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Towards an updated checklist of the Libyan flora

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Abstract

The Libyan flora was last documented in a series of volumes published between 1976 and 1989. Since then there has been a substantial realignment of family and generic boundaries and the discovery of many new species. The lack of an update or revision since 1989 means that the Libyan Flora is now out of date and requires a reassessment using modern approaches. Here we report initial efforts to provide an updated checklist covering 43 families out of the 150 in the published flora of Libya, including 138 genera and 411 species. Updating the circumscription of taxa to follow current classification results in 11 families (*Coridaceae, Guttiferae, Leonticaceae, Theligonaceae, Tiliaceae, Sterculiaceae, Bombacaeae, Sparganiaceae, Globulariaceae, Asclepiadaceae* and *Illecebraceae*) being included in other generally broader and less morphologically well-defined families (APG-IV, 2016). As a consequence, six new families: *Hypericaceae, Adoxaceae, Lophiocarpaceae, Limeaceae, Gisekiaceae* and *Cleomaceae* are now included in the Libyan Flora. This update results in those 43 families being represented by 38 accounts. Fifty-five percent of species remain unchanged, the remaining 45% are reclassified at the family, genus or species level based on modern treatments, illustrating the need for this update and the urgent need for a review of the entire floristic treatment of Libya in support of the conservation of Libya's biodiversity.

Key words: floristics, taxonomy, Libya, North Africa, APG IV

Introduction

A knowledge and record of the national flora is key to any country fulfilling its obligations and commitments under the Convention on Biological Diversity (Raustiala & Victor, 1996). However, many countries have a poor or incompletely recorded flora. Libya is lucky in that a descriptive flora was written in the 1970s-1980s (Ali, El-Gadi, & Jafri, eds 1976–1989) that provides a good baseline. Sadly, that flora is now long out of date, taxonomic systems have changed, the ways of studying a flora have evolved, and new species have been discovered. Future development needs for Libya will in part be dependent on knowledge of the vegetation as a source of food, fodder, medicines and to stabilize soils under changing climate conditions.

Libya is located in North Africa, bordering the Mediterranean Sea to the north, Egypt to the east, Sudan to the south-east, Chad and Niger to the south, Tunisia and Algeria to the west (Figure 1), between latitude 18°–33° N and 9°–25°E. Libya comprises 1,759,540 km^2 and is characterised by desert, hills, mountains and valleys. There are three areas of high biodiversity in Libya that account for >75% of the species diversity: Jabal Nafosa; Jabal Tibesti and Jabal Alakhdar area located in the province of Cyrenaica (Figure 1). A recent study of the flora of Jabal Alakhdar showed high plant diversity (El-Barasi *et al.*, 2003)

History of the floristic and taxonomic studies conducted in Libya

A major collection expedition to Libya was completed in 1819 by Della Cella and this formed the basis of the first checklist of the Libyan flora (Della Cella & Viviani, 1819). Five years later, Domenico Viviani published *Florae Libycae specimen* (Viviani, 1824).

The first attempt to produce a Flora of the whole country (*Florae Libycae Prodromus*) was carried out by Durand & Barratte in 1910 (Durand *et al.*, 1910). In 1931 Renaton Pampanini published the *magnum opus, Prodomo Della*

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Flora Cirenaica in which he gave full descriptions of the species and their communities accompanied by taxonomic keys. A preliminary check-list of the entire Libyan flora was published in 1965 (Keith, 1965). Boulos conducted a study between 1971–1972 that was published in a work entitled "Flora and vegetation of Libya" (Boulos, 1972). A checklist of the Libyan flora was published by Boulos 1977–1979 (Boulos, 1977, 1979 a, 1979 b) and a series of volumes of *The Flora of Libya* was published by Tripoli University, in cooperation with the Arab Development Institute between 1976 and 1989 in 150 parts. Each part treats one family with species descriptions and identification keys (Ali *et al.*, eds 1976–1989).

More recently, Brullo reported the occurrence of several plant species and families (Brullo & Salvatore, 1979; Brullo, 1978, 1982, 1984). A critical analysis of the Libyan flora was undertaken by Qaiser & El-Gadi, (1984), in which they presented a list of endemic plants. El-Gadi *et al.* (1987) described six plant species that were new to the Libyan flora.

This paper builds on the above Floras by updating previous reports within the current circumscriptions of plant families, genera and lower taxa. Families treated here are Primulaceae to Illecebraceae in *Flora of Libya,* parts 1–37, as a demonstration of the level of changes needed to update the entire flora. This covered 22% of the Libyan flora.

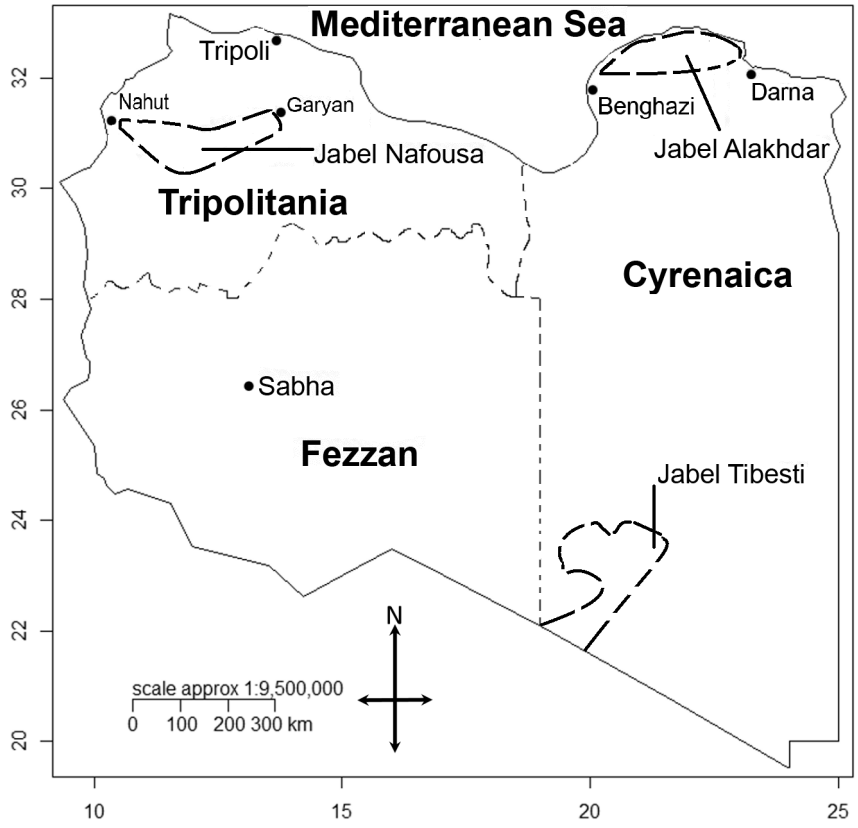

FIGURE 1. The three major areas of biodiversity in Libya: Jabel Al Akhdar, Jebel Nafusa and Jabel Tibesti.

