



## Re-assessment of the near-endemic taxa in the Egyptian Flora

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### Abstract

This paper aims to answer the following questions: 1- what is the actual number of near-endemic taxa in the Egyptian flora?, 2- what are the reasons and justifications for addition or exclusion of plants to or from the final list of near-endemic taxa?, 3- what are the conservation categories of near-endemic taxa according to IUCN?, 4- How can we make a red list of these taxa?, 5- what are the services and goods offered by near-endemic taxa?, and 6- what are the threats that impact these taxa most?. These aims are achieved through preparing a recent list for the near-endemic taxa and their habitats in the Egyptian flora. The lists were analyzed in terms of taxonomic diversity, life and sex forms, size structure, flowering activity, dispersal types, economic potential, threats and national floristic distribution, and IUCN categories. The total number of near-endemic taxa in the prepared recent list is 73, belonging to 58 genera and 28 families; and were recorded in 11 habitats. The life form represented most is the therophytes while the ballochores and pogonochores are the most represented dispersal types. There was a gradual increase in the frequency of the flowered taxa until reaching a maximum value from March to May, and then decreased again reaching a minimum value from August to January. Near endemics are distributed in Egypt and adjacent countries as follows: 39 taxa with Palestine, 19 with Libya, 8 with Saudi Arabia, 4 with Sudan, 2 with Jordan, and only one with Lebanon. Fifty-one taxa had a distribution in only one phyto-geographical region, while the remaining taxa had a distribution in two or more regions. All near-endemic taxa have at least one aspect of economic goods and exposed to at least one type of threats, where the most represented good was the medicinal uses, while over-collecting and over-cutting were the most represented threats. In this paper, 30 near-endemics were evaluated according to IUCN categories as follows: 12 endangered, 5 critically endangered, 4 extinct and 1 vulnerable, while 8 species are data deficient. In addition, 36 near-endemics were also evaluated in previous studies according to IUCN categories as follows: 15 endangered, 11 critically endangered, 7 vulnerable, 2 rare and 1 least concern.

**Key words:** Endemism, Egyptian Flora, Near-endemics, Biodiversity, Conservation, IUCN categories.

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### Introduction

From a bio-geographical view point, endemism is the restriction of the natural range of a taxon to a defined geographical distribution or habitat type (Anderson 1994 and Gaston 1994); with either political boundaries of a country (endemics), or eco-geographical boundaries of two or more countries regardless of their political boundaries (near- endemics), however the narrow-distributed taxa are called steno-endemics (Gaston 1994) or steno- near endemics. Apart from the loss of natural habitats and climatic changes, the excessive human activities (e.g. over exploitation) may generally make endemics and near-endemics to become extinct taxa (Thomas *et al.* 2004). Also, some important natural threats were

recorded such as the aridity of the area with very scarce precipitation year round (Thomas *l.c.*). Human impacts, animal grazing, and traditional plant collection for medicinal uses, further intensify the natural threats of aridity and fragmentation, thus pushing these taxa to the extinction (Zaghloul *et al.* 2006 and Mansour *et al.* 2013). In the recent centuries, the rate of extinction has been accelerated, causing hundreds or perhaps thousands of species, subspecies and varieties to become extinct every year (Cunningham and Cunningham 1997).

Egypt lies in the northeastern part of Africa and extends to Asia (Sinai Peninsula). According to Wickens (1992), Egypt is perhaps the most arid country in North Africa

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in which desert conditions prevail throughout the country. Egypt contains four main geographical regions: Western Desert including the Mediterranean coastal belt (681,000 km<sup>2</sup>), Eastern Desert (223,000 km<sup>2</sup>), Nile Land (25,000 km<sup>2</sup>) and Sinai Peninsula (61,000 km<sup>2</sup>). The Nile Land includes several islands in the main stream of the River and its Delta branches. Fayium depression (1700 km<sup>2</sup>) is connected to the Nile region by a principal irrigation canal called Youssef Sea (Zahran and Willis 2009).

Boulos (2009) reported that the near-endemic taxa in Egypt are 93, while Hosni *et al.* (2013) reduced them to 61. Many studies have been carried out to provide a conservation assessment for different plant species. Although many conservation studies have taken place in Egypt for sometimes, yet there is a lack of comprehensive information on species distribution and recent IUCN categories (Hosni *et al.* 2013). IUCN (1998) listed 82 threatened species in Egypt of which two are extinct and 19 endangered. Following IUCN (1994) categories, El-Hadidi and Hosni (2000) provided a list of 457 threatened species in the Egyptian flora; however, most of these studies did not apply the appropriate criteria used to evaluate species conservation status (Hosni *et al.* 2013). Because of the continuing decline of plant diversity, many initiatives have developed over recent decades for conservation of the most threatened diversity (Mace *et al.* 2008, Jetz and Freckleton 2015 and Maes *et al.* 2015). The IUCN red list of threatened species is widely recognized as the most objective approach for evaluating the conservation status of species and categorizing them according to their estimated risk of extinction (e.g. Mace *et al.* 2008, Jetz and Freckleton 2015 and Maes *et al.* 2015). The IUCN red list uses criteria with quantitative thresholds based on population size, rate of decline, and area of distribution to

assign species to categories of relative extinction risk, ranging from least concern, through near threatened, vulnerable, endangered and critically endangered to extinct in the wild and extinct (IUCN 2001). Traditionally, IUCN red list has served not only to highlight species at greatest risk of extinction, but also to guide conservation responses, primarily by identifying key and priority habitats for species, sites to be safeguarded, and actions required (Collar 1993–1994, 1996).

