Fl. Medit. 22: 45-62
doi: 10.7320/FlMedit22.045
Version of Record published online on 28 December 2012

Sami Rabei & Kadry Abdel Khalik

Conventional keys for *Convolvulaceae* in the flora of Egypt

Abstract

Rabei, S. & Abdel Khalik K. A.: Conventional keys for *Convolvulaceae* in the flora of Egypt. — Fl. Medit. 22: 45-62. 2012. — ISSN: 1120-4052 printed, 2240-4538 online.

Three keys to 44 species belonging to the family *Convolvulaceae* in the flora of Egypt are prepared to facilitate the identification of those species, based on 72 characters. These keys were constructed using the DELTA key-generating programs. The first key was built using all characters and the second key was built using 56 characters (vegetative, floral and fruit characters). The first key is considered as main key and can be confirmed by the second key in the field. The third one was built using 16 characters (pollen grains, seed and cell wall characters) which are to be used to identify and confirm the specimen in the laboratory.

Key words: DELTA, Morphological characters, pollen grains characters, seed characters.

Introduction

Convolvulaceae (morning glory family) is a large family, comprising approximately 50-60 genera with some 1600-1700 species (Mabberley 1987), exhibiting a rich diversity of morphological characters and a wide range of ecological habitats. It is herbaceous, twining, or woody, climbing or trailing vines, shrubs or trees. Takhtajan (1997) placed this family in its own order, *Convolvulales*, due to a number of morphological characters.

Convolvulaceae has been studied by many authors. Hallier (1893) recognized the usefulness of pollen characters and divided the family into two subfamilies: *Echinoconiae* and *Psiloconiae*. Sengupta (1972) studied the pollen of 170 species in 30 genera, and described four pollen types, each with several subtypes. Tellera & Daners (2003) studied the pollen of 75 species, and described three main pollen types. Osman & Abdel Khalik (2005) studied the pollen morphology of *Convolvulaceae* in Egypt and recognized three main pollen types. Sampathkumar & Agyangar (1978) studied the seed coat anatomy and morphology of the family *Convolvulaceae* and separated *Cuscuta* into another family *Cuscutaceae*. Abdel Khalik & Osman (2007) investigated the seed morphology of 31 taxa of *Convolvulaceae* in Egypt and cited the importance of seed morphology to distinguish between the studied taxa. Abdel Khalik (2008) studied the phenetic characters of the *Convolvulaceae* in Egypt and recognized five main groups: *Convolvuleae*, *Cuscuteae*, *Cresseae*, *Dichondreae* and a mixed group from *Ipomoeeae* and *Merremieae.*

In the flora of Egypt, *Convolvulaceae* is represented by about 47 species belonging to 10 genera, assigned to 6 tribes (Boulos 2000). Members of these tribes are distributed over a wide range of habitats: weeds of farmland and waste places, desert herbs, subshrubs or shrubs in the Mediterranean coastal land, the oases, and the mountains of Sinai and Elba as well as inland salt marshes.

Members of the *Convolvulaceae* are easy to distinguish morphologically, but it is difficult to identify at species level. This is largely due to the wide range of morphological and structural modifications related to the plants' ability to adapt to a multitude of habitat types. Such plants possess similar floral and vegetative parts, which render their identification by manually constructed keys highly problematic. The problems extend further to the process of manual key construction for such taxa with unusual structural attributes so that the keys built for their identification depended almost invariably on floral and micromorphological characters.

DELTA (Descriptive Language for Taxonomy) has been selected to carry out the taxonomical work of this study. DELTA is a multipurpose format for generating identification keys (Dallwitz 1980; Dallwitz & Paine 1986; Partridge et al., 1988). It was designed as an easy and flexible format for recording descriptive data and for people to use it. On the other hand, a degree of complexity was necessary to avoid loss of significant information (Dallwitz 1993; Dallwitz & al. 2000).

Key-generating computer programs seemed to offer a useful tool to overcome the difficulties involved in botanical identification in general (El-Gazzar 1976). This view is supported by the many successes achieved in studies performed on various groups in different parts of the world (http://delta-intkey.com/www/refs.htm) and in Egypt (Rabei & El-Gazzar 2007; El-Gazzar & al. 2008; Rabei 2011). Therefore, we have embarked on the present study to benefit from the facilities of the flexible key-generating suite of programs DELTA (Dallwitz & al. 2000) in resolving the problems of identifying representatives of the *Convolvulaceae* in the flora of Egypt.

Material and Methods

The present work is based on the collections kept in Cairo University herbarium (CAI),Wageningen University Herbarium (WAG),as well as on fresh materials collected during field trips to the Mediterranean region, Eastern Desert, Isthmic Desert, Sinai, and the Nile Delta. The list of these species is shown in Appendix 1. The studied species are carefully examined for their general morphology. The available characters are recorded as well as some micromorphological characters (pollen and seed characters). DELTA program is used in this study for building keys. The development of the character list is an ongoing process aimed at eventually producing a list to record data for all the species of the Egyptian *Convolvulaceae*. Character order and wording are manipulated in the character list with the aim of improving the flow of language in the natural-language descriptions generated by CONFOR (Dallwitz & al. 1993; 2000). Appendix 2 shows the characters (72) and character states scored for plant (vegetative, floral and fruit morphology), seed, and pollen morphology averaged for each taxa. Data for each species are coded in DELTA format. The coded description can be converted by the program CONFOR into the

format used by KEY and Tonatr for producing automatic description (Watson & al. 1989; Dallwitz & al. 2000). CONFOR (Format-Conversion Program) is a program for translating DELTA-format data into other formats, including natural language. KEY (Key Generation Program) is a program for constructing taxonomic keys. Keys are produced in the conventional bracketed form or in tabular form in tree-diagram format. The KEY program (Dallwitz 1974) was used as a basis for producing a traditional key to the species in the family. 3 keys are generated using different characters combination.

Results

CONFOR (Format Conversion): CONFOR is used to manipulate the various types of data files used by the DELTA system. CONFOR translates input 'directives' and data files into output files in a variety of formats. Such formats include Natural Language descriptions.