Materials and Methods

Herbarium research

To ensure the historic floras were updated to account for modern plant collections and new discoveries, and to estimate the proportion of the flora represented by specimens in Libyan herbaria, herbarium specimens were reviewed and photographed during three extended visits to the Herbaria of Benghazi University (Cyrenaica Herbarium, CYH), Omer Al-Mukhtar University (OMH) and Tripoli University (ULT). These were supplemented by collections at the University of Reading Herbarium (RNG), and the Royal Botanic Gardens Kew (K).

Updating nomenclature and taxonomic circumscription

Initial family circumscription was based on the flora of Libya (Ali *et al.*, eds 1976–1989). To update the nomenclature

of the Libyan Flora we used Angiosperm Phylogeny Group APG IV (APG IV 2016) to re-circumscribe families, Euro+Med PlantBase (Euro+Med, 2012) and the North African Checklist (African Plants Database, 2012) were used to check regional species lists and The Plant List (The Plant List, 2013) was used for the currently accepted name of plants in some families treated in WCSP (WCSP, 2017): Apocynaceae, Cynomoriaceae; Fagaceae; Gisekiaceae; Hypericaceae; Juncaceae; Juncaginaceae & Rubiaceae. The families updated are the first 37 in Flora of Libya plus additional families from later volumes that are now confamilial with members of the first 37 (see Table 2 for a complete list). This sample was sufficient to illustrate the scale of the work needed but to update the entire flora at this stage would be too time consuming.

Data handling

BRAHMS (Botanical Research and Herbarium Management System, (Filer, 2010) was used for data management and checklist production.

Results

An updated checklist covering Primulaceae to Caryophyllaceae from the Flora of Libya

The results of applying revised family delimitation to the Primulaceae to Caryophyllaceae of Libya are summarised in Table 1. Of the species documented as occurring in Libya, only around 60% can be found in Libyan herbaria and it is likely the remainder are held as historic collections in Europe dating back to the first records of the Libyan flora. This illustrates the need for substantial investment in Libyan plant collection for Libyan herbaria.

TABLE 1. An updated checklist starting with the Primulaceae ending with Caryophyllaceae, contain 138 genera and 411 species.

Family and species
1. **Primulaceae**
Lysimachia arvensis (L.) U. Manns & Anderb. [2,3,4, ↔]
Lysimachia monelli (L.) U. Manns & Anderb. [2,3,4, ↔]
Lysimachia arvensis f. *latifolia* (L.) B. Bock [4, ↔]
Androsace maxima L. [3,4, ›]
Lysimachia linum-stellatum L. [2,3,4, ↔]
Coris monspeliensis L. [1,3,4, ↓]
Coris monspeliensis subsp. *syrtica* (Murb.) Masclans [1,3,4, ↓↔]
#*Cyclamen rohlfsianum* Aschers. [3,4, ›]
Samolus valerandi L. [3,4, ›]
2. **Hypericaceae**
Hypericum aegypticum L. [1,3,4, ↓]
#*Hypericum aegypticum* L. subsp. *aegypticum* [1,3,4, ↓↔]
#*Hypericum decaisneanum* Coss. & Daveau [1,3,4, ↓]
Hypericum empetrifolium Willd. [1,3,4, ↓]
Hypericum pubescens Boiss. [1,3,4, ↓]
Hypericum triquetrifolium Turra [1,3,4, ↓]
Hypericum tetrapterum Fr. [1,4, ↓↔]
3. **Berberidaceae**
Bongardia chrysogonum (L.) Spach. [1,3,4, ↓]
Leontice leontopetalum L. [1,3,4, ↓]
Leontice leontopetalum L. subsp. *leontopetalum* [1,3, ↓↔]
4. **Saxifragaceae**
Saxifraga hederacea L. [3,4, ›]
Saxifraga tridactylites L. [3,4, ›]
5. **Oxalidaceae**
Oxalis corniculata L. [4, ›]
Oxalis pes-caprae L. [4, ›]
Oxalis articulata Savigny [4, ›]
6. **Rubiaceae**
Theligonum cynocrambe L. [1,4, ↓]

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TABLE 1. (Continued)

Family and species
Asperula aristata L. f. [3,4, ›]
Asperula arvensis L. [3,4, ›]
Asperula hirsuta Desf. [3,4, ›]
Callipeltis cucullaris (L.) Steven [3,4, ›]
Crucianella aegyptiaca L. [3,4, ›]
Crucianella angustifolia L. [3,4, ›]
Crucianella latifolia L. [3,4, ›]
Crucianella maritima L. [3,4, ›]
Galium aparine L. [3,4, ›]
[#]*Galium cossonianum* Jafri [3,4, ›]
Galium mollugo L. [3,4, ›]
Galium murale (L.) All. [3,4, ›]
Galium parisiense L. [3,4, ›]
Galium recurvum DC. [3,4, ›]
Galium setaceum Lam. [3,4, ›]
Galium spurium L. [3,4, ›]
Galium tricornutum Dandy [3,4, ›]
Galium verrucosum Huds. [3,4, ›]
Plocama reboudiana (Coss.& Durieu) Ehrend. & Schönb.-Tem. [2,3,4, ↔›]
Plocama calabrica (L. f.) M. Backlund & Thulin [2,3,4, ↔›]
Rubia peregrina L. [3,4, ›]
Rubia tenuifolia d'Urv. [3,4, ›]
Rubia tinctorium L. [3,4, ›]
Sherardia arvensis L. [3,4, ›]
Valantia hispida L. [3,4, ›]
Valantia lanata Delile ex Coss. [3,4, ›]
Valantia muralis L. [3,4, ›]
7. **Apocynaceae**
Acokanthera oblongifolia (Hochst.) Benth. & Hook.f. ex B.D.Jacks [4, ›]
Apteranthes europaea (Guss.) Murb. [1,2,4, ↓↔›]
Apteranthes europaea (Guss.) Murb. var. europaea [1,2,4, ↓↔›]
Catharanthus roseus (L.) G. Don [›]
Calotropis procera (Aiton) W.T. Aiton. [1,3, ↓›]
Cynanchum acutum L. [1,3, ↓›]
Cynanchum acutum L. subsp. *acutum* [1,3,4, ↓›]
Glossonema boveanum (Decne.) Decne. [1,4, ↓›]
Glossonema boveanum (Decne.) Decne. subsp. *boveanum* [1,4, ↓›]
Leptadenia lanceolata (Poir.) Goyder [1,2,4, ↓↔›]
Leptadenia pyrotechnica (Forsk.) Decne. [1,3,4, ↓›]
Nerium oleander L. [3,4, ›]
Nerium oleander L. subsp. *oleander* [3, ↔]
Pergularia tomentosa L. [1,3,4, ↓›]
Periploca laevigata subsp. *angustifolia* (Labill.)Markgr [1,2,3,4, ↓↔›]
Plumeria rubra L. [2, ↔›]
Cascabela thevetia (L.) Lippold [2, ↔›]
Trachelospermum jasminoides Lem. [›]
Solenostemma argel (Delile) Hayne [1,3,4, ↓›]
8. **Malvaceae**
Abelmoschus esculentus (L.) Moench. [›]
Abutilon fruticosum Guillemin & Perrottet [3,4, ↔]
Abutilon fruticosum Guillemin & Perrottet var. *fruticosum* [4, ↔]
Alcea rosea L. [4, ›]
Althaea hirsuta L. [3,4, ›]
Althaea ludwigii L. [3,4, ›]
Bombax ceiba L. [1, ↓›]
Brachychiton populneus (Schott. & Endl.) R. Br. [1, ↓›]
Ceiba crispiflora (Kunth) Ravenna [1,2, ↓↔›]

