



Numerical re-assessment of the phenetic relationship between Apocynaceae and Asclepiadaceae

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Abstract

Recognition of the Apocynaceae and Asclepiadaceae as one family or as two separate but related families with five subfamilies was for long highly controversial. Raising some of the subfamilies to the rank of family was also disputable. To resolve this issue, 55 morphological and palynological characters were recorded in a data matrix comprising a sample of 41 species belonging to 24 genera of Apocynaceae and 75 species from 31 genera of the Asclepiadaceae. The data matrix was subjected to cluster analysis using the Sørensen's measure of dissimilarity and Ward's method of clustering in the PC-ORD version 5. Out of three possible interpretations of the result, we opted for that which suggested considering the five subfamilies Apocynaceae-Rauwolfioideae, Apocynaceae-Apocynoideae, Asclepiadaceae-Asclepiadoideae, Asclepiadaceae-Periplocoideae and Asclepiadaceae-Secamonoideae as five distinct, neatly defined and homogeneous families of equal rank based on a unique set of diagnostic structural and functional characters for each of them.

Key words: Apocynaceae, Asclepiadaceae, classification, cluster analysis, morphology, pollinia, tetrads.

Introduction

The Apocynaceae are one of the largest families of angiosperms with 375 genera and over 5100 species (Endress *et al.*, 2007). According to Watson and Dallwitz (1992), Li Ping-tao *et al.*, (1995) and APG IV (2016) members of the Apocynaceae are mostly trees, shrubs, or vines, rarely subshrubs or herbs, containing milky latex or rarely watery juice. Leaves simple, opposite, sometimes whorled or alternate, pinnately veined; stipules absent or rarely present. Inflorescences cymose, axillary or terminal, with bracteoles. Flowers bisexual, 5- [or 4]-merous, actinomorphic. Calyx 5- or rarely 4-partite, quincuncial, basal glands usually present. Corolla 5- or rarely 4-lobed, funnelform, salverform, urceolate, or rarely rotate. Stamens 5 or rarely 4; filaments short; anthers mostly sagittate, free or connivent into a cone adherent to the stigma, dehiscing longitudinally, base rounded, cordate, sagittate, or prolonged into an empty spur; pollen in monads or tetrads. Ovaries superior, rarely half-inferior, connate or distinct, 1- or 2-locular; ovules 2–numerous per locule. Style 1; stigma capitate, conical, or lampshade-shaped, base stigmatic, apex 2-cleft

and not stigmatic. Fruit a berry, drupe, capsule, or follicle. Seeds with or without coma. The Apocynaceae are cosmopolitan, except in the arctic regions. Numerous species are grown for their medicinal and ornamental values, and the wood of trees such as *Alstonia* and *Dyera* species is a source of lightweight hardwood (Alan and Wilkes, 1964; Chin *et al.*, 2006). A similar account of the Asclepiadaceae *s.l.* was recently given by El-Gazzar *et al.* (2018).

The Apocynaceae were established by Jussieu (1789) as (“Apocineae”) to include 24 genera subdivided into three groups essentially defined by characteristics of fruits and seeds. Brown (1810a and b) separated seven genera (*Ceropegia*, *Pergularia*, *Stapelia*, *Periploca*, *Cynanchum* and *Asclepias*) from Jussieu’s “Apocineae” and combined them with 46 newly described genera to establish a separate family, the Asclepiadaceae. Brown also recognized three groups within the Asclepiadaceae: the “Asclepiadeae verae” (= Asclepiadoideae), the Periploceae, and an unnamed mono-generic group containing only *Secamone*. In 1838, Endlicher divided the latter genus into three genera (*Secamone*,

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Toxicarpus and *Goniostemma*) and assigned them the rank of “subordo” ‘Secamoneae’. Numerous new genera were added to the Apocynaceae and Asclepiadaceae during the succeeding decades and Schumann (1895a and b) proposed comprehensive classifications of the two families. Schumann (1895a) divided the Apocynaceae *sensu stricto* into two subfamilies: the Plumerioideae (with three tribes and six subtribes), and the Echitoideae (with two tribes). Similarly, he (1895b) classified the Asclepiadaceae into two subfamilies: the Periplocoideae (with a single tribe) and the Cynanchoideae (with five tribes and seven subtribes). The name ‘Cynanchoideae’ in Schumann’s (1895b) scheme had to be changed to Asclepiadoideae R. Br. ex Burnett, as it included the type genus of the family (*Asclepias*), while the name Plumerioideae K. Schum. was replaced with Rauvolfioideae Kostel. In subsequent classifications of the Asclepiadaceae, Schumann’s tribe ‘Asclepiadaceae-Secamoneae’ was elevated to the rank of subfamily Secamonoideae Endl. (e.g. Klackenbergh, 2001; Livshultz, 2010).

A controversy over the taxonomic relationship between the Apocynaceae and Asclepiadaceae persisted ever since. Some authors (e.g. Judd *et al.*, 1994; Struwe *et al.*, 1994; Sennblad and Bremer, 1996; APG IV, 2016) considered the Apocynaceae and Asclepiadaceae as one large family the Apocynaceae *s.l.* Other authors (e.g. Takhtajan, 1987; Cronquist, 1981 and 1988; Dahlgren, 1983; Rosatti 1989a and 1989b) treated them as two distinct families. Whether this assemblage of genera and species are treated as one family or as two families, their subdivision into subfamilies remained almost unaltered: the Apocynaceae are divided into the Rauvolfioideae and Apocynoideae, while the Asclepiadaceae comprise the Asclepiadoideae, Periplocoideae and Secamonoideae (Endress and Bruyns, 2000 and Endress *et al.*, 2007). Schlechter (1905) raised the Asclepiadaceae-Periplocoideae to family Periplocaceae, which was later accepted by other authors (e.g. Bullock, 1956; Hutchinson, 1959; Dyer, 1975).

Subsequent phylogenetic studies supported the reunion of the Apocynaceae *s.s.* and Asclepiadaceae into the Apocynaceae *s.l.*, with the same five subfamilies (e.g. Sennblad and Bremer, 1996; Potgieter and Albert, 2001; Endress and Bruyns 2000; Endress *et al.*, 2007; Livshultz, 2010). Furthermore, Potgieter and Albert (2001) showed that the Asclepiadoideae, Secamonoideae and Periplocoideae are well-supported and monophyletic, but no support could be found for the monophyly of the Apocynoideae and Rauvolfioideae as delimited previously by Endress and Bruyns (2000). Similar support for the three subfamilies was evident from the cluster analysis of a comprehensive set of characters of vegetative and floral morphology combined with types and features of pollen aggregation (El-Gazzar *et al.*, 2018).

The apparent contradiction between considering the Apocynaceae and Asclepiadaceae as two distinct families or as one family prompted us to initiate the present study with a view to put the currently accepted classifications of this closely knit assemblage of genera and species to a rigorous practical test.

Material and methods

Herbarium specimens of a cosmopolitan sample of 41 species from 24 genera of the Apocynaceae *sensu stricto* and 75 species from 31 genera of the Asclepiadaceae were examined in the Cairo University herbarium (CAI; acronym according to Holmgren *et al.*, 1990). The number of specimens representing each taxon ranged between one and 30. Identity of taxa was confirmed using appropriate local floras and nomenclature of the species was updated according to the two websites (<http://www.theplantlist.org/>), and (<http://www.tropicos.org>), where full lists of synonyms can be found. Full names with author citations of taxa and collection data of the specimens examined are given in Appendix 1.

Variation in vegetative, floral and pollen morphology observed in the available specimens was recorded comparatively in a data matrix. The outcome was subjected to cluster analysis under the combination of Sørensen’s distance measure and Ward’s clustering method and the dendrogram method

was selected to express the result. All methods are available in PC-ord version 5 (McCune, 1997).

Results

States of the 55 characters observed in the available specimens of 116 species

representing the 55 genera of the Apocynaceae and Asclepiadaceae were defined accurately to express the variation in the plants' vegetative and floral morphology as well as their pollen characteristics. Of the 55 characters in Table 1, 12 are multistate and the rest are binary.

Table 1: List of the 55 characters and character-states recorded comparatively for the 116 taxa belonging to 55 genera representing the Apocynaceae and Asclepiadaceae in the present study.

1. Plant	herb 1/ shrub 0
2. Stem	herbaceous 1/ woody 0
3. Stem	cylindrical 1/ angled 0
4. Stem	erect 1/ climbing-twinning 2/ procumbent 3
5. Stem	obese 1/ not obese 0
6. Stem	articulated 1/ continuous 0
7. Stipules	present 1/ absent 0
8. Leaves	petioled 1/ sessile–subsessile 2/ absent 3
9. Leaves	fleshy 1/ not fleshy 0
10. Calcium oxalate prismatic	present 1/ absent 0
11. Calcium oxalate druses	present 1/ absent 0
12. Leaf arrangement	alternate 1/ opposite 2/ whorled 3
13. Leaves	simple 1/ pinnate 2/ absent 3
14. Leaf shape	ovate-elliptic 1/ oblong 2/ orbicular 3/ linear-lanceolate 4/ cordate 5/ absent 6
15. Leaf blade	hairy 1/ glabrous 0
16. Glandular hairs on leaves	present 1/ absent 0
17. Midrib and vines	hairy 1/ glabrous 0
18. Base of leaf blade	symmetric 1 /asymmetric 0
19. Leaf margin	entire and pellucid 1/ undulate 0
20. Leaf margin	hairy 1 /smooth 0
21. Leaf apex	acute 1/ obtuse 0
22. Inflorescence	solitary 1/ umbel 0
23. Flowers	pedicelled 1/ sessile–subsessile 0
24. Calyx lobes	as long as corolla tube or shorter 1/ much longer than corolla tube 0
25. Sepal apex	acute 1/ obtuse 0
26. Sepals	united 1/ free 0
27. Sepals outer surface	hairy 1/ glabrous 0
28. Corolla shape	campanulate 1/ funnel-shaped 0
29. Petal outer surface	hairy 1/ glabrous 0
30. Petal apex	acute 1/ obtuse 0
31. Corona	Five translators 1 /tubular 0
32. Color of corona	same as petal lobes 1/ different 0
33. Corona	single 1/double 0
34. Corona	attached to the corolla 1/ attached to the staminal column 0
35. Corona	toothed 1/ toothless 0
36. Staminal filaments	hairy 1/ glabrous 2/ reduced 3
37. Anthers	sagittate 1/ not sagittate 0
38. Appendages on anthers	sagittatum 1/ glabrous filamentous 2/ hairy filamentous 3/ absent 4

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39. Caudicles	long 1/ inconspicuous 0
40. Pollen structure	monads 1/ tetrads 2/ pendant twin pollinia 3/ erect twin pollinia 4/ tetrads of twin pollinia 5
41. Stamens	free 1/ adhering around the style 0
42. Style	slender 1/ filiform 2/ reduced 3
43. Style	united 1/ free 0
44. Stigma	cylindrical 1/ globose 2/ two-lobed 3/ tetragonal 4/ pentagonal 5
45. Corpuscles on stigmatic corners	present 1/ absent 0
46. Ovary	hairy 1/ glabrous 0
47. Ovary	superior 1/ sunken in the disc 0
48. Ovaries	united 1/ free 0
49. Nectar disc	present 1/ absent 0
50. Gynophore	present 1/ absent 0
51. Fruit shape	divaricate follicles 1/ indehiscent mericarps 2/ berry 3
52. Fruit surface	smooth 1/ warty 2/ spiny 3
53. Fruit apex	hooked 1/ not hooked 0
54. Seeds	flattened 1/ discoid 0
55. Distal tuft of hairs on seed	present 1/ absent 0

Cluster analysis

The entire set of taxa is divided in Figs. 1-4 into two main Groups A and B, which are roughly equivalent to the Apocynaceae and Asclepiadaceae *sensu* Schumann (1895a, 1895b), respectively. Distribution of the genera between Groups A and B and their sub-groups is summed up in Table 2. Only two of the 55 genera have crossed the boundary between the two families: *Cryptostegia* of the Asclepiadaceae-Periplocoideae joined sub-group A-D (consisting of Apocynaceae-Echitoideae and Plumerioideae), whereas *Cascabela* shifted from its traditional place in the Apocynaceae-Plumerioideae to join the Asclepiadaceae-Cynanchoideae in sub-group B-E (Figs 1-4 and Table 2).

Group A is further split into two sub-groups C and D (Fig. 2), which coincide largely with the two traditional subfamilies of the Apocynaceae, the Rauvolfioideae and Apocynoideae, respectively. Similarly, Group B is divided into the three sub-groups E, F and G (Figs. 3 and 4), which correspond largely with the three traditional subfamilies of the Asclepiadaceae: Asclepiadoideae,

Periplocoideae and Secamonoideae, respectively. It is worth noting that the latter two subfamilies seem to have a closer relationship between them than that between each of them and the Asclepiadoideae (Figs. 1 and 4).

