Synonyms:

= *Oxalis villosa* M. Bieb., Fl. Taur. -Caucas. 1:355(1808).
= *Oxalis corniculata* var. *villosa* (M. Bieb.) Hohen., Bull. Soc. Imp. Naturalistes Moscou,11(4): 395 (1838).
= *Oxalis radicosa* A. Rich., Tent. Fl. Abyss. 1:123 (1847).
= *Oxalis corniculata* var. *atropurpurea* Planch., J. Gén. Hort.12:47, pl. 1205 *(1857)*.
= *Oxaliscorniculata* subsp. *albicans* (Kunth) Lourteig, Phytologia 42: 197

English name: Yellow Sorrel

Uses: Medicine

Distribution in Egypt: wide spread weed in cultivated lands of western Mediterranean region, Oases, Nile Delta and Nubian Nile; also reported from Galala Desert and south Sinai.

Representative Specimens:
Mm: Bramly's grotto, Burg El-Arab, 1-4-1960; *El-Batanouny* s.n. (CAI)-- Burg El Arab, 10-3-1986; *M. A. El-Raauf* 3094 (TANE)

Nv: Damietta, 12-4-1922, *Simpson* 1003 (CAIM) - Edku, 19-10-2012; *A. Keshta s.n*. (TANE) - Bishla, Mansoura, 3-9-1975; *Gazzar & Abdel Aziz* s.n. (CAI)-- Kafer El-Sheikh, 18.5.1996; *Y.M .AlSodany* s.n. (TANE)-- El Bagor, Monufia,12-4-2019; *A. Draz* s.n. (CAIRC)--Abu-Zaabal, N Cairo, 9-4-1954; *Boulos* s.n. (CAI)-- El Khanka, 20-10-1965; *El Hadidi & Khattab* s.n. (CAI)-- Geziret El Warraq, near Cairo; 26-6-1931 *Drar* s.n. (CAIM)--De Guiza Pres Du Caire, 7-2 - 1908; *Hartmann* 479 (CAIM)-- National research center garden, Giza, 13-5-2019 & 22-9-2020; *A.Draz* s.n. (CAI, CAIRC)-- Zawyet Abu Musallam, Beni Suef, Giza, 19-11-1974, *El khanagry* 11 (CAIM)-- Canal banks, West El Fayoum city, 23-9-1993; *El Garf* s.n. (CAIRC)-- Beni suef, 8-1952; *Boulos* s.n. (CAI)-- New Kurna village, Luxor, 22-4-1967*; El Hadidi et al.* s.n. (CAI).

Nn: Kom Ombo, 11-2-1964; *V. Täkholm* s.n. (CAI) -- Along irrigation canals, along the eastern banks of the Nile, Elephantine Island, 20-1-1979; *Boulos* 12727 (CAIRC).