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TABLE 1. (Continued)

Family and species
Corchorus depressus (L.) Stocks [1, ↓]
Corchorus olitorius L. [1, ↓]
Gossypium arboreum L. [›]
Gossypium barbadense L. [4, ›]
Gossypium somalense (Gürke) J. B. Hutch. [4, ↔]
Gossypium herbaceum L. [›]
Gossypium hirsutum L. [›]
Hibiscus arnottianus A.Gray [›]
Hibiscus cannabinus L. [›]
Hibiscus mutabilis L. [›]
Hibiscus rosa-sinensis L. [›]
Hibiscus sabdariffa L. [›]
Hibiscus schizopetalus (Mast.). Hook. F. [›]
Hibiscus trionum L. [3,4, ›]
Lagunaria patersonia (Andrews) G. Don [›]
Malva aegyptia L. [3,4, ›]
Malva arborea (L.) Webb & Berthel. [2,3,4, ↔›]
Malva multiflora (Cav.) Banfi & Galasso [2,3,4, ↔›]
Malva nicaeensis All. [3,4, ›]
Malva olbia (L.) Alef. [2,3,4, ↔›]
Malva parviflora L. [3,4, ›]
Malva sylvestris L. [3,4, ›]
Malva unguiculata (Desf.) Alef. [2,3,4, ↔›]
Malva verticillata L. [3,4, ›]
Malvaviscus arboreus Cav. [›]
Melhania ovata (Cav.) Spreng. [1,4, ↓›]
Phymosia umbellata (Cav.) Kearney [2, ↔›]
Tilia platyphyllos Scop. [1, ↓›]
9. **Juncaginaceae**
Triglochin barrelieri Loisel. [3,4, ↔]
Triglochin bulbosa L. [›]
Triglochin laxiflora Guss. [3,4, ›]
10. **Capparaceae**
Cadaba farinosa Forsk. [›]
Capparis aegyptia Lam. [3,4, ↔]
Capparis cartilaginea Dacne [4, ›]
Capparis decidua (Forsk.) Edgew. [3,4, ›]
Capparis orientalis Veill. [3,4, ↔]
Capparis spinosa L. [2,3,4, ↔]
Capparis ovata Desf. subsp. *ovata* [3,4, ↔]
Capparis ovata subsp. *myrtifolia* Inocencio, D.Rivera & al. [4, ↔]
Capparis sicula Veill. [3, ›]
Capparis spinosa L. subsp. *spinosa* [›]
Maerua crassifolia Forsk. [3,4, ›]
11. **Cleomaceae**
Cleome amblyocarpa Barratte & Murb [1,2,3,4, ↓↔]
Cleome arabica L. [1,4, ↓↔]
Cleome brachycarpa Vahl ex DC [1,4, ↓›]
Cleome chrysantha Decne. [1,4, ↓›]
Cleome droserifolia (Forsk.) Del. [1,4, ↓›]
Cleome paradoxa R. Br. ex DC. [1,4, ↓›]
Cleome scaposa DC. [1,4, ↓›]
Cleome gynandra L. [1,2,3,4, ↓↔›]
12. **Violaceae**
Viola scorpiuroides Coss. [4, ›]
Viola arborescens L. [›]
Viola odorata L. [›]

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TABLE 1. (Continued)

Family and species
Viola tricolor L. [›]
13. **Santalaceae**
Osyris alba L. [3,4, ↔]
[#]*Thesium erythronicum* Pamp. [3,4, ›]
Thesium humile Vahl [3,4, ›]
14. **Neuradaceae**
Neurada procumbens L. [3,4, ›]
15. **Thymelaeaceae**
[#]*Daphne jasminea* Sibth. Et Sm. [3,4, ›]
[#]*Daphne jasminea* subsp. *jasmilae* Halda [4, ↔]
Daphne oleoides Schreb. [›]
Thymelaea hirsuta (L.) Endl. [3,4, ›]
Thymelaea microphylla Coss. & Durieu ex Meisn. [3,4, ›]
16. **Cynomoriaceae**
Cynomorium coccineum L. [3,4, ›]
17. **Polygalaceae**
[#]*Polygala aschersoniana* Chodat [4, ›]
Polygala erioptera DC. [›]
Polygala erioptera DC. subsp. *erioptera* [4, ↔]
18. **Typhaceae (** includes Sparganiaceae)
Sparganium erectum L. [1,2,3,4, ↓↔›]
Sparganium erectum subsp. *neglectum* (Beeby) K. Richt [1,2,3,4, ↓↔›]
Typha angustifolia L. [3, ↔]
Typha domingensis Pers. [4, ›]
Typha elephantina Roxb. [4, ›]
19. **Vahliaceae**
Vahlia dichotoma (Murr.) O. Kuntze [4, ›]
20. **Gentianaceae**
Centaurium erythraea Rafn [2,3, ↔›]
Centaurium pulchellum (Swartz) Druce [2,3, ↔›]
Centaurium spicatum (L.) Fritsch [3, ›]
Centaurium tenuiflorum (Hoffmanns & Link) Fritsch [3, ›]
21. **Adoxaceae**
Viburnum tinus L. [1,4, ↓›]
Viburnum tinus L. subsp. *tinus* [1,3,4, ↓↔]
22. **Caprifoliaceae**
Lonicera etrusca Santi [4, ›]
[#]*Lonicera nummulariifolia* Jaub. & Spach [4, ›]
[#]*Lonicera nummulariifolia* subsp. *occidentalis* (Pamp) Brullo &Furnari [3,4, ↔]
23. **Molluginaceae**
Mollugo cerviana (L.) Ser. ex DC. [3, ›]
Mollugo nudicaulis Lam. [3,4, ›]
24. **Limeaceae**
Limeum obovatum Vicary [1,3,4, ↓›]
25. **Lophiocarpaceae**
Corbichonia decumbens (Forssk.) Exell [1,3,4, ↓›]
26. **Gisekiaceae**
Gisekia pharnaceoides L. [1,3,4, ↓›]
27. **Aizoaceae**
Aizoanthemum hispanicum (L.) H. E. K. Hartmann [2,4, ↔›]
Aizoon canariense L. [4, ›]
Carpobrotus acinaciformis (L.) L. Bolus [›]
Carpobrotus edulis (L.) N. E. Brown [4, ›]
Carpobrotus edulis (L.) N. E. Br. var. edulis [4, ↔]
Mesembryanthemum cordifolium L. f. [2,4, ↔›]
Mesembryanthemum cryptanthum Hook. f. [2,↔›]
Mesembryanthemum crystallinum L. [4, ›]

