Annals of Agricultural Science (2015) 60(1), 67–85

HOSTED BY

ELSEVIER

Faculty of Agriculture, Ain Shams University

Annals of Agricultural Science

www.elsevier.com/locate/aoas

Computer-generated keys to the flora of Egypt. 6. The Boraginaceae

Abel El-Gazzar [a,*], Abbas El-Ghamery [b], AlBaraa El-Saied [b], Adel H. Khattab [c], Alaa A. El-Kady [b]

[a] *Botany Department, Faculty of Science, Suez Canal University (El-Arish Branch), N. Sinai, Egypt*
[b] *Department of Botany and Microbiology, Faculty of Science, Al-Azhar University, Cairo, Egypt*
[c] *The Herbarium, Botany Department, Faculty of Science, Cairo University, Cairo, Egypt*

Received 16 March 2015; accepted 23 March 2015
Available online 3 July 2015

KEYWORDS

Boraginaceae;
Conventional key;
DELTA;
Egypt;
Flora;
Identification

Abstract Manually-constructed keys to many groups of the Egyptian flora are in urgent need of improvement and updating. To construct a conventional substitute of the key to representatives of the Boraginaceae, a data matrix was compiled to accommodate 54 characters recorded comparatively for the 49 species belonging to 14 genera which represent this family in the flora of Egypt. The 54 characters were accurately and lucidly defined to cover as much of the easily observable aspects of vegetative and floral variation in the plants as possible. The data matrix was analyzed using the key-generating package of programs DELTA. The analysis produced a conventional key with a detailed description of every species in terms of the 54 characters. The key is decidedly a marked improvement over its predecessors in that it is strictly comparative and leads directly to the full scientific name of any taxon, instead of having to use a key to the genera followed by a second key to the infra-generic taxa.

Introduction

The Boraginaceae Jussieu comprises 110 genera and 1595 species (Angiosperm Phylogeny Group; APG III, 2014), but the numbers reach 130–135 genera with 2400–2600 species in Bergianska website (2014). The plants are perennial, biennial, or annual herbs, less often lianas, shrubs, or trees, usually bristly or pubescent and scabrid. Leaves are simple, alternate, rarely opposite, with serrate or entire margin. Inflorescences often scorpioid cymes, sometimes solitary; bracts present or absent. Flowers are bisexual, actinomorphic or, rarely, slightly zygomorphic. Calyx is usually 5-parted or lobed, mostly persistent. Corolla tubular, funnel-shaped, campanulate or rotate; tube with 5 appendages, rarely more, mostly trapeziform, rarely absent, a ring of hairs present sometimes; limb usually 5-parted; lobes overlapping, rarely twisted in bud. Stamens 5, inserted on corolla tube, included or rarely exserted; anthers introrse, 2-loculed, usually dorsifixed at base, less usually medifixed, dehiscence longitudinal. Nectaries present on disk below ovary or at base of corolla tube. Ovary is superior, 2-carpels; locules 2 and each with 2 ovules, or divided by secondary septa

* Corresponding author.
E-mail address: elgazzar_adel@hotmail.com (A. El-Gazzar).

Peer review under responsibility of Faculty of Agriculture, Ain-Shams University.

http://dx.doi.org/10.1016/j.aoas.2015.03.002

into 4 locules each with 1 ovule; ovules nearly anatropous, semi-anatropous, or atropous. Style gynobasic or, rarely, terminal, branched or not. Fruit 1–4-seeded drupe or 4 nutlets (mericarps); nutlets mostly dry, often ornamented with wings, prickles and/or glochids (stiff bristles with barbed or anchor-like tips). Seeds vertical or oblique, with basal attachment; endosperm oily or absent; embryo straight, less often curved; cotyledons flat, fleshy; coat membranous (Barroso, 1986; Al-Shehbaz, 1991; Watson and Dallwitz, 1992 onwards; APG III, 2014).

The map shown in the APG III (2014) account of the Boraginaceae indicates that members of this family are widely distributed in the world. They cover the whole of N. America, Europe, Asia (except most of India and the Indonesian Archipelago), Australia, New Zealand, North Africa, East Africa, Madagascar, the Cape Province, and western South America. Detailed accounts of the geographical distribution of the Boraginaceae are given by Al-Shehbaz (1991) and Thorne (1992). According to Retief and Vanwyk (1997) members of this family grow mainly in dry, cliffy and sunny habitats.

Anatomical studies on members of the Boraginaceae are numerous and only a representative selection of the more recent studies is presented here. Selvi and Bigazzi (2001) studied leaf surface and anatomy in tribe Boragineae. Foliar anatomy of *Heliotropium* was also the subject of study by Abbasi et al. (2011), Ahmed and Kordofani (2012), and Alwahibi and Bukhary (2013). Similarly, foliar anatomy was studied by Akçin and Baki (2007) in three *Symphytum* species, by Akçin et al. (2012) in four *Cynoglossum* species, and by Güven et al. (2013) in six *Onosma* species. Stomatal profile in the foliar epidermis was studied by Dasti et al. (2003) in 31 species belonging to 15 genera, while foliar trichomes were extensively surveyed by Al-Nowaihi et al. (1987), Selvi and Bigazzi (2001), Diane et al. (2003), Taia (2006), Ventrella and Marinho (2008), Perveen (2009), and Mehrabian et al. (2014). Ovchinnikova (2009) used details of nutlet surface sculpture to determine the position of tribe Eritrichieae in the Boraginaceae, while Keshavarzi et al. (2013) used 23 characters of stem and fruit anatomy to evaluate the relationships of four *Anchusa* species. Nodal anatomy is rarely studied in angiosperms and it seems that the only study concerning members of the Boraginaceae is that of Trivedi et al. (1976) on certain representatives of the family in India. According to the account of Boraginaceae in the Bergianska website (2014), the nodes are usually unilacunar with one or three leaf traces, or trilacunar with three leaf traces. Using scanning electron microscopy, Rabaey et al. (2010) were able to elucidate the phylogenetic significance of the distribution of bordered pits in the secondary xylem of 105 species representing the major groups of the Boraginaceae.

Pollen morphology of the Boraginaceae was studied extensively. Thus, Clarke (1977) maintained that the Boraginaceae is one of the most eurypalynous families. Diez and Valdes (1991) studied the pollen morphology of 33 species of Boraginaceae from the Iberian Peninsula belonging to the tribes Cynoglosseae and Eritrichieae and they confirm the eurypalinous character of this family. Scheel et al. (1996) studied the pollen morphology of 30 taxa and classified them into nine pollen types based on aperture characteristics and surface ornamentation. Other palynological studies of different members of the Boraginaceae from various parts of the world include those by Nowicke and Miller (1990), El-Ghazaly (1995), Qureshi (1997), Bigazzi and Selvi (1998), Liu et al. (2001a,b), Khatamsaz (2001), Hargrove and Simpson (2003), Bigazzi et al. (2006), Melo et al. (2006), Binzet et al. (2010), Binzet (2011), Falatoury et al. (2011), Mehrabian et al. (2012), Coutinho et al. (2012) and Fukuda and Ikeda (2012).

Members of the Boraginaceae are of little economic importance. Only a few species are used in traditional medicine for treating wounds, fever, chest pain, and skin diseases (Neuwinger, 2000). Some species are grown as ornamentals, sources of timber or dye producers. The family is generally regarded as closely related to the Hydrophyllaceae (with similar coiled inflorescence), and the Lamiaceae (with gynobasic style); Watson and Dallwitz (1992 onwards), APG III (2014).

Boulos (2002) maintained that the Boraginaceae is represented in the flora of Egypt by 19 genera and 58 species and provided identification keys to these taxa. However, there is plenty of room for improvement in these keys. The present study has been undertaken to benefit from the inherent facilities of the program package DELTA in producing much improved keys for the identification of the genera and species representing the Boraginaceae in the flora of Egypt. Reference to previous applications of this package to other groups in the Egyptian flora with successful results can be found in El-Gazzar et al. (2013).