The lower reaches of Fig. 1 are taxonomically worth considering and shed some light on the robustness of the five subfamilies of the Apocynaceae and Asclepiadaceae. Table 2 shows that each of the two traditional subfamilies of the Apocynaceae (Echitoideae and Plumerioideae) is split nearly equally between the two subgroups A-C and A-D. Likewise, none of the three traditional subfamilies of the Asclepiadaceae emerged intact in Fig. 1 and Table 2: representative genera of the Schumann's (1895b) Cynanchoideae (=Asclepiadoideae) are spread across sub-groups B-E and B-G, while the six genera representing the relatively small Periplocoideae are scattered in sub-groups A-D, B-E and B-F. The subfamilies recognized in the USDA National Plant Germplasm System (2018) suffered a similar fate.

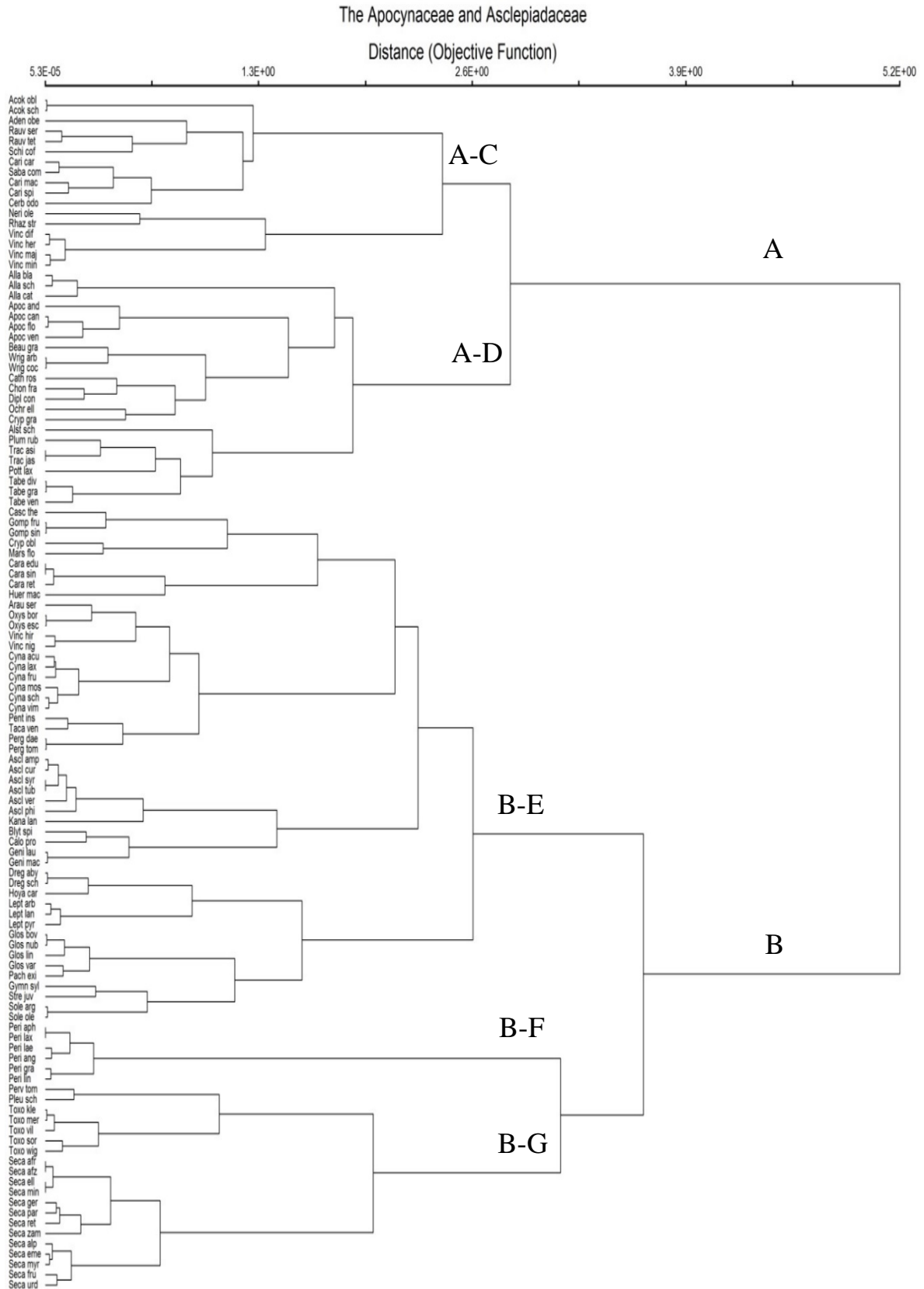


Figure 1. Dendrogram illustrating the hierarchical classification of 116 taxa representing 55 genera of the Apocynaceae and Asclepiadaceae based on the 55 characters listed in Table 1 and analysed under Sørensen's measure of similarity and Ward's method of clustering; abbreviations of scientific names of taxa and their full versions are listed alphabetically in Appendix 1.

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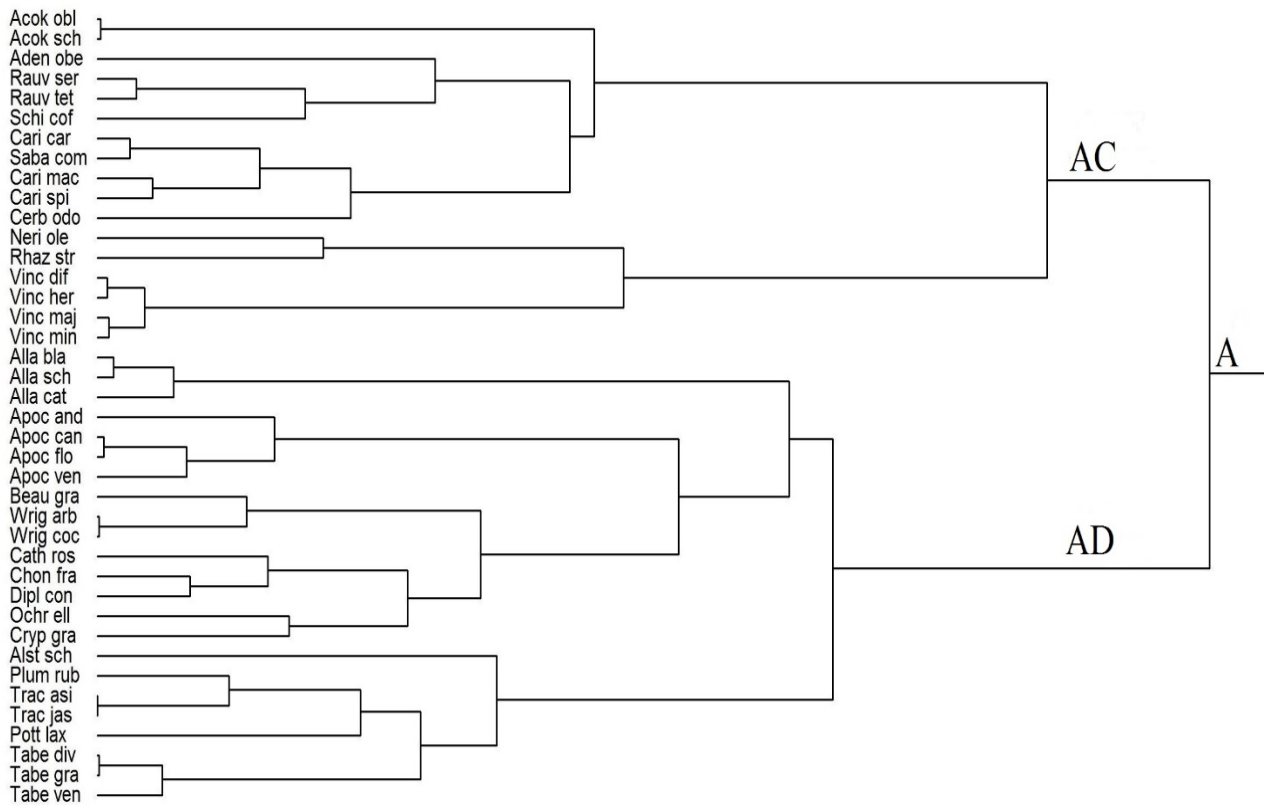


Figure 2. Part of Figure 1 enlarged to show abbreviations of names of taxa in Group A and its two subgroups AC and AD. Group A takes in *Cryptostegia grandiflora* (Cryp gra) of the Asclepiadaceae-Periplocoideae and all representatives of the Apocynaceae except *Cascabela thevetia* (in Group BE).

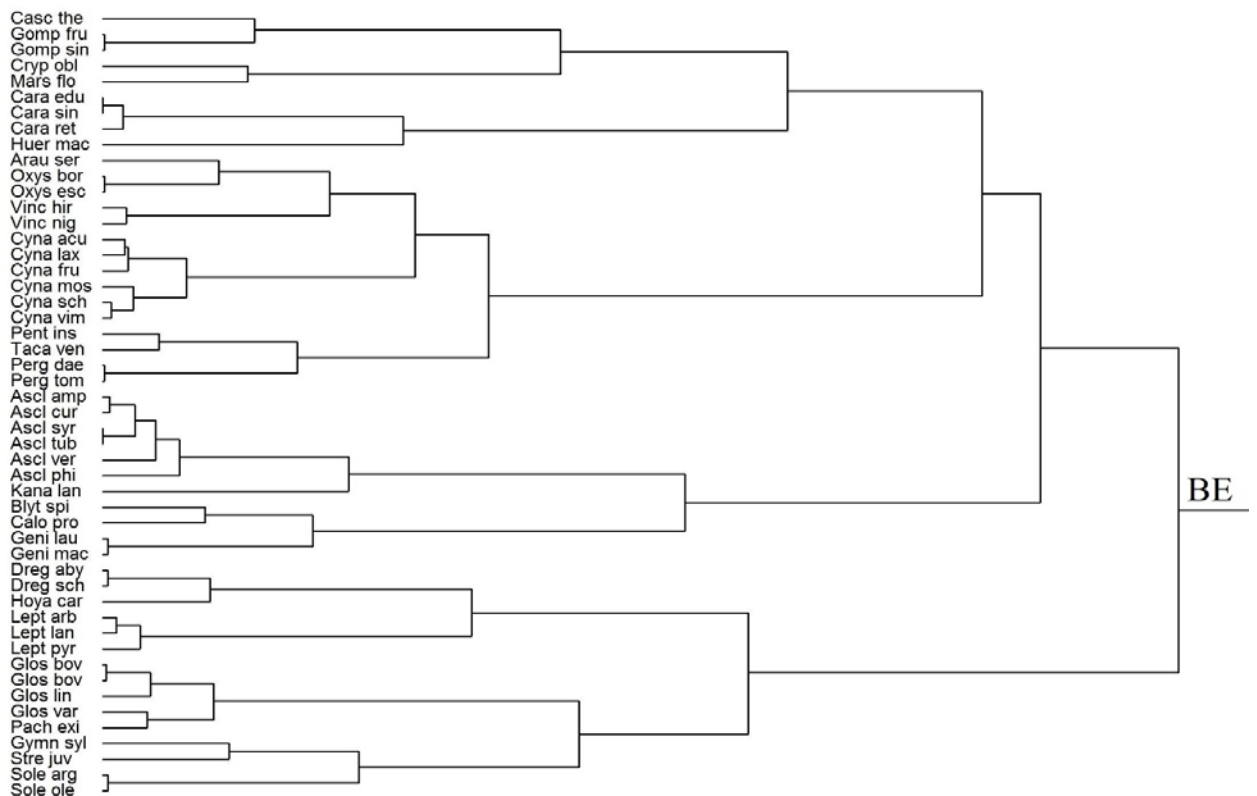


Figure 3. Part of Figure 1 enlarged to show abbreviations of names of taxa in Group BE. It includes all representatives of the Asclepiadaceae-Asclepiadoideae plus *Cascabela thevetia* (Casc the) of the Apocynaceae-Plumerioideae.

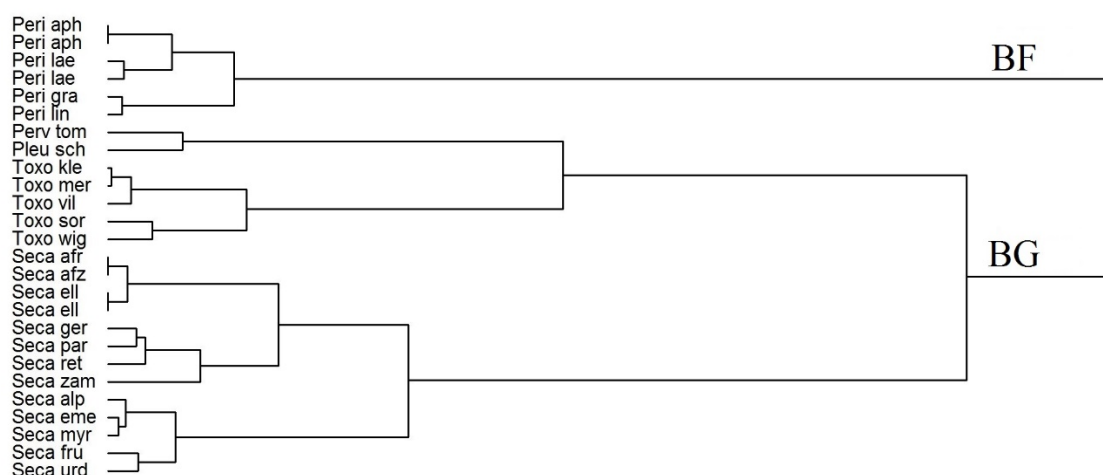


Figure 4. Part of Figure 1 enlarged to show abbreviations of names of taxa of Groups BF and BG, which consist of taxa representing the Asclepiadaceae-Periplocoideae (except *Cryptostegia grandiflora*, in Group AD) and the Asclepiadaceae-Secamonoideae, respectively.