The coded format as following for one species:

Convolvulus\i{} arvensis\i0{} L./

1,2 2,2 3,3 4,1 5,1 6,60 7,2 8,2 9,2 10,2 11,1 12,1 13,2 14,1 15,3 16,1.2 17,1 18,5 19,6 20,1 21,1 22,3 23,4 24,2 25,3 26,1 27,4.5 28,4 29,2 30,1 31,1 32,1 33,2 34,20 35,6 36,2 37,8 38,2 39,4 40,1 41,1 42,1 43,1 44,3 45,2 46,2 47,2 48,6.5 49,4.5 50,1 51,2 52,2 53,5 54,1 55,2 56,14 57,1 58,1 59,3 60,1 61,4 62,4 63,1 64,2 65,2 66,3 67,5 68,1 69,1 70,1 71,2 72,5

After using Tonatr with Confor; the Natural Language descriptions become as following:

***Convolvulus arvensis* L.**

Plant life Not parasite. Plant colour Green. Perennial. Herb. Stem nature Herbaceous. Plant height 60 cm. Stem habit Prostrate to twining. Mode of perennation rhizomatous. Nature of branches Not spinescent. Plant surface Glabrous to sparsely hairs. Hairs patent Spreading. Hair shape Simple. Lower leaves arrangement No rosette. Green leaves Present. Leaves petiole Petiolate. Leaf petiole length 1.2 cm. Leaf venation Pinnate. Leaf shapes Sagittate to hastate. Leaf apex Obtuse to acute. Leaf margin Entire. Inflorescence Bracts present. Inflorescence position Axillary. Peduncle mean length 4 cm. Flowers numbers Solitary or in pairs. Flower pedicle Pedicellate. Flower bract Present. Sepal mean length 4.5 mm. Sepal shape Oblong to obovate. Sepal apex Apiculate. Sepal surface Glabrous. Sepals patent at fruit maturity Erect. Corolla shape Funnel- shape. Corolla margin Shallow lobed or bifid. Corolla mean length 20 mm. Corolla colour Pink to white. Corolla surface Glabrous with hairy bands outside. Filament mean length 8 mm. Filament surface With sessile glandular hairs at the base. Anther shape Oblong. Stamens and styles Included. Style number One. Style shape Filiform. Style surface Glabrous. Style length (compared to stigma) Longer than stigma. Styles branching Not forked. Stigma number 2. Stigma shape Cylindrical. Fruit mean length 6.5 mm. Fruit mean width 4.5 mm. Fruit dehiscence Dehiscent. Fruit shape Subglobose. Number of fruit locules 2. Fruit patent Recurved. Fruit surface Glabrous. Surface of fruit pedicel Hairy. Fruit pedicel mean length 14 mm. Pollen types Tricolpate. Pollen surface Smooth to micro-granulate. Pollen shape Prolate spheroidal. Exine sculpture Tectate, punctuate, micro-granulate. Number of seeds in fruit 4. Seed shape Pyramidal. Seed surface Glabrous. Seed architecture Tuberculate. Seed size(mm) (Length × width) 1.5–4 × 1.3–3.7. Seed colour Brown. Epidermal cell paterns Isodiametric, 4–5–6 polygonal or elongate in one direction. Anticlinal walls Straight. Relief of cell wall boundaries Raised. Sculpture of anticlinal boundaries Smooth. Curvature of outer periclinal cell wall Flat to concave. Secondary cell wall sculpture Micro-reticulate.

The following conventional keys have been generated by the program Key (Dallwitz 1974, 1978; Dallwitz & al. 2000). Three keys are constructed; the first key is considered as the main key and the other two keys are considered as confirmatory and vice versa.

1. Main Key

In this key all the characters are used except the size characters. This key can be used to identify the specimen in the field.

1. Plant surface glabrous.....2
   Plant surface glabrous to sparsely hairy.....12
   Plant surface hairy.....16
2(1). Parasitic non chlorophyllous plant; corolla campanulate.....3
   Non parasitic plant, chlorophyllous; corolla funnel- shaped.....7
3(2).Inflorescence terminal; inflorescence bracts absent; stamens and styles exserted.....4
   Inflorescence axillary; inflorescence bracts present; stamens and styles included.....6
4(3). Flower bract absent; style length shorter than stigma; pollen types pantocolpate…..... *Cuscuta epilinum*
   Flower bract present; style longer than stigma; pollen types tricolpate.....5
5(4). Flower sessile; sepal apex acute, surface glabrous to sparsely hairs; fruit patent appressed..... *Cuscuta brevistylosa*
   Flower pedicellate; sepal apex obtuse, surface glabrous; fruit calyx spreading ..... *Cuscuta campestris*
6(3). Flower sessile; fruit shape globose; sepal oblong; apex obtuse ..... *Cuscuta planiflora*
   Flower pedicellate; fruit shape subglobose; sepal ovate, apex obtuse to acute or mucronate .....*Cuscuta chinensis*
7(2). Inflorescence bracts present.....8
   Inflorescence bracts absent.....11
8(7). Fruit shape globose.....9
   Fruit shape subglobose.....10
9(8). Sepal oblong; apex obtuse to acute or mucronate; fruit patent spreading; stem twining .....*Convolvulus scammonia*
   Sepal shape ovate, apex acute; fruit patent recurved; stem climbing..... *Merremia semisagitta*
10(8). Corolla white; leaf shape cordate to sagittate, apex acute.....*Calystegia silvatica*
   Corolla yellow to white; leaf shapes reniform to elliptical, apex retuse.....*Ipomoea stolonifera*
   Corolla pink; leaf shapes cordate to ovate, apex obtuse to acute.....*Convolvulus fatmensis*
   Corolla violet; leaf shapes ovate to lanceolate, apex mucronate.....*Ipomoea cairica*
11(7). Flower bract present; sepal apex acute, fruit subglobose; fruit calyx erect ..... *Ipomoea carnea*
   Flower bract absent; fruit globoid; sepal apex obtuse; fruit patent spreading .....*Ipomoea pes-caprae*
12(1).Non-chlorophyllous plant; parasite; style equal the stigma.....13
   Chlorophyllous plant; not parasite; style longer than stigma.....14
13(12). Flower sessile; fruit shape globose; sepal cordate to ovate, apex acute ..Cus*cuta palaestina*
   Flower short pedicellate; fruit shape conical; sepal orbicular to ovate, apex obtuse ....*Cuscuta monogyna*
14(12).Corolla campanulate; sepals patent at fruit calyx erect to spreading; style number two; styles branching forked.....*Evolvulus nummularius*
   Corolla shape funnel- shape; sepals patent at fruit maturity erect; style number one; styles branching not forked.....15