Material and methods

It was possible to collect herbarium specimens of only 49 species representing 14 genera of this family from the two major herbaria in Egypt: the herbarium of Botany Department, Faculty of science, Cairo University (CAI) and the herbarium of Flora and Phytotaxonomy Researches Unit at the Agricultural Museum, Ministry of Agriculture, Dokki, Giza (CAIM); acronyms are according to the *Index Herbariorum* (Holmgren et al., 1990). The number of specimens representing each taxon ranged between one and eight. The identity of available specimens was verified by re-identifying them with the aid of the local flora (Boulos, 2002) and the floras of neighboring countries (e.g. Andrews, 1956; Feinbrun-Dothan, 1977, 1978). Nomenclature was updated from the two websites (http://www.theplantlist.org/), and (http://www.tropicos.org), where full lists of synonyms and author citations can be found. Full names with author citations of taxa and collection data of most of the specimens are given in Appendix A.

As many aspects of variation in vegetative and floral morphology as can be found in the available specimens were recorded comparatively in a data matrix. The wide range of anatomical, cytological, palynological and chemical variation in members of this family was deliberately avoided so that only the easily observable features were recorded. For uniformity in the usage of the descriptive terminology to define the characters and their states, reference was made to the standard comprehensive dictionary compiled by Stearn (1966).

The data matrix was subjected to analysis under the program suit DELTA which is a multi-purpose format for generating conventional (i.e. printable) and interactive (i.e. online) identification keys (Dallwitz et al., 1993 onwards; Dallwitz and Paine, 2005; Dallwitz, 2010; http://delta-intkey.com; www.sourceforge.net). Being essentially a format for translating taxonomic data, DELTA produces descriptions of taxa in natural language (detailed descriptions) and in serial numbers of characters and character-states (item descriptions).

Results

The characters

Definition of the 54 characters and their character-states which were recorded comparatively for the 49 species belonging to 14 genera representing the Boraginaceae in the flora of Egypt is listed in Table 1. The numbers of qualitative, multistate and quantitative characters in that list are 49, 3 and 2, respectively.

Detailed descriptions

Alkanna tinctoria Tausch. Plant herb. Stem hairy. Stem prostrate. Stem branching above the base. Internode length 0.7–1.4 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals present. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.3–0.6 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.6–0.9 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Alkanna orientalis (L.) Boiss. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.7–1.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves ovate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin undulate. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals present. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.5–1.5 cm. Petal color Yellow or white. Petal outer surface glabrous. Petal length 1.1–1.6 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Alkanna strigosa Boiss. & Hohen. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 0.1–0.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafy. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion more than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.5–1 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 1–1.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Anchusa aegyptiaca (L.) DC. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.5–4 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin serrate. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.2–0.4 cm. Petal color Yellow or white. Petal outer surface glabrous. Petal length 0.5–0.8 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Anchusa hispida Forssk. Plant herb. Stem hairy. Stem prostrate. Stem branching above the base. Internode length 1–2.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin undulate. Leaf apex obtuse. Simple hairs on leaves present. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals

Table 1 List of the 54 characters and character-states recorded comparatively for 14 genera and 49 species representing the Boraginaceae in the flora of Egypt and used to construct a conventional key to them.

#1. Plant/1. herb/2. woody shrub/
#2. Stem/1. glabrous/2. hairy/
#3. Stem/1. erect/2. prostrate/
#4. Stem branching/1. from base/2. above the base/
#5. Internode length/cm/**
#6. Basal leaves/1. alternate/2. opposite/
#7. Leaves/1. pedicelled/2. sessile to sub-sessile/
#8. Leaves blade/1. simple/2. pinnatipartite/
#9. Leaves/1. lanceolate/2. linear/3. oblong/4. ovate/*
#10. Leaf surface/1. wrinkled/2. smooth/
#11. Base of leaf blade/1. symmetric/2. asymmetric/
#12. Leaf veins/1. prominent/2. not prominent/
#13. Leaf margin/1. entire/2. serrate/3. undulate/*
#14. Leaf apex/1. acute/2. obtuse/
#15. Simple hairs on leaves/1. present/2. absent/
#16. Glandular hairs on leaves/1. present/2. absent/
#17. Bulbs hairs on leaves/1. present/2. absent/
#18. Hispid hairs on leaves/1. present/2. absent/
#19. Woolly hairs on leaves/1. present/2. absent/
#20. Bracteoles/1. present/2. absent/
#21. Bracteoles/1. enclosing calyx/2. not enclosing calyx/
#22. Inflorescence/1. raceme/2. circinnate/
#23. Inflorescence/1. leafy/2. leafless/
#24. Number of flowers/bract/1. less than 8/2. more than 10/
#25. Flower/1. pedicelled/2. sessile to sub-sessile/
#26. Pedicle/1. much longer than calyx/2. as long as calyx or shorter/
#27. Sepal fusion/1. more than half the length/2. Less than half the length/
#28. Apex of calyx lobes/1. acute/2. filiform/
#29. Simple hairs on sepals/1. present/2. absent/
#30. Glandular hairs on sepals/1. present/2. absent/
#31. Hispid hairs on sepals/1. present/2. absent/
#32. Woolly hair on sepals/1. present/2. absent/
#33. Sepal length/cm/**
#34. Petal color/1. blue, purple or pink/2. Yellow or white/
#35. Petal outer surface/1. hairy/2. glabrous/
#36. Petal length/cm/**
#37. Petal apex/1. acute/2. obtuse/
#38. Petal fusion/1. more than half the length/2. Less than half the length/
#39. Petal lobes/1. equal/2. unequal/
#40. Corolla throat/1. with scales (5 fornices; Fig. 1)/2. without scales/
#41. No. of stamens/1. 2/2. 5/
#42. Anthers/1. exerted/2. included/
#43. Staminal filaments/1. hairy/2. glabrous/3. reduced/*
#44. Appendix on anther/1. present/2. absent/[Fig. 4]
#45. Anthers/1. sagittate/2. not sagittate/[Fig. 4]
#46. Style/1. hairy/2. glabrous/
#47. Style/1. terminal (Fig. 3)/2. gynobasic (Fig. 2)/
#48. Style/1. inserted/2. exerted/
#49. Style/1. Bifid (Fig. 2)/2. Undivided (Figs. 1 and 3)/
#50. Stigma/1. Conical (Fig. 3)/2. capitate-globose (Figs. 1 and 2)/
#51. Stigma/1. as long as style or shorter/2. much longer than style/
#52. Ovary/1. hairy/2. glabrous/
#53. Nectar disk/1. present/2. absent/(Fig. 3)
#54. Gynophore/1. present/2. absent/(Figs. 2 and 3)

The Key

Application of the program suite DELTA to the data recorded for the 14 genera and 49 species of Boraginaceae led to the construction of the following conventional key

Characters: 54 indata, 51 included, 34 in key
Items: 49 indata, 49 included, 49 in key
Parameters: Rbase = 1.40 Abase = 2.00 Reuse = 1.01 Varywt = 0.80
Characters included: 1–4 6–32 34–35 37–54
Character reliabilities: 1–54,5