Contrary to the status of the traditional subfamilies of Apocynaceae and Asclepiadaceae, the genera in both families are taxonomically much stronger. None of the

genera represented in the present study with two or more species was fragmented between any of the two major Groups or their five sub-groups (Table 2).

Table 2. Comparison between generic constitution of Groups A and B and their sub-groups in Fig. 1 and the classifications of the Apocynaceae and Asclepiadaceae proposed by Schuman (1895a and 1895b) the U.S. National Plant Germplasm System at the subfamily and tribal levels. Asc- = Asclepiadaceae; Apo- = Apocynaceae.

Genera in Groups in Fig. 1		Subfamilies & Tribes in Schumann's classification (1895a, 1895b)	Subfamilies in USDA National Plant Germplasm System (2018)	
A	C	<i>Adenium</i>	Apo-Echitoideae	Apocynoideae
		<i>Nerium</i>	Apo-Echitoideae	Apocynoideae
		<i>Acokanthera</i>	Apo-Plumerioideae-Arduineae	Rauvolfioideae
		<i>Carissa</i>	Apo-Plumerioideae-Arduineae	Rauvolfioideae
		<i>Saba</i>	Apo-Plumerioideae-Arduineae	Rauvolfioideae
		<i>Cerbera</i>	Apo-Plumerioideae-Plumerieae	Rauvolfioideae
		<i>Rauvolfia</i>	Apo-Plumerioideae-Plumerieae	Rauvolfioideae
		<i>Rhazya</i>	Apo-Plumerioideae-Plumerieae	Rauvolfioideae
		<i>Schizogygia</i>	Apo-Plumerioideae-Plumerieae	Rauvolfioideae
		<i>Vinca</i>	Apo-Plumerioideae-Plumerieae	Rauvolfioideae
		<i>Apocynum</i>	Apo-Echitoideae	Apocynoideae
		<i>Beaumontia</i>	Apo-Echitoideae	Apocynoideae
		<i>Chonemorpha</i>	Apo-Echitoideae	Apocynoideae
		<i>Pottsia</i>	Apo-Echitoideae	Apocynoideae
		<i>Trachelospermum</i>	Apo-Echitoideae	Apocynoideae

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D	<i>Wrightia</i>	Apo-Echitoideae	Apocynoideae		
	<i>Allamanda</i>	Apo-Plumerioideae- Arduineae	Rauvolfioideae		
	<i>Alstonia</i>	Apo-Plumerioideae- Arduineae	Apocynoideae		
	<i>Tabernaemontana</i>	Apo-Plumerioideae- Arduineae	Apocynoideae		
	<i>Catharanthus</i>	Apo-Plumerioideae- Plumerieae	Rauvolfioideae		
	<i>Diplorhynchus</i>	Apo-Plumerioideae- Plumerieae	Rauvolfioideae		
	<i>Ochrosia</i>	Apo-Plumerioideae- Plumerieae	Rauvolfioideae		
	<i>Plumeria</i>	Apo-Plumerioideae- Plumerieae	Apocynoideae		
	<i>Cryptostegia</i>	Asc-Periplocoideae	Periplocoideae		
B	E	<i>Cascabela</i>	Apo-Plumerioideae- Plumerieae	Rauvolfioideae	
		<i>Asclepias</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Blyttia</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Calotropis</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Araujia</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Cynanchum</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Gomphocarpus</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Kanahia</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Oxystelma</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Pentarrhinum</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Vincetoxicum</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Glossonema</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Pachycarpus</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Solenostemma</i>	Asc-Cynanchoideae- Asclepiadeae	Asclepiadoideae	
		<i>Marsdenia</i>	Asc-Cynanchoideae-Tylophoreae	Asclepiadoideae	
		<i>Caralluma</i>	Asc-Cynanchoideae-Tylophoreae	Asclepiadoideae	
		<i>Huernia</i>	Asc-Cynanchoideae-Tylophoreae	Asclepiadoideae	
		<i>Pergularia</i>	Asc-Cynanchoideae-Tylophoreae	Asclepiadoideae	
		<i>Dregea</i>	Asc-Cynanchoideae-Tylophoreae	Asclepiadoideae	
		<i>Hoya</i>	Asc-Cynanchoideae-Tylophoreae	Asclepiadoideae	
		<i>Leptadenia</i>	Asc-Cynanchoideae-Tylophoreae	Asclepiadoideae	
		<i>Gymnema</i>	Asc-Cynanchoideae-Tylophoreae	Asclepiadoideae	
		<i>Cryptolepis</i>	Asc-Periplocoideae	Periplocoideae	
		<i>Tacazzea</i>	Asc-Periplocoideae	Periplocoideae	
		<i>Streptocaulon</i>	Asc-Periplocoideae	Periplocoideae	
		<i>Genianthus</i>	Asc-Cynanchoideae-Secamoneae	Secamonoideae	
		F	<i>Periploca</i>	Asc-Periplocoideae	Periplocoideae
		G	<i>Pleurostelma</i>	Asc-Cynanchoideae-Asclepiadeae	Asclepiadoideae
			<i>Pervillaea</i>	Asc-Cynanchoideae- Tylophoreae	Secamonoideae
	<i>Toxocarpus</i>		Asc-Cynanchoideae-Secamoneae	Secamonoideae	
	<i>Secamone</i>		Asc-Cynanchoideae-Secamoneae	Secamonoideae	

Discussion

The arrangement of genera and species shown in Figs. 1-4 and Table 1 may be viewed in three alternative ways:

- (a) The entire group of genera and species are lumped together in one family. This is the widest concept of the Apocynaceae maintained by Sennblad and Bremer (1996 and 2002), Endress (2001), Livshultz *et al.* (2007), Soares e Silva *et al.* (2012), Meve and Liede-Shumann (2012), Liede-Shumann *et al.* (2012 and 2014), Endress *et al.* (2014), Surveswaran *et al.* (2014), Khanum *et al.* (2016), APG IV (2016), and Meve *et al.* (2017). This concept of Apocynaceae *s.l.* comprises two subfamilies: the Apocynoideae and the Asclepiadoideae, which correspond to the Apocynaceae and Asclepiadaceae *sensu* Schumann (1895a, 1895b), respectively. The former subfamily includes two informal tribes (Rauvolfieae and Apocyneae) and the latter comprises three informal tribes (Asclepiadeae, Periploceae and Cynancheae),
- (b) The group of genera and species is treated as two distinct families: the Apocynaceae (with two subfamilies corresponding to Rauvolfioideae and Apocynoideae in Schumann's (1895a) classification, and the Asclepiadaceae (with the three subfamilies Asclepiadoideae, Periplocoideae and Secamonoideae recognized by Schumann (1895b) and numerous other authors, and
- (c) The entire group of genera and species may be divided directly into five distinct and homogeneous entities of equal taxonomic rank.

None of these three alternative options is in full accord with any of the existing classifications of this group of plants. Furthermore, each of the three options has its pros and cons. For instance, the much-enlarged concept of the Apocynaceae renders them a notoriously heterogeneous array consisting of taxa with almost all types of pollen aggregation and floral configuration known in the Angiosperms, in addition to the numerous entailing differences in their pollination biology. Option (b) is tantamount to accepting the classical treatment proposed

by Brown (1812) and expanded by Schumann (1895a, b), but the two families remain heterogeneous in pollen aggregation and pollination biology as well as in several other floral and vegetative features. Option (c), on the other hand, offers a novel concept of at least the Rauvolfioideae and Secamonoideae, which were never raised to the rank of families despite the universal consensus that they are markedly different from all other members of their respective families, the Apocynaceae and Asclepiadaceae. This option seems taxonomically more attractive than the other two because it is the only scheme which produces five structurally and functionally homogeneous assemblages of genera.

For extraction of diagnoses of the Groups and subgroups in Fig. 1, the original data matrix was re-arranged with some additional data from Swarupanandan *et al.* (1996), and Verhoeven and Venter (1998). For ease of comparison, these diagnoses are shown in Table 3 and read as follows:

1. Group A-C (~Rauvolfioideae): pollen in monads; caudicles and corpuscles absent; translators absent; mostly trees and shrubs, pollination anemophilous.
2. Group A-D (~Apocynoideae): pollen predominantly in monads, minority of taxa with tetrads; caudicles and corpuscles absent; translators absent; predominantly lianas, pollination anemophilous.
3. Group B-E (~Asclepiadoideae): single pollinium per locule; each pollinium is enveloped by a thick common wall; caudicles hard; corpuscles hard and longitudinally sulcate; translators absent; mostly lianas and some xerophytic succulents or semi-succulents, pollination entomophilous.
4. Group B-F (~Periplocoideae): pollen in tetrads or pseudo-pollinia (aggregate of tetrads without a common wall); four pseudo-pollinia per locule; caudicles and corpuscles absent; spatulate translators present; mainly woody climbers; pollination anemophilous.
5. Group B-G (~Secamonoideae): pollen in pseudo-pollinia; two pseudo-pollinia per locule; caudicles reduced; corpuscles soft

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and not longitudinally sulcate; translators absent; commonly lianas, corpuscles soft

and not longitudinally sulcate, entomophilous pollination.

Table 3. Diagnostic characters of Groups A and B and their five subgroups C, D, E, F and G in Fig. 1 and their approximate equivalents of families and subfamilies in Schumann's (1895a, b) classification. * = data extracted from Swarupanandan *et al.* (1996) and Verhoeven and Venter (1998).

	Group A (~Apocynaceae <i>s.s.</i>)		Group B (~Asclepiadaceae)		
	A-C (Rauvolfioideae)	A-D (Apocynoideae)	B-E (Asclepiadoideae)	B-F (Periplocoideae)	B-G (Secamonoideae)
Pollen*	monads	monads, few tetrads	true pollinia	tetrads forming pseudo-pollinia	tetrads forming pseudo-pollinia
Pollinia/locule*	-	-	1	4	2
Pollinium wall*	absent	absent	present	absent	absent
Caudicles	absent	absent	rigid	absent	soft
Corpuscles	absent	absent	rigid, sulcate	absent	soft, not sulcate
Translators	absent	absent	absent	present	absent
Membrane Enveloping pollinia	absent	absent	present	absent	absent
Gynostegium	absent	absent	present	absent	absent
Pollination	anemophily	anemophily	entomophily	anemophily	entomophily
Latex	present	present	present	absent	present

Clearly, each of the five sub-groups in Table 3 has its own unique set of distinctive characters. Therefore, it seems plausible to suggest that the five homogeneous sub-groups A-C, A-D, B-E, B-F and B-G in Figs. 1-4 are better regarded as five taxa of equal rank. The fact that relocation of a few genera between these five sub-groups adds to their close taxonomic resemblance to the five subfamilies Apocynaceae-Rauvolfioideae, Apocynaceae-Apocynoideae, Asclepiadaceae-Asclepiadoideae, Asclepiadaceae-Periplocoideae and Asclepiadaceae-Secamonoideae, respectively, seems to indicate that these five subfamilies may well be treated as five distinct but closely related families.

References

- APG IV (2016).** An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. *Bot. J. Linn. Soc.* **181**: 1-20.
- Brown, R. (1810a).** *Prodromus Florae Novae Hollandiae et Insulae van Diemen*. London.
- Brown, R. (1810b).** On the Asclepiadeae, a natural order of plants separated from the Apocineae of Jussieu. Preprint of *Mem. Wern. Nat. Hist. Soc.* **1**: 12-78.
- Bullock, A.A. (1956).** Notes on African Asclepiadaceae 6. *Kew Bull.* **11**: 265-282.
- Cronquist, A. (1981).** *An Integrated System of Classification of Flowering Plants*. New York: Columbia University Press.
- Cronquist, A. (1988).** *The Evolution and Classification of Flowering Plants*. 2nd ed., New York Botanical Garden.