15(14). Sepal lanceolate; leaf apex acuminate; corolla violet.....*Ipomoea purpurea*
Sepal oblong to obovate; leaf apex obtuse to acute; corolla pink to white.....*Convolvulus arvensis*
Sepal ovate; leaf apex apiculate; corolla yellow.....*Ipomoea obscura*
Sepal cordate to ovate; leaf apex acute; corolla pink.....*Ipomoea sinensis*
16(1). Fruit shape globose 17
Fruit shape subglobose 23
Fruit shape obovate.....29
17(16). Flower sessile.....18
Flower short pedicellate 19
Flower pedicellate.....20
18(17). Stem prostrate; fruit calyx erect to spreading; corolla pink; pollen shape prolate spheroidal .....*Convolvulus rhyniospermus*
Stem prostrate to twining; fruit calyx spreading; corolla white; pollen shape oblate spheroidal.... .....*Convolvulus glomeratus*
Stem ascending to erect; fruit calyx erect; corolla yellow to white; pollen shape spheroidal..... .....*Convolvulus secundus*
19(17). Corolla funnel- shape; inflorescence axillary; sepal ovate; apex obtuse to acute or mucronate .....*Seddera latifolia*
Corolla campanulate; inflorescence terminal; sepal obovate, apex acute.....*Cressa cretica*
20(17). Non-chlorophyllous plant; parasite, fruit surface papillate .....*Cuscuta pedicellata*
Chlorophyllous plant; fruit surface glabrous.....21
21(20). Flower bract present; corolla funnel- shape; stamens and styles included; corolla margin shallow lobed or bifid.....22
Flower bract absent; corolla campanulate; stamens and styles exserted; corolla margin deeply lobed.....*Dichondra micrantha*
22(21). Fruit calyx erect; leaf apex acute; corolla blue; stem prostrate to ascending ....*Evolvulus alsinoides*
Fruit calyx erect to spreading; leaf apex acute to acuminate; corolla blue to pink or white; stem twining .....*Jacquemontia tamnifolia*
Fruit calyx spreading; leaf apex mucronate; corolla white; stem erect.....*Seddera arabica*
Fruit patent recurved; leaf apex obtuse to acute; corolla colour violet; stem habit prostrate to twining.....*Convolvulus stachydifolius* Choisy
23(16). Flow sessile.....*Convolvulus schimperi*
Flower short pedicellate.....24
Flower pedicellate.....25
24(23). Sepal lanceolate to oblong, apex acuminate; sepal surface hairy, fruit surface glabrous ....*Convolvulus prostratus*
Sepal oblong to obovate, apex acute, surface glabrous; fruit surface hairy.....*Convolvulus humilis*
25(23). Inflorescence terminal and axillary; stem woody; style surface hairy; outer periclinal cell wall flat .....*Convolvulus oleifolius*
Inflorescence axillary; stem herbaceous; style surface glabrous; outer periclinal cell wall flat to concave 26
26(25). Flower bract absent; leaf venation palmate .....*Merremia aegyptia*
Flower bract present; leaf venation pinnate 27
27(26). Corolla funnel- shape, surface glabrous with hairy bands outside; sepals patent at fruit maturity erect; fruit surface glabrous 28
Corolla tubular shape, surface glabrous without hairy bands; sepals patent at fruit maturity spreading; fruit surface hairy.....*Ipomoea eriocarpa*

28(27). Stem ascending; leaf oblong to lanceolate; corolla pink; anticlinal walls undulate ....*Convolvulus pilosellifolius*
Stem prostrate to ascending; leaf shape ovate to lanceolate; corolla blue; anticlinal walls straight to slightly sinuous.....*Convolvulus siculus* subsp. *agrestis*
Stem prostrate to twining; leaf cordate to ovate; corolla violet to pink; anticlinal walls straight... .....*Convolvulus althaeoides*
29(16). Branches spinescent; stem woody; flower sessile; hairs patent spreading.....30
Branches not spinescent; stem nature herbaceous; flower pedicle pedicellate; hairs patent appressd 31
30(29). Stem ascending to erect, sepal oblong to obovate, apex acuminate; fruit calyx spreading ....*Convolvulus lanatus*
Stem ascending; sepal obovate, apex obtuse to acute or mucronate; fruit calyx erect..... .....*Convolvulus hystrix*
31(29). Inflorescence terminal and axillary; sepal lanceolate to oblong, apex acute; fruit calyx erect .....*Convolvulus lineatus*
Inflorescence axillary; sepal obovate, apex obtuse to acute or mucronate; fruit calyx spreading . .....*Convolvulus dorycnium*

2. Confirmatory Key

The following key was built using 56 characters (vegetative, floral and fruit characters). This key can be used to confirm the identification for the specimen which was identified by the main key.
1. Corolla funnel- shape 2
Corolla campanulate 18
Corolla tubular shape.....*Ipomoea eriocarpa*
2(1). Inflorescence bract present 3
Inflorescence bract absent.....17
3(2). Flower bract present.....4
Flower bract absent .....*Merremia aegyptia*
4(3). Sepal apex acuminate.....5
Sepal apex apiculate 7
Sepal apex acute 8
Sepal apex obtuse to acute or mucronate 14
Sepal apex obtuse.....*Calystegia silvatica*
5(4). Fruit patent appressed .....*Convolvulus secundus*
Fruit patent spreading 6
Fruit patent recurved.....*Ipomoea sinensis*
6(5). Style length shorter than stigma; leaves sessile .....*Convolvulus prostratus*
Style length equal the stigma; leaves short-petiolate .....*Convolvulus lanatus*
Style length longer than stigma; leaves petiolate.....*Convolvulus glomeratus*
7(4).Sepal surface glabrous; leaf margin entire; plant surface glabrous to sparsely hairs; anther shape oblong.....*Convolvulus arvensis*
Sepal surface glabrous to sparsely hairs; leaf margin crenate; plant surface glabrous; anther shape sagittate.....*Convolvulus fatmensis*
8(4). Fruit patent erect 9
Fruit patent erect to spreading 10
Fruit patent spreading 11
Fruit patent recurved.....13

9(8). Corolla surface glabrous; fruit surface glabrous; leaf apex acute; style longer than stigma ....*Evolvulus alsinoides*
Corolla surface glabrous with hairy bands outside; fruit surface hairy; leaf apex obtuse to acute; style length equal the stigma .....*Convolvulus lineatus*
10(8).Corolla surface glabrous; leaf apex acute to acuminate; leaf margin entire; anther shape sagittate.....*Jacquemontia tamnifolia*
Corolla surface glabrous with hairy bands outside; leaf apex obtuse; leaf margin undulate; anther shape oblong to sagittate.....*Convolvulus schimperi*
11(8). Leaf apex mucronate .....*Seddera arabica*
Leaf apex acuminate .....*Ipomoea purpurea*
Leaf apex apiculate .....*Ipomoea obscura*
Leaf apex obtuse .....*Convolvulus humilis*
Leaf apex obtuse to acute 12
12(11). Corolla surface glabrous; fruit surface glabrous; leaves petiolate; style equal the stigma ....*Convolvulus rhyniospermus*
Corolla surface glabrous with hairy bands outside; fruit surface hairy; leaves sessile; style length shorter than stigma.....*Convolvulus oleifolius*
13(8).Sepal surface glabrous; corolla surface glabrous; leaf apex acute; leaf margin dissected or divided .....*Merremia semisagitta*
Sepal surface hairy; corolla surface glabrous with hairy bands outside; leaf apex obtuse to acute; leaf margin entire .....Convolvulus *siculus* subsp. *agrestis*
14(4). Leaf apex mucronate .....*Ipomoea cairica*
Leaf apex acute to acuminate.....*Convolvulus scammonia*
Leaf apex obtuse .....*Seddera latifolia*
Leaf apex retuse .....*Ipomoea stolonifera*
Leaf apex acute 15
Leaf apex obtuse to acute 16
15(14). Style length shorter than stigma; stigma shape Filiform .....*Convolvulus pilosellifolius*
Style equal the stigma; stigma shape cylindrical .....*Convolvulus dorycnium*
Style longer than stigma; stigma shape clavate to cylindrical .....*Convolvulus hystrix*
16(14). Sepal surface glabrous to sparsely hairs; corolla surface glabrous; Fruit calyx recurved; leaf margin dentate to crenate .....*Convolvulus stachydifolius*
Sepal surface Hairy; Corolla surface Glabrous with hairy bands outside; fruit calyx spreading; leaf margin crenate to lobed.....*Convolvulus althaeoides*
17(2). Flower bract Present; sepal apex acute; fruit calyx erect; leaf apex acute ....*Ipomoea carnea*
Flower bract absent; sepal apex obtuse; fruit patent spreading; leaf apex emarginate..... .....*Ipomoea pes-caprae*
18(1). Inflorescence Bracts present 19
Inflorescence Bracts absent 25
19(18). Flower bract absent .....*Dichondra micrantha*
Flower bract present 20
20(19). Sepal apex acute.....21
Sepal apex obtuse to acute or mucronate 23
Sepal apex obtuse 24
21(20). Sepal surface glabrous to sparsely hairs; plant surface glabrous to sparsely hairs; style equal the stigma.....*Cuscuta palaestina*
Sepal surface hairy; plant surface hairy; style longer than stigma 22