1. Leaves lanceolate 2
   Leaves linear 13
   Leaves oblong 27
   Leaves ovate 33
2(1). Staminal filaments hairy 3
   Staminal filaments glabrous 4
   Staminal filaments reduced 7
3(2). Leaf apex acute; hispid hairs on leaves present; woolly hairs on leaves absent; bracteoles present . . . . . ***Nonea vivianii* DC.**
   Leaf apex obtuse; hispid hairs on leaves absent; woolly hairs on leaves present; bracteoles absent . . . . . ***Paracaryum intermedium* (Fresen.) Lipsky**
4(2). Leaf margin entire 5
   Leaf margin serrate . . . . . ***Anchusa milleri* Spreng.**
   Leaf margin undulate 6
5(4). Leaf apex acute; stem branching from base; glandular hairs on leaves present; inflorescence circinnate . . . . . ***Echium sabulicolum* Pomel var *sabulicolum***
   Leaf apex obtuse; stem branching above the base; glandular hairs on leaves absent; inflorescence raceme . . . . . ***Anchusa humilis* (Desf.) I.M. Johnst.**
6(4). Stem erect; simple hairs on leaves absent; glandular hairs on leaves absent; bulbs hairs on leaves present . . . . . ***Anchusa undulata* L. ssp *hybrida* (Ten.) Beg. in Beg & Furi**
   Stem prostrate; simple hairs on leaves present; glandular hairs on leaves present; bulbs hairs on leaves absent . . . . . ***Anchusa hispida* Forssk.**
7(2). Leaf margin entire 8
   Leaf margin serrate 12
   Leaf margin undulate . . . . . ***Heliotropium bacciferum* Forssk. ssp *bacciferum* var *bacciferum***
8(7). Basal leaves alternate; leaf surface smooth; simple hairs on leaves present; bracteoles not enclosing calyx 9
   Basal leaves opposite; leaf surface wrinkled; simple hairs on leaves absent; bracteoles enclosing calyx 10
9(8). Leaf apex acute; plant woody shrub; leaves pedicelled leaf veins prominent . . . . . ***Heliotropium zeylanicum* (Burm. f.) Lam.**
   Leaf apex obtuse; plant herb; leaves sessile to sub-sessile; leaf veins not prominent . . . . . ***Lappula sinaica* (DC.) Asch. & Schweinf.**
10(8). Glandular hairs on leaves present; bulbs hairs on leaves absent; number of flowers/bract more than 10 . . . . . ***Trichodesma africanum* (L.) R.Br. var *africanum***
   Glandular hairs on leaves absent; bulbs hairs on leaves present; number of flowers/bract less than 8 11
11(10). Style hairy; style terminal; ovary hairy; nectar disk present . . . . . ***Trichodesma africanum* (L.) R.Br. var *heterotrichum* Bornm. & Kneuk.**
   Style glabrous; style gynobasic; ovary glabrous; nectar disk absent . . . . . ***Trichodesma africanum* (L.) R.Br. var. *abyssinicum* Brand in Engl.**
12(7). Leaf apex acute; leaves sessile to sub-sessile; simple hairs on leaves present; bulbs hairs on leaves absent . . . . . ***Anchusa aegyptiaca* (L.) DC.**
   Leaf apex obtuse; leaves pedicelled; simple hairs on leaves absent; bulbs hairs on leaves present . . . . . ***Heliotropium pterocarpum* (DC.) Hochst. & Steud. ex Bunge**
13(1). Staminal filaments hairy 14
   Staminal filaments glabrous 15
   Staminal filaments reduced 24
14(13). Style hairy; stem branching from base; leaves sessile to sub-sessile; hispid hairs on leaves present . . . . . ***Moltkiopsis ciliata* (Forssk.) I.M. Johnst.**
   Style glabrous; stem branching above the base; leaves pedicelled; hispid hairs on leaves absent . . . . . ***Heliotropium strigosum* Willd. var *brevifolium* (Wal.) C.B. Clarke**
15(13). Hispid hairs on leaves present; hispid hairs on sepals present 16
   Hispid hairs on leaves absent; hispid hairs on sepals absent 20
16(15). Leaf apex acute 17
   Leaf apex obtuse 18
17(16). Style hairy; leaf veins prominent; apex of calyx lobes filiform; simple hairs on sepals present . . . . . ***Arnebia decumbens* (Vent.) Coss. & Kralik var *decumbens***
   Style glabrous; leaf veins not prominent; apex of calyx lobes acute; simple hairs on sepals absent . . . . . ***Arnebia hispidissima* (Lehm.) DC.**

(*continued on next page*)

18(16).	Style hairy; leaf veins prominent; bulbs hairs on leaves present; petal fusion more than half the length	19
	Style glabrous; leaf veins not prominent; bulbs hairs on leaves absent; petal fusion less than half the length	***Buglossoides incrassata* (Guss.) I.M. Johnst.**
19(18).	Inflorescence raceme; number of flowers/bract more than 10; glandular hairs on sepals present; petal color yellow or white	***Arnebia linearifolia* DC.**
	Inflorescence circinnate; number of flowers/bract less than 8; glandular hairs on sepals absent; petal color blue, purple or pink	***Echium rauwolfii* Delile**
20(15).	Leaf apex acute	21
	Leaf apex obtuse	22
21(20).	Stem erect; style glabrous; plant woody shrub; leaf veins not prominent	***Alkanna strigosa* Boiss. & Hohen.**
	Stem prostrate; style hairy; plant herb; leaf veins prominent	***Echium angustifolium* Mill. ssp. *sericeum* (Vahl) Klotz**
22(20).	Style hairy; stem branching from base; bulbs hairs on leaves present; bracteoles enclosing calyx	23
	Style glabrous; stem branching above the base; bulbs hairs on leaves absent; bracteoles not enclosing calyx	***Buglossoides tenuiflora* (L.*f.*) I.M. Johnst.**
23(22).	Plant herb; leaf veins prominent; simple hairs on leaves absent; inflorescence circinnate	***Echium angustifolium* Mill. ssp. *angustifolium***
	Plant woody shrub; leaf veins not prominent; simple hairs on leaves present; inflorescence raceme	***Echiochilon fruticosum* Desf.**
24(13).	Style hairy; simple hairs on leaves absent	25
	Style glabrous; simple hairs on leaves present	26
25(24).	Plant herb; stem branching above the base; leaf veins prominent; inflorescence leafless.	***Arnebia decumbens* (Vent.) Coss. & Kralik var *macrocalyx* Coss. & Kralik**
	Plant woody shrub; stem branching from base; leaf veins not prominent; inflorescence leafy.	***Lappula spinocarpos* (Forssk.) Asch. ex Kuntze var *spinocarpos***
26(24).	Stem erect; plant woody shrub; stem branching from base; glandular hairs on leaves absent.	***Lappula spinocarpos* (Forssk.) Asch. ex Kuntze var *inermis* Botsch.**
	Stem prostrate; plant herb; stem branching above the base; glandular hairs on leaves present	***Alkanna tinctoria* Tausch.**
27(1).	Staminal filaments hairy	28
	Staminal filaments glabrous	29
	Staminal filaments reduced	32
28(27).	Leaf margin entire; leaf apex obtuse; leaves sessile to sub-sessile; bulbs hairs on leaves absent	***Echium horridum* Batt.**
	Leaf margin serrate; leaf apex acute; leaves pedicelled; bulbs hairs on leaves present	***Heliotropium ramosissimum* (Lehm.) Sieb. ex DC.**
29(27).	Stem erect; leaf veins not prominent; glandular hairs on leaves present; bulbs hairs on leaves absent	30
	Stem prostrate; leaf veins prominent; glandular hairs on leaves absent; bulbs hairs on leaves present	31
30(29).	Basal leaves alternate; leaf apex acute; style glabrous; stem branching above the base.	***Asperugo procumbens* L.**
	Basal leaves opposite; leaf apex obtuse; style hairy; stem branching from base	***Arnebia tinctoria* Forssk.**
31(29).	Leaf margin entire; leaf apex obtuse; style hairy; stem branching from base.	***Echium rubrum* Forssk.**
	Leaf margin serrate; leaf apex acute; style glabrous; stem branching above the base	***Coldenia procumbens* L.**
32(27).	Plant herb; stem hairy; leaves sessile to sub-sessile; leaf surface smooth	***Paracaryum rugulosum* (DC.) Boiss.**
	Plant woody shrub; stem glabrous; leaves pedicelled; leaf surface wrinkled	***Heliotropium curassavicum* L.**
33(1).	Staminal filaments hairy	***Heliotropium hirsutissimum* Grauer in Weber**
	Staminal filaments glabrous	34
	Staminal filaments reduced	38
34(33).	Leaf margin entire; flower pedicelled; style terminal	35
	Leaf margin undulate; flower sessile to sub-sessile; style gynobasic	37
35(34).	Leaf apex acute; simple hairs on leaves present; bulbs hairs on leaves absent	36
	Leaf apex obtuse; simple hairs on leaves absent; bulbs hairs on leaves present	***Heliotropium lasiocarpum* Fisch. & C.A. Mey.**
36(35).	Plant herb; stem branching above the base; leaf veins prominent; woolly hairs on leaves present	***Heliotropium supinum* L.**
	Plant woody shrub; stem branching from base; leaf veins not prominent; woolly hairs on l eaves absent	***Heliotropium ovalifolium* Forssk.**
37(34)	Leaf apex acute; style glabrous; leaf surface smooth; glandular hairs on leaves present	***Heliotropium arabinense* Fresen.**
	Leaf apex obtuse; style hairy; leaf surface wrinkled; glandular hairs on leaves absent	***Heliotropium aegyptiacum* Lehm.**
38(33).	Leaf apex acute; bracteoles present; bracteoles enclosing calyx; petal outer surface glabrous	39
	Leaf apex obtuse; bracteoles absent; bracteoles not enclosing calyx; petal outer surface hairy	40
39(38).	Basal leaves alternate; leaf margin undulate; style glabrous; plant herb	***Alkanna orientalis* (L.) Boiss.**
	Basal leaves opposite; leaf margin entire; style hairy; plant woody shrub	***Trichodesma ehrenbergii* Schweinf.**
40(38).	Bulbs hairs on leaves present; woolly hairs on leaves absent; number of flowers/bract more than 10; glandular hairs on sepals present	***Heliotropium digynum* (Forssk.) Asch. Ex C. Chr.**
	Bulbs hairs on leaves absent; woolly hairs on leaves present; number of flowers/bract less than 8; glandular hairs on sepals absent.	***Heliotropium bacciferum* Forssk. ssp. *bacciferum* var. *erosum* Hadidy in Boulos**

* Multistate character.
** Quantitative character.