- Dahlgren, R., (1983).** General aspects of angiosperm evolution and macrosystematics. *Nord. J. Bot.* **3**: 119-149.
- Dyer, R.A. (1975).** *The Genera of Southern African Flowering Plants*. Department of Agricultural Technical Services, Pretoria, **1**: 756 pp.
- El-Gazzar, A.; Khattab, A.H.; El-Saied, A. and El-Kady, A.A. (2018).** Numerical taxonomy of the Asclepiadaceae *s.l.* *Egypt. J. Bot.*, in press.
- Endress, M.E. 2001.** Apocynaceae and Asclepiadaceae: united they stand. *Haseltonia* **8**: 2–9.
- Endress, M.E. and Bruyns, P.V. (2000).** A revised classification of the Apocynaceae *s.l.* *Bot. Rev.* **66**(1): 1–56.
- Endress, M.E.; Liede-Schumann, S. and Meve, U. (2007).** Advances in Apocynaceae: the enlightenment, an introduction. *Ann. Miss. Bot. Gard.* **94**: 259– 267.
- Endress, M.E.; Liede-Schumann, S. and Meve, U. (2014).** An updated classification for Apocynaceae. *Phytotaxa* **159**(3): 175-194.
- Endlicher, S.L. (1838).** Ordo CXXXIII Asclepiadeae. *Genera Plantarum Secundum Ordines Naturales*. Fr. Beck, Wien. pp. 586-599.
- Hutchinson, J. (1959).** *The Families of Flowering Plants 1: Dicotyledons*. Oxford, pp.510.
- Judd, W.S.; Sanders, R.W. and Donoghue, M.J. (1994).** Angiosperm family pairs: Preliminary phylogenetic analyses. *Harv. Pap.Bot.* **5**: 1-51.
- Jussieu, A. de. (1789).** *Genera Plantarum*. Viduam Herissant, Paris, pp 526.
- Khanum, R.; Surveswaram, S.; Meve, U. and Liede-Schumann, S. (2016).** *Cynanchum* (Apocynaceae: Asclepiadoideae): a pantropical asclepiadoid genus revisited. *Taxon* **65**(3): 467-486.
- Klakenberg, J. (2001).** Notes on Secamonoideae (Apocynaceae) in Africa. *Adansonia*, ser. 3, **23**(2): 317-335.
- Li, Pingtao; Leeuwenberg, A.J.M. and Middleton, D.J. (1995).** *Flora of China* **16**: 143–188.
- Liede-Schumann, S.; Kong, H.; Meve, U. and Thiv, M. (2012).** *Vincetoxicum* and *Tylophora* (Apocynaceae-Asclepiadoideae-Asclepiadeae), two sides of the same medal: independent shifts from tropical to temperate habitats. *Taxon* **61**(4): 803-825.
- Liede-Schumann, S.; Nikolaus, M.; Silva, U.C.S.S.; Rapini, A.; Mangelsdorff, R.D. and Meve, U. (2014).** Phylogenetics and biogeography of the genus *Metastelma* (Apocynaceae-Asclepiadoideae-Asclepiadeae-Metastelmatinae). *Syst. Bot.* **39**(2): 594-612.
- Livshultz, T. (2010).** The phylogenetic position of milkweeds (Apocynaceae subfamilies Secamonoideae and Asclepiadoideae): evidence from the nucleus and chloroplast. *Taxon* **59**: 1016-1030.
- Livshultz, T.; Middleton, D.J.; Endress, M.E. and Williams, J.K. (2007).** Phylogeny of Apocynoideae and the APSA clade (Apocynaceae *s.l.*). *Ann. Miss. Bot. Gard.* **94**: 324-359.
- McCune, B. (1997).** PC-ORD version 5, for windows. Specification. (<http://home.centurytel.net/mjm/winspecs.htm>).
- Meve, U. and Liede-Schumann, S. (2012).** Taxonomic dissolution of *Sarcostemma* (Apocynaceae-Asclepiadoideae). *Kew Bulletin* **67**: 751-759.
- Meve, U.; Heiduk, A. and Liede-Schumann, S. (2017).** Origin and early evolution of Ceropegieae (Apocynaceae-Asclepiadoideae). *Syst. Biodiv.* **15**(2): 143-155.
- Potgieter, K. and Albert, V.A. (2001).** Phylogenetic relationships within Apocynaceae *s.l.* based on trnL intron and trnL-F spacer sequences and propagule characters. *Ann. Miss. Bot. Gard.* **88**: 523-549.
- Rosatti, T.J. (1989a).** The genera of suborder Apocinaeae (Apocynaceae) in the Southeastern United States. *Journ. Arnold Arb.* **70**: 307–401.
- Rosatti, T. J. (1989b).** The genera of suborder Apocinaeae (Asclepiadaceae) in the Southeastern United States. *Journ. Arnold Arb.* **70**: 443–514.
- Schlechter, F.R. (1905).** *Periplocaceae*. In: Schumann, K., Lauterbach, K. (eds.), *Nachträge zur Flora des Deutschen Schutzgebiete in der Südsee* **8**: 351–353. Borntraeger, Leipzig.
- Schumann, K. (1895a).** *Apocynaceae*, in A. Engler and K. Prantl's *Die natürlichen Pflanzenfamilien*. 4 (2): 109-189. Verlag von Wilhelm Engelmann, Leipzig.

Numerical re-assessment of the phenetic relationship

- Schumann, K. (1895b).** *Asclepiadaceae*, in A. Engler and K. Prantl's *Die Natürlichen Pflanzenfamilien*. 4(2): 189-306. Verlag von Wilhelm Engelmann, Leipzig.
- Sennblad, B. and Bremer, B. (1996).** The familial and subfamilial relationships of Apocynaceae and Asclepiadaceae evaluated with rbcL data. *Pl. Syst. Evol.* **202**: 153-176.
- Sennblad, B. and Bremer, B. (2002).** Classification of Apocynaceae *s.l.* according to a new approach combining Linnaean and phylogenetic taxonomy. *Syst. Biol.* **51**: 389-409.
- Soares e Silva, U.C.; Rapini, A.; Liede-Schumann, S.; Ribeiro, P.L. and Van den Berg, C. (2012).** Taxonomic considerations on Metastelmatinae (Apocynaceae) based on plastid and nuclear DNA. *Syst. Bot.* **37(3)**: 795-806.
- Struwe, L.; Albert, V. A. and Bremer, B. (1994).** Cladistics and family level classification of the Gentiales. *Cladistics* **10**: 175-206.
- Surveswaran, S.; Sun, M.; Grimm, G.W. and Liede-Schumann, S. (2014).** On the systematic position of some Asian enigmatic genera of Asclepiadoideae (Apocynaceae). *Bot. J. Linn. Soc.* **174**: 601-619.
- Swarupanandan, K.; Mangaly, J.K.; Sonny, T.K.; Kishorekumar, K. and Chand Basha, S. (1996).** The subfamilial and tribal classification of the family Asclepiadaceae. *Bot. J. Linn. Soc.* **120(4)**: 327-369.
- Takhtajan, A., (1987).** *Systema Magnoliophytorum*. Nauka, Leningrad.
- Verhoeven, R. and Venter, H.J.T. (1998).** Pollinium structure in Periplocoideae. *Grana* **37**: 1-14.
- USDA, Agricultural Research Service, National Plant Germplasm System. (2018).** Germplasm Resources Information Network (GRIN-Taxonomy). National Germplasm Resources Laboratory, Beltsville, Maryland. URL: <https://npgsweb.ars-grin.gov/gringlobal/taxonomydetail.aspx?30895>. Accessed 20 May 2018.

Appendix 1. Collection data of the specimens of the 24 genera and 41 taxa representing the Apocynaceae and 67 species from 31 genera of the Asclepiadaceae in the present study. Full names of genera and species are in heavy bold and arranged alphabetically. Each name is preceded by its abbreviation in Fig. 1 in heavy bold, bracketed and underlined. Specimens collected by Alaa El-Kady are kept in the herbarium of the Botany and Microbiology Department, Faculty of Science in Cairo, Al-Azhar University; all other specimens are kept in the Herbarium of the Botany Department, Faculty of Science, Cairo University.

1. The Apocynaceae

(Aco oblo) *Acokanthera oblongifolia* (Hochst.) Benth. & Hook.f. ex B.D.Jacks: M. Hassib, 22/1/1928, Orman Garden, Egypt. M.T. Hefnawy, 26/4/1928, Orman Garden, Egypt. Vivi Täckholm, 29/10/1959, University Garden, Giza, Egypt. Vivi Täckholm, 30/10/1959, University Garden, Giza, Egypt. Vivi Täckholm, 30/10/1959, Zohria Garden, Gezira, Cairo, Egypt. Vivi Täckholm, 2/11/1959, Faculty of Agriculture, Giza, Egypt. Abdel Rahman El Sheikh, 2/1/1961, University Garden, Giza, Egypt. Mohamed El Mahdi, 22/5/1965, University Garden, Giza, Egypt.

(Aco schi) *Acokanthera schimperi* (A.DC.) Schweinf.: Ahmed Khattab and J. R. Shabetai, k392, 25/4/1944, bet. Med elaleed, olal, Yemen. Loutfy Boulos, 25 October 1976, 4 km west of China Hasen, 31 km NW of Jijiga, Ethiopia.

(Ade obes) *Adenium obesum* (Forssk.) Roem. & Schult.: Mohamed Drar, 6/4/1938, Malik, Sudan. Mohamed Drar, 10/4/1938, Bahr El Ghazal, Way Goba to Yei, Sudan. Mohamed Drar, 28/4/1938, Gabal Leir, Tonga, Kordafan. Ahmed Khattab and J. R. Shabetai, 25/3/1944. Madinet El Aseed, Obal, Adana, Yemen. Ahmed Khattab and J. R. Shabetai, 25/4/1944. Wady Deli, Abha, S. Heagaz, Saudi Arabia. Kamal Mustafa Ibrahim, Jan 1964, El Hemia north of Taiz, Yemen. M. Kassas, M. D. El Khalifa and M. O. Mobarak, 21/12/1965, Gebel Marra, Sudan. M. Kassas, M. D. El Khalifa and M. O. Mobarak, 29/12/1965, University of Khartoum, Sudan. Kamal Mustafa Ibrahim, Dec/1966, Taiz, Yemen. Kamal Mustafa Ibrahim, Jan/1967, Taiz, Yemen. No name, 23/5/1972, in the mountains between Sanaa and Hodeida, Yemen. Dr. A. Al-Sheik, 1/8/1975, Bashawat Shemran. Dr. A. Al-Sheik, August/1975, Gizan, Abu-Arish, Saudi Arabia.

(All bla) *Allamanda blanchetii* A. DC.: D. Burch and L. Peaden, 30/July/1970, no locality.

(All cath) *Allamanda cathartica* L.: Vivi Täckholm, 30/10/1959, Zohria Garden, Cairo, Egypt. Mohamed El Mahdi, 7/8/1963, Zohria Garden, Zamalek, Gezira, Egypt. Mohamed El Mahdi, 6/11/1963, Zohria Garden, Zamalek, Gezira, Egypt. D. Burch and L. Peaden, July/1970, no locality.

(All scho) *Allamanda schottii* Pohl: D. Burch and D. Allen, July/1970, no locality.

(Als scho) *Alstonia scholaris* (L.) R. Br.: Mohamed El Mahdi, 1/10/1963, Orman Gardens, Giza, Egypt. Mohamed El Mahdi, 25/4/1968, Zoological Garden, Giza, Egypt. Mohamed El Mahdi, 3/12/1969, Zoological Garden, Giza, Egypt.

(Apo andr) *Apocynum androsaemifolium* L.: Fr. Rolland, 25/Juillet/1967, Germain. Alma L. Moldenke and Harold N. Moldenke, 27/June/1974, Burlington County, New Jersey.

(Apo cann) *Apocynum cannabinum* L.: Alma L. Moldenke and Harold N. Moldenke, 28/June/1974, Ocean County, New Jersey. Alma L. Moldenke and Harold N. Moldenke, 8/July/1974, Oxford, Warren County, New Jersey.

(Apo flor) *Apocynum* × *floribundum* Greene: R. F. and D. McIntire, 23/ June/1966, Bruneau and Dames, Owyhee County, Idaho Desert Oasis.

(Apo vene) *Apocynum venetum* L.: Harald Lindberg, Iter 1939, Famagusta, in lidore arenosa inter opp. Famagusta et Salamis. Carl Steurer & Giozgie, 18/7/1952, Italy.

(Bea gran) *Beaumontia grandiflora* Wall.: M. Hassib, 24/4/1928, cultivated in Orman Garden, Giza, Egypt. Vivi Täckholm, 29/10/1959, Faculty of Agriculture Gardens, Giza, Egypt. Vivi

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Täckholm, 2/11/1959, Faculty of Agriculture Gardens, Giza, Egypt. Soliman Sisi, 6/4/1961, University Garden, climbing on the palms behind Library Building, Giza, Egypt. Vivi Täckholm, Spring 1959, University Garden, behind the Library Building, Giza, Egypt. Mohamed El Mahdi, 22/10/1965, Plant Island, Assuan, Egypt. Mohamed El Mahdi, 17/4/1973, Cairo University Garden, Giza, Egypt. Adel Gazzar, 1/6/1975, Faculty of Science Garden of Alexandria University, Moharram Bey, Alexandria, Egypt.