Near-endemics are considered as taxa restricted to Egypt and a neighboring country (Boulos 2009). They are important components in the flora of most regions of the world. Most of these species have become exposed to extinction within the last years as a result of a lot of reasons such as environmental conditions and human activities. Extinction of these species is considered as a major threat to biodiversity, therefore, there is an urgent need to study these species in the Egyptian flora and evaluate them according to IUCN categories, and to prepare conservation strategy for them. This paper aims at: 1- preparing a recent list for the near-endemic species in the Egyptian flora, 2- reporting the reasons and justifications for addition or exclusion of plants to or from the final list of near-endemic species, 3- determining the conservation categories of near-endemic taxa according to IUCN, 4- preparing a red list of these taxa, 5- recording the services and goods offered by the near-endemics, and 6- determining threats that impact these taxa.

### **Material and Methods**

Ten field visits were conducted during summer 2015 to spring 2018 to many locations all over Egypt including Saint-Catherine, Matrouh, Alexandria, Aswan and Assiut for collecting the near-endemic taxa in Egypt as live material or from herbaria. The available

information and data such as: main habitats, coordinates, uses and threats for taxa were recorded through visiting different sites. Other information was collected from the herbaria of Cairo University (CAI), Tanta University (TANE), Agriculture Museum (CAIM), Aswan University (ASW), Assiut University (ASTU) and Alexandria University (ALEX). In each location, specimens of plant taxa were collected from different sites, and seed samples representing the recorded taxa were also collected as can as possible. Other notifications were taken into account, if possible, such as sex form, size structure, life form, flowering time and dispersal type of diaspores. Other information was collected from the herbaria of Cairo University (CAI), Tanta University (TANE), Agriculture Museum (CAIM), Aswan University (ASW), Assiut University (ASTU) and Alexandria University (ALEX). Information from the available literature (papers, books, M. Sc. and Ph.D. Theses, and scientific reports) was also taken into consideration.

A recent checklist including 73 near-endemics arranged alphanetically according to LAPG III (The Linear Angiosperm Phylogeny group) system (Haston *et al.* 2009) and based on literature and database reviews. These resources include previous floras and available literature (Täckholm *et al.* 1941, Täckholm and Drar 1950, 1969, Andrews 1950- 1956, Townsed and Guest 1966- 1980, Zohary 1966, 1987, Davis *et al.* 1972-1982, Täckholm 1956,1974, Jafri and El-Gadi 1977-1988, Feinbrun-Dothan 1978, 1986, Collenette 1985,1999, Migahid 1988- 1990, Boulos 1999-2009, El-Hadidi and Hosni 2000, Ahmed 2009, Shaltout *et al.* 2010, and Ibrahim *et al.* 2016). The following websites were also consulted to collect more information about the recorded plants:

- 1- Euro +Med plant base (<http://ww2.bgbm.org/EuroPlusMed/query.asp>).
- 2- Kew world checklist of different plant families (<http://wcsp.science.kew.org>).
- 3- International Plant Name Index (IPNI; <http://www.ipni.org>).
- 4- The Plant List (<http://www.theplantlist.org>).
- 5- Plants of the World Online-Kew Science (<http://www.plantsoftheworldonline.org>).
- 6- Catalogue of Life (<http://www.catalogueoflife.org/annual-checklist/2010>).
- 7- Tropicos (<http://www.tropicos.prg/Home.aspx>).
- 8- Global Biodiversity Information Facility (GBIF; <http://www.gbif.org/occurrence>).
- 9- African Plant database (<http://www.village.ch/musinfo/bd/cjb/africa>).
- 10- JSTOR Global Plant Science (<http://plants.jstore.org>).

Following Boulos (2009), the near-endemic taxa are those restricted to Egypt and only an adjacent country. Identification of plant specimens was carried out depending on the previous mentioned literature. Some identifications were revised in TANE based on the available authentic materials. Voucher specimens were deposited in TANE and Kafr El-Sheikh University Herbaria. The phyto-geographical regions of the studied species were recorded according to those proposed by Boulos (2009). Dispersal type of the recorded taxa was assessed using the system of Dansereau and Lems (1957), while life forms were assessed using the system of Raunkiaer (1937). A theoretical framework of an eight-celled table is proposed by Rabinowitz (1981) for the different types of rarity depending on range, habitat specificity and local abundance.