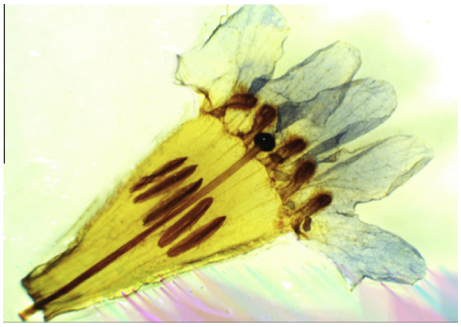

Fig. 1 Variation in floral morphology of Boraginaceae. *Anchusa undulata* ssp. *hybrida*. Simple style with (black) capitate stigma and 5 (brown) appendages at corolla throat and opposite to corolla blue lobes.

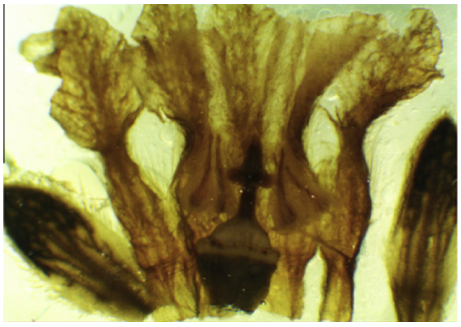

Fig. 3 Variation in floral morphology of Boraginaceae. *Heliotropium strigosum*. Ovary syncarpous, on nectar disk; style (black) simple, with one black conical (arrow-head) stigma.

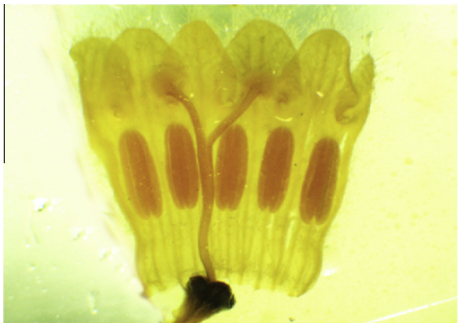

Fig. 2 Variation in floral morphology of Boraginaceae. *Arnebia hispidissima*. Ovary (black) deeply divided; style gynobasic, bifid with two capitate stigmas.

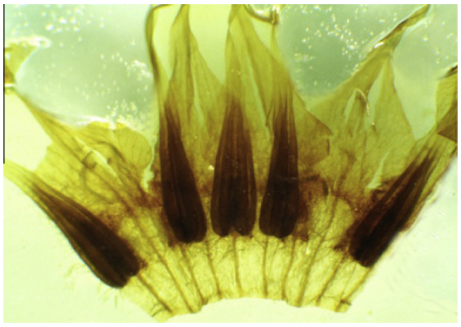

Fig. 4 Variation in floral morphology of Boraginaceae. *Trichodesma africanum*. Five dark brown anthers with cordate base and long tapering apices.

present. Woolly hair on sepals absent. Sepal length 0.1–0.4 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.1–0.3 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes unequal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Anchusa humilis (Desf.) I.M. Johnst. Plant herb. Stem hairy. Stem prostrate. Stem branching above the base. Internode length 2–5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.2–0.5 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.5–0.9 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Anchusa milleri Spreng. Plant herb. Stem hairy. Stem prostrate. Stem branching above the base. Internode length 0.1–0.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin serrate. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.3–0.6 cm. Petal color Yellow or white. Petal outer surface glabrous. Petal length 0.8–1.1 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes unequal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not

sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Anchusa undulata L. ssp. *hybrida* (Ten.) Beg. in Beg & Furi. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.2–0.9 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin undulate. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles not enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion more than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals present. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.5–1.1 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.6–1.6 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Arnebia decumbens (Vent.) Coss. & Kralik var. *decumbens*. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 1–2 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes filiform. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.5–1.2 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.5–1.4 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Arnebia decumbens (Vent.) Coss. & Kralik var. *macrocalyx* Coss. & Kralik. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 1–3.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.5–1.3 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.5–1.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary hairy. Nectar disk absent. Gynophore absent.

Arnebia hispidissima (Lehm.) DC. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.1–0.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.4–0.7 cm. Petal color Yellow or white. Petal outer surface glabrous. Petal length 0.5–1 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Arnebia linearifolia DC. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 1–3.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals present. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.4–1.3 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.5–1.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style

gynobasic. Style inserted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Arnebia tinctoria Forssk. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 2–3.5 cm. Basal leaves opposite. Leaves pedicelled. Leaves blade simple. Leaves oblong. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion more than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals present. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.5–1 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.5–1.2 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style inserted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Asperugo procumbens L. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 1–4 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves oblong. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles not enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle much longer than calyx. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.1–0.8 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.3–1.1 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Buglossoides incrassata (Guss.) I.M. Johnst. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.6–1.6 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.2–0.5 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 0.3–0.5 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Buglossoides tenuiflora (L.f.) I.M. Johnst. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.4–1.3 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles not enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.2–0.6 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 0.2–0.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary hairy. Nectar disk absent. Gynophore absent.

Coldenia procumbens L. Plant herb. Stem hairy. Stem prostrate. Stem branching above the base. Internode length 0.3–1 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade pinnatipartite. Leaves oblong. Leaf surface wrinkled. Base of leaf blade asymmetric. Leaf veins prominent. Leaf margin serrate. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafy. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.1–1.1 cm. Petal color Yellow or white. Petal outer surface glabrous. Petal length 0.1–0.2 cm. Petal apex acute. Petal fusion Less than half the length. Petal lobes unequal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Echiochilon fruticosum Desf. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 0.1–0.2 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafy. Number of flowers/bract less than 8. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.1–0.3 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 0.4–1 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes unequal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Echium angustifolium Mill. ssp. *angustifolium*. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 1.5–4.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.4–1 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 1–3.2 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes unequal. Corolla throat without scales. No. of stamens 5. Anthers exerted. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style exerted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk present. Gynophore absent.

Echium angustifolium Mill. ssp. *sericeum* (Vahl) Klotz. Plant herb. Stem hairy. Stem prostrate. Stem branching from base. Internode length 0.2–2.1 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.4–0.8 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 1–2.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes unequal. Corolla throat without scales. No. of stamens 5. Anthers exerted. Staminal filaments glabrous. Appendix on anther absent. Anthers sagittate. Style hairy. Style gynobasic. Style exerted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk present. Gynophore absent.

Echium horridum Batt. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 1.5–3.2 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves oblong. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafy. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.5–1.4 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 1–2.2 cm. Petal apex acute. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments hairy. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style inserted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk present. Gynophore absent.

Echium rauwolfii Delile. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.4–2 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.4–0.9 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 0.8–1.4 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers exerted. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style exerted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Echium rubrum Forssk. Plant herb. Stem hairy. Stem prostrate. Stem branching from base. Internode length 0.6–3.3 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves oblong. Leaf surface smooth. Base of leaf blade

symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion more than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.5–1.1 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 1–2 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes unequal. Corolla throat without scales. No. of stamens 5. Anthers exerted. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style exerted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary hairy. Nectar disk present. Gynophore absent.