22(21).Corolla surface glabrous; fruit surface papillate; anther shape oblong; stigma shape cylindrical.....*Cuscuta pedicellata*
Corolla surface glabrous with hairy bands outside; fruit surface glabrous; anther shape sagittate; stigma shape capitate.....*Cressa cretica*
23(20). ..Sepal surface glabrous; fruit calyx patent ; corolla surface glabrous; plant surface glabrous .....*Cuscuta chinensis*
Sepal surface hairy; fruit calyx erect to spreading; corolla surface glabrous with hairy bands outside; plant surface glabrous to sparsely hairs..... *Evolvulus nummularius*
24(20). Fruit patent erect to spreading; fruit surface papillate; plant surface glabrous to sparsely hairs; Style equals the stigma .....*Cuscuta monogyna*
Fruit patent spreading; fruit surface glabrous; plant surface glabrous; style shorter than the stigma .....*Cuscuta planiflora*
25(18).Flower bract present; style longer than stigma.....26
Flower bract absent; style shorter than stigma.....*Cuscuta epilinum*
26(25). Sepal apex acute; sepal surface glabrous to sparsely hairs; fruit calyx appressed; fruit surface glabrous to sparsely hairs.....*Cuscuta brevistylosa*
Sepal apex obtuse; sepal surface glabrous; fruit patent spreading; fruit surface glabrous ....*Cuscuta campestris*

3- Confirmatory Key using seed and pollen characters only.

The following key was built using 16 characters (pollen grains, seed and cell wall characters). This key can be used to confirm the identification for the specimen in the laboratory which was identified by the first and second keys.

1. Seed colour black.....2
Seed colour black to brown 15
Seed colour brown 20
Seed colour yellow to brown 30
Seed colour orange 32
2(1). Pollen shape oblate spheroidal.....3
Pollen shape spheroidal 6
Pollen shape prolate spheroidal 12
3(2). Seed shape obovoid; curvature of outer periclinal cell wall flat to convex 4
Seed shape ovoid; curvature of outer periclinal cell wall flat to concave 5
4(3). Secondary cell wall sculpture smooth .....*Seddera latifolia*
Secondary cell wall sculpture folded.....*Seddera arabica*
5(3). Seed architecture smooth; number of seeds in fruit 2; anticlinal walls straight to slightly sinuous.....*Cressa cretica*
Seed architecture tuberculate; number of seeds in fruit 2-4; anticlinal walls straight ....*Convolvulus glomeratus*
6(2). Exine sculpture reticulate microgranulate .....*Cuscuta monogyna*
Exine sculpture tectate, punctuate, micro-granulate.....7
Exine sculpture, microreticulate-echinate-microgranulate.....10
7(6). Pollen types pantoporate; seed shape obovoid .....*Calystegia silvatica*
Pollen types tricolpate; seed shape ovoid.....8
8(7). Number of seeds in fruit 4; secondary cell wall sculpture smooth to fine folded...*Cuscuta palaestina*
Number of seeds in fruit 2; secondary cell wall sculpture micro-reticulate; relief of cell wall boundaries raised 9

9(8).Seed 0.6-1.5 × 0.4-1.3; epidermal cell patterns isodiametric or 4-5-6 polygonal; sculpture of anticlinal boundaries smooth ..... *Cuscuta pedicellata*.
Seed 4-9 × 3.8-8 mm; epidermal cell patterns irregular or polygonal cells; sculpture of anticlinal boundaries folded.....*Merremia aegyptia*
10(6). Seed surface long hairy .....*Ipomoea carnea*
Seed surface short hairy .....*Ipomoea cairica*
Seed surface glabrous 11
11(10). Number of seeds in fruit 4; seed 1.5-4 × 1.3-3.7 mm; secondary cell wall sculpture smooth to fine folded.....*Ipomoea eriocarpa*
Number of seeds in fruit 6; seed 4-9 × 3.8-8 mm; secondary cell wall sculpture folded.....
.....*Ipomoea purpurea*
12(2). Seed shape oblong.....*Convolvulus schimperi*
Seed shape obovoid.....*Convolvulus prostratus*
Seed shape ovoid 13
13(12). Seed surface glabrous; seed architecture tuberculate; seed 4-9 × 3.8-8 mm .....
.....*Convolvulus siculus* subsp. *agrestis*
Seed surface short hairy; seed architecture smooth; size 1.5-4 × 1.3-3.7 mm 14
14(13). Number of seeds in fruit 2-4; epidermal cell patterns irregular or polygonal cells; anticlinal walls undulate .....*Convolvulus pilosellifolius*
Number of seeds in fruit 4; epidermal cell patterns isodiametric or 4-5-6 polygonal; anticlinal walls straight to slightly sinuous.....*Convolvulus lineatus*
15(1). Pollen types tricolpate.....16
Pollen types pantocolpate 18
Pollen types pantoporate.....19
16(15). Pollen shape spheroidal; seed 0.6-1.5 × 0.4-1.3 mm; anticlinal walls straight to slightly sinuous.....*Cuscuta brevistylosa*
Pollen shape prolate spheroidal; seed 1.5-4 × 1.3-3.7 mm; anticlinal walls undulate.....17
17(16). Seed shape oblong; number of seeds in fruit 2; curvature of outer periclinal cell wall flat to concave ..... *Convolvulus lanatus*
Seed shape pyramidal; number of seeds in fruit 4; curvature of outer periclinal cell wall concave
..... *Convolvulus fatmensis*
18(15). Seed shape obovoid; secondary cell wall sculpture micro-reticulate.*Evolvulus nummularius*
Seed shape ovoid; secondary cell wall sculpture smooth to fine folded .....*Evolvulus alsinoides*
19(15). Number of seeds in fruit 4. Seed surface short hairy; secondary cell wall sculpture smooth to fine folded; number.....*Ipomoea stolonifera*
Number of seeds in fruit 2-4. Seed surface long hairy; secondary cell wall sculpture micro-reticulate;.....*Ipomoea pes-caprae*
20(1). Pollen shape oblate spheroidal.....21
Pollen shape spheroidal 24
Pollen shape prolate spheroidal 27
21(20). Exine sculpture tectate, punctuate, microechinate; pollen types pantocolpate
..... *Jacquemontia tamnifolia*
Exine sculpture tectate, punctuate, micro-granulate; pollen types tricolpate.....22
22(21). Seed shape ovoid; seed 0.6-1.5 × 0.4-1.3 mm..... *Convolvulus oleifolius*
Seed shape oblong; seed size 1.5-4 × 1.3-3.7 mm 23
23(22). Seed surface glabrous; number of seeds in fruit 4 .....*Convolvulus stachydifolius*
Seed surface short hairy; number of seeds in fruit 2 .....*Merremia semisagitta*
24(20). Pollen types pantocolpate .....*Cuscuta epilinum*
Pollen types tricolpate 25