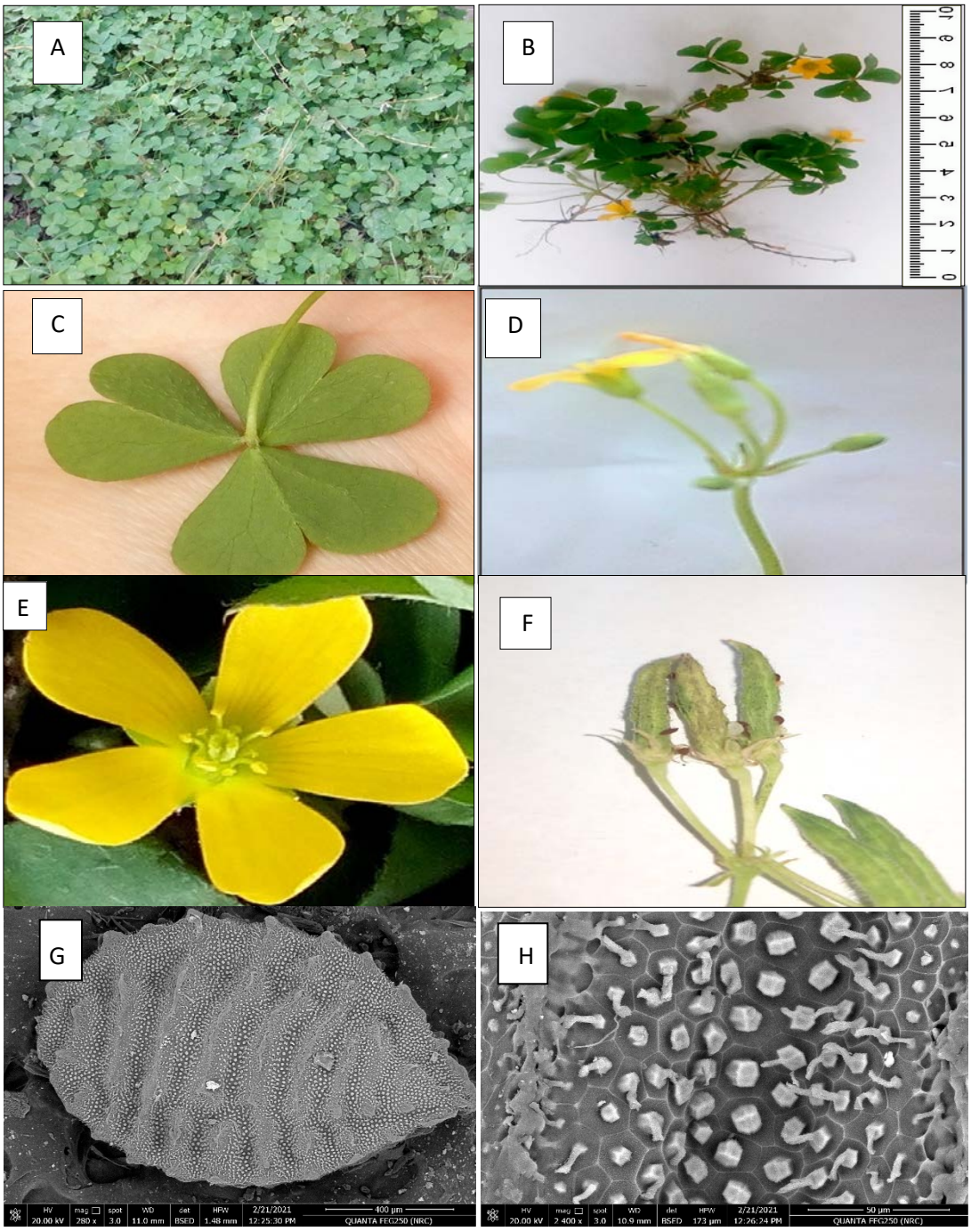


Plate (1): *O. corniculata* var. *corniculata:* (A) Plant in its habitat, (B): A branch showing habit, (C): Lower surface of leaf, (D): Inflorescence, (E): Flower, (F): Fruit, (G): Whole seed (X280), (H): Testa sculpture (X 2400)

Dg: Nifisha, Ismailia, 21-12-1959; *Khattab* 358 (CAIM)--At Timsah lake S of the town, Ismailia, 18-3-1927; *G. Täckholm* s.n. (CAI).

Ol: In a date palm grove, Ain Bishmu, Bawiti, 25-1-1978; *M. Abd El Ghani* 48 (CAI)—Ain Ibswai, Farafra Oasis, 22-3-1940; *Drar* 27 (CAIM)

On: Gardens in the town, El Qasr, Dakhla Oasis, 16-3-1967; *El Hadidi et al.* s.n. (CAI)-- Bir Romani, Budkhulu, Dakhla, 12-2-1952; *Täckholm & Kassas* 185 (CAI)-- Rashada, Dakhla Oasis, 19-1-1929; *Shabetai Z.* 539 (CAIM)--Farafra Oasis, 3-2-1988; *Bot. Dept. Group* s.n. (TANE).

S: Wadi Feiran, 19-10-2012*; A. Keshta* s.n. (TANE).

1.b. *O. corniculata* L. var. ***repens*** (Thunb.) Zucc., Nacht. Monogr. Amer. *Oxalis* 54 (1831). **(Plate 2)**

Basionym: *Oxalis repens* Thunb., Diss. *Oxalis* 16, t.11 (1781).

Type: Several specimens in Herb. Thunb., one apparently from the cape

province of South Africa collected by Thunberg (UPS, syn.).

Synonyms:
= *Oxalis procumbens* Steud. ex A. Rich., Tent. Fl. Abyss. 1:123 (1847).

Flowering period: April-December.

Habitat: Weed in cultivated terraces.

Distribution in Egypt: Very rare weed, recorded from Nile valley.

Global distribution: Native range to Uganda, Kenya, to Tropical E Africa.

Representative Specimens:

Nv: National research center garden, Giza, 13-5-2019, *A. Draz* s.n. (CAI, CAIRC); ibid, 22-9-2020, *A. Draz* s.n. (CAI, CAIRC) --ibid, 18-4-2021, *A. Draz* s.n. (CAI, CAIRC).

Section: *Cernuae* Knuth

2. *Oxalis pes-caprae* L., Sp. Pl. ed. 1: 434 (1753). **(Plate 3)**

Type: "Habitat in Aethiopia" Hb. Linn. 600/13. (LINN).

Synonyms:

= *Oxalis cernua* Thunb., Diss. *Oxalis* 14 no.12, t.2 (1781).

= *Acetosella cernua* (Thunb.) Kuntze, Revis. Gen. Pl. 1: 90 (1891).

= *Bolboxalis cernua* (Thunb.) Small, N. Amer. Fl. 25(1): 28 (1907).

General description:
Geophyte, tufted perennial herb, 17 – 30 cm tall. **Bulb** solitary**,** ovoid to pyriform,10-20 x 7-24 mm, attenuate at apex; tunics brown, papery with finely longitudinal ridges, glabrous; with contractile roots. **Rhizome** vertical, thin, whitish, 4.5-15 cm long, upper rhizome nodes with pale, glabrous, semi-amplexicaul scales and small bulbils, bulbils ovoid, 6-10 x 2-4 mm. Above-ground stem absent. **Leaves** arranged in a basal rosette. **Petioles** 8 - 18.5 cm long, glabrous or with sparsely silky hairs. **Stipules** ovate – oblong, 2-8 x 1.8-2 mm, with curled silky hairs at margin. **Leaflets** ± equal, broadly obcordate, cuneate, 7-18 x 15-27 mm, sub-sessile, asymmetric bilobed with wide sinus, 10 - 15mm apart, glabrous with brown dots above and appressed silky hairs below. **Inflorescence** basal, 5-8 flowered per peduncle in umbelliform cymes. *Peduncle* ±glabrous, 9-28 cm long, longer than petioles. **Bracts** lanceolate to ovate, 2-4 x 3-5 mm, hairy, apex acute, with 2-brownish calli. **Flowers** golden yellow, pedicellate, **pedicels** 7-20 mm long with glandular hairs. **Sepals** 5, subequal, lanceolate, 6-8 x 1.5-2.5 mm, with glandular and eglandular hairs, apex subacute with 2 small linear, brownish calli, and membranous margin. **Petals** 5, spathulate, 15-25 x 8-10 mm, sparsely hairs, apex rounded. **Stamens** 10, long stamens 6-7mm long, glabrous with dorsal appendage near the base, up to 1mm long and short stamens 4-5 mm long, glabrous. **Ovary** oblong, 3 x 1.5 mm, hairy; styles 5, densely hairy, about 1.5 mm long, including the capitate stigma. **Fruit** not seen

Flowering period: April - September.