Echium sabulicolum Pomel var. *sabulicolum*. Plant herb. Stem hairy. Stem prostrate. Stem branching from base. Internode length 1–2.1 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.4–1.1 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 1–2.1 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers exerted. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style exerted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk present. Gynophore absent.

Heliotropium aegyptiacum Lehm. Plant woody shrub. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.9–2.5 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface wrinkled. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin undulate. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.2–0.4 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.3–0.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers sagittate. Style hairy. Style gynobasic. Style inserted. Style undivided. Stigma conical. Stigma as long as style or shorter. Ovary hairy. Nectar disk absent. Gynophore absent.

Heliotropium arabinense Fresen. Plant woody shrub. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.5–1 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin undulate. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals present. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.2–0.6 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.4–0.7 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma conical. Stigma much longer than style. Ovary hairy. Nectar disk present. Gynophore absent.

Heliotropium bacciferum Forssk. Ssp. *bacciferum* var. *bacciferum*. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 0.6–1.9 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin undulate. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.1–0.8 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.2–0.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma much longer than style. Ovary glabrous. Nectar disk present. Gynophore absent.

Heliotropium bacciferum Forssk. Ssp. *bacciferum* var. *erosum* Hadidy in Boulos. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 0.4–1.5 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin undulate. Leaf apex obtuse. Simple hairs on leaves present. Glandular hairs on

leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves present. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.2–1 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.4–1.2 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma much longer than style. Ovary glabrous. Nectar disk present. Gynophore absent.

Heliotropium digynum (Forssk.) Asch. ex C. Chr. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 0.5–1.6 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin undulate. Leaf apex obtuse. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals present. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.1–0.5 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.3–0.6 cm. Petal apex acute. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma as long as style or shorter. Ovary hairy. Nectar disk present. Gynophore absent.

Heliotropium hirsutissimum Grauer in Weber. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 1–4.5 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.2–0.6 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.5–1.1 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments hairy. Appendix on anther absent. Anthers sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma much longer than style. Ovary hairy. Nectar disk absent. Gynophore absent.

Heliotropium lasiocarpum Fisch. & C.A. Mey. Plant woody shrub. Stem hairy. Stem erect. Stem branching above the base. Internode length 1–7 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.1–0.3 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.1–0.3 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma much longer than style. Ovary hairy. Nectar disk absent. Gynophore absent.

Heliotropium ovalifolium Forssk. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 0.5–3 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.1–0.3 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.2–0.3 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers not sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma much longer than style. Ovary hairy. Nectar disk absent. Gynophore absent.

Heliotropium pterocarpum (DC.) Hochst. & Steud. ex Bunge. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 1–3 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin serrate. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number

of flowers/bract less than 8. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.2–0.4 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.3–0.6 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers sagittate. Style glabrous. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma as long as style or shorter. Ovary glabrous. Nectar disk present. Gynophore absent.

Heliotropium ramosissimum (Lehm.) Sieb. ex DC. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 0.5–4 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves oblong. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin serrate. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.1–0.6 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.2–0.7 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments hairy. Appendix on anther absent. Anthers sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma as long as style or shorter. Ovary hairy. Nectar disk absent. Gynophore absent.

Heliotropium strigosum Willd. Var. *brevifolium* (Wal.) C.B. Clarke. Plant woody shrub. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.5–2.5 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.1–0.3 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.2–0.4 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 2. Anthers included. Staminal filaments hairy. Appendix on anther absent. Anthers sagittate. Style glabrous. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma as long as style or shorter. Ovary glabrous. Nectar disk present. Gynophore present.

Heliotropium supinum L. Plant herb. Stem hairy. Stem erect. Stem branching above the base. Internode length 0.5–1.5 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves present. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.1–0.3 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.2–0.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments glabrous. Appendix on anther absent. Anthers sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma as long as style or shorter. Ovary hairy. Nectar disk absent. Gynophore absent.

Heliotropium zeylanicum (Burm. f.) Lam. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 0.9–2 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion more than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.1–0.2 cm. Petal color Yellow or white. Petal outer surface hairy. Petal length 0.3–0.7 cm. Petal apex acute. Petal fusion Less than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma as long as style or shorter. Ovary hairy. Nectar disk present. Gynophore absent.

Heliotropium curassavicum L. Plant woody shrub. Stem glabrous. Stem erect. Stem branching from base. Internode length 0.5–2.5 cm. Basal leaves alternate. Leaves pedicelled. Leaves blade simple. Leaves oblong. Leaf surface wrinkled. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower sessile to sub-sessile. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals absent. Glandular hairs on sepals absent. Hispid hairs on

sepals absent. Woolly hair on sepals absent. Sepal length 0.1–0.2 cm. Petal color Yellow or white. Petal outer surface glabrous. Petal length 0.1–0.3 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers sagittate. Style glabrous. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma much longer than style. Ovary glabrous. Nectar disk absent. Gynophore absent.

Lappula sinaica (DC.) Asch. & Schweinf. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 0.1–0.6 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles not enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals absent. Sepal length 0.1–0.2 cm. Petal color Yellow or white. Petal outer surface glabrous. Petal length 0.2–0.3 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers sagittate. Style glabrous. Style terminal. Style inserted. Style undivided. Stigma conical. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Lappula spinocarpos (Forssk.) Asch. ex Kuntze var. *spinocarpos*. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 1–2 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafy. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.2–0.4 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 0.2–0.5 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Lappula spinocarpos (Forssk.) Asch. ex Kuntze var. *inermis Botsch*. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 1–2 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafy. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.2–0.4 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 0.2–0.5 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style bifid. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Moltkiopsis ciliata (Forssk.) I.M. Johnst. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 0.5–1.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves linear. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.3–0.5 cm. Petal color blue, purple or pink. Petal outer surface hairy. Petal length 0.8–1.3 cm. Petal apex obtuse. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers exerted. Staminal filaments hairy. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style exerted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore present.

Nonea vivianii DC. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 1–3.6 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves present. Woolly hairs on leaves absent. Bracteoles present. Bracteoles not enclosing calyx. Inflorescence raceme. Inflorescence leafy. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion more than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals present. Woolly hair on sepals absent. Sepal length 0.5–1.4 cm. Petal

color blue, purple or pink. Petal outer surface glabrous. Petal length 0.6–1.5 cm. Petal apex acute. Petal fusion more than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments hairy. Appendix on anther absent. Anthers not sagittate. Style hairy. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Paracaryum intermedium (Fresen.) Lipsky. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 0.5–2 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves lanceolate. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves present. Glandular hairs on leaves absent. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves present. Bracteoles absent. Bracteoles not enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.1–0.2 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.1–0.3 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments hairy. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Paracaryum rugulosum (DC.) Boiss. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 0.1–0.5 cm. Basal leaves alternate. Leaves sessile to sub-sessile. Leaves blade simple. Leaves oblong. Leaf surface smooth. Base of leaf blade symmetric. Leaf veins not prominent. Leaf margin entire. Leaf apex obtuse. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence raceme. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle as long as calyx or shorter. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.2–0.5 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.4–0.6 cm. Petal apex obtuse. Petal fusion Less than half the length. Petal lobes equal. Corolla throat covered with scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther absent. Anthers not sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore present.

Trichodesma africanum (L.) R.Br. var. *abyssinicum* Brand in Engl. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 5–8 cm. Basal leaves opposite. Leaves pedicelled. Leaves blade simple. Leaves lanceolate. Leaf surface wrinkled. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle much longer than calyx. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.5–1.1 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.5–1.3 cm. Petal apex acute. Petal fusion Less than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther present. Anthers sagittate. Style glabrous. Style gynobasic. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Trichodesma africanum (L.) R.Br. var. *africanum*. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 0.8–5 cm. Basal leaves opposite. Leaves pedicelled. Leaves blade simple. Leaves lanceolate. Leaf surface wrinkled. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves present. Bulbs hairs on leaves absent. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract more than 10. Flower pedicelled. Pedicle much longer than calyx. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.3–1 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.5–1.2 cm. Petal apex acute. Petal fusion Less than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther present. Anthers sagittate. Style glabrous. Style terminal. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary glabrous. Nectar disk absent. Gynophore absent.