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TABLE 1. (Continued)

Family and species
Mesembryanthemum nodiflorum L. [4, ›]
Tetragonia tetragonioides (Pall.) Kuntze [4, ↔]
Zaleya pentandra (L.) C. Jeffrey [4, ›]
28. **Fagaceae**
Quercus coccifera L. [3,4, ›]
Quercus faginea Lam. [›]
Quercus ilex L. [3,4, ›]
Quercus suber L. [›]
29. **Lauraceae**
Cinnamomum camphora (L.) J. Presl [›]
Cinnamomum verum J. Presl [2,4, ↔›]
Laurus azorica (Seub.) J. Franco [›]
Laurus nobilis L. [4, ›]
Nectandra grandiflora Nees & Mart. ex Nees [›]
Persea americana Mill. [›]
30. **Juncaceae**
Juncus acutus L. [2,3,4, ↔]
Juncus acutus subsp. *leopoldii* (Parl.) Snogerup [3,4, ↔]
Juncus articulatus L. [2,3, ↔]
Juncus bufonius L. [3,4, ›]
Juncus bufonius L. subsp. *bufonius* [4, ↔]
Juncus capitatus Weigl [3,4, ›]
Juncus foliosus Desf. [4, ↔]
Juncus fontanesii J. Gay [2,3,4, ↔]
Juncus fontanesii subsp. *pyramidatus* (Laharpe) Snogerup [3,4, ↔]
Juncus hybridus Brot. [3,4, ↔]
Juncus littoralis C.A. Mey. [4, ↔]
Juncus maritimus Lam. [4, ›]
Juncus punctorius L. f. [3,4, ›]
Juncus pygmaeus Rich. [2,3,4, ↔›]
Juncus rigidus Desf. [2,3,4, ↔›]
Juncus subulatus Forssk. [3,4, ›]
31. **Rhamnaceae**
Colubrina rufa Reiss. [›]
Paliurus spina-christi Mill. [4, ›]
Rhamnus alaternus L. [4, ›]
Rhamnus alaternus subsp. *alaternus* [3,4, ›]
[#]*Rhamnus alaternus* subsp. *pendula* (Pamp.) Jafri [3,4, ›]
Rhamnus lycioides L. [4, ›]
Rhamnus lycioides subsp. *oleoides* (L.) Jahandiez & Maire [2,3,4, ↔›]
Rhamnus myrtifolia Willk. [4, ↔]
Ventilago viminalis Hook. [›]
Ziziphus lotus (L.) Lam. [4, ›]
Ziziphus lotus (L.) Lam. subsp. *lotus* [3,4, ↔]
Ziziphus spina-christi (L.) Desf. [4, ›]
Ziziphus jujuba Mill. [3,4, ›]
32. **Rosaceae**
Crataegus azarolus L. [3, ↔]
Crataegus germanica (L.) Kuntze [3, ↔]
Crataegus laciniata Ucria [›]
Crataegus laevigata (Poir.) DC. [3,4, ›]
Crataegus monogyna Jacq. [4, ›]
Crataegus pallasii Griseb. [4, ›]
Cydonia oblonga Mill. [3,4, ›]
Eriobotrya japonica (Thunb.) Lindl. [3, ›]
Fragaria vesca L. [3,4, ›]
Malus angustifolia Michx. [›]

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TABLE 1. (Continued)

Family and species
Malus pumila Mill. [3,4,↔]
Malus sylvestris Mill. [›]
Photinia serrulata Lindl. [›]
Potentilla reptans L. [3,4,›]
Prunus armeniaca L. [2,3,4,↔›]
Prunus avium (L.) L. [2,3,↔›]
Prunus cerasifera Ehrh. [3,4,›]
Prunus cerasus L. [3,↔]
Prunus domestica L. [3,›]
Prunus dulcis (Mill.) D. A. Webb [2,3,4,↔›]
Prunus laurocerasus L. [2,3,↔›]
Prunus persica (L.) Batsch [2,3,4,↔›]
Prunus serotina Ehrh. [3,↔›]
Prunus japonica Thunb. [›]
Prunus insititia L. [2,↔›]
Pyrus communis L. [3,4,›]
Pyrus communis L. subsp. *communis* [3,4,↔]
Raphiolepis indica (L.) Lindl. [›]
Rosa exicana Mill. [›]
Rosa damascena Mill. [4,›]
Rosa gallica L. [3,4,›]
[#]*Rubus cyrenaicae* Hruby [3,↔]
Rubus idaeus L. [3,↔]
Rubus idaeus L. subsp. *idaeus* [3,↔]
Rubus loganobaccus L. H. Bailey [3,↔]
Rubus sanctus Schreber [3,4,›]
Sanguisorba mauritanica Desf [4,›]
Sanguisorba megacarpa (Lowe) Muñoz Garm. & C. Navarro [3,↔]
Sanguisorba minor Scop. [3,4,›]
Sanguisorba minor Scop. subsp. *minor* [3,4,›]
Sanguisorba verrucosa (G. Don) Ces. [3,4,↔]
Sarcopoterium spinosum (L.) Spach [3,4,›]
33. **Cucurbitaceae**
Bryonia cretica L. [4,›]
Bryonia acuta Desf. [4,↔]
Bryonia dioica Jacq. [4,↔]
Citrullus colocynthis (L.) Schrader [4,›]
Citrullus lanatus (Thunb.) Matsum. & Nakai [4,›]
Trichosanthes cucumerina L. [2,↔›]
Cucumis melo L. [4,›]
Cucumis sativus L. [›]
Cucumis utilissima Roxb. [›]
Cucurbita maxima Duch. [›]
Cucurbita moschata (Duch.) Duch. [›]
Cucurbita pepo L. [›]
Ecballium elaterium (L.) A. Rich [4,›]
Ecballium elaterium (L.) A. Rich. subsp. *elaterium* [4,↔]
Lagenaria siceraria (Molina) Standley [›]
Luffa cylindrica (L.) M. Roem [›]
Momordica balsamina L. [›]
Momordica charantia L. [›]
Sechium edule Swartz [›]
34. **Resedaceae**
Caylusea hexagyna (Forsk.) M. L. Green [3,4,›]
Ochradenus baccatus Delile [3,4,›]
Oligomeris linifolia (Vahl) J. F. Macbride [3,4,›]
Randonia africana Coss. [3,4,›]