Habitat: Moist and cultivated grounds, Orchards and open habitats.

English name: African wood-sorrel, Sour grass.

Uses: A source of oxalic acid and Medicine.

Distribution in Egypt: Rare in the western Mediterranean coastal land and Nile Delta.

Global distribution: Native to Namibia to Cape Province, invasive species and noxious weed in many other parts of the world, including Mediterranean region, West Europe, North Africa, Iran, Turkey, South West Asia and some parts of W Americas.

Taxonomic notes: *O. pes-caprae* is relatively similar to *O. anthelmintica*, the former can be distinguished by its yellow flowers (vs. flowers purple in *O. anthelmintica*), leaflets asymmetric bi-lobed with wide sinus (vs. leaflets symmetric bilobed with emarginate at apex) and long stamens with appendage (vs. long stamens without appendage).

Representative Specimens:

Mm: Mersa Matruh, 19-3-1927; *Simpson* 4686 (CAIM)-- Mariut, Burg El Arab, 2-4-1960; *Ghabbour* s.n. (CAI)-- Bramly's grotto, Burg El-Arab, 28-2-2019; *A. Draz* s.n. (CAIRC)-- Behig, 4-5-1976; *Ahmed & Mokhtar* 71 (CAIM)-- Mariut, 10-3-1937; *Runkewitz* s.n. (CAI)-- Maruit, 23-3-2006; *D.A. Ahmed* 2937& 501 (TANE)-- Behind Nuzha gardens, Samouha cultivations, Alexandria, 23-3-1956; *Täckholm* & *El Hadidi* s.n. (CAI).

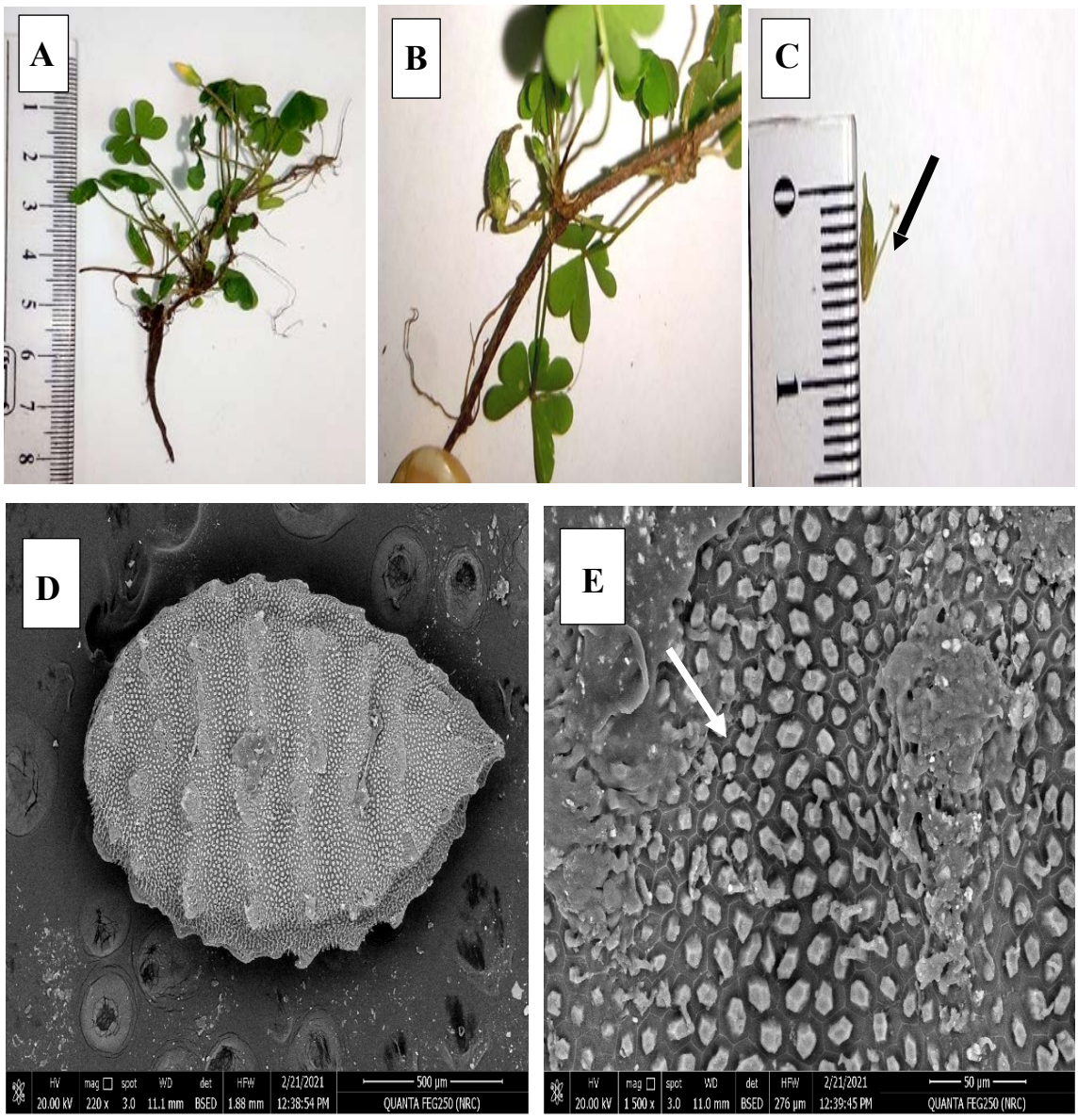


Plate (2): *O. corniculata* var. *repens*: (A) Whole plant, (B) A branch showing leaves and fruit, (C) deflexed fruit, (D) Whole seed (X 220); (E) Testa sculpture, the arrow showing pectin granules (X 1500).