(Car cara) *Carissa carandas* L.: M. Hassib, 4/8/1928, High School of Agriculture, Giza, Egypt. Vivi Täckholm and Ibrahim Elsayed, 4/1/1962, West garden, Alfred Bircher's Gardens, El Saff, Egypt. Vivi Täckholm and Ibrahim Elsayed, 17/5/1962, North Garden, Alfred Bircher's Gardens, El Saff, Egypt. Mohamed El Mahdi, 13/4/1964, Plant Island, Assuan, Egypt. Mohamed El Mahdi, 4/12/1972, Zoological Garden, Giza, Egypt.

(Car macr) *Carissa macrocarpa* (Eckl.) A. DC.: Vivi Täckholm and Ibrahim Elsayed, 28/11/1961, Alfred Bircher's Gardens, El Saff, Egypt. Vivi Täckholm and Ibrahim Elsayed, 24/5/1962, West Garden, Alfred Bircher's Gardens, El Saff, Egypt. Mohamed El Mahdi, 8/8/1963, Zoological Garden, Giza, Egypt. Mohamed El Mahdi, 15/4/1964, Plant Island Garden, Assuan, Egypt.

(Car spin) *Carissa spinarum* L.: Mohammed Drar, 12/2/1938, Gabal Marra, Wadi Saria, Darfur, Sudan. Mohammed Drar, 5/3/1938, Erkuit, Red Sea Hills, Sudan. Mohammed Drar, 6/3/1938, Erkuit, Gebal Sila, Red Sea Hills, Sudan. Mohammed Drar, 14/4/1938, Way Yei, Emadi, Bahr El Ghazal Country, Sudan. Mohammed Drar, 20/4/1938, Bahr El Ghazal Country, Sudan. Mohammed Drar, 12/5/1938, Wadi Saria, Gebal Marra, Darfur, Sudan. M. Kassas, 21/12/1953, Erkuit, Sudan. Vivi Täckholm and Ibrahim Elsayed, 23/6/1961, Alfred Bircher's Garden, El Saff, Northeastern Garden, Egypt. Vivi Täckholm and Ibrahim Elsayed, 22/11/1961, Northeastern Garden, Alfred Bircher's Garden, El Saff, Egypt. Vivi Täckholm and Ibrahim Elsayed, 22/11/1963, Northeastern Garden, Alfred Bircher's Garden, El Saff, Egypt. Mohamed El Mahdi, 16/7/1963, Orman Garden, Giza, Egypt. Mohamed El Mahdi, 8/8/1963, Zoological Garden, Giza, Egypt. Mohamed El Mahdi, 22/10/1963, Zoological Garden, Giza, Egypt. Mohamed El Mahdi, 23/11/1963, Zoological Garden, Giza, Egypt. Mohamed El Mahdi, 15/12/1963, Orman Garden, Giza, Egypt. Mohamed El Mahdi, 1/9/1969, Zoological Garden, Giza, Egypt.

(Cas they) *Cascabela thevetia* (L.) Lippold: M. Hassib, 22/12/1927, Cultivated in the School of Agriculture, Giza, Egypt. M.T. Hefnawy, 11/12/1928, Zohria garden, Egypt. M. Hassib, 3/9/1929, Zaafaran Palace Garden, Ain Shams University, Abbassia, Cairo, Egypt. Mohammed Drar, 24/2/1938, Cultivated in Khartoum, Sudan. Vivi Täckholm and Ibrahim Elsayed, 4/1/1952, Alfred Bircher's garden, El Saff, Western garden, Egypt. Loutfy Boulos, July/1952, Fouad 1st. Univ. Street, in front of Faculty of Agriculture, Giza Egypt. Ahmed Aly Fadeel, 2/1/1953, Inshas, Egypt. Vivi Täckholm, 30/3/1956, Barrage, Egypt. Soliman Sisi, 1/4/1956, Giza, Egypt. Vivi Täckholm, 2/11/1959, Faculty of Agriculture, in the Garden, Giza, Egypt. Vivi Täckholm and Ibrahim Elsayed, 8/1/1961, Medicinal Garden, Barrage, Egypt. Vivi Täckholm, 27/5/1961, Alfred Bircher's garden, Central garden, El Saff, Egypt. Vivi Täckholm and Ibrahim Elsayed, 1/6/1961, Alfred Bircher's garden, El Saff, Eastern garden, Egypt. Vivi Täckholm and Ibrahim Elsayed, 1/6/1961, Alfred Bircher's garden, El Saff, Western garden, Egypt. Ibrahim Elsayed, 13/7/1963, Cairo University garden, Giza, Egypt. Ibrahim Elsayed, 15/7/1963, Cairo University garden, Giza, Egypt. Mohamed El Mahdi, 24/7/1963, Orman Gardens, Giza, Egypt. Mohamed El Mahdi, 29/1/1968, Barrage Medicinal Garden, Egypt.

(Cat rose) *Catharanthus roseus* (L.) G. Don: M. T. Hefnawy, 11/12/1928, Zohria garden, Egypt. M. Hassib, 3/9/1929, Zaafaran Palace garden, Ain Shams University, Abbassia, Cairo, Egypt. Mohammed Drar, 24/2/1938, Cultivated in Khartoum, Sudan. Mohammed Drar, 29/5/1938,

Cultivated in Meroe, Dongola, Sudan. M. Hassib, 29/4/1941, cultivated in the garden of the Faculty of Agriculture, Giza, Egypt. Loutfy Boulos, July/1952, Zoological Garden, Giza, Egypt. Vivi Täckholm, 14/10/1959, Cultivated outside the Herbarium Building, Faculty of Science, Giza, Egypt. Vivi Täckholm and Ibrahim Elsayed, 8/1/1961, Barrage Medicinal garden, Egypt. Vivi Täckholm and Ibrahim Elsayed, 15/5/1961, Alfred Bircher's garden, El Saff, South garden, Egypt. Vivi Täckholm, 27/5/1961, Alfred Bircher's garden, El Saff, central garden, Egypt. Mohamed El Mahdi, 15/10/1963, Faculty of Pharmacy garden, Boulaq Dakrou, Giza, Egypt. Mohamed El Mahdi, 4/2/1968, Barrage Medicinal garden, Egypt. D. Burch and M. Smith, July/1972, Johns County, Florida. Christina Brydolf, 24/5/1972, Northwest Taiz, Yemen. M. Mahdi, 3/23/1977, Orman Garden, Egypt.

(Cer odol) *Cerbera odollam* Gaertn.: Vivi Täckholm, 27/10/1959, Orman Gardens, Giza, Egypt. Mohamed El Mahdi, 2/9/1963, Agricultural Museum Garden, Dokki, Giza, Egypt. Mohamed El Mahdi, 17/7/1963, Orman Gardens, Giza, Egypt. Mohamed El Mahdi, 2/8/1963, Agricultural Museum Garden, Dokki, Giza, Egypt. Mohamed El Mahdi, 11/6/1970, Zoological Garden, Giza, Egypt. Mohamed El Mahdi, 6/8/1973, Orman Gardens, Giza, Egypt.

(Cho frag) *Chonemorpha fragrans* (Moon) Alston: Ezz El Din, 15/8/1970, Faculty of Agriculture Garden, Giza, Egypt. Ezz El Din, 15/7/1971, Faculty of Agriculture Garden, Giza, Egypt.

(Dip cond) *Diplorhynchus condylocarpon* (Müll.Arg.) Pichon: Sebastian Chuwa, 14/6/1995, Mwanaihana Forest Mwaya River, Tanzania. No name, No date, Mwanaihana Forest Mwaya River, Tanzania.

(Ner olea) *Nerium oleander* L.: Qwuarie, 18 Augst 1908, Sidi Qareer, Alexandria, Egypt. M. Hassib, 3/9/1929 Zaafaran Palace garden, Ain Shams University, Abbassia, Cairo, Egypt. Loutfy Boulos, 2/8/1952, Faculty of Agriculture, Giza, Egypt. M. I. Naguib, 19/11/1957, Sidi Mesri district 2 km. E. of Tripoli. Vivi Täckholm, 30/10/1959, Zohria Garden, Gezira, Cairo, Egypt. Abdel Aziz Hashem, 1963, Morocco. Mohamed El Mahdi, 17/7/1963, Orman Garden, Giza, Egypt. Mohamed El Mahdi, 31/7/1963, Agricultural Museum garden, Dokki, Giza, Egypt. Mohamed El Mahdi, 15/10/1963, Faculty of Pharmacy Garden, Boulaq Dakrou, Giza, Egypt. Mohamed El Mahdi, 8/4/1964, Agricultural Museum garden, Dokki, Giza, Egypt. Soliman Sisi, 6/5/1964, Faculty of Agriculture Garden, Giza, Egypt. Loutfy Boulos, 19/1/1967, Wadi El-Teir, Gebel Akhdar, 24 km W. Derna, along Coastal road to Susa, Lybia. Salah Eid, 20/8/1972, Gebel Akhdar near Derna, Libya. J. R. Edmondson, 23/3/1980, Wadi Hajar mts, Jabal Akhdar, Gorge of Wadi Bany Ghafir near Sidaq, Oman. Alaa El-Kady, 29/2/2016, Faculty of Pharmacy Garden, Al-Azhar University, Nasr City, Cairo, Egypt.

(Och elli) *Ochrosia elliptica* Labill.: Vivi Täckholm, 28/10/1959, Cairo University Garden, Giza, Egypt. Vivi Täckholm, 10/6/1960, Botanical Garden of El Saff, Egypt. Vivi Täckholm and Ibrahim Elsayed, 23/6/1961, Alfred Bircher's garden, El Saff, North eastern garden, Egypt. Vivi Täckholm and Ibrahim Elsayed, 14/11/1961, Bircher's garden, El Saff, North garden, Egypt. Vivi Täckholm and Ibrahim Elsayed, 28/11/1961, North garden Alfred Bircher's garden, El Saff, Egypt. Vivi Täckholm and Ibrahim Elsayed, 24/1/1962, west garden Alfred Bircher's garden, El Saff, Egypt. Mohamed El Mahdi, 14/4/1964, Plant Island, Assuan, Egypt. Mohamed El Mahdi, 20/10/1965, Plant Island, Assuan, Egypt. Mohamed El Mahdi, 23/5/1969, Plant Island, Assuan, Egypt. Ezz El Din, 20/6/1971, Faculty of Agriculture, Giza, Egypt. Ezz El Din, 3/8/1971, Faculty of Agriculture garden, Giza, Egypt.

(Plu rubr) *Plumeria rubra* L.: G. H. Runkewitz, 26/1/1938, Private Gardens, Luxor, Egypt. David Rayyis, August/1953, Gaza, Palestine. Vivi Täckholm, 28/10/1959, Cairo University garden, Giza, Egypt. Vivi Täckholm, 10/6/1960, Cultivated in Alfred Bircher's garden, El Saff, Egypt. Vivi Täckholm and Ibrahim Elsayed, 14/11/1961, North garden Alfred Bircher's garden, El Saff, Egypt.

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Mohamed El Mahdi, 21/8/1963, Zohria Garden, Gezira, Egypt. Mohamed El Mahdi, 24/10/1964, Agricultural Museum garden, Dokki, Giza, Egypt. Fathy Salem, 1/3/1970, Zohria Garden, Gezira, Egypt.

(Pot laxi) *Pottsia laxiflora* (Blume) Kuntze: J.W. Helfer, 1937, in Bengalia circa Calcuttam, India.

(Rau serp) *Rauwolfia serpentina* (L.) Benth. ex Kurz: M. Hassib, 29/11/1929 Zohria garden, Egypt. Mohamed El Mahdi, 15/10/1963, Faculty of Pharmacy Garden, Boulaq Dakrou, Giza, Egypt.

(Rau tetr) *Rauwolfia tetraphylla* L.: Mohamed El Mahdi, 15/10/1963, Faculty of Pharmacy Garden, Boulaq Dakrou, Giza, Egypt.

(Rha stri) *Rhazya stricta* Decne.: M. Towfik, 31/5/1936, Gebal El Mogash, Yemen. M. Towfik, 13/10/1936, Wadi Ankadoun, Hadramaut, Arabia. Hussein El Bably, January/1940, Masagid-El Hegaz. A. Khattab and J. R. Shabetai, 20/7/1944, Quba, Hedjaz. A. Khattab, 7/1/1945, Wadi Fatma, West Mecca, Saudi Arabia. Kamal Mustafa Ibrahim, Jan. /1964, East Taiz, Yemen. Kamal Mustafa Ibrahim, Jan. /1964, 30 km. west Taiz, Yemen. M. Saed El Naggar, March/1964, Wadi Hanifa near Riad, Saudi Arabia. Standing and A. Saleh, 5/March/1967, Near Badaya, South Arabia. No name, spring 1968, Hair, 30 km South of Riyadh, Saudi Arabia. Ali El Qasim and Ibrahim El Ghamdi, January/1970, Belad Ghamid, Saudi Arabia. Prof. Dr. A. M. Migahid, 27/2/1973, El-Jafi Valley, El-Dahna, Saudi Arabia. M. Fatahallah, 5/6/1974, Hadramout Valley. Mr. M. Sabery El-Sayed, 25/2/1975, Hanifa Valley, Saudi Arabia. A. M. Migahid, 10/6/1977, Wadi Shera, South-Western-Arabia. K. H. Batanouny, 30/3/1988, Near Riyadh, Saudi Arabia.