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TABLE 1. (Continued)

Family and species

Reseda alba L.[3,4, ›]
Reseda alba L. subsp. *alba* [3,4, ›]
Reseda decursiva Forssk. [2,3,4, ↔›]
Reseda arabica Boiss. [3,4, ›]
Reseda arabica Boiss. subsp. *arabica* [4, ↔]
Reseda collina Mull. Arg. [3,4, ↔]
Reseda lutea L. [3,4, ›]
Reseda lutea L. subsp. *lutea* [4, ›]
Reseda lutea subsp. *neglecta* (Müll. Arg.) Ball [4, ↔]
Reseda lutea subsp. *petrovichiana* (Müll. Arg.) Maire [4, ›]
Reseda luteola L. [3,4, ›]
Reseda luteola L. subsp. *luteola* [4, ↔]
Reseda muricata C. Presl [›]
Reseda odorata L. [3,4, ›]
Reseda orientalis (Mull. Arg.) Boiss. [3,4, ›]
Reseda urnigera Webb. [2,3,4, ↔›]
Reseda phyteuma L. [3, ›]
Reseda phyteuma L. subsp. *phyteuma* [3, ↔]
Reseda stricta Pers. [3, ↔]
Reseda stricta Pers. subsp. *stricta* [4, ↔]
Reseda villosa Coss. [3,4, ›]

35. **Linaceae**

Linum bienne Miller [4, ›]
Linum decumbens Desf. [4, ›]
Linum nodiflorum L. [4, ›]
Linum strictum L. [2,4, ↔›]
Linum trigynum L. [4, ›]
Linum usitatissimum L. [4, ›]

36. **Arecaceae**

Chamaerops humilis L. [3,4, ›]
Huphaene thebaica (Del.) Mart. [4, ›]
Phoenix dactylifera L. [3,4, ›]
Phoenix canariensis Chaub. [›]

37. **Plantaginaceae**

Globularia alypum Linn. [1,4, ↓›]
Globularia arabica Jaub. & Spach. [1,4, ↓›]
Kickxia acerbiana (Boiss.) Täckh. & Boulos. [1,4, ↓›]
Kickxia aegyptiaca (L.) Nábelek [1,4, ↓›]
Kickxia aegyptiaca (L.) Nábelek subsp. *aegyptiaca* [1,4, ↓›]
Kickxia aegyptiaca subsp. *battandieri* (Maire) Wickens [1,4, ↓›]
Kickxia aegyptiaca subsp. *fruticosa* (Desf.) Wickens [1,4, ↓›]
Kickxia commutata (Bernh. ex Rchb.) Fritsch [1,4, ↓›]
Kickxia commutata (Bernh. ex Rchb.) Fritsch subsp. *commutata* [1,4, ↓›]
Kickxia heterophylla (Schousb.) Dandy [1,4, ↓›]
Kickxia lanigera (Desf.) Hand.-Mazz. [1,4, ↓›]
Plantago afra L. [3,4, ↔]
Plantago albicans L. [3,4, ↔]
Plantago albicans L. subsp. *albicans* [3,4, ↔]
Plantago amplexicaulis Cav. [3,4, ↔]
Plantago amplexicaulis Cav. subsp. *amplexicaulis* [3,4, ↔]
Plantago arenaria Waldst. & Kit. [3,4, ↔]
Plantago ciliata Desf. [4, ↔]
Plantago coronopus L. [2,3,4, ↔]
Plantago crassifolia Forssk. [3,4, ↔]
Plantago crassifolia Forssk.var. *crassifolia* [3,4, ↔]
Plantago crypsoides Boiss. [3,4, ›]
[#]*Plantago cyrenaica* E. A. Durand & Barratte [3,4, ›]

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TABLE 1. (Continued)

Family and species
Plantago lagopus L. [3,4, ›]
Plantago lagopus L. subsp. *lagopus* [3,4, ›]
[#]*Plantago lagopus* subsp. *ptolemaidis* Brullo & Furnari [3,4, ›]
Plantago lanceolata L. [2,3,4, ↔]
Plantago lanceolata subsp. *cyrenaica* Maire & Weiller [4, ↔]
[#]*Plantago libyca* Bég. & A. Vacc. [3,4, ›]
Plantago major L. [3,4, ›]
Plantago notata Lag. [3,4, ›]
Plantago ovata Forssk. [3,4, ›]
Plantago phaeostoma Boiss. & Heldr. [3,4, ›]
Plantago squarrosa Murray [4, ↔]
Plantago weldenii Rchb. [4, ↔]
Plantago weldenii Rchb. subsp. *weldeni* [4, ↔]
Veronica agrestis L. [1,4, ↓›]
Veronica anagallis-aquatica L. [1,4, ↓›]
Veronica cymbalaria Bodard [1,4, ↓›]
Veronica cymbalaria Bodard subsp. *cymbalaria* [1,4, ↓›]
Veronica hederifolia L. [1,4, ↓›]
Veronica hederifolia L. subsp. *hederifolia* [1,4, ↓›]
Veronica peregrina L. [1,4, ↓›]
Veronica persica Poir. [1,4, ↓›]
Veronica polita Fr. [1,4, ↓›]
38. **Caryophyllaceae**
Agrostemma githago L. [3,4, ›]
Arenaria serpyllifolia subsp. *leptoclados* (Rchb.) Nyman [2,3,4, ›]
Arenaria serpyllifolia L. [4, ↔]
Arenaria serpyllifolia L. subsp. *serpyllifolia* [4, ↔]
Cerastium comatum Desv. [3,4, ›]
Cerastium dichotomum L. [3,4, ›]
Cerastium diffusum Pers. [3,4, ›]
Cerastium diffusum subsp. *gussonei* (Tod. ex Lojac.) P. D. Sell & Whitehead [3,4, ›]
Cerastium glomeratum Thuill. [3,4, ›]
Cerastium ligusticum Viv. [3,4, ›]
Cerastium pentandrum L. [4, ↔]
Cerastium semidecandrum L. [3,4, ›]
Cerastium siculum Guss. [3,4, ›]
Dianthus caryophyllus L. [4, ↔]
Dianthus crinitus Sm. [3,4, ›]
Dianthus serratifolius Sm. [3,4, ›]
Dianthus serrulatus Desf. [3,4, ›]
Dianthus serrulatus Desf. subsp. *serrulatus* [3,4, ›]
[#]*Dianthus serrulatus* subsp. *cyrenaicus* (Pamp.) Maire [3,4, ›]
Gymnocarpos decandrus Forssk. [1,3,4, ↓›]
Gymnocarpos sclerocephalus (Decne.) Ahlgren & Thulin [1,2,4, ↓↔›]
Gypsophila elegans M. Bieb. [3,4, ↔]
Gypsophila pilosa Huds. [3,4, ↔]
Herniaria hirsuta subsp. *cinerea* (DC.) Cout. [1,2,4, ↓↔›]
Herniaria cyrenaica F. Herm. [1,3,4, ↓›]
[#]*Herniaria ericifolia* C. C. Towns. [1,3,4, ↓›]
Herniaria fontanesii J. Gay [1,3,4, ↓›]
Herniaria glabra L. [1,3,4, ↓›]
Herniaria hemistemon J. Gay [1,3,4, ↓›]
Herniaria hirsuta L. [1,3,4, ↓↔›]
Loeflingia hispanica L. [3,4, ↔]
Loeflingia hispanica L. subsp. *hispanica* [4, ↔]
Minuartia campestris L. [3,4, ↔]
Minuartia campestris subsp. *squarrosa* Mattf. [3,4, ↔]