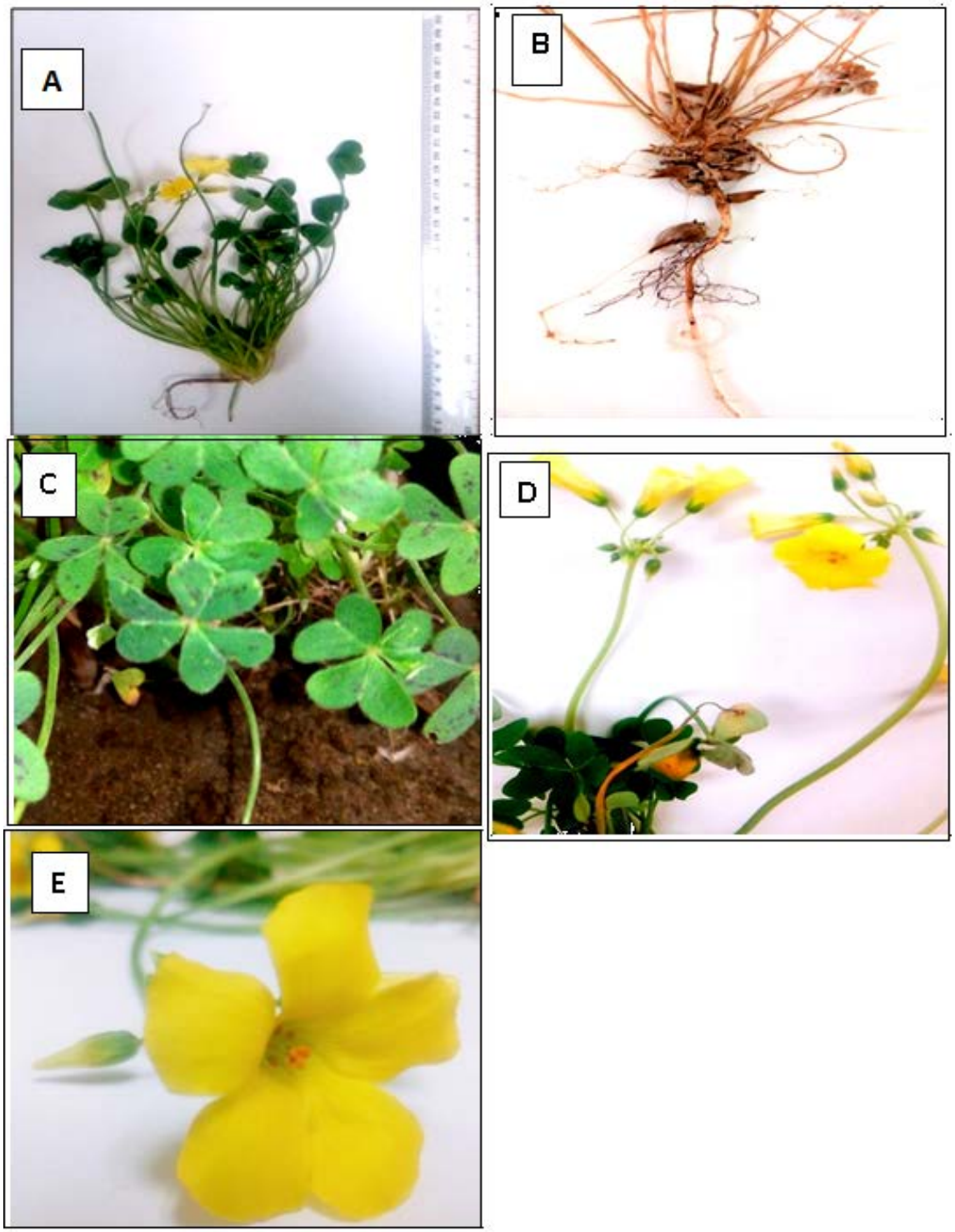


Plate (3): *Oxalis pes-caprae*: (A) whole plant showing leaves and flowers, (B) Bulb & rhizome bearing bulbils, (C) Arrow showing brown dots of the leafleat (D) Umbeliform cymes inflorescence, (E) Magnified Flower

Nv: Lake Edku,17-4-2003; *T. Galal* s.n (TANE)-- Kafr El Sheikh, 23-3-2006; *D.A. Ahmed*, 546 &350 (TANE)-- Barrage, 6-3-1952; *El Hadidi* s.n. (CAI)-- Faculty of agriculture, Mushtuhur, Qalubaya, January 1979; *El Khanagry* s.n. (CAIM)--Agricultural Museum Garden, Dokki, Giza, 6-5-1964; *El-Mahdi* s.n. (CAI).

3. *Oxalis anthelmintica* A. Rich., Tent. Fl. Abyss.1: 124 (1847). **(Plate 4)**

Type: Ethiopia, Tigre, valley of R. Tacazze near "Dschelads cheranne", *Quartin Dillon* (P, holo).

Synonyms:
= *Oxalis abyssinica* Turcz., Bull. Soc. Imp. Naturalistes Moscou 31(1): 432 (1858) non (A. Rich.) Walp. (1852), nom. Illeg.

= *Oxalis caprina* L. var. *abyssinica* (Turcz.) Oliv., Fl. Trop. Afr. 1: 296 (1868).

= *Oxalis purpurata* Jacq. var. *anthelmintica* (A. Rich.) Knuth, in Engl., Pflanzenr. IV, 130: 304 (1930).