(Sab como) *Saba comorensis* (Bojer ex A.DC.) Pichon: Mohammed Drar, 12/4/1938, Kagalu, Bahr El Ghazal, Sudan. Mohammed Drar, 17/4/1938, Bahr El Ghazal, Road to Tambora, Sudan.

(Sch coff) *Schizogygia coffaeoides* Baill.: G. Massawe, 28/June/1999, Mang'ula Village, beside Chinese Water intake, Tanzania.

(Tab diva) *Tabernaemontana divaricata* (L.) R.Br. ex Roem. & Schult.: H. Runkewitz, 18/11/1933, Garden Sultana Palace, Luxor. Egypt. Vivi Täckholm, 2/11/1959, Faculty of Agriculture garden, Giza, Egypt. Vivi Täckholm and Ibrahim Elsayed, 1/6/1961, Alfred Bircher's garden, El Saff, Eastern garden, Egypt. Vivi Täckholm and Ibrahim Elsayed, 17/5/1962, Eastern garden, Alfred Bircher's garden, El Saff, Egypt. Mohamed El Mahdi, 17/7/1963, Orman Garden, Giza, Egypt. Mohamed El Mahdi, 7/8/1963, Zohria Garden, Gezira, Cairo, Egypt. Mohamed El Mahdi, 15/4/1964, Plant Island, Assuan, Egypt. Ezz El Din and Mohamed El Mahdi, 26/5/1968, Zohria Garden, Gezira, Egypt. Mohamed El Mahdi, 20/5/1969, Plant Island, Assuan, Egypt. Ezz El Din, 16/6/1969, Zohria Garden, Gezira, Egypt. Mohamed El Mahdi, 28/8/1973, Zoological Garden, Giza, Egypt.

(Tab gran) *Tabernaemontana grandiflora* Jacq.: M. Hassib, 22/12/1927, cultivated in the Higher School of Agriculture, Giza, Egypt. Vivi Täckholm and Ibrahim Elsayed, 8/1/1961, Barrage Medicinal Garden, Egypt. Vivi Täckholm and Ibrahim Elsayed, 14/11/1961, North garden, Alfred Bircher's garden, El Saff, Egypt.

(Tab vent) *Tabernaemontana ventricosa* Hochst. ex A.DC: A. S. Mkeya. 16 December 1999, Arusha National Park, Ngurdoto Forset near Ngurdoto Gate, Tanzania.

(Tra asia) *Trachelospermum asiaticum* (Siebold & Zucc.) Nakai: T. Nakaike, 13 Jun. 1970, Honshu. Pref., Shizuoka, Mt. Kanukiyam, Japan.

(Tra jasm) *Trachelospermum jasminoides* (Lindl.) Lem.: M. Hassib, 26/4/1928, Orman Garden, Giza, Egypt. Mohamed El Mahdi, 5/10/1963, Agricultural Museum Garden, Dokki, Giza, Egypt.

(Vin diff) *Vinca difformis* Pourr.: A. Faure., 6 Juin 1926, Talus de la route des Cascades, Tlemcen, Algeria.

(Vin herb) *Vinca herbacea* Waldst. & Kit.: V. Halacsy, No date, Simferopol., in collibus apricis prope coloniam Neusatz, Germany.

(Vin majo) *Vinca major* L.: A. F., 10/1922, Foret de m'sila, El Aneoz Jeres la Maison forestiere. Christina Brydolf, 13/3, 20 km. west Dyidyellia, Algasur.

(Vin mino) *Vinca minor* L.: C. Baenitz, 3/5/1909, Flora Silesiaca: Breslau; Gopperthain. Larissa Koock, May/1935, Odlad Dalbyo. M. Hassib, 1936, Cambridge. Hj. Hylander, 9/5/1936, Blehiuge, Gredby. Torvard Laurent, 16/8/1943, Mockleby, Öland, Sweden. Eric Albertshofer, no date, Germany.

(Wri arbo) *Wrightia arborea* (Dennst.) Mabb.: Mohamed El Mahdi, 16/6/1965, Zoological Garden, Giza, Egypt. Mohamed El Mahdi, 5/6/1968, Zoological Garden, Giza, Egypt.

(Wri cocc) *Wrightia coccinea* (Roxb. ex Hornem.) Sims: Ezz El Din, 13/6/1970, Zohria Garden, Gezira, Egypt.

2. The Asclepiadaceae

(Arau ser) *Araujia sericifera* Brot.: C. Baenitz, 27/4/1904, Flora Istriaca: Lussinpiccolo, in Bernhoffs Garten, Peru.

(Ascl amp) *Asclepias amplexicaulis* Sm.: David Castaner 2265, 29 May 1972, about 5.5 miles north of Warrensburg, Johnson County, Missouri, USA; Alma L. Moldenke and Harold N. Moldenke, 26 June 1974, Ocean County, New Jersey, USA.

(Ascl cur) *Asclepias curassavica* L.: Ahmed Ali Abd El Fadeel, 2/1/1953, cultivated in Farouk's Garden in Inshas, Egypt. Vivi Täckholm, 28/10/1959, Cairo University Garden, Giza, Egypt. Vivi Täckholm and Ibrahim Elsayed, 8/1/1961, Medicinal Garden, Barrage, Egypt. Soliman Sisi, 6/4/1961, Giza, Egypt. Mohamed El Mahdi, 21/9/1963, Faculty of Agriculture Garden, Giza, Egypt. Mohamed El Mahdi, 15/10/1963, Faculty of Pharmacy garden, Boulaq Dakrou, Giza, Egypt. Nabil El Hadidy, 26/8/1967, Canal bank at Maamoura, Alexandria. Adel El-Gazzar, 3/May/1975, Botanic Garden, Faculty of Science, Alexandria University, Moharram Bey, Alexandria, Egypt. Alma L. Moldenke and Harold N. Moldenke 29840, 19/May/1975, Bostwick, Putnam County, Florida, USA. Ramadan, 26/10/1976, Zamalek at the Nile, Egypt. Loutfy Boulos 16190, 28 September 1986, Agricultural Research Station at Omariya, Kuwait City.

(Ascl phi) *Asclepias phillipsiae* N.E. Br.: M. Kassas, M.D. El Khalifa and M.O. Mobarak 571, 18/12/1965, Toratong, Gebel Marra, Sudan.

(Ascl syr) *Asclepias syriaca* L.: Vivi Täckholm, 28/10/1959, Cairo University garden, Giza, Egypt.

(Ascl tub) *Asclepias tuberosa* L.: Alma L. Moldenke and Harold N. Moldenke 28611, 28/June/1974, Tabernacle, Burlington County, New Jersey, USA.

(Ascl ver) *Asclepias verticillata* L.: Andrew R. Moldenke and Harold N. Moldenke 27721, 14/August/1973, Sanders, Apache County, Arizona, USA.

(Blyt spi) *Blyttia spiralis* (Forssk.) D.V.Field & J.R.I.Wood: Gunnar Täckholm, 21/1/1929, at the Red Sea Coast, about 3 km N. of Mersa Halaib, Egypt. Gunnar Täckholm, 22/1/1929, in the Wadies W. of Mersa Halaib, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M.A. Zahran, 31/1/1962, old water reservoir at Suakin El Qadem, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M.A. Zahran, 7/2/1962, mouth of wadi Serimtai, Expedition to the Gebel Elba district, Egypt.

(Calo pro) *Calotropis procera* (Aiton): Dr. M. Helmy, 14/4/1927, Kharga Oasis, Egypt. Gunnar Täckholm, 16/1/1928, Kharga Oasis, near the town, Egypt. Nabil El Hadidy, Spring/1955, in the garden of Medicinal plants at Barrage, Egypt. Mostafa Imam, 11/9/1956, Suez Road, Egypt. Sami and William, 6/11/1959, along Suez Road, Egypt. M. Imam, 6/2/1959, Kharga Oasis, Boulaq, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W.A. Girgis and M.A. Zahran, 27/9/1960, Cairo-Suez Road on kilo 68-69 from Cairo, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W.A. Girgis and M.A. Zahran, 27/9/1960, Cairo-Ismailia Road, in the beginning near Suez, Egypt. Vivi Täckholm, M. Kassas, M.

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Samy, W.A. Girgis and M.A. Zahran, 14/10/1960, Wadi Foll at the Suez Road, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W.A. Girgis and M.A. Zahran, 30/12/1960, Cairo-Suez Road Wadi El Forn, Egypt. Vivi Täckholm and Ibrahim Elsayed, 8/1/1961, Medicinal Garden, Barrage, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W.A. Girgis and M.A. Zahran, 28/2/1961, Wadi el Gafra on Cairo-Suez Road, Egypt. S.I. Ghallowan, 3/3/1961, Cairo-Suez Road, km 90, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M.A. Zahran 397, 23/1/1962, Wadi Saremtai, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M.A. Zahran 1048, 28/1/1969, upstream part of Wadi Mawaw across Gebel Asotriba, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, 18/3/1966, Cairo-Suez Road at kilo 70 from Cairo, Egypt. Dale J. Osborn and Ibrahim Helmy, 21/10/1966, Bahariya Oasis, North edge of Mandisha sand dunes, Egypt. Dale J. Osborn and Ibrahim Helmy, 2/12/1966, El Maharik 17 miles NE of Kharga, Egypt. Dale J. Osborn and Ibrahim Helmy, 5/5/1969, El Alamona, North of Dakhla Oasis, Egypt. M. Imam, 15/9/1971, Baharia Oasis, El-Kasr, Ain Maroun, Egypt. Hadidy *et al.*, 20/4/1976, Cairo-Suez desert road, Egypt. Monier Abd El Ghani 65, 28/2/1978, Governmental Farm, Outside Farmland, Bahariya Oasis, Western Desert, Egypt. Monier Abd El Ghani 491, 17/7/1978, Bawiti, Ain Miftilla, Bahariya Oasis, Western Desert, Egypt. A. El Bakry 3165, 14/9/1981, Cairo-Ismailia desert road 10 km of Cairo, Egypt. L.M. Hassan 270, 15/3/1982, beginning of Idfu-Mersa Alam Road at 6 km, Egypt. Alaa El-Kady, 8/3/2016, At Biotechnology and Fermentation Research Center Garden, Al-Azhar University, Nasr City, Cairo, Egypt.; Alaa El-Kady, 29/2/2016, in front of Faculty of Pharmacy, Al-Azhar University, Nasr City, Cairo, Egypt. Alaa El-Kady, 22/4/2016, Ain Badr, Al-Harrah, Bahryia Oasis, Egypt. Alaa El-Kady, 28/4/2016, Wadi Feran, Saint Catherine, south Sinai, Egypt.

(Cara edu) *Caralluma edulis* (Edgew.) Benth. ex Hook.f.: M. Kassas, M.O. Mobarak and Hamad A. Omar 922, 21/12/1966, Bakiyai Islands (Aqiq), Red Sea, Sudan.

(Cara ret) *Caralluma retrospiciens* (Ehrenb.) N.E. Br.: Gunnar Täckholm, 23-27/January/1929, Gebel Elba, in the S. E. Corner of Egypt. M. Hassib, 18-25/1/1930, Gebel Elba, in the S. E. Corner of Egypt. M. Hassib, 1930, Gebel Elba, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M.A. Zahran 942, 28/1/1962, Wadi Mawaw, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 21/1/1962, Wadi Aideib, Expedition to the Gebel Elba district, Egypt.

(Cara sin) *Caralluma sinaica* (Decne.) A. Berger: A. Khattab and J.R. Shabetai F4648, 19/4/1945, Elmethnah, El Tayef, Hedjaz, Saudi Arabia.

(Cryp gra) *Cryptostegia grandiflora* Roxb. ex R. Br.: Loutfy Boulos, July 1952, in front of Faculty of Agriculture, Giza, Egypt. Vivi Täckholm, 28/10/1959, University Garden, Giza, Egypt. Vivi Täckholm and Ibrahim Elsayed, 8/1/1961, Barrage Medicinal Garden, Egypt. Mohamed El Mahdi, 17/7/1963, Orman Garden, Giza, Egypt. Mohamed El Mahdi, 22/5/1965, Cairo University Garden, Giza, Egypt. Mohamed El Mahdi, 24/10/1965, Plant Island, Assuan, Egypt. Mohamed El Mahdi, 21/5/1968, Barrage, Medicinal Garden, Egypt. Mohamed El Mahdi, 27/8/1973, Cairo University Garden, Giza, Egypt. Adel El-Gazzar, 13/7/1976, Zaafaran Palace garden, Ain Shams University, Abbassia, Cairo, Egypt.

(Cryp obl) *Cryptolepis oblongifolia* (Meisn.) Schltr.: J. Lewalle, 30/4/1967, Bujumbura, Kabezi, Burundi.