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TABLE 1. (Continued)

Family and species
Minuartia hybrida (Vill.) Schischk. [3,4, ↔]
Minuartia hybrida (Vill.) Schischk. subsp. *hybrida* [3,4, ↔]
Minuartia hybrida subsp. *munbyi* (Boiss.) Greuter & Burdet [4, ↔]
Minuartia mediterranea (Link) K. Maly [3,4, ↔]
Minuartia montana L. [3,4, ↔]
Minuartia sandwithii Maire & N. D. Simpson [3,4, ↔]
Paronychia arabica (L.) DC. [1,3,4, ↓›]
Paronychia arabica (L.) DC. subsp. *arabica* [1,3,4, ↓↔]
Paronychia arabica subsp. *cossoniana* (J. Gay ex Batt.) Batt. [1,3,4, ↓↔]
Paronychia arabica subsp. *longiseta* (Batt.) Batt. [1,3,4, ↓↔]
Paronychia arabica subsp. *tibestica* Quezel [1,3,4, ↓↔]
Paronychia argentea Lam. [1,3,4, ↓›]
Paronychia capitata (L.) Lam. [1,3,4, ↓›]
Paronychia capitata (L.) Lam. subsp. *capitata* [1,3,4, ↓↔]
Paronychia chlorothyrsa Murb. [1,3,4, ↓›]
Paronychia chlorothyrsa Murb. var. *chlorothyrsa* [1,4, ↓↔]
Paronychia kapela (Hacq.) A. Kern. [1,3,4, ↓›]
Paronychia kapela (Hacq.) A. Kern. subsp. *kapela* [1,3, ↓↔]
Pteranthus dichotomus Forsskal [1,4, ↓›]

Using: [1]Angiosperm Phylogeny Group (APG IV), [2]The Plant List, 2013 (PL), [3]Euro+Med PlantBase (E&M) and [4]North African Checklist (NF) as literature sources.

(›) No alteration to the species name from the last Libyan Flora.

(↓) Species move was due to inclusion of its previous family in to a new family.

(↔) Species have been added.

(↔›) Species name has been changed due to change in taxonomic concept.

(#) Endemic Species.

Overall, 15 families were updated following APG IV, 232 species changed to follow Euro + Med PlantBase, 318 species were updated to follow the North African Plants Checklist, 49 species updated following The Plant List (ed. 2) and there are 17 listed endemic taxa.

Nomenclatural changes

The updated checklist of 43 families (Primulaceae to Caryophyllaceae) comprises 138 genera and 411 species. According to the Angiosperm Phylogeny Group (APG IV), 11 Families: *Coridaceae, Guttiferae, Leonticaceae, Theligonaceae, Tiliaceae, Sterculiaceae, Bombacaeae, Sparganiaceae, Globulariaceae, Asclepiadaceae* and *Illecebraceae* have become synonyms of other families (see table 1). Six Families: *Hypericaceae, Adoxaceae, Lophiocarpaceae, Limeaceae, Gisekiaceae,* and *Cleomaceae* are now new names for the Libyan Flora. Table 2 shows the cross map between Flora of Libya families and APG IV families. According to APG IV the change in family circumscription has resulted in the transfer of several genera and their component species (Table 3).

The Plant List recommends updates to the generic circumscription of several genera in the Libyan flora as well as changes to some specific epithets to follow current taxonomic thinking (Table 4). Table 5 shows how many species that have been recorded in the new checklist have changed names.

The percentage of change in the families, Primulaceae to Caryophyllaceae in this update, after excluding the species shared in the four literature sources was as following; APG 22%, Euro + Med Plantbase 4%, African Plant Database 8%, both Euro + Med Plantbase and African Plant Database 11%, The Plant List 12% and species that have not changed 55% (Figure 2).

TABLE 2. The cross map between families before and after update.

Family Number	Serial number before update	Family before update	Number of species before update	Number of species after update	Family after update	Serial number (Updated checklist)
1	1	Primulaceae	6	6	Primulaceae	1
2	6	Coridaceae	1	-	Primulaceae	-
3	2	Guttiferae	5	7	Hypericaceae	2

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TABLE 2. (Continued)

Family Number	Serial number before update	Family before update	Number of species before update	Number of species after update	Family after update	Serial number (Updated checklist)
4	3	Leonticaceae	2	3	Berberidaceae	3
5	5	Saxifragaceae	2	2	Saxifragaceae	4
6	7	Oxalidaceae	3	6	Oxalidaceae	5
7	8	Theligonaceae	1	-	Rubiaceae	6
8	65	Rubiaceae	27	28	Rubiaceae	-
9	9	Asclepiadaceae	8	-	Apocynaceae	7
10	98	Apocynaceae	6	19	Apocynaceae	-
11	10	Malvaceae	29	37	Malvaceae	8
12	19	Tiliaceae	3	-	Malvaceae	-
13	91	Sterculiaceae	2	-	Malvaceae	-
14	141	Bombacaeae	2	-	Malvaceae	-
15	11	Juncaginaceae	2	3	Juncaginaceae	9
16	12	Capparaceae	15	11	Capparaceae	10
-	-	Capparaceae	-	8	Cleomaceae	11
17	13	Violaceae	5	4	Violaceae	12
18	14	Santalaceae	2	3	Santalaceae	13
19	15	Neuradaceae	1	1	Neuradaceae	14
20	16	Thymelaeaceae	5	5	Thymelaeaceae	15
21	17	Cynomoriaceae	1	1	Cynomoriaceae	16
22	18	Polygalaceae	2	3	Polygalaceae	17
23	20	Typhaceae	2	5	Typhaceae	18
24	131	Sparganiaceae	2	-	Typhaceae	-
25	21	Vahliaceae	1	1	Vahliaceae	19
26	22	Gentianaceae	5	4	Gentianaceae	20
27	24	Caprifoliaceae	3	2	Adoxaceae	21
-	-	Caprifoliaceae	-	3	Caprifoliaceae	22
28	25	Molluginaceae	5	2	Molluginaceae	23
-	-	Molluginaceae	-	1	Limeaceae	24
-	-	Molluginaceae	-	1	Lophiocarpaceae	25
-	-	Molluginaceae	-	1	Gisekiaceae	26
29	26	Aizoaceae	9	11	Aizoaceae	27
30	27	Fagaceae	4	4	Fagaceae	28
31	28	Lauraceae	6	6	Lauraceae	29
32	29	Juncaceae	9	16	Juncaceae	30
33	30	Rhamnaceae	11	13	Rhamnaceae	31
34	31	Rosaceae	30	42	Rosaceae	32
35	32	Cucurbitaceae	16	19	Cucurbitaceae	33
36	34	Resedaceae	18	25	Resedaceae	34
37	35	Linaceae	7	6	Linaceae	35
38	36	Arecaceae	4	4	Arecaceae	36
39	37	Plantaginaceae	11	45	Plantaginaceae	37
40	4	Globulariaceae	2	-	Plantaginaceae	-
41	88	Scrophulariaceae	18	-	Plantaginaceae	-
42	37	Illecebraceae	22	53	Caryophyllaceae	38
43	59	Caryophyllaceae	21	-	Caryophyllaceae	-
Total			336	411		