25(24). Number of seeds in fruit 1; seed 1.5-4 × 1.3-3.7 mm .....*Convolvulus secundus*
Number of seeds in fruit 4; seed 0.6-1.5 × 0.4-1.3 mm 26
26(25). Relief of cell wall boundaries raised; secondary cell wall sculpture smooth; epidermal cell paterns isodiametric or 4-5-6 polygonal .....*Cuscuta campestris*
Relief of cell wall boundaries raised-channeled; secondary cell wall sculpture smooth to fine folded; epidermal cell patterns irregular or polygonal cells.....*Cuscuta planiflora*
27(20). Seed shape oblong .....*Convolvulus dorycnium*
Seed shape pyramidal.....*Convolvulus arvensis*
Seed shape ovoid .....*Convolvulus rhyniosperm*
Seed shape obovoid 28
28(27). Seed architecture smooth; seed 0.6-1.5 × 0.4-1.3 mm .....*Dichondra micrantha*
Seed architecture tuberculate; seed 4-9 × 3.8-8 mm 29
29(28). Number of seeds in fruit 2-4; epidermal cell patterns irregular or polygonal cells; anticlinal walls straight to slightly sinuous.....*Convolvulus scammonia*
Number of seeds in fruit 4; epidermal cell paterns isodiametric, 4-5-6 polygonal or elongate in one direction; anticlinal walls straight.....*Convolvulus althaeoides*
30(1)Pollen shape prolate spheroidal; pollen types tricolpate; pollen surface smooth to micro-granulate.....*Convolvulus hystrix*
Pollen shape Spheroidal; pollen types pantoporate; pollen surface spinulose.....31
31(30). Seed surface short hairy; seed 1.5-4 × 1.3-3.7 mm; secondary cell wall sculpture smooth to fine folded .....*Ipomoea sinensis*
Seed surface long hairy; seed 4-9 × 3.8-8 mm; secondary cell wall sculpture folded .....
.....*Ipomoea obscura*
32(1).. Pollen shape spheroidal; seed shape ovoid; seed architecture smooth.....
.....*Cuscuta chinensis*
Pollen shape prolate spheroidal; seed shape obovoid; seed architecture tuberculate .....
..... *Convolvulus humilis*

Discussion

The software package DELTA is a sophisticated and powerful data-basing program which stores morphological data for export in a number of different forms. In this way it acts as a manager of taxonomic research which can be used on a local, regional or worldwide (Coleman & al. 2010).

DELTA is a modern software package that manages taxonomic research (Dallwitz 2009). In this work DELTA is selected because It promotes consistency in descriptive taxonomy, can produce descriptive taxonomy in natural language ready for publication and produce conventional (dichotomous) keys.

Identification is the process of finding the taxon to which a specimen belongs. Several methods are available for aiding this process (e.g. Pankhurst 1991). The most important are conventional identification keys and interactive keys.

Conventional keys should provide some flexibility for the user by placing alternative characters at each node, but the possibilities for doing this are limited, because the characters must have identical distributions of their states among the taxa (Dallwitz & al. 2002). The size characters are omitted from the main key and the second one to facilitate

using them in the field. However, in the third key size characters are used for confirmation in the laboratory. All the characters of pollen grains, seed and cell wall are used .

After any identification, it is good practice to check its accuracy by comparing the specimen with a description or illustrations of the taxon, or with other specimens in the herbarium known to belong to the taxon, and to use confirmatory keys. The excluded size characters were used with the other characters for generating Natural-language descriptions.

The main key and the second one are generating depending on vegetative, floral and fruit characters. These characters are available and easy to distinguish in the field or in the lab. However, Boulos (2000) used also pollen grains in his main key for identification of the genera of *Convolvulaceae* of Egypt.

Acknowledgements

We are grateful to the Director and Curator of Cairo University Herbarium (CAI) and Wageningen University Herbarium (WAG). Our great thanks are due to Prof. Dr. van der Maesen, Professor of Plant Taxonomy in the Biosystematics Group, Dept. of Plant Sciences,Wageningen University, the Netherlands and Prof. Dr. Hasnaa Hosni, Professor of Plant taxonomy in Botany Department, Faculty of Science, Cairo University, Egypt for going through the manuscript and making valuable suggestions. Special thanks to Prof. Dr. Klaus Mummenhoff, Plant Taxonomy, Biology Dept., Osnabruck Univ., Germany for his valuable suggestions and comments on the manuscript.

References

Abdel Khalik, K. & Osman, K. A. 2007: Seed morphology of some species of *Convolvulaceae* from Egypt (Identification of species and systematic significance). – Feddes Repert. **1-2:** 27-34.

— 2008: Phenetic Study of *Convolvulaceae* from Egypt based on analysis of morphological characters. – Fl. Medit. **18:** 65-87.

Austin, D. F. 1973: The American *Erycibeae* (*Convolvulaceae*): Maripa, Dicranostyles & Lysiostyles I. Systematics. – Ann. Missouri Bot. Gard. **60:** 306-412.

— 1998: Parallel and convergent evolution in the *Convolvulaceae*. – Pp. 201-234 in: Mathiews, P., Sivadasan, M., (eds). Biodiversity and taxonomy of tropical flowering plants. – Calicut.

Boulos, L. 2000: Flora of Egypt, **2.** – Cairo.

Coleman, C. O., Lowry, J. K. and Macfarlane, T. 2010: DELTA for Beginners: An introduction into the taxonomy software package DELTA. – ZooKeys **45:** 1-75.

Dallwitz, M. J. 1974: A flexible program for generating identification keys. – Syst. Zool. **3:** 50-57.

— 1978: User's guide to Key. A computer program for generating identification keys. – CSIRO Division of Entomology, Report No. 11. – Canberra.

— 1980: A general system for coding taxonomic descriptions. – Taxon **29:** 41-46.

— 2009: Overview of the DELTA System. http://delta-intkey.com/www/overview.htm [23 November 2011]

— & Paine, T. A. 1986: User's guide to the DELTA system: A general system for processing taxonomic descriptions. 3° ed. – CSIRO Division of Entomology, Report No. 13. – Canberra.