General description:
Geophyte, perennial herb, 7-20 cm tall. **Bulb** solitary, ovoid, 12-16 x 8-9 mm with acute apex; tunics brownish, papery, glabrous, with acuminate apex and membranous margin, nerves indistinct. **Rhizome** vertical, 3-11cm long, glabrous to sub-glabrous. **Leaves** arranged in a basal rosette, sometimes spaced and alternate. **Petioles** 6.5-10.5 cm long, glabrous or with sparsely long hairs. **Stipules** ovate-oblong to elliptic, 6-13 x1.4-4mm, glabrous to subglabrous. **Leaflets** ± equal, subcircular to obovate, cuneate, 12-20 x 12-23mm, sessile, symmetric bilobed with emarginate at apex, subglabrous above, with a few hairs at least on the midrib below, sometimes gland-dotted at the edge. **Inflorescence** basal, 3-4 flowered per peduncle in umbelliform cymes. **Peduncle** sparsely hairy, 6 - 11 cm long, slightly longer than petioles. **Bracts** linear, 2 x 0.3 mm, sub-glabrous, apex acute rarely with apical calli. **Flowers** purple, pedicellate. **Pedicels** 10-18 mm long with pilose hairs. **Sepals** 5, equal, lanceolate to ovate-lanceolate, 4-6 x 1-1.5mm, subglabrous, apex acute to subacute, scarious with longitudinal patches on the upper half, with or without orange apical calli, and entire margin. **Petals** 5 spathulate, 14-15 x 3.2-3.4mm, glabrous, apex rounded. **Stamens** 10, basely connate, long stamens 8-9 mm long, pubescent and short stamens 3-3.5 mm long, glabrous. **Ovary** oblong to ellipsoid, 2 x 1 mm, sub-glabrous; styles 5, hairy, 4-5mm long, including the capitate stigma, intermediate in length between or longer than the 2 stamens whorls. **Fruit** not seen.

Flowering period: January –April.

Habitat: Sandy and loamy soils.

English name: (Not detected)

Uses: Medicine.

Distribution in Egypt: Very rare in wadi beds of Gebel Elba district of Egypt.

Global distribution: Native range from The Sudan to S. Tropical Africa.

Taxonomic notes:
The Tropical African species *O. anthelmintica* is known in Egypt from Gebel Elba which may represents its northern distribution. The species reproduces vegetative through bulbs, although it reproduces both vegetatively and by seeds in its native countries (Bayisa & Hundesa, 2017).

Representative specimens:
Ge: Gebel Ekwal, Gebel Elba, 25-1-1933; *Shabetai Z.* 2696 (CAIM)-- Gebel Hamam, Gebel Elba, 5- 3- 1938; *Shabetai* Z. 5202 (CAIM)-- Khor Wadi Yahameib across Gebel Elba, 22-1-1962; *Täckholm et al.* 231 (CAI)-- Mountain tributary, Wadi Akwametra, Gebel Elba, 27-2-1967; *Osborn & Helmy* s.n. (CAI)-- Wadi Darawein, Gebel Elba, 3-2-1979; *Boulos* 12924 (CAIRC)-- Gebel Elba, 23-1-1929; *G. Täckholm* s.n. (CAI)-- Gebel Elba, 27-1-1933; *Hassib* s.n. (CAI)-- Gebel Elba in the SE corner of Egypt, 14-1 to 6-2-1933; *Fahmy & Hassib* s.n. (CAI).

Section: *Ionoxalis* (Small) Knuth

4. *Oxalis corymbosa* DC., Prodr. 1: 696. (1824). **(Plate 5)**

Lectotype: Insula Borbona (G-DC).

Synonyms:

= *Oxalis debilis* Kunth var. *corymbosa* (DC.) Lourteig in Ann. Miss. Bot. Gard. 67: 840 (1980).

= *Oxalis debilis* Kunth subsp. *corymbosa* (DC.) O. Bolòs & Vigo, Fl. Països Catalans 2:286 (1990).

= *Oxalis maritiana* Zucc., Denkschr. Königl. Akad. Wiss. München 9: 144 (1823-1824 publ. 1825).

= *Acetosella grandifolia* (DC.) Kuntze, Revis. Gen. Pl.1: 92 (1891).

= *Acetosella martiana* (Zucc.) Kuntze, Revis. Gen. Pl. 1: 90 (1891).

= *Onoxalis martiana* (Zucc.) Small, Fl. S.E. U.S. 665(1903).

General description:
Geophyte, perennial herb, 22-30 cm tall. **Bulb** globose,25-30 x 30-35 mm, with many small and sessile bulbils around its base; bulbils ovoid, uniform in size, 8-10 x 4-6 mm, sheathed in outer protective scales; tunics pale brown, fleshy, with curly hairs and three orange central nerves, apex sharp acute and ciliate hyaline margin. Bulb with fleshy, translucent tuberous root at the base, 4-5cm long. **Rhizome** and above ground stem absent. **Leaves** arranged in a basal rosette. **Petioles** flexuous near the base,14- 28 cm long, with sparse unicellular hairs. **Stipules** oblong-lanceolate, 9-15x1.8-2 mm, 3 nerves, nerves brownish, conspicuous, convergent below the apex; margin ciliate. **Leaflets** ±equal, obcordate, cuneate, 12-25 x 14-35 mm, sessile, symmetric bilobed with narrow sinus 1-2 mm apart, glabrous above, with silky unicellular hairs below and brownish calli near the margin. **Inflorescence** bifid branching cymes, 7-16 flowered per peduncle in umbelliform. **Peduncle** hairy, 16-26 cm long, longer