TABLE 3. Genera that have been moved to a new familial position.

Family on previous Flora of Libya	Genus	APG4 Family	Species
Coridaceae	*Coris*	Primulaceae	2
Guttiferae	*Hypericum*	Hypericaceae	7
Leonticaceae	*Bongardia*	Berberidaceae	1
Leonticaceae	*Leontice*	Berberidaceae	2

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TABLE 3. (Continued)

Family on previous Flora of Libya	Genus	APG4 Family	Species
Theligonaceae	*Theligonum*	Rubiaceae	1
Asclepiadaceae	*Calotropis*	Apocynaceae	1
Asclepiadaceae	*Apteranthes*	Apocynaceae	2
Asclepiadaceae	*Cynanchum*	Apocynaceae	2
Asclepiadaceae	*Glossonema*	Apocynaceae	2
Asclepiadaceae	*Leptadenia*	Apocynaceae	2
Asclepiadaceae	*Pergularia*	Apocynaceae	1
Asclepiadaceae	*Periploca*	Apocynaceae	1
Asclepiadaceae	*Solenostemma*	Apocynaceae	1
Tiliaceae	*Tilia*	Malvaceae	1
Tiliaceae	*Corchorus*	Malvaceae	2
Sterculiaceae	*Brachychiton*	Malvaceae	1
Sterculiaceae	*Melhania*	Malvaceae	1
Bombacaceae	*Bombax*	Malvaceae	1
Bombacaceae	*Ceiba*	Malvaceae	1
Capparaceae	*Cleome*	Cleomaceae	8
Sparganiaceae	*Sparganium*	Typhaceae	2
Caprifoliaceae	*Viburnum*	Adoxaceae	2
Molluginaceae	*Limeum*	Limeaceae	1
Molluginaceae	*Corbichonia*	Lophiocarpaceae	1
Molluginaceae	*Gisekia*	Gisekiaceae	1
Globulariaceae	*Globularia*	Plantaginaceae	2
Scrophulariaceae	*Kickxia*	Plantaginaceae	9
Scrophulariaceae	*Veronica*	Plantaginaceae	9
Illecebraceae	*Gymnocarpos*	Caryophyllaceae	2
Illecebraceae	*Herniaria*	Caryophyllaceae	7
Illecebraceae	*Paronychia*	Caryophyllaceae	12
Illecebraceae	*Pteranthus*	Caryophyllaceae	1
Total 15	32	14	89

TABLE 4. Species that have been updated to new accepted names.

	Previous name	Current name
1	*Anagallis arvensis* L.	*Lysimachia arvensis* (L.) U. Manns & Anderb.
2	*Anagallis monelli* L.	*Lysimachia monelli* (L.) U. Manns & Anderb.
3	*Asterolinon linum-stellatum* (L.) Duby	*Lysimachia linum-stellatum* L
4	*Gaillonia reboudiana* Coss.& Durieu	*Plocama reboudiana* (Coss. & Durieu) Ehrend. & Schönb.Tem.
5	*Putoria calabrica* (L. f.) DC.	*Plocama calabrica* (L. f.) M. Backlund & Thulin
6	*Caralluma europaea* (Guss.) N. E. Br.	*Apteranthes europaea* (Guss.) Murb.
7	*Caralluma europaea* (Guss.) N. E.Br.subsp. *europaea*	*Apteranthes europaea* (Guss.) Murb. var. *europaea*
8	*Leptadenia hastata* (Pers.) Decne.	*Leptadenia lanceolata* (Poir.) Goyder
9	*Periploca angustifolia* Labill.	*Periploca laevigata* subsp. *angustifolia* (Labill.) Markgr
10	*Plumeria acutifolia* Poir.	*Plumeria rubra* L.
11	*Thevetia yccotli* DC.	*Cascabela thevetia* (L.) Lippold
12	*Chorisia crispiflora* H. B. & K.[1]	*Ceiba crispiflora* (Kunth) Ravenna
13	*Lavatera arborea* L.	*Malva arborea* (L.) Webb & Berthel.
14	*Lavatera cretica* L.	*Malva multiflora* (Cav.) Banfi & Galasso
15	*Lavatera olbia* L.	*Malva olbia* (L.) Alef.
16	*Lavatera bryoniifolia* Miller	*Malva unguiculata* (Desf.) Alef.
17	*Sphaeralcea umbellata*(Cav.) G. Don	*Phymosia umbellata* (Cav.) Kearney
18	*Capparis ovata* Desf.	*Capparis spinosa* L.
19	*Cleome africana* Botsch.	*Cleome amblyocarpa* Barratte & Murb
20	*Gynandropsis gynandra* (L.) Briq.	*Cleome gynandra* L.
21	*Sparganium erectum* aggr.	*Sparganium erectum* L.
22	*Sparganium neglectum* Beeby	*Sparganium erectum* subsp. *neglectum* (Beeby) K. Richt
23	*Centaurium minus* Moench	*Centaurium erythraea* Rafn
24	*Centaurium meyeri* (Bunge) Druce	*Centaurium pulchellum* (Swartz) Druce

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TABLE 4. (Continued)