(Cyna acu) *Cynanchum acutum* L.: Evert Hartmann, 19/9/1910, Ghizeh near Cairo, Egypt. Prof. G. Runkewitz, 25/11/1934, Luxor, Egypt. A. Khattab & J.R. Shabetai K190, 16/2/1944, Djedda, El-Leith, Hedjaz, Saudi Arabia. Nabil El Hadidy, 28/8/1952, Faculty of Agriculture Farm, Alexandria University, Egypt. Nabil El Hadidy, Jan., 1953, Kom Aushim, near Faiyum, Egypt. Vivi Täckholm,

21/9/1959, Kom Aushim, Faiyum, Egypt. Loutfy Boulos, 15/7/1960, Kom Aushim, Faiyum, Egypt. M.A. Zahran and Boulos, 27/12/1969, Siwa Oasis, Egypt. Alaa Amer 11904, 16/7/1987, Behiera Province, Rosetta, Egypt. Alaa Amer 13742, 19/9/1987, Behiera Province, Rosetta, Egypt. Ramadan Bedair, 3/2014, Bahi El-Dien, Siwa Oasis, Egypt. Ramadan Bedair, 10/2014, Nejden, Siwa Oasis, Egypt. Alaa El-Kady, 8/3/2016, beside Faculty of Agriculture, Al-Azhar university, Nasr City, Cairo, Egypt. Alaa El-Kady, 21/4/2016, Ain Badr, Al-Harrah, Bahryia Oasis, Egypt. Alaa El-Kady, 29/4/2016, Wadi El-Arbaeen, Saint Catherine, south Sinai, Egypt.

(Cyna fru) *Cynanchum fruticosum* Decne.: A. Khattab and J.R. Shabetai, 16/2/1944, Djedda, El Leith, Hedjaz, Saudi Arabia. A. Khattab 1109, 13/1/1945, Mecca, Arafat, mount of Wadi No'man, Hedjaz, Saudi Arabia.

(Cyna lax) *Cynanchum laxum* Bartl.: Jos. Ullepitsch, June/1891, Zips, Wien, Austria.

(Cyna mos) *Cynanchum mossambicense* K. Schum.: *s.n.*, no date, Mozambique.

(Cyna sch) *Cynanchum schistoglossum* Schltr.: no name, 25/Janvier/1967, Plaine de la Rusizi, Bujumbura, Burundi.

(Cyna vim) *Cynanchum viminalis* (L.) L.: Mohamed Drar, 10/4/1938, Bahr El Ghazal, Way Goba to Yei, Sudan. M. Kassas, 8/1/1956, Khor Alent, Hill Side, Red Sea Hills, Sudan. M. Kassas, M.D. El Khalifa and M. O. Mobarak, 22/12/1965, Sunni, Sudan. M. Kassas, M.D. El Khalifa and M.O. Mobarak, 23/12/1965, Gebel Marra, Sudan. M. Kassas, M.O. Mobarak and Hamad A. Omar, 6/12/1966, Erkuut, Sudan. M. Kassas, M.O. Mobarak, B. Fadlallah, H.A. Omar and M. Osman, 27/12/1967, Ingassana-Eurmuk, Sudan.

(Dreg aby) *Dregea abyssinica* (Hochst.) K. Schum.: Mohamed Drar, 13/5/1938, Kurana, Gebel Marra, Darfur, Sudan. A. Khattab and J.R. Shabetai, 25/3/1944, Wadi Seham, Obal, Yemen. Refaat B. Salama and Staff, December/1970, Gebel El Nuba area, Sudan.

(Dreg sch) *Dregea schimperii* (Decne.) Bullock: M. Kassas, M.O. Mobarak and Hamad A. Omar, 6/12/1966, Erkuut, Sudan.

(Geni lau) *Genianthus laurifolius* (Roxb.) Hook. f.: Shocks Law, no Date.

(Geni mac) *Genianthus macrophyllus* (Blume) Boerl.: Dr. G. Kjellberg, 1929, no locality.

(Glos bov) *Glossonema boveanum* (Decne.) Decne.: Riad El Halwagy, 1959, Desert near Omdurman, Sudan. Kadry and Collaborators, 1961, Arabia. Kadry and Khodeir, Spring/1962, Arabia, Kharj Road.

(Glos nub) *Glossonema boveanum* subsp. *nubicum* (Decne.) Bullock: M. Hassib, 13/1/1930, Bir Abraq, Western Desert, Egypt. M. Hassib, 1/2/1933, Gebel Elba, Egypt. M. Hassib, 19/1/1933, Gebel Elba, Egypt. M. Kassas, 24/8/1954, J. Qunan Fattasha, Sudan. M. Kassas, 31/7/1954, Fattasha, Sudan. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 7/2/1961, Gabal Hamata, Red Sea Coast, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 11/2/1961, Gabal Um Gurdi, Red Sea, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 12/2/1961, Wadi El Faraied, Red Sea Coast, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 24/1/1962, El-Aaw Hill, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 24/1/1962, Wadi Shallal, Expedition to the Gebel Elba district, Egypt.

(Glos lin) *Glossonema lineare* (Fenzl) Decne.: Kamal Obeid, 28/9/1967, from J. Geili to Abu Zellig, Sudan.

(Glos var) *Glossonema varians* (Stocks) Benth. ex Hook. f.: Loutfy Boulos, 2/April/1977, Al Kharrarah and the area 5 km away towards the northeast, Miocene, Qatar. K.H. Batanoney, 18/1/1978, Qatar. K.H. Batanoney, 30/11/1978, Karrarah, Qatar.

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(Gomp fru) *Gomphocarpus fruticosus* (L.) W.T.Aiton: Vivian Holmén, 10/5/1965, cultivated in a garden, El Maadi, Egypt. Christina Brydolf, 13/2/1967, Thosy-Sakahara, S.W. Madagascar. **(Gomp sin)** *Gomphocarpus sinaicis* Boiss.: Alaa El-Kady, 29/4/2016, Wadi El-Arbaeen, Saint Catherine, south Sinai, Egypt. Alaa El-Kady, 29/4/2016, Hamatet Ebada, Saint Catherine, south Sinai, Egypt. Alaa El-Kady, 29/4/2016, Shak El-Gerageniah, Saint Catherine, south Sinai, Egypt. Alaa El-Kady, 30/4/2016, Wadi Faraah, Saint Catherine, south Sinai, Egypt. Alaa El-Kady, 30/4/2016, Shak Musa, Saint Catherine, south Sinai, Egypt. Alaa El-Kady, 1/5/2016, Gebel Musa, Saint Catherine, south Sinai, Egypt.

(Gymn syl) *Gymnema sylvestre* (Retz.) R.Br.: M. Kassas 85, 7/12/1965, Nyala, Darfur, Sudan. M. Kassas, M. O. Mobarak and Hamad A. Omar 1047, 25/12/1966, Jebel Dambobei-Karora, Sudan. J. Lewalle 1898, 30/4/1967, Kabezi, Bujumbura, Burundi.

(Hoya car) *Hoya carnosa* (L.f.) R.Br.: L. Zoleran, IV/1911, Süd China. Mervet Abdel Rihim, no date, Orman Garden, Egypt.

(Huer mac) *Huernia macrocarpa* N.E.Br.: M. Kassas 256, 21/12/1953, Erkuit, Sudan. M. Kassas, 8/4/1954, Jebel Nafi, Erkuit, Sudan. M. Kassas, 10/1/1956, Red Sea Hills, Sudan. M. Kassas, M. O. Mobarak and Hamad A. Omar 253, 8/12/1966, Jebel Erbab, Erkuit, Sudan. Refaat B. Salama and Staff, December/1970, Gebel El Nuba area (Diling, Kadugli, Hiban & Rashad), Sudan. Mrs. S.A. Robertson 1518, 16/5/1971, Kajiado Dist., on circular route to west of Ngong Hills, Kenya.

(Kana lan) *Kanahia laniflora* (Forssk.) R.Br.: Mohamed Drar, 25/2/1938, Khartoum at the Blue Nile, Sudan. M. Kassas 544, 15/7/1954, Nile Bank, Khartoum, Sudan. M. Kassas, M. O. Mobarak, B. Fadlallah, H. A. Omar and M. Osman, 28/12/1967, Kurmuk, Sudan.

(Lept arb) *Leptadenia arborea* (Forssk.) Schweinf.: Mohamed Drar, 14/3/1938, El Gash, Kassala, Sudan. Mohamed Drar, 19/3/1938, Umm Gaili, Sennar, Sudan. Mohamed Drar, 15/5/1938, Kabbeh, Gebel Marra, Sudan. M. Kassas, 10/8/1953, Enclosure in Khartoum, Sudan. M. Kassas, 15/1/1954, Khor Shuliat-Karai Hills, Sudan. Riad El-Halwagy, 1959, Desert N. E. of Kurmuk, Sudan. Samir I. Ghabbour, 7/4/1967, Dongola, Sudan. M. Kassas, M. O. Mobarak, B. Fadlallah, H. A. Omar and M. Osman, 7/12/1967, J. Avitola-K., Tagando, Sudan. M. Kassas, M. O. Mobarak, B. Fadlallah, H. A. Omar and M. Osman, 28/12/1967, Kurmuk, Sudan.

(Lept lan) *Leptadenia lancifolia* (Schumach. & Thonn.) Decne.: Mohamed Drar, 5/3/1938, Erkuit, Red Sea, Sudan. Mohamed Drar, 4/5/1938, Way Obaid to Nohoud, Kordofan, Sudan. Mohamed Drar, 28/4/1938, Tunga, Gebel Leir, Kordofan, Sudan. M. Kassas, 5/2/1954, Omdurman-Obeid Road, Sudan. M. Kassas, 6/2/1954, Merikueat, Sudan. Riad Halwagy, 1-3/Sept. /1960, Nile Island near Khartoum, Sudan. M. Kassas, M. D. El Khalifa and M. O. Mobarak, 25/12/1965, Fasher, Darfur, Sudan. M. Kassas, M. O. Mobarak and Hamad A. Omar, 25/12/1966, Jebel Dambobei-Karora, Sudan.

(Lept pyr) *Leptadenia pyrotechnica* (Forssk.) Decne.: M. Hassib, 11/1/1930, Wadi Kharit, Egypt. J. R. Shabetai and A. Khattab, 4/7/1932, Wadi Habib, Egypt. Vivi Täckholm, 25/4/1958, Wadi Aber of Gebel Ataqa, Suez, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 3/9/1960, 75 km. E. of Qena, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 21/1/1962, El-Aawayed Hill, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 8/2/1962, Wadi Aideib, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, W. A. Girgis and M. A. Zahran, 5/2/1964, Kom Ombo desert, Wadi Natash, Expedition to Nubia of the Nile, Egypt. Dale J. Osborn and Ibrahim Helmy, 11/2/1967, Wadi Hodein, Gabal Elba, Egypt. Dale J. Osborn and Ibrahim Helmy, 7/3/1967, Wadi Gemal, Red Sea Coast, Egypt. Kamal & Zahran, Sept. /1968, Thall, W. Pakistan. Hadidi *et al.*, 20/4/1976, Cairo-Suez desert Road, Egypt. A. El Bakry, 18/4/1980, Suez-

Sokhna desert Road, 43 km. S. of Suez, Egypt. M. N. El Hadidi *et al.*, 17/8/1982, Wadi Madsose, Sinai, Egypt. S. M. El Naggar, 22/5/1998, Wadi Khuda.

(Mars flo) *Marsdenia floribunda* (Brongn.) Schltr.: Mohamed El Mahdi, 12/12/1964, Agricultural Museum Garden, Dokki, Giza, Egypt. Ezz el Din, 5/7/1969, Zohria garden, Gezira, Egypt.

(Oxys bor) *Oxystelma bornouense* R. Br.: M. Kassas, December/1953, Khartoum Province, Sudan.

(Oxys esc) *Oxystelma esculentum* var. *alpini* (Decne.) N.E. Br.: Loutfy Boulos, 28/9/1953, Beni-Suef Station, Egypt. Loutfy Boulos, 28/9/1953, Beni-Suef Station, On Ibrahimia Eastern Bank, Egypt. Loutfy Boulos, 17/10/1956, on E. Nile Bank, Egypt. Bror Pettersson and Teuvo Ahti, 19/10/1962, Nile Delta, Prov. Giza, SE tip of the Island Gueziera, along Mountaza Street, along the Shore of the Nile, Egypt. Loutfy Boulos, 20/11/1963, Plant Island, Aswan, Egypt. Loutfy Boulos, 20/11/1963, Wadi Nile, Near Aga Khan Tomb, Aswan, Egypt. Abd El Sabur, J. Kohwra and J. Chlack, 18/4/1967, Nabatat Garden, Aswan.

(Pach exi) *Pachycarpus eximius* (Schltr.) Bullock: Ouplicafe, 21/11/1966. Herbar J. Lewalle, 21/Nov./1966, the de Nyanza Lac, Bujumbura, Burundi.

(Pent ins) *Pentarrhinum insipidum* E. Mey.: Mohammed Drar, 11/5/1938, Wadi Saria, Gabal Marra, Darfur, Sudan.