—, — & Zurcher, E. J. 1993: User's guide to the DELTA system: A general system for processing taxonomic descriptions. 4° ed. – Canberra.

—, — & — 2000: User's guide to the DELTA system: A general system for processing taxonomic descriptions. 4, 12° ed. – Canberra.

—, — & — 2002: Interactive identification using the Internet. In 'Towards a global biological information infrastructure - challenges, opportunities, synergies, and the role of entomology'. – Pp. 23-33 in: Saarenmaa, H. & Nielsen, E. S. (eds), European Environment Agency Technical Report 70. – Copenhagen.

El-Gazzar, A. 1976: The identification of cultivated plants. 1. A general commentary on botanical identification. – Phytologia **34(3):** 240-244.

—, Rabei, S. H., Aboel Atta, A. I., Kamel, E. A., Loutfy, M. H. A. and Shalabi, L. F. 2008. Computer-generated keys to the flora of Egypt. 2. The *Chenopodiaceae*. – Taeckholmia **28:** 209-225.

Hallier, H. 1893: *Convolvulaceae Africanae*. – Bot. Jahrb. Syst. Pflanz. Pflanzengeogr. **18:** 81-160.

Mabberley, D. J. 1987: The Plant-book. – Cambridge.

Osman, K. A. & Abdel Khalik, K. 2005: A Palynological Study on some Egyptian species of *Convolvulaceae* and its taxonomic significance. – Taeckholmia **18:** 57-69.

Pankhurst, R. J. 1991. Practical Taxonomic Computing. – Cambridge.

Partridge, T. R., Dallwitz, M. J. & Watson, L. 1999: A Primer for the DELTA System, Ed. 3.01. – Canberra.

Rabei, S. 2011: A morphological, anatomical and taxonomic study of *Umbelliferae* in Egypt. – Köln.

— & El-Gazzar, A. 2007: Computer-generated Keys to Species of *Hyptis* s.l. (*Labiatae*). – Taeckholmia **27:** 11-39.

Sampathkumar, R. & Ayyangar, K. R. 1978: Seed morphology of *Convolvulaceae*. –J. Indian Bot. Soc. **57:** 28.

Sengupta, S. 1972: On the pollen morphology of *Convolvulaceae* with special reference to taxonomy. – Rev. Palaeobot. Palynol. **13:** 157-212.

Takhtajan, A. L. 1997: Diversity and classification of flowering plants. – New York.

Telleria, M. C. & Daners, G. 2003. Pollen types in Southern New World *Convolvulaceae* and their taxonomic significance. – Pl. Syst. Evol. **243:** 99-118. doi: 10.1007/s00606-003-0069-z

Watson, L., Russell, G. E. & Dallwitz, M. J. 1989: Grass genera of southern Africa: interactive identification and information retrieval from an automated data bank. – S. African J. Bot. **55:** 452-463.

Addresses of the Authors:
Sami Rabeia[1] & Kadry Abdel Khalik[2 & 3]
[1] Botany Department, Faculty of Science at Damietta, Mansoura University, New Damietta, Post Box 34517 Damietta, Egypt. e-mail: samirabei@mans.edu.eg
[2] Biology Department, Faculty of Science, Umm-Al-Qura University, Mecca 673, Saudi Arabia.
[3] Botany Department, Faculty of Science, Sohag University, Sohag 82524, Egypt

Appendix 1

List of specimens used for the study; species arranged alphabetically within tribes according to Austin (1973; modified 1998).

1. *Calystegia silvatica* (Kit.) Griseb.
   Gebel Elba, Wadi Yahameib, Abdel Khalik s.n. (SHG).
2. *Convolvulus althaeoides* L.
   Burg El Arab, Abdel Khalik 585 (SHG); Mariut, Abdel Khalik 600 (SHG); Sidi Abdel Rahman, Abdel khalik 605 (SHG); Mersa Matrouh, Abdel Khalik 650 (SHG); Abu Sir, Mariut, Sand dunes, Tackholm s.n. (CAI).
3. *C. arvensis* L.
   Burg El Arab, Abdel Khalik 588 (SHG); Mariut, Abdel Khalik 602 (SHG); Sohag, El Kola, Abdel Khalik 114 (SHG); El Maragha, Abdel Khalik 139 (SHG); Sagholta, Abdel Khalik 145 (SHG); Assiut University garden, N. El Hadidi s.n. (CAI).
4. *C. dorycnium* L.
   Sallum, Matrouh, Abdel Khalik s.n. (SHG).
5. *C. fatmensis* Kunze
   Dakhla Oasis, Bed Kulo, Abdel Khalik 441 (SHG); Dakhla Oasis, Mout, Abdel Khalik 445 (SHG); Wadi Daeeb, Abdel Khalik s.n. (SHG).
6. *C. glomeratus* Choisy
   Gebel Elba, Wadi Mawaw, Tackholm & al. s.n. (CAI); Wadi Yahameib, Abdel Khalik s.n. (SHG); Wadi Abo Saafa, Wadi Hodeein , Abdel Khalik & al. s.n. (SHG); Wadi Daeeb, Alt. 205 m, Abdel Khalik et al. S.n. (SHG).
7. *C. humilis* Jacq.
   ALGERIA: Saida, cultivated land, B. Balansa 357 (WAG).
8. *C. hystrix* Vahl
   Wadi Wizr, 42 Km from Qusser, Abdel Khalik 329 (SHG); Gebel Elba, Wadi Sermatii, Abdel Khalik s.n. (SHG).
9. *C. lanatus* Vahl
   Cairo-Suez desert road, 52 Km from Cairo, Abdel Khalik 547 (SHG); El Arish, Bir Lehfin, Abdel Khalik 640 (SHG); Cairo-Alexandria desert road, 100 km from Cairo, Abdel Khalik s.n. (SHG); Mariut, Burgel Arab M. Zareh s.n. (CAI).
10. *C. lineatus* L.
    Dakhla Oasis, Mout, Abdel Khalik s.n. (SHG); Wadi El Teir, Boulos 1178 (CAI).
11. *C. oleifolius* Desr.
    Ras El Hekma, Tackholm s.n. (CAI).
12. *C. pilosellifolius* Desr.
    Siwa, Een El Saghier road, Fahmy, G. 191 (CAI); Wadi Abraq, around Bir El Sonta, Abdel Khalik et al. s.n. (SHG).
13. *C. prostratus* Forssk.
    Gebel Elba, Karam Elba, Abdel Khalik s.n. (SHG); Wadi Daeeb, Abdel Khalik s.n. (SHG).
14. *C. rhyniospermus* Choisy
    Gebel Elba, Wadi Yahameib, Abdel Khalik s.n. (SHG); Shalateen area, Wadi Baaneed, Abdel Khalik et al. s.n. (SHG); Gebl karm Elba, Abdel Khalik s.n. (SHG).
15. *C. scammonia* L.
    Alexandria-Matrouh coastal road, 7 km east of Al- Hemma, Tackholm 8934 (CAI).
16. *C. schimperi* Boiss.
    Gebel El Asfar, Tackholm & al. s.n. (CAI); Sinai, Wadi Fayran, Schimper s.n. (WAG).
17. *C. secundus* Desr.
    PALESTINE: Gaza, Boissier s.n. (WAG).