	Previous name	Current name
25	*Aizoon hispanicum* (L.) H. E. K. Hartma	*Aizoanthemum hispanicum* (L.) H. E. K. Hartmann
26	*Aptenia cordifolia* (L. f.) Schwantes	*Mesembryanthemum cordifolium* L. f.
27	*Mesembryanthemum forskahlii* Hochst. ex Boiss.	*Mesembryanthemum cryptanthum* Hook. f.
28	*Cinnamomum zeylanicum* Blume	*Cinnamomum verum* J. Presl
29	*Juncus acutus* L. subsp. *acutus*	*Juncus acutus* L.
30	*Juncus articulatus* L. subsp. *articulatus*	*Juncus articulatus* L.
31	*Juncus fontanesii* J. Gay ex Laharpe subsp. *fontanesii*	*Juncus fontanesii* J. Gay Laharpe
32	*Juncus mutabilis* Lam.	*Juncus pygmaeus* Rich.
33	*Juncus maritimus* var. *arabicus* Asch. & Buch	*Juncus rigidus* Desf.
34	*Rhamnus oleoides* L.	*Rhamnus lycioides* subsp. *oleoides* (L.) Jahandiez & Maire
35	*Armeniaca vulgaris* Lam	*Prunus armeniaca* L.
36	*Cerasus avium* (L.) Moench.	*Prunus avium* (L.) L.
37	*Amygdalus communis* L.	*Prunus dulcis* (Mill.) D. A. Webb
38	*Laurocerasus officinalis* Roem.	*Prunus laurocerasus* L.
39	*Persica vulgaris* Mill.	*Prunus persica* (L.) Batsch
40	*Prunus nigra* Ait.	*Prunus insititia* L.
41	*Cucumis anguria* L.	*Trichosanthes cucumerina* L.
42	*Reseda alba* subsp. *decursiva* (Forssk.) Maire	*Reseda decursiva* Forssk.
43	*Reseda pampaniniana* Maire & Weill.	*Reseda urnigera* Webb.
44	*Linum strictum* var. *spicatom* Pers.	*Linum strictum* L.
45	*Plantago coronopus* L. subsp. *coronopus*	*Plantago coronopus* L.
46	*Plantago lanceolata* L. subsp. *lanceolata*	*Plantago lanceolata* L.
47	*Sclerocephalus arabicus* Boiss.	*Gymnocarpos sclerocephalus* (Decne.) Ahlgren & Thulin
48	*Herniaria cinerea* DC.	*Herniaria hirsuta subsp. cinerea* (DC.) Cout.
49	*Arenaria leptoclados* (Rchb.) Guss.	*Arenaria serpyllifolia* subsp. *leptoclados* (Rchb.) Nyman

1 The correct authority for this species is Kunth however 'H. B. & K.' is used in the original text of this Flora.

TABLE 5. Families and species that have been moved to new taxonomical positions.

Families changed according to (APG IV)	15 families
Species now included in a new family.	89 species
Species name has been changed due to change in taxonomic concept according to The Plant List	49 species
New taxa reported for the Libyan flora according to only Euro+Med Plant Base	16 species
New taxa reported for the Libyan flora according to only North African Checklist	33 species
New taxa reported for the Libyan flora according to both Euro+Med Plant Base and North African Checklist	47 species
Species nomenclature remaining the same as the last Libyan Flora	272 species

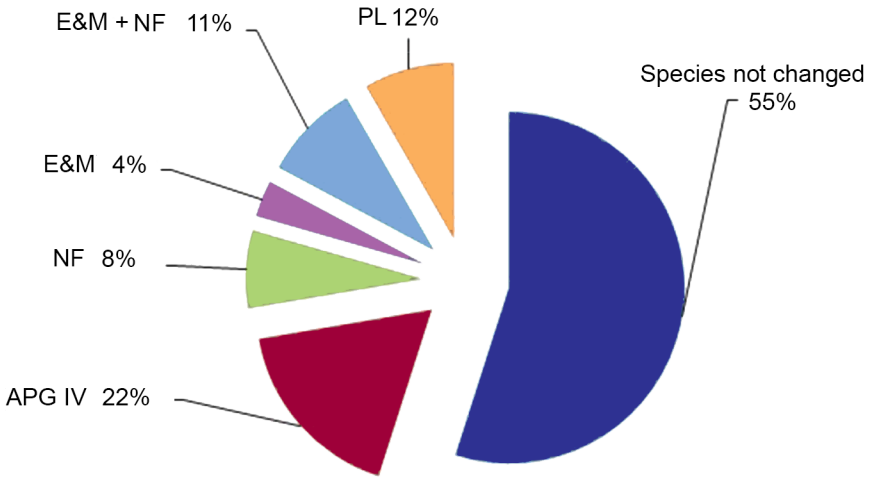

FIGURE 2. The percentage of change in 43 families of Libyan flora after excluding the species shared in the four literature sources. (PL) The Plant List, (NF) North African Checklist, (E&M) Euro+Med PlantBase, (APG IV) Angiosperm Phylogeny Group.

Discussion

Plant classification has been transformed by the wide scale adoption of the Angiosperm Phylogeny group system of classification. While not everyone accepts their decisions, these family groupings are stable and have become widely adopted in herbaria and scientific literature. Bringing the Libyan checklist in to this system is therefore an essential first step in updating the Flora more generally because it allows Libyan botanists to link their work to that of other botanists in the area and around the world. Further updating the checklist to use other major lists such as Euro+Med enhances the ability to communicate internationally even further. While the updating of existing names is primarily a process-based exercise, the addition of newly recorded species further increases the value of the checklist as an inventory of the Libyan flora.

The number of species and subspecies has increased from 336 to 411. Of these, 96 are newly reported taxa for the Libyan flora, while 49 are synonyms. The use of APG IV (2016), Euro+Med PlantBase (Euro+Med, 2012), the North African Checklist by (Dobignard & Chatelain, 2010-2013) and the plant list (The Plant List, 2013) has resulted in many changes. The review of APG IV shows that 15 families have been changed and consequently 32 of the 138 genera have been moved to a new family. This number is equal to 23% of all the genera reviewed. There are likely to be additional changes with respect to those families of the Libyan Flora not included in this study.

The changes summarised above confirm that the Libyan Flora of Ali *et al.* (eds 1976–1989) requires significant updating. This update has added six new family names and excluded eight old ones to the Libyan flora. Finally, the addition of the families *Hypericaceae, Adoxaceae, Lophiocarpaceae, Limeaceae, Gisekiaceae*, and *Cleomaceae* are reported for the first time in Libyan flora making the new checklist comparable to those of the surrounding Mediterranean.

Conclusion

Our update of the angiosperm families Primulaceae to Caryophyllaceae has resulted in the necessity of a large number of nomenclatural changes. Such changes will allow greater efficiency in the research on Libyan plants through better access to published literature using current names and concepts. If Libyan taxonomists follow the recent taxonomic consensus in updating their flora this will support greater efficiency in the assessment of extinction threats and the fulfilment of its obligations under the Convention of Biological Diversity.

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