Trichodesma africanum (L.) R.Br. var. *heterotrichum* Bornm. & Kneuk. Plant herb. Stem hairy. Stem erect. Stem branching from base. Internode length 1–5 cm. Basal leaves opposite. Leaves pedicelled. Leaves blade simple. Leaves lanceolate. Leaf surface wrinkled. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle much longer than calyx. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.3–0.8 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.5–1 cm. Petal apex acute. Petal fusion Less than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5.

Anthers included. Staminal filaments reduced. Appendix on anther present. Anthers sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary hairy. Nectar disk present. Gynophore absent.

Trichodesma ehrenbergii Schweinf. Plant woody shrub. Stem hairy. Stem erect. Stem branching from base. Internode length 2–4.9 cm. Basal leaves opposite. Leaves pedicelled. Leaves blade simple. Leaves ovate. Leaf surface wrinkled. Base of leaf blade symmetric. Leaf veins prominent. Leaf margin entire. Leaf apex acute. Simple hairs on leaves absent. Glandular hairs on leaves absent. Bulbs hairs on leaves present. Hispid hairs on leaves absent. Woolly hairs on leaves absent. Bracteoles present. Bracteoles enclosing calyx. Inflorescence circinnate. Inflorescence leafless. Number of flowers/bract less than 8. Flower pedicelled. Pedicle much longer than calyx. Sepal fusion Less than half the length. Apex of calyx lobes acute. Simple hairs on sepals present. Glandular hairs on sepals absent. Hispid hairs on sepals absent. Woolly hair on sepals present. Sepal length 0.2–0.5 cm. Petal color blue, purple or pink. Petal outer surface glabrous. Petal length 0.4–0.6 cm. Petal apex acute. Petal fusion Less than half the length. Petal lobes equal. Corolla throat without scales. No. of stamens 5. Anthers included. Staminal filaments reduced. Appendix on anther present. Anthers sagittate. Style hairy. Style terminal. Style inserted. Style undivided. Stigma capitate-globose. Stigma as long as style or shorter. Ovary hairy. Nectar disk absent. Gynophore absent.

Discussion

Comparison between the key resulting from the present study and previous keys to genera and species of the Boraginaceae in Egypt reveals the numerous advantages of the former over the latters. The present key is based on a much wider range of characters from vegetative and floral morphology. The characters were recorded and used in key generation in a strictly comparative way, so that alternative entries of any couplet in the key are distinguished from each other by means of contrasting character-states of the same character or set of characters. The prelude to the key shows that of the 54 characters recorded for each of the 49 taxa, only 34 were sufficient to generate the key successfully with a surplus of 20 characters. All 54 characters are included in the detailed description of every taxon, thus serving the all-important function of confirming the identity of these taxa. In fact, the number of confirmatory characters is much greater than the number of surplus characters. For example, the name of the last taxon in the key would be reached by only 10 characters so that the confirmatory characters in the detailed description of that taxon would be 44. Other species will be identified with much fewer characters: the name *Heliotropium hirsutissimum* will be reached by only two characters because of its ovate leaves (couplet 1) and hairy staminal filaments (couplet 33).

According to Boulos (2002), the Boraginaceae is represented in the Egyptian flora by 19 genera and 58 species with a number of infra-specific taxa, but the present key comprises only 49 species representing 14 genera. No specimens of the remaining 5 genera and 9 species could be located in the two major herbaria in Egypt CAI and CAIM. However, if at any future time specimens of any of these missing genera and species are re-discovered in the country, the data matrix on which the present key is based can be expanded to accommodate them together with their characters and a re-run of the DELTA package of key-generating programs would produce the updated key and descriptions.

Appendix A

List of taxa and collection data of the 14 genera and 49 species representing the Boraginaceae in the flora of Egypt and used in key-generation. Genera and species are arranged alphabetically.

No.	Taxa	Collection data
1	*Alkanna tinctoria* Tausch.	Gunnar Täckholm, 26/3/1927, Abukir; CAI
2	*Alkanna orientalis* (L.) Boiss.	A. El Hadidy, 19/8/1982, Wadi el Arbain, S. Sinai; CAI. Nabil El Hdidy, 10/5/1965, outside the monastery of st. Catherine; CAI.
3	*Alkanna strigosa* Boiss. & Hohen.	Zohary & Jaffe, 17/2/1931, Jerusalem, eastern slopes of Mt. Scopus; CAI
4	*Anchusa aegyptiaca* (L.) DC.	Adel Gazzar, March 1973, Amria; CAI
5	*Anchusa hispida* Forssk.	Loutfy Boulos, 28/4/1955, 3 km north of El-Arish; CAI. A. Kadry, Spring 1964, Arabia: Khurais Rd., 75 km from Riyadh; CAI. Täckholm, et al., 2/6/1964, Ras El-Hekma; CAI
6	*Anchusa humilis* (Desf.) I.M. Johnst.	Alaa Amer, 20/3/1987, Alexandria; CAI
7	*Anchusa milleri* Spreng.	M. Kassas, 26/2/1964, Wadi Amloug 50 km south of Suez; CAI
8	*Anchusa undulata* L. ssp. *hybrida* (Ten.) Beg. In Beg &	Amal Amin, 13-14/3/1952, Mariut; CAI Mustafa Imam, 22/3/1965, Alexandria-Burg El Arab road; CAI. Christina Brydolf, 12/3/1969, Cyrene, Cyrenaica (Libya); CAI.
9	*Arnebia decumbens* (Vent.) Coss. & Kralik var. *decumbens*	Botany Dept. Excursion, 2/5/1955, Ras El Hekma; CAI.
10	*Arnebia decumbens* (Vent.) Coss. & Kralik var. *macrocalyx* Coss. &	M. N. Shourbagy, June 1956, Hamadan, west of Tehran, Iran; CAI. Loutfy Boulos, W. Jallad and J. Lahham, 11/4/1974, 35 km NE of H-4; CAI.
11	*Arnebia hispidissima* (Lehm.) DC.	K. H. Batanouny, 22/1/1990, Hurgada-Safaga Road; CAI