18. *C. siculus* subsp. *agrestis* (Schweinf.) Verdc.
Gebel Elba, Karam Elba, Abdel khalik s.n. (SHG); Wadi Yahameb, 500-600 m, Abdel Khalik s.n. (SHG).
19. *C. stachydifolius* Choisy
Wadi Asharcoan, affluent from Wadi Aideep, Abdel Khalik & al. s.n. (SHG).
20. *Jacquemontia tamnifolia* (L.) Griseb.
SUDAN: Kordofan, J. R. Shabetai. (CAI).
21. *Cressa cretica* L.
El-Faiyum, El-Roda, Monier Abdel Ghani s. n. (CAI); El Dekhela-Alexandria coastal road, Abdel Khalik s. n. (SHG); Dakhla Oasis, Bed Kulo, Abdel Khalik 449 (SHG).
22. *Evolvulus alsinoides* (L.) L.
Gebel Elba, Wadi Merakwan, Hassib s. n. (CAI); Wadi Yahameib, Abdel Khalik s.n. (SHG).
23. *E. nummularius* (L.) L.
Gebel Elba, Karam Elba, Abdel Khalik 700 (SHG).
24. *Seddera arabica* (Forssk.) Choisy
Gebel Elba, Wadi Yahameb, Abdel Khalik s.n. (SHG); Wadi Asharcoan, affluent from Wadi Aideep, Abdel Khalik & al. s.n. (SHG).
25. *S. latifolia* Hochst. & Steud.
Gebel Elba, Wadi Yahameib, M. Hassib s. n. (CAI); Gebel Elba, Wadi Yahameib, Abdel Khalik 750 (SHG).
26. *Cuscuta brevistylosa* R. Br.
Gebel Elba, Wadi Mawaw, Tackholm 930 (CAI).
27. *C. campestris* Yunck.
Siwa Oasis, Tegzerti Farm, Tackholm & al. s.n. (CAI); Gabal Serbal, S. Sinai, Fayed & al. s.n. (SHG).
28. *C. chinensis* Lam.
Gebel Elba, Wadi Yahameb,Abdel Khalik s.n. (SHG); Wadi Aideeb, Abdel Khalik s.n. (SHG); Wadi Sarara, affluent from Wadi Sermataii, Abdel Khalik s.n. (SHG).
29. *C. epilinum* Weihe
Bahtim near Cairo, Hadidi s.n. (CAI).
30. *C. monogyna* Vahl
Without location, Tackholm & al. s. n. (CAI).
31. *C. palaestina* Boiss.
S. Sinai, Gabal Serbal, Fayed & al. s. n. (SHG); S. Sinai, Wadi Gebaal, Fayed & al. s. n. (SHG).
32. *C. pedicellata* Ledeb.
Giza, Kirdasa, Hadidi s. n. (SHG); Gebel Elba, Wadi Drawina, abdel Khalik s.n. (SHG).
33. *C. planiflora* Ten.
Shalateen area, Wadi Baaneed, Abdel Khalik & al. s. n. (SHG).
34. *Dichondra micrantha* Urb.
ETHIOPIA: Wollega region, 25 km on Ghimbi-Dembidolo, M. Gillbert & M. Thulin 760 (WAG).
35. *Ipomoea cairica* (L.) Sweet
Ismailia canal at Abu Zaabal, Hadidi & al. s. n. (CAI).
36. *I. carnea* Jacq.
Giza, University garden, V. Tackholm s. n. (CAI); Sohag, El Kola, canal bank, Abdel Khalik s. n. (SHG); Assiuit-Sohag agricultural road, Abdel Khalik s. n. (SHG).
37. *I. eriocarpa* R. Br.
El Khanka, W. Amer 1075 (CAI); Behiera, Abu Qir, Alaa Amer s. n. (CAI).
38. *I. obscura* (L.) Ker-Gawl.
Wadi Akaw, Gebel Elba, Abdel Khalik s. n. (SHG); Mouth of Wadi Aideep, Abdel Khalik s. n.

(SHG); Wadi Yahameb, Abdel Khalik s. n. (SHG); Gebl Karm Elba, Abdel Khalik s. n. (SHG).

39. *I. pes-caprae* (L.) R. Br.
Ismailia, Tackholm , G. 4780 (CAI); Giza, V. Tackholm s. n. (CAI).

40. *I. purpurea* (L.) Roth
Idku, A. Amer 9720 (CAI).

41. *I. sinensis* (Desr.) Choisy
Gebel Elba, Wadi Yahameib, Tackholm & al. s.n. (CAI).

42. *I. stolonifera* (Cyr.) Gmel.
N. Sinai, Rafah, Tackholm et al. s.n. (CAI).

43. *Merremia aegyptia* (L.) Urb.
Gebel Elba, Wadi Yahameib, Abdel Khalik, s. n. (SHG); Gebel Elba, Wadi Shallal V. Tackholm & al. s. n. (CAI).

44. *M. semisagitta* (Peter) Dandy
SAUDI ARABIA: Gedda, A. Khattab, s. n. (CAI).

Appendix 2.