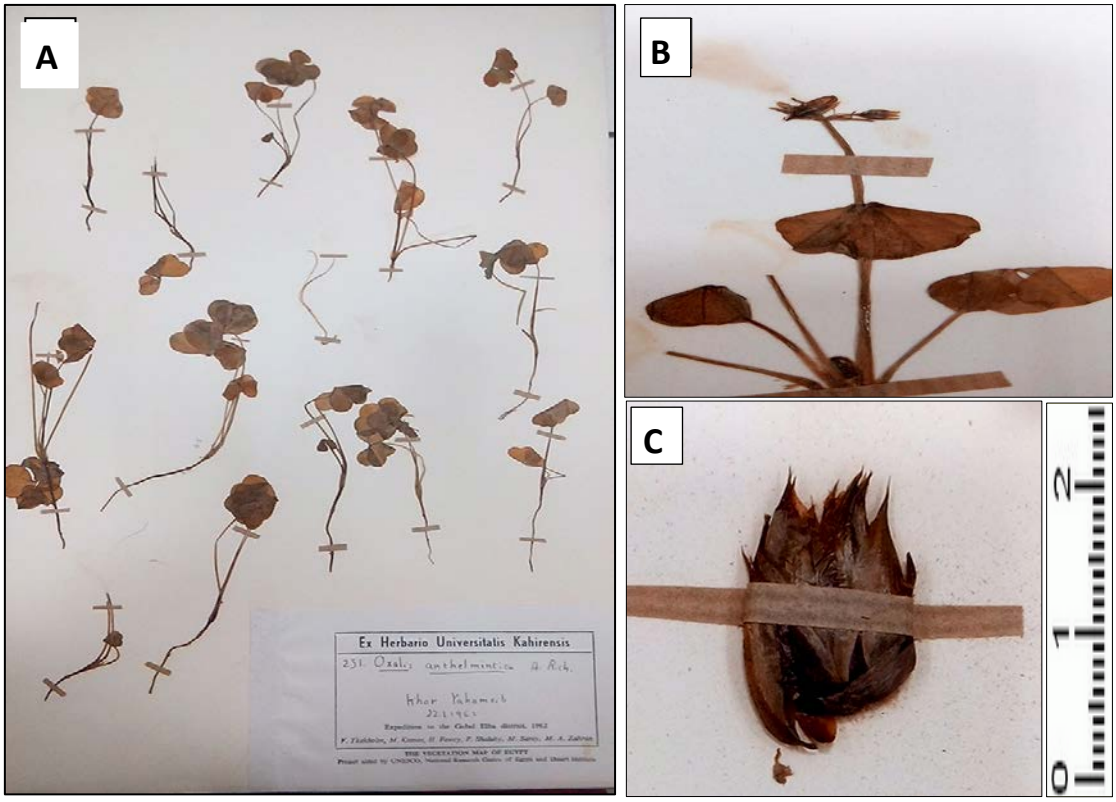


Plate (4): *O. anthelmintia*: (A) Plant habit (herbarium specimen); (B) Leaves and Inflorescence, (C) Magnified Bulb.

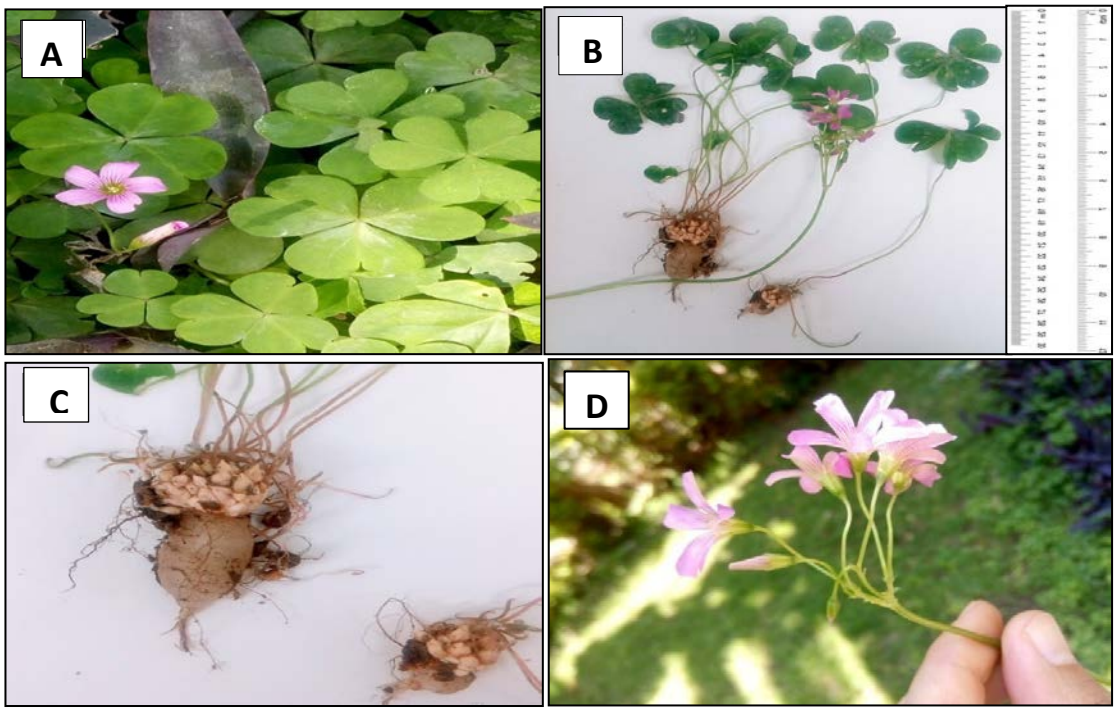


Plate (5): *Oxalis corymbosa*: (A) plant in its habitat; (B) whole plant showing leaves, flowers and bulb; (C) Tuberous root & bulb with numerous bulbils; (D) Bifid branching cymes inflorescence.

than petioles. **Bracts** 2, opposite, at the base of inflorescence branches, ovate, 2-3 x 0.4-1 mm, sparsely hairs, apex subacute with papery and ciliate margin; **bracteoles** inserted near the base of the pedicels, 1-1.5 x 0.3 -0.6 mm, both bracts and bracteoles with 1-2 calli. **Flowers** pinkish to purple, pedicellate; **pedicels** 1.7 - 4.5 mm long, pubescent. **Sepals** 5, subequal, lanceolate, 3-4.5 x 1.2-1.5 mm, glandular hairy, apex acute with tuft white hairs and two orange apical calli, margin hyaline. **Petals** 5 obovate, cuneate, 15-17 x 2.3-2.6 mm, subglabrous, with rounded apex and clawed base. **Stamens** 10, basely connate, long stamens 4-6.5 mm long, pubescent and short stamens 2.5 - 4mm long, glabrous. **Ovary** oblong to ellipsoid, 2 x 1 mm, sub-glabrous, Styles 5, pubescent, 3.6–4.3mm long, including the laciniate stigma, as long as the short stamens whorl or intermediate in length between the 2 stamens whorls. **Fruit** not seen**.**

Flowering period: December – May.