No.	Taxa	Collection data
12	*Arnebia linearifolia* DC.	A. El Hadidy, 3/4/1980, Cairo-Alexandria desert Road 160 km far from Cairo; CAI.
13	*Arnebia tinctoria* Forssk.	Nabil El Hadidi & K. H. Batanouny, 2/3/1956, Suez Road; CAI.
14	*Asperugo procumbens* L.	A. El Hadidy, 24/4/1983, Gebel Catherine, St. Catherine S. Sinai; CAI.
15	*Buglossoides incrassata* (Guss.) I.M. Johnst.	E. K. Balls & W. B. Garlay, 2/5/1934, Asia Minor (Turkey); CAI.
16	*Buglossoides tenuiflora* (L.f.) I.M. Johnst.	Christina Brydolf, 22/2/1970, 20 km north Tan-Tan, Morocco; CAI.
17	*Coldenia procumbens* L.	J. R. Shabetai, Z4478, 15/10/1941, around Lake Faruk, Kom Oshim, Fayum; CAI.
18	*Echiochilon fruticosum* Desf.	Vivi Taecholm, 16/2/1965, Burg el Arab – Alamein road; CAI.
19	*Echium angustifolium* Mill. ssp. *angustifolium*	Vivi Täckholm, I. Elsayed and M. El Mahdi, 7/4/1967, Iking Mariut; CAI. Amal Amin 13/3/1972, Burg el Arab; CAI.
20	*Echium angustifolium* Mill. Ssp *sericeum* (Vahl)	Ibrahim El-Garf, 29/12/1989, Sidi Barrani; CAI.
21	*Echium horridum* Batt.	Vivi Täckholm, et al., 6/2/1961, Bir Hafafit, Red Sea Coast; CAI.
22	*Echium rauwolfii* Delile	Vivi Täckholm, L. Boulos, and M. Zahran, 14-18/11/1963 and 11/2/1964, Aniba (near Aswan) and Kom Ombo; CAI.
23	*Echium rubrum* Forssk	Christina Brydolf, April 1968, Leptis Magna, Libya; CAI. Ibrahim El-Garf, April 1999, Wadi Hashem, 48 km before Mersa Matruh; CAI.
24	*Echium sabulicolum* Pomel var *sabulicolum*	A. G. Fahmy 1084, 2/5/1988, Mersa Matruh-Sallum Road 60 km east of Sallum; CAI.
25	*Heliotropium aegyptiacum* Lehm.	R. Muschler, 4/1904, Idfu; CAI. Dr. Pfund, (1875–1876), Dongola, Soudan; CAI.
26	*Heliotropium arabinense* Fresen.	Gaher, 17/3/1957, Burg el Arab; CAI
27	*Heliotropium bacciferum* Forssk. ssp. *bacciferum* var. *bacciferum*	M. Kassas, 26/2/1964, 60 km south of Suez; CAI.
28	*Heliotropium bacciferum* Forssk ssp *bacciferum* var *erosum* Hadidy in Boulos	Loutfy Boulos, 27/5/1961, Grand Canaries; CAI.
29	*Heliotropium digynum* (Forssk.) Asch. Ex C. Chr.	Adel Gazzar, 5/2/1973, Nekhel, Central Sinai; CAI. Wafaa Amer, 28/3/2005, Bir El-Abd, N. Sinai; CAI.
30	*Heliotropium hirsutissimum* Grauer in Weber	Gwaine, 16/6/1907, Sporting Club, Alexandria; CAI. Vivi Täckholm, July 1962, Tulkarm, Jordan; CAI.
31	*Heliotropium lasiocarpum* Fisch. & C.A. Mey.	Imam, Ibrahim, Mahdi and Sisi, 31/10/1971, 5 km south of Rosetta; CAI. Adel Gazzar, 1/6/1975, Faculty of Science Garden, Alexandria; CAI. Ibrahim El-Garf, 28/4/1955, Wadi Araba; CAI.
32	*Heliotropium ovalifolium* Forssk.	M. Kassas, et al. E39(a), E35, 7/12/1967, Jebel Avitola-Khor Tagando, Kassala, Sudan; CAI
33	*Heliotropium pterocarpum* (DC.) Hochst. & Steud. Ex Bunge	Vivi Täckholm et al. 1495a., 5/2/1962, Mouth of Wadi Laseitit, Gebel Elba; CAI. Vivi Taeckholm et al., 9/2/1962, Gebel Elba; CAI.
34	*Heliotropium ramosissimum* (Lehm.) Sieb. Ex DC.	M. Kassas et al. 410, 10/12/1966, Khor Gwab, Red Sea, Sudan; CAI.
35	*Heliotropium strigosum* Willd. Var *brevifolium* (Wal.) C.B.	M. Kassas 75, 12/10/1953, Merkheat Hills, Sudan; CAI. Vivi Täckholm et al., 1025, 28/1/1962, Gebel Elba; CAI. V. Täckholm et al., 928. 28/1/1962, Wadi Mawaw, Gebel Elba; CAI.
36	*Heliotropium supinum* L.	Nabil El Hadidy, 22/7/1954, on the drain, near Tukh, Qalubeya; CAI.
37	*Heliotropium zeylanicum* (Burm. F.) Lam.	Gunnar Täckholm, 23–27/1/1929, Gebel Elba; CAI
38	*Heliotropium curassavicum* L.	Täckholm, Nabil and Imam, 3/9/1966, Wadi Digla, near Maadi; CAI
39	*Lappula sinaica* (DC.) Asch. & Schweinf.	Schweinfurth, (original burnt in Berlin); CAI.
40	*Lappula spinocarpos* (Forssk.) Asch. ex Kuntze var *spinocarpos*	M. Imam, 4/4/1957, Suez desert Road; CAI.
41	*Lappula spinocarpos* (Forssk.) Asch. ex Kuntze var *inermis* Botsch.	Loutfy Boulos 8757, 7/5/1976, University Campus, Al-Jubaiha, near Amman, Jordan; CAI.
42	*Moltkiopsis ciliata* (Forssk.) I.M. Johnst.	Wafaa Amer, Gebel Libna, N. Sinai; CAI.
43	*Nonea vivianii* DC.	Loutfy Boulos, 24/3/1955, Khan Yunis, Palestine; CAI. Loutfy Boulos 2256, 13/3/1968, Al-Tamimi, East Derna, Gebel Akhdar, Libya; CAI.
44	*Paracaryum intermedium* (Fresen.) Lipsky	Azza El Hadidy, 23/4/1983, S. Sinai, Wadi Tala; CAI. Adel Gazzar, Feb. 1993, El Hasana, C. Sinai; CAI.

(*continued on next page*)

No.	Taxa	Collection data
45	*Paracaryum rugulosum* (DC.) Boiss.	L. Boulos, David Addiss and Mazin Qumsiyeh, 8718, 2/5/1976, Wadi Bayir, Jordan; CAI.
46	*Trichodesma africanum* (L.) R.Br. var *abyssinicum* Brand in Engl.	Kassas et al., 287, 11/12/1965, Golol, Sudan; CAI. Dale Osborn & Ibrahim Helmy, 10/4/1967, Gebel Uwainat, Wadi el Brins; CAI.
47	*Trichodesma africanum* (L.) R.Br. var *africanum*	Vivi Täckholm et al., 4/3/1961, Wadi Hankalia, near the gold mines Red Sea coast; CAI.
48	*Trichodesma africanum* (L.) R.Br. var. *heterotrichum* Bornm. & Kneuk.	Vivi Täckholm et al., 22/11/1960, El Maadi desert; CAI.
49	*Trichodesma ehrenbergii* Schweinf.	Khattab 152B, 16/1/1945, Gibal Arforat, Mecca, Saudi Arabia; CAI

References

Abbasi, M., Attar, F., Ghahremani Nejad, F., 2011. Anatomical studies on several species of *Heliotropium* L. in Iran. Notulae Sci. Biol. 3 (4), 35–43.

Ahmed, H.O., Kordofani, M.A., 2012. Leaf and stem anatomy of five species from the genus *Heliotropium* L. (Boraginaceae) in Sudan. J. Chem. Pharm. Res. 4 (10), 4575–4581.

Akçin, O.E., Baki, H., 2007. Micromorphology and anatomy of three *Symphytum* (Boraginaceae) taxa from Turkey. Bangaladesh J. Bot. 36 (2), 93–103.

Akçin, O.E., Çoşkunçelebi, K., Şenel, G., 2012. Foliar anatomy of Cynoglossum L. (Boraginaceae) from North Anatolia, Turkey. Bangaladesh J. Plant Taxon. 19 (2), 101–108.

Al-Nowaihi, A.S., Khalifa, S.F., Hamed, K., 1987. A contribution to the taxonomy of Boraginaceae. Phytologia 62, 107–125.

Al-Shehbaz, I.A., 1991. The genera of Boraginaceae in the Southeastern United States. J. Arnold Arborertum Suppl. Ser. 1, 1–169.

Alwahibi, M., Bukhary, N., 2013. Anatomical study of four species of *Heliotropium* L. (Boraginaceae) from Saudi Arabia. Afr. J. Plant Sci. 7 (1), 35–42.

Andrews, F.W., 1956. The Flowering Plants of the Sudan. In: (Compositae-Gramineae), vol. 3. T. Buncle & Co., Arbroath, Scotland.

APG III, 2014. Angiosperm Phylogeny Group. <http://www.mobot.org>.

Barroso, G.M., 1986. Sistemática de Angiospermas do Brasil, v. 3. Universidad Federale do Viçosa.

Bergianska, 2014. <http://angio.bergianska.se/asterids/Boraginales/Borag-inales.html>.

Bigazzi, M., Selvi, F., 1998. Pollen morphology in the Borageneae (Boraginaceae) in relation to the taxonomy of the tribe. Plant Systeatics Evol. 213, 121–151.

Bigazzi, M., Nardi, E., Selvi, F., 2006. Palynological contribution to the systematics of *Rindera* and the allied genera *Paracaryum* and *Solenanthes* (Boraginaceae-Cynoglosseae). Willdenowia 36, 37–46.

Binzet, R., 2011. Pollen morphology of some *Onosma* species (Boraginaceae) from Turkey. Pak. J. Bot. 43 (2), 731–741.