(Perg dae) *Pergularia daemia* (Forssk.) Chiov.: Gunnar Täckholm, 23-27/January/1929, wadi Kansisrob, Gebel Elba, in the S. E. Corner of Egypt. Dr. I. R. Fahmy and M. Hassib, 14/January-27/Feb./1933, Gebel Elba, in the S. E. Corner of Egypt. Loutfy Boulos, 24/October/1956, Wadi Kansisrob, G. Elba, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 22/1/1962, Wadi Aideib, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 24/1/1962, Gorge across the North-East Slope of Gebel Elba, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 27/1/1962, Wadi Oolak, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 28/1/1962, North-West and west Slope of Gebel Asortiba, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 3/2/1962, Bir Kansisrob, Expedition to the Gebel Elba district, Egypt. M. Kassas, M. O. Mobarak, B. Fadlallah, H. A. Omar and M. Osman, 28/22/1967, Kurmuk, Sudan. Nabil, Ibrahim, Sisi and Abdel Aziz, 29/6/1973, Cairo-Suez Road, Egypt.

(Perg tom) *Pergularia tomentosa* L.: Loutfy Boulos, 3/10/1952, Wadi Digla, Egypt. Fikry Ibrahim Francis, 20/10/1952, Wadi Hof, Egypt. Nabil, 25/1/1956, Suez desert Road, K. 34, Egypt. Vivi Täckholm, 9/2/1956, W. Qiseib, N. Galala, Egypt. Amal Amin and Sami Kenawi, 13/2/1956, Wadi Bukheit, Egypt. Mostafa Imam, 11/9/1956, Suez Road, Egypt. Botany Dept. Excursion, 2/12/1956, Gebel Ahmar. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 4/2/1960, Wadi Araba (between the two Galalas), Egypt. Vivi Täckholm, M. Kassas, M. Samy, W. A. Gigis and M. A. Zahran, 6/2/1960, Cretaceous foot hills of S. Galala, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 29/2/1960, Wadi Garawi, Helwan Desert, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 22/1/1962, Khor wadi Siamtit, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 27/1/1962, Wadi Oolak, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 27/1/1962, upstream part of wadi Sarimtai, Expedition to the Gebel Elba district, Egypt. Dale J. Osborn and Ibrahim Helmy, 29/3/1966, Wadi Dehmit, Bir Umm Hibal, Nubia. S. Soliman, No date, wadi Liblh.

(Peri aph) *Periploca aphylla* Decne. subsp. *aphylla*: Ahmed Khattab and J. R. Shabetai, 11/2/1945, El Adinih, Abar Ali and El Freish, Saudi Arabia. Ahmed Khattab and J. R. Shabetai, 22/5/1945,

Numerical re-assessment of the phenetic relationship

Gebal El Hoda, El Tayef, Hedjaz, Saudi Arabia. A. M. Migahid and Ali El Qasim, Spring/1970, El Mansouryeh, Saudi Arabia. A.M. Migahid and Ali El Qasim, spring/1970, Gebal Toweriq, Saudi Arabia. Yousif Al-Sewaidi, 5/3/1972, Salbok Highway, Saudi Arabia. Prof. Dr. A.M. Migahid, 16/2/1973, El-Dereieh and Hanifa Valley, Saudi Arabia. Prof. Dr. A. M. Migahid, 22/2/1974, Hanifa Valley. Prof. Dr. A. M. Migahid and M. Sabry Elsayed, 21/3/1975, Haa Valley, Saudi Arabia. A. M. Migahid, 10/3/1976, Haa Valley, Riyadh area, Saudi Arabia.

(Peri aph) *Periploca aphylla* Decne. subsp. *laxiflora* Browicz: Gunnar Täckholm, 23-27/January/1929, Gebel Elba, in the S. E. Corner of Egypt. M. Hassib, 18-25/1930, Gebel Elba, in the S. E. Corner of Egypt. I.R. Fahmy and M. Hassib, 17/1/1933, Gebel Elba, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 22/1/1962, Khor Wadi Yahameib, Expedition to the Gebel Elba district, Egypt. Vivi Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy and M. A. Zahran, 7/2/1962, Gebel Karma, Elba, Expedition to the Gebel Elba district, Egypt. K. H. Batanony, 9/3/1978, El Fareesh, Hedjaz, Saudi Arabia.

(Peri gra) *Periploca graeca* L.: C. Baenitz, 20/6/1911, Silesiaca: Bresian: Scheitinger Park. Adel El Gazzar, 8/8/1975, Öland, Sweden.

(Peri lae) *Periploca laevigata* Aiton: Abdel Aziz Hashem, October/1962, Rabat, Jardin J. D. C., Morocco. Loutfy Boulos, 19/1/1967, Wadi El-Teir, Gebel Akhder, c. 24 km. wadi Derna, along Coastal Road to Susa, Libya. Loutfy boulos, 31/3/1970, Wadi Derna, Libya.

(Peri ang) *Periploca laevigata* subsp. *angustifolia* (Labill.) Markgr.: M. Abdel Aleem, 23/4/2005, Wadi Knuda, Sallum area, Egypt. M. Abdel Aleem, 22/4/2006, Sallum-Barani Road, Egypt. M. Abdel Aleem, 22/4/2006, 20 km. before Sallum, Egypt.

(Peri lin) *Periploca linearifolia* Quart.-Dill. & A. Rich.: Herbier J. Lewalle, 19/Juin/1971, Muramura, Bukeye, Mt Teza.

(Perv tom) *Pervillaea tomentosa* Decne.: Karl Afzelius, 30/3/1912, Majeuga.

(Pleu sch) *Pleurostelma schimperi* (Vatke) Liede: Mohamed Drar, 3/8/1938, Suikat, Red Sea Hills, Sudan. M. Kassas, 22/12/1953, Suikat, Erkuit Plain, Sudan. M. Kassas, 24/12/1954, Khor Abent, Suakin, Sudan. M. Kassas, 7/1/1956, Khor Abent (Jebel Slope) Red Sea Hills, Sudan. M. Kassas, M. O. Mobarak and Hamad A. Omar, 5/12/1966, Sinkat, Erkuit, Sudan. M. Kassas, M. O. Mobarak and Hamad A. Omar, 7/12/1966, Erkuit, Sudan. M. Kassas, M. O. Mobarak and Hamad A. Omar, 8/12/1966, Erkuit (Khem Amat), Sudan. M. Kassas, M. O. Mobarak and Hamad A. Omar, 23/12/1966, Jebal Wad Noboo, Red Sea, Sudan.

(Seca afr) *Secamone africana* (Oliv.) Bullock: R. B. Drummond and J. H. Hemsely, 28/9/1953, West Bugwe Forest Reserve, Busia-Bugiri Road, Busoga District.

(Seca afz) *Secamone afzelii* (Roem. & Schult.) K. Schum.: G. Zenker, 1913, Bipinde, Urwaldgebiet, Kamerun. F.A. Melville and T. Hooker, 15/Aug./1958, Kortright-Klasy Kreek, footpath downhill, Scrambling over 10 ft.

(Seca alp) *Secamone alpini* Schult.: J. B. Kelleet, 3/12/1952, no locality.

(Seca ell) *Secamone elliptica* R. Br.: H. A. Longman, 1911, 5/Jun./1927, Kaw Somani, Kenwensi.

(Seca min) *Secamone elliptica* subsp. *minutiflora* (Woodson) Klack.: Albert N. Steward and H. C. Cheo, 17/7/1933, Valley on Rocks, China.

(Seca eme) *Secamone emetica* (Retz.) R. Br. ex Schult.: C.S. Venkatesh, 11/June/1944, Yeswantakur, Bangalore.

(Seca fru) *Secamone frutescens* (E. Mey.) Decne.: R. O. Strey, 27/1/1967, Dukuduka, S. Africa.

(Sec ager) *Secamone gerrardii* Harv. ex Benth.: R. H. Comptow, 21/10/1958, Swaziland.

- (Seca myr)** *Secamone myriantha* K.Schum.: Zenker, no Date, Yanunde, Urwaldgebiet, Kamerun.
- (Seca par)** *Secamone parvifolia* Bullock: A. D. J. Meeuse, 18/10/1957, Transvaal. P.K. Rwaburindore, 16/March/1999, Buhweju Country, Bushenyi, Ankol District, Rugongo.
- (Seca ret)** *Secamone retusa* N.E. Br.: H. G., 1940, no locality.
- (Seca urd)** *Secamone urdanetensis* Elmer: A.D.E. Elmer, August /1912, Island of Mindanao, Philippine.
- (Seca zam)** *Secamone zambesiaca* Schltr.: N.C. Chase, 20/12/1947, Umvumvumu R., Salisbury Zimbabwe.
- (Sole arg)** *Solenostemma argel* (Delile) Hayne: G. H. Runkewitz, 15/12/1936, Bir Umm Deffa, near G. Schavib. A. Khattab, 17/2/1945, Bir Owa, Wady el Akik Madiena, Saudi Arabia. A. Khattab, 17/2/1945, El Madinah, Between Ebiar Ali and Orwa well, Saudi Arabia. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 10/2/1960, Bir Umm Dalfa of Gebel Shayeb, near Hurghada, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W. A. Gigis and M. A. Zahran, 19/2/1960, Wadi Umm Sidr, Hurghada District, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 10/2/1961, 196 km. E. of Edfu, Egypt. Vivi Täckholm, M. Kassas, M. Samy, W. A. Girgis and M. A. Zahran, 14/2/1961, Bir Umm Dalfa near Hurghada, Red Sea Coast, Egypt. Vivi Täckholm, M. Kassas, W. A. Girgis and M. A. Zahran, 21/1/1963, wadi at the feet of Gebel Muqsim, Expedition to Nubia east of the Nile, Egypt. M. A. Zahran, W. A. Girgis, 23/10/1963, Edfu-Mersa Alam Road, Egypt. Ibrahim El Garf, 26/4/1995, slopes of Gebel El Shayeb, Egypt. A. Hegazy, M. Soliman and A. El Khateeb, March/2006, Gebel El Dokhan, Egypt.
- (Sole ole)** *Solenostemma oleifolium* (Neck.) Bullock & E.A.Bruce: D. Podlech, 17/3/1980, Wilaya Ouargla, Tassili, N. Ajjer, 10 km. W Djanet an der Piste nach Fort Gardel (Zaouatallaz), Algerien. D. Podlech, 22/3/1980, Wilaya Tamanrasset, Hoggar massif, 28 km. W Hirafok an der Piste nach Anguel, Algerien. D. Podlech, 26/3/1980, Wilaya Tamanrasset, 7 km. N Djanet in Sekket an der Strasse von Tamanrasset nach Ain Salah, Algerien. M. N. El Hadidi *et al*, 8/5/1982, Sant Kathrina, Sinai, Egypt. M. N. El Hadidi *et al*, 18/8/1982, Sharm El Sheik, Wadi Malg, Sinai, Egypt.
- (Stre juv)** *Streptocaulon juvenas* (Lour.) Merr.: J. W. Helfer, 1937, no locality.
- (Taca ven)** *Tacazzea venosa* Decne.: M. Kassas, M. O. Mobarak, B. Fadlallah, H. A. Omar and M. Osman, 19/12/1967, Doka-Gallabat, Sudan. M. Kassas, M. O. Mobarak, B. Fadlallah, H. A. Omar and M. Osman, 21/12/1967, Doka-Gallabat, Sudan.
- (Toxo kle)** *Toxocarpus kleinii* Wight & Arn.: No data.
- (Toxo mer)** *Toxocarpus merrillii* Schltr.: no Name, June-July/1917, Philippine.
- (Toxo sor)** *Toxocarpus sorsogonensis* Elmer: no Name, September/1916, Island of Luzon, Philippine.
- (Toxo vil)** *Toxocarpus villosus* (Blume) Decne.: Dr. A.F. G. Kerr, 18/Dec./1924, Tameen, .
- (Toxo wig)** *Toxocarpus wightianus* Hook. & Arn.: Fourth Hainan Expedition of Sun Yatsen University, 2/sept./1933, Hainan, China. Shiu Ying Hu, 10/July/1970, Shek Kong, Hong Kong.
- (Vinc hir)** *Vincetoxicum hirundinaria* Medik.: Carl Johan, 20/6/1918. Hildesheiru, Mai/1925, Hirundinariae. Larissa Kooock, 2/8/1930, Stenig Backe, Vedavåg, Sweden. H. J. Hylander, 2/7/1935, Sweden. Torvard Laurent, 17/8/1943, Hornsjon, Öland, Sweden. Loutfy Boulos, 10/8/1958, Ramsholmen, Trosa Archipelago, Sweden. No Name, 6/6/1968, Zebegny, Hungary. Elsa Johansson, no Date, Sweden. David J. Goyder and Stephen L. Jury, 1/Aug./1982, Spain. D. J. N. Hind, 21/June/1983, Italy.
- (Vinc nig)** *Vincetoxicum nigrum* (L.) Moench: F.V. Ranzoni, 28/May/1962, at edge of angiosperm woods at Vassar College, New York, USA. A. Raimundo et J.A. Guerra 5060, 22/7/1960, Alto Alentejo, Sierra d'Casa, Spain. J. C. Ledoux, 16/4/1974, France.