Habitat: Cultivated grounds and open habitats

English name: Lilac *Oxalis*, Pink wood sorrel.

Uses: Leaves eaten as vegetable in African countries.

Distribution in Egypt: Cultivated, escaped and naturalized in farm lands of Western Mediterranean, Nile Delta and Nubian Nile.

Global distribution: Native to Central America to Guyana and Paraguay. Introduced and naturalized in many parts of Africa, Asia, Australia, Europe and Northern America.

Taxonomic notes:

Oxalis corymbosa was mentioned as a new record to the flora of Egypt by El-Khanagry (2005), as a weed of disturbed places or in gardens; the species is now collected from many places in Egypt as exotic weed. The newly recorded species may be misidentified as *O. anthelmintica*, both having pink flowers. The most important characters used to distinguish *O. corymbosa* are: Bulb composed of numerous, sessile, bulbils, with translucent tuberous root and Inflorescence bifid branching cymes, 7-16 flowered per peduncle in umbelliform.

Representative specimens:

Mm: Alexandria, 26-5-1976, K. Mansour s.n. (CAI).

Nv: Kafr El-Ragalat, Qalubia, Orange orchard, 12-1-2001 & 20-5-2003; *El Khanagry* s.n. (CAIM)-- Cairo University garden, Giza, 4-11-1967; El *Mahdi* s.n. (CAI)-- Giza, Agriculture faculty experimental Farm, 13-4-1977*; Chertek & Kosanova* s.n. (CAI)-- Giza, 12-4-2020, *A. Draz* s.n. (CAI)--Dokki, 20-2-2021, *H. Hosni* s.n. (CAI)-- In gardens, 6 October Distric, Giza, January 2021; *El Garf* s.n. (CAI)-- Botanic Garden, Ain- Shams University, 15-6-2004; *Sami* s.n. (CAIM)—Alfred Bircher's garden, El Saff, south garden, 15-5-1961 & 1-6-1961; *Täckholm* & *I. El Sayed* s.n. (CAI).

Nn: Aswan, Gezeret el Nabatat, 17-3-1962; *M. Abdalla & F. Saad* (CAI)-- Aswan botanical garden, 4-11-1995; *Rofaeel* 29097 (CAIM).

5. *Oxalis latifolia* Kunth, Nov. Gen. Sp. (quarto. ed.) 5: 237. t. 467 (1821-1822**). (Plate 6)**

Type: Mexico, Campeche, *Humboldt et Bonpland* (P-HB, holotype)

Synonyms:

= *Oxalis mauritiana* C. Lodd., Bot. Cab. 18: 178, t. 1780 (1831).

= *Ionoxalis latifolia* (Kunth) Rose, Contr. U.S. Natl. Herb. 10: 113 (1906).

= *Oxalis tenuiloba* (Rose) Knuth, Notizbl. Königl. Bot. Gart. Berlin 7(67): 315 (1919).

= *Acetosella violacea* (L.) Kuntze subsp. *latifolia* (Kunth) Kuntze, Revis Gen. Pl 1: 90 (1891).

General description:

Geophyte, perennial herb, 22-47cm tall. **Bulb** ovoid or globose, 8-20 x 7-15mm, outer protective tunics papery, pale brown, inner nutritive tunics fleshy, lanceolate, 4-10 x2-4 mm long, whitish with three orange central nerves, apex acute and ciliate hyaline margin. Bulb with fibrous and contractile roots at the base, 1.5-9 cm long. **Stolon** conspicuous and aerial stem absent. **Leaves** arranged in a basal rosette. **Petiole** ascendant, 20-30 cm long, pubescent. **Stipules** ovate or rectangular, 2.5-4x1-2 mm, 3-nerves, nerves brownish, conspicuous, arising from the base, apex auriculate with glandular margin. **Leaflets** ±equal, obdeltoid or obtriangular, cuneate, 6-20 x 15-40 mm, subsessile, symmetric bilobed, divergent, subglabrous above, sparsely hairs below on the nerves and ciliate margin. **Inflorescence** basal, 10-15 flowered per peduncle in umbelliform cymes. **Peduncle** sparsely hairy, 15-25cm long, shorter than the petioles. **Bracts** triangular, 2-3 x 1-1.5 mm, sparsely hairs, apex acute. **Flowers** purple with a green throat, pedicellate; **pedicels** 10-15mm long, subglabrous. **Sepals** 5, subequal, ovate-oblong, 3.5-4.5 x 1.5-2 mm, subglabrous, apex acute with two orange apical calli and entire margin. **Petals** 5 obovate, cuneate, 12-15 x 4-5mm, subglabrous, apex rounded. **Stamens** 10, basely connate, long stamens 4-5 mm long, hairy and short stamens 2.5 - 3mm long, subglabrous. **Ovary** oblong to ellipsoid, 2 x 1 mm, sub-glabrous, **Styles** 5, pubescent, 1- 1.5mm long, including the capitate stigma, as long as the short stamens whorl. **Fruit** not seen**.**

Flowering period: June-September.

Habitat*:* Cultivated fields and waste places.

English name: garden pink-sorrel.