List of characters and their character states used in Key building of the *Convolvulaceae*
Vegetative Characters
#1. Plant life/ 1. Parasite/ 2. Not parasite/
#2. Non-chlorophyllous 1/chlorophyllous 2
#3. Plant duration/ 1. Annual/ 2. annual or short lived perennial/ 3. Perennial/
#4. Plant habit/ 1. herb/ 2. sub-shrub/ 3. shrub/
#5. Stem nature/ 1. Herbaceous/ 2. Woody/
#6. Plant height/ cm/?
#7. Stem habit/ 1. Prostrate/ 2. Prostrate to twining/ 3. Twining/ 4. Climbing/ 5. Prostrate to ascending/ 6. Ascending/ 7. Ascending to erect/ 8. Erect/
#8. Mode of perennation/ 1. Rhizomatous/ 2. Not rhizomatous/
#9. Nature of branches/ 1. Spinescent/ 2. Not spinescent/
#10. Plant surface/ 1. Glabrous/ 2. Glabrous to sparsely hairs/ 3. Hairy/
#11. Hairs patent/ 1. Spreading/ 2. Appressd/
#12. Hair shape/ 1. Simple/ 2. Simple and glandular/ 3. Simple and vasculate/
#13. Lower leaves arrangement/ 1. Rosette-forming/ 2. No rosette/
#14. Green leaves/ 1. Present/ 2. Absent/
#15. Leaves petiole/1. Sessile/ 2. Sessile to short petiolate/ 3. Petiolate/
#16. Leaf petiole length/ cm/
#17. Leaf venation/ 1. Pinnate/ 2. Palmate/
#18. Leaf shapes/ 1. Linear to lanceolate/ 2. Oblong to lanceolate/ 3. Ovate to lanceolate/ 4. Spathulate to oblanceolate/ 5. Sagittate to hastate/ 6. Cordate to sagittate/ 7. Cordate to ovate/ 8. Reniform to elliptical/ 9. Reniform/ 10. Orbicular/
#19. Leaf apex/ 1. Mucronate/ 2. Acuminate/ 3. Apiculate/ 4. Acute to acuminate/ 5. Acute/ 6. Obtuse to acute/ 7. Obtuse/ 8. Retuse/ 9. Emarginate/
#20. Leaf margin/ 1. Entire/ 2. Crenate/ 3. Dentate to crenate/ 4. Undulate/ 5. Crenate to lobed/ 6. Dissected or divided/
Floral Characters
#21. Inflorescence Bracts/ 1. present/ 2. absent/
#22. Inflorescence position/ 1. Terminal/ 2. Terminal and axillary/ 3. Axillary/
#23. Peduncle mean length/ cm/
#24. Flowers numbers/ 1. Solitary/ 2. Solitary or in pairs/ 3. 2 to 10/ 4. more than 10/
#25. Flower pedicle/ 1. Sessile/ 2. Sessile to short-pedicellate/ 3. Pedicellate/
#26. Flower bract/ 1. Present/ 2. Absent/
#27. Sepal mean length/ mm/
#28. Sepal shape/ 1. Lanceolate/ 2. Lanceolate to oblong/ 3. Oblong/ 4. Oblong to obovate/ 5. Obovate/ 6. Ovate/ 7. Cordate to ovate/ 8. Orbicular to ovate/
#29. Sepal apex/ 1. Acuminate/ 2. Apiculate/ 3. Acute/ 4. Obtuse to acute to mucronate/ 5. Obtuse/
#30. Sepal surface/ 1. Glabrous/ 2. Glabrous to sparsely hairs/ 3. Hairy/
#31. Sepals patent at fruit maturity/ 1. Erect/ 2. Erect to spreading/ 3. Spreading/
#32. Corolla shape/ 1. Funnel- shape/ 2. Campanulate/ 3. Tubular shape/
#33. Corolla margin/ 1. Deeply lobed/ 2. Shallowly lobed or bifid/
#34. Corolla mean length/ mm/
#35. Corolla colour/ 1. White/ 2. Yellow to white/ 3. Yellow/ 4. Yellow to brown/ 5. Pink/ 6. Pink to white/ 7. Violet/ 8. Violet to pink/ 9. Blue/ 10. Blue to pink or white/
#36. Corolla surface/ 1. Glabrous/ 2. Glabrous with hairy bands outside/ 3. Hairy/
#37. Filament mean length/ mm/

#38. Filament surface/ 1. Glabrous/ 2. With sessile glandular hairs at the base/ 3. Hairy/
#39. Anther shape/ 1. Globose/ 2. Sagittate/ 3. Oblong to sagittate/ 4. Oblong/
#40. Stamens and styles/ 1. Included/ 2. Exserted/
#41. Style number/ 1. One/ 2. Two/
#42. Style shape/ 1. Filiform/ 2. Stout/
#43. Style surface/ 1. Glabrous/ 2. Hairy/
#44. Style length (compared to stigma)/ 1. Shorter than stigma/ 2. Equal the stigma/ 3. Longer than stigma/
#45. Styles branching/ 1. Forked/ 2. Not forked/
#46. Stigma number/ 1. One or bi-lobed/ 2. 2/ 3. 4/
#47. Stigma shape/ 1. Filiform/ 2. Cylindrical/ 3. Clavate to cylindrical/ 4. Clavate/ 5. Globose/ 6. Capitate/ 7. Peltate/
Fruit Characters
#48. Fruit mean length/ mm/
#49. Fruit mean width/ mm/
#50. Fruit dehiscence/ 1. Dehiscent/ 2. Indehiscent/
#51. Fruit shape/ 1. Globose/ 2. Subglobose/ 3. Obovate/ 4. Oblong/ 5. Conical/
#52. Number of fruit locules/ 1. 1/ 2. 2/ 3. 2–3/ 4. 3/
#53. Persistent calyx/ 1. Appressd/ 2. Erect/ 3. Erect to spreading/ 4. Spreading/ 5. Recurved/
#54. Fruit surface/ 1. Glabrous/ 2. Glabrous to sparsely hairs/ 3. Hairy/ 4. Papillate/
#55. Surface of fruit pedicel/ 1. Glabrous/ 2. Hairy/
#56. Fruit pedicel mean length/ mm/
Pollen Characters
#57. Pollen types/ 1. Tricolpate/ 2. Pantocolpate/ 3. Pantoporate/
#58. Pollen surface/ 1. Smooth to micro-granulate/ 2. Spinulose/
#59. Pollen shape/ 1. Oblate spheroidal/ 2. Spheroidal/ 3. Prolate spheroidal/ 4. Subprolate/ 5. Prolate/
#60. Exine sculpture/ 1. Tectate, punctuate, micro-granulate/ 2. Semitectate, reticulate microgranulate/ 3. Tectate, punctuate, microechinate/ 4. Semitectate, microreticulate-echinate-microgranulate/
Seed Characters
#61. Number of seeds in fruit/ 1. 1/ 2. 2/ 3. 2–4/ 4. 4/ 5. 6/
#62. Seed shape/ 1. Oblong/ 2. Obovoid/ 3. Ovoid/ 4. Pyramidal/
#63. Seed surface/ 1. Glabrous/ 2. Short hairy/ 3. Long hairy/
#64. Seed architecture/ 1. Smooth/ 2. Tuberculate/
#65. Seed size(mm) (Length × width)/ 1. 0.6–1.5 × 0.4–1.3/ 2. 1.5–4 × 1.3–3.7/ 3. 4–9 × 3.8–8/
#66. Seed colour/ 1. Black/ 2. Black to brown/ 3. Brown/ 4. Yellow to brown/ 5. Orange/
Cell Wall Characters
#67. Epidermal cell patterns/ 1. Isodiametric or 4–5–6 polygonal/ 2. Irregular or 4–5–6 polygonal/ 3. Irregular or polygonal cells/ 4. 4–5 gonal or elongate in one direction/ 5. Isodiametric, 4–5–6 polygonal or elongate in one direction/
#68. Anticlinal walls/ 1. Straight/ 2. Straight to slightly sinuous/ 3. Undulate/
#69. Relief of cell wall boundaries/ 1. Raised/ 2. Raised-channeled/ 3. Channeled/
#70. Sculpture of anticlinal boundaries/ 1. Smooth/ 2. Smooth to fine folded/ 3. Folded/
#71. Curvature of outer periclinal cell wall/ 1. Flat/ 2. Flat to concave/ 3. Concave/ 4. Flat to convex/ 5. Rugulate/
#72. Secondary cell wall sculpture/ 1. Smooth/ 2. Smooth to fine folded/ 3. Folded/ 4. Striate/ 5. Micro-reticulate/