Binzet, R., Kandemir, I., Orcan, N., 2010. Palynological classification of *Onosma* L. (Boraginaceae) species from east Mediterranean region in Turkey. Acta Bot. Croat. 69 (2), 259–274.

Boulos, L., 2002. Flora of Egypt. In: Verbenaceae-Compositae, vol. 3. Al Hadara Publishing, Cairo, 373 pp.

Clarke, C.G.S., 1977. The Northwest European Pollen Flora: 10. Boraginaceae. Rev. Palaeobot. Palynol. 24 (2), 59–101.

Coutinho, A.P., Castro, S., Carbajal, R., Ortiz, S., Serrano, M., 2012. Pollen morphology of the genus *Omphalodes* Mill. (Cynoglosseae, Boraginaceae). Grana 51 (3), 194–205.

Dallwitz, M.J., 2010. Overview of the DELTA system. <http://delta-intkey.com/www/overview.htm>.

Dallwitz, M.J., Paine, T.A., 2005. Definition of the DELTA format. <http://delta-intkey.com/standard.htm>.

Dallwitz, M.J., Paine, T.A., Zurcher, E.J., 1993 onwards. User's Guide to the DELTA System: A General System for Processing Taxonomic Descriptions, fourth ed. <http://delta-intkey.com>.

Dasti, A.A., Bokhari, T.Z., Malik, S.A., Akhtar, R., 2003. Epidermal morphology in some members of family Boraginaceae in Baluchistan. Asian J. Plant Sci. 2, 42–47.

Diane, N., Jacob, C., Hilger, H.H., 2003. Leaf anatomy and foliar trichomes in Heliotropiaceae and their systematic relevance. Flora 198 (6), 468–485.

Diez, M.J., Valdes, B., 1991. Pollen morphology of the tribes Eritrichieae and Cynoglosseae (Boraginaceae) in the Iberian Peninsula and its taxonomic significance. Bot. J. Linn. Soc. 107 (1), 49–66.

El-Gazzar, A., Abdel Ghani, M.M., El-Husseini, N.M., Khattab, A.A., 2013. Computer-generated keys to the flora of Egypt. 5. The Leguminosae-Papilionoideae. Assiut Univ. J. Bot. 41 (2), 129–181.

El-Ghazaly, G., 1995. Pollen morphology of the family Boraginaceae in Qatar. Qatar Univ. Sci. J. 15 (1), 65–75.

Falatoury, A.N., Pakravan, M., Sharifnia, F., 2011. Palynological study of *Nonea* (Boraginaceae-Borageneae) in Iran. Prog. Biol. Sci. 1 (2), 36–43.

Feinbrun-Dothan, N., 1977. *Flora Palaestina*, Part 3, Plates. The Israel Academy of Sciences and Humanities, Jerusalem.

Feinbrun-Dothan, N., 1978. *Flora Palaestina*, Part 3, Text. The Israel Academy of Sciences and Humanities, Jerusalem.

Fukuda, T., Ikeda, H., 2012. Palynological analysis and taxonomic position of the genus *Mertensia* (Boraginaceae). Botany 90 (8), 722–730.

Güven, S., Beyazoglu, O., Makbul, S., Türkmen, Z., Kandemir, A., 2013. Anatomical features of six *Onosma* L. (Boraginaceae) species from Turkey. Iran. J. Bot. 19 (1), 94–103.

Hargrove, L., Simpson, M.G., 2003. Ultrastructure of heterocolpate pollen in *Cryptantha* (Boraginaceae). Int. J. Plant Sci. 164, 137–151.

Holmgren, P.K., Holmgren, N.H., Barnett, L.C., 1990. Index Herbariorum. Part 1. The Herbaria of the World. Regnum Veg. 120, 693.

Keshavarzi, M., Nasrollahi, F., Sheidai, M., 2013. Stem and fruit anatomical study of the *Anchusa* species (Boraginaceae iin Iran. Phytol. Bacanica 19 (2), 193–199.

Khatamsaz, M., 2001. Pollen morphology of Iranian Boraginaceae family and its taxonomic significance. Iran. J. Bot. 9 (1), 27–40.

Liu, Jia-Xi, Xi, Yizhen, Ning, Jian-Chang, Zhang, Jing-Mei, Li, Yaxuan, Zhao, Yun-Yun, Sun, Xiao-Hong, 2001a. Pollen morphology and exine ultrastructure of genus *Cordia* in Boraginaceae in China. Acta Bot. Sin. 43 (9), 893–898.

Liu, Jia-Xi, Zhang, Yu-Long, Ning, Jian-Chang, Zhao, Yun-Yun, Li, Ya-Xuan, Zhang, Jing-Mei, 2001b. Pollen morphology of the tribe Cynoglosseae of Boraginoideae (Boraginaceae) in China. Acta Bot. Sin. 39 (6), 515–522.

Mehrabian, A.-R., Shaidai, M., Noormohammadi, Z., Mozaffarian, V., Asrei, Y., 2012. Palynological diversity in the genus Onosma L. (Boraginaceae) of Iran. Ann. Biol. Res. 3 (8), 3885–3893.

Mehrabian, A.-R., Shaidai, M., Mozaffarian, V., 2014. Morphology of leaf trichomes in *Onosma* (Boraginaceae) and their systematic relevance in Iran. Phytol. Balcanica 20 (1), 33–48.

Melo, J.I.M., Sales, M.F., Santos, F.A.R., 2006. Morfologia polinica das especies de Heliotropium L. (Boraginaceae) ocorrentes em Pernambuco, Brasil. Ernestia 16 (1), 69–79.

Neuwinger, H.D., 2000. African Traditional Medicine. A dictionary of Plant Uses and Applications. Medpharm Scientific Publishers, Stuttgart.

Nowicke, J.W., Miller, J.S., 1990. Pollen morphology of the Cordioideae (Boraginaceae): *Auxemma*, *Cordia* and *Patagonula*. Plant Syst. Evol. 5, 103–121.

Ovchinnikova, S., 2009. On the position of the tribe Eritrichieae in the Boraginaceae system. Bot. Serbica 33 (2), 141–146.

Perveen, A., 2009. Trichomes morphology as a taxonomic marker in the subfamily Heliotropioideae (Boraginaceae) from Pakistan and Kashmir. Int. J. Biol. Biochem. 6, 13–19.

Qureshi, U.S., 1997. Pollen Morphology of the Family Boraginaceae of Pakistan and Kashmir. Ph.D. Thesis, Sind University, Pakistan, 246 pp.

Rabaey, D., Lens, F., Smets, E., Jansen, S., 2010. The phylogenetic significance of vestured pits in Boraginaceae. Taxon 59 (2), 510–516.

Retief, E., Vanwyk, A.E., 1997. Palynology of southern African Boraginaceae: the genera *Lobostemon*, *Echiostachys* and *Echium*. Grana 36, 271–278.

Scheel, R., Ybert, J.-P., Barth, O.M., 1996. Pollen morphology of the Boraginaceae from Santa Catarina State (southern Brazil), with comments on the taxonomy of the family. Grana 35, 138–153.

Selvi, F., Bigazzi, M., 2001. Leaf surface and anatomy in Boraginaceae tribe Boragineae with respect to ecology and taxonomy. Flora 196, 269–285.

Stearn, W.T., 1966. Botanical Latin. Hafner Publishing Co., New York, 566 pp.

Taia, W.K., 2006. Family Boraginaceae. Hair variations and their significance in the systematic of the genera. Asian J. Plant Sci. 5 (3), 441–454.

Thorne, R.F., 1992. Classification and geography of the flowering plants. Bot. Rev. 58 (3), 225–348.

Trivedi, M.L., Khanna, V., Shailja, J., 1976. Nodal anatomy of crtain members of Boraginaceae. Proc. Indian Acad. Sci. – Sect. Bot. 84, 31–36.

Ventrella, M.C., Marinho, C.R., 2008. Morphology and histochemistry of glandular trichomes of Cordia verbenacea DC. (Boraginaceae) leaves. Rev. Bras. Bot. 31 (3), 457–467.

Watson, L., Dallwitz, M.J., 1992 onwards. The Families of Flowering Plants: Descriptions, Identification and Information Retrieval. Version 19th, August 2014. <http://delta-intkey.com>.