Uses: Medicine

Distribution in Egypt: Invasive weed in farmlands of Nile Delta.

Global distribution: Native to Tropical and Subtropical America. Now is found worldwide as invasive species in many parts of the world.

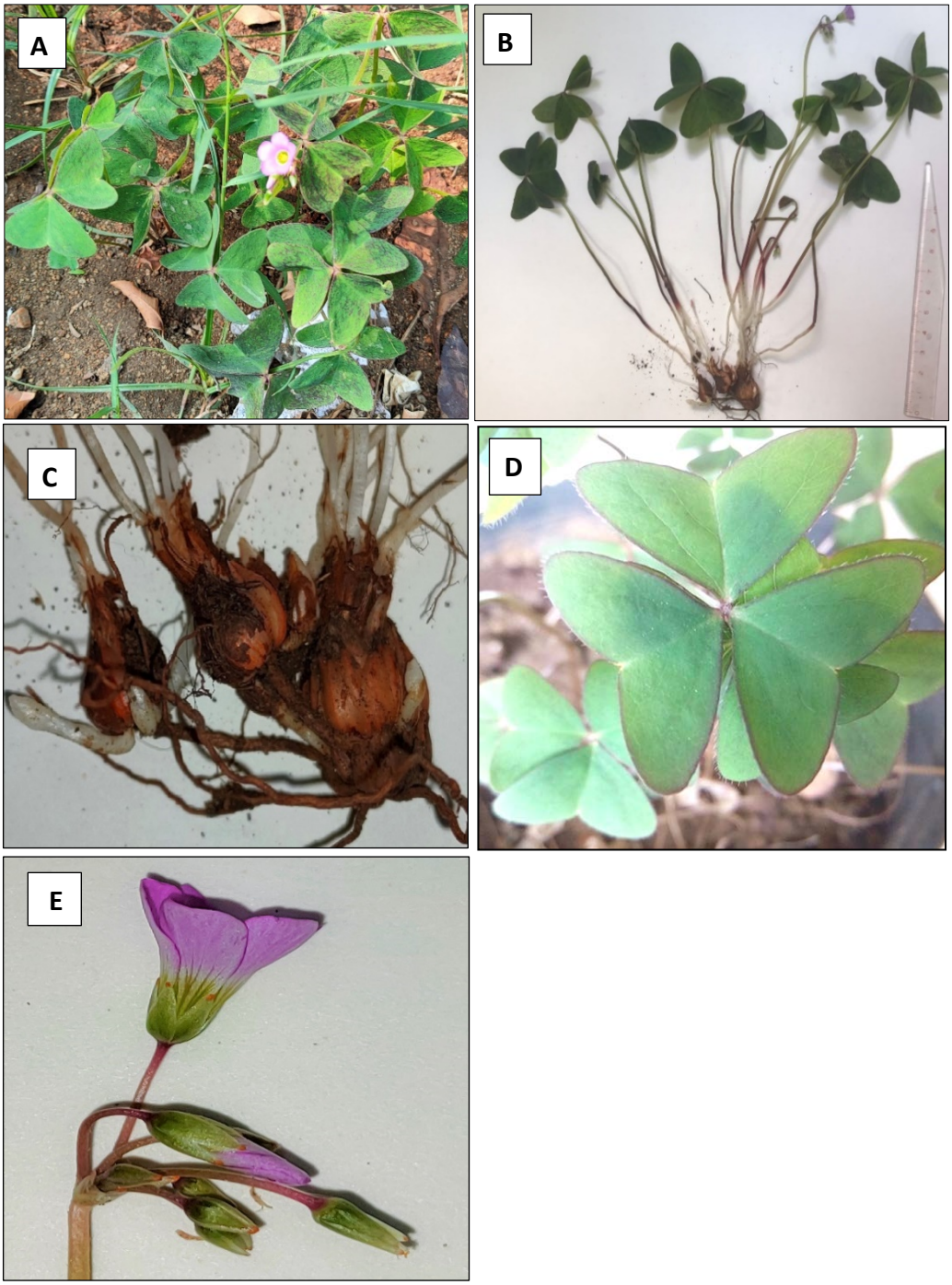


Plate (6): *O. latifolia*: (A) plant in its habitat, (B) whole plant showing leaves and bulb, (C) Magnified Bulbs & fibrous root, (D) Deltoid leaflets, (E) Inflorescence with magnified flower

Taxonomic notes:

Oxalis latifolia was recorded for the first time to the Egyptian flora by El-Khanagry (2005). *O. latifolia* can be easily distinguished from other related taxa by possessing conspicuous stolon and obdeltoid or obtriangular leaflets without brownish calli at the margin being bilobed divergent. The species reproduces vegetatively in Egypt and this is in accordance with Marshall (1987) who reported the vegetative reproduction of the species. Tsai *et al.* (2010), however, reported vegetative reproduction of the species even in its native habitat.

Representative specimens:

Nv: El-Deir, Qalubia, strawberry fields, 19-1-2001; *El Khanagry* s.n. (CAIM)--Arab El-Hussa, Qalubia, strawberry fields, 29-4-2001; *El Khanagry* s.n. (CAIM)-- Arab El-Ghadir, Qalubia, Orange Orchard, 1-5-2002; *El Khanagry* s.n. (CAIM)-- Arab El-Ghadir, Qalubia, French bean, 20-5-2003; *El Khanagry* s.n. (CAIM)-- Faculty of science, Cairo University, Giza, 1-3-2020 & 22-3-2020; *A. Draz* s.n. (CAI)-- Cairo University Garden, 15-4-2021, *E. Shamso* s.n. (CAI).

Acknowledgment

The authors are grateful to Dr. Amal Hossny (Botany & Microbiology Department, Faculty of Science, Cairo University) for valuable comments and critical revision of the manuscript.

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