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Assessment of the near-endemic taxa in Egypt included in the list prepared in the present study is based on IUCN categories (IUCN 2003). According to further revisions published by IUCN (2003), there are three principle categories for species at high risk of extinction: critically endangered, endangered and vulnerable. Species are assigned to a category if they meet the appropriate quantitative threshold for at least one of five criteria. There are four criteria which are based on the size and the rate of decline of the population and/ or geographical range, with the fifth related to quantitative models of extinction risk such as population viability analyses (Butchart *et al.* 2004). The evaluation process includes three steps: 1- previously prepared list by IUCN (1998) modified in 2013, 2014 and 2017 (Hosni *et al.* 2013, Omar 2014-2017); 2- previously prepared list by El-Hadidi and Hosni (2000); and 3- the present list based on the recent data and the Geocat software (<http://www.geocat.Kew.org>). The present study depended on the criterion B which is concerned with geographic range in the form of either extent of occurrence (EOO) or area of occupancy (AOO). Calculations of both AOO and EOO and assessment process were carried out using the Geocat software, with the appropriate category depending on the different coordinates of plants.

### Results

The present list of near-endemic species in the Egyptian flora included 73 near-endemic taxa (73 species, 5 subspecies and 8 varieties) belonging to 58 genera and 28 families (**Table 1**). The most represented genera among the

near-endemics are *Bellevalia* and *Allium* (4 taxa for each). Monocotyledons are represented by 12 species and 2 subspecies belonging to 7 genera and 6 families. The families represented most are Asparagaceae (6 taxa), followed by Amaryllidaceae (4 taxa). In addition, 22 dicotyledonous families are represented. The families represented most are Fabaceae, Asteraceae (8 taxa each), followed by Apiaceae, Scrophulariaceae (5 taxa each), and Lamiaceae (4 taxa). Near-endemic taxa are distributed in the neighboring countries as follows: 39 taxa with Palestine, 19 taxa with Libya, 8 taxa with Saudi Arabia, 4 taxa with Sudan, 2 taxa with Jordan and 1 taxon with Lebanon. The variation of the recorded taxa according to their habitats revealed that the rocky surfaces and sandy formations are the richest in terms of varieties, sub-species, species, and families (**Table 2**). The relation between the frequencies of the near-endemic taxa in the Egyptian flora in relation to the number of the habitats in which they occur approximates an inverse J-shape distribution (**Fig. 1**).

There is a gradual decrease of the taxa frequency with the increase of the number of habitats, starting with the taxa that occur in one habitat (44 taxa = 60.3 %), and ending with those in four habitats (only one taxon: *Carduncellus mareoticus*).

The determination of the life forms indicated that the therophytes are the most represented (24 taxa = 32.9 % of the total taxa), followed by chamaephytes (20 taxa = 27.4 %) and hemicryptophytes (12 taxa = 16.4 %) (**Fig. 2**).

**Table 1.** Characteristics of the near-endemic taxa in the Egyptian Flora. The phytogeographical regions are abbreviated as follows: N: Nile region, O: Oases of the western desert, M: Mediterranean coastal region, D: All deserts of Egypt except that of Sinai, De: Desert east of the Nile, Dw: Desert west of the Nile, R: Red Sea region, GE: Gebel Elba region and S: Sinai Peninsula. The dispersal types are coded as follows: Bal: balochore, Pog: pogonochore, Des: desmochore, Pte: pterochore, Mic: microsclerochore and Sac: sarchochore. The life forms are coded as follows: GH; geophyte-helophyte, Ge: geophyte, Th: therophyte, Ch: chaemaphyte, Ph: phanerophyte and Hi: hemicryptophyte, \*: refers to endemic plants transferred to near endemic plants in the present study. The habitats are coded as follows: BW: banks of water bodies, PDW: desert plains, depressions and wadis, SF: sandy formations, AL: alluvial soils, CF: cultivated fields, MH: mountains and hills, RF: rocky surfaces, WS: well sides, RS: roadsides, CG: calcereous ground and FW: Fallow fields and waste ground.

Taxa	Life form	Dispersal type	Geographic distribution	Neighboring country	Flowering time	Habitat
<b>Amaranthaceae</b>						
1- <i>Haloxylon negevensis</i> (Iljin & Zohary) Boulos	Hi	Pog.	S	Palestine	Sep-Dec	RF
2- <i>Anabasis syriaca</i> Iljin var. <i>syriaca</i>	Ch	Pog.	S	Libya	Oct-Nov	RF, PDW
<b>Amaryllidaceae</b>						
3- <i>Allium barthianum</i> Asch. & Schweinf.	GH	Bal.	M	Libya	Mar- May	RF
4- <i>Allium crameri</i> Bornm. & Gauba *	GH	Bal.	De, S	Palestine	Mar- Apr	RF, SF
5- <i>Allium stamineum</i> Boiss. subsp. <i>decaisnei</i> (C. Presl) Kollmann	GH	Bal.	S	Palestine	Feb- Mar	RF
6- <i>Allium tel-avivense</i> Eig	Ge	Bal.	M, De, S	Palestine	Feb.- Mar	CG, MH, RF
<b>Anacardiaceae</b>						
7- <i>Pistacia khinjuk</i> Stocks var. <i>microphylla</i> Boiss.	Ph	Sar.	De	Saudi Arabia	Mar- Apr	MH
<b>Apiaceae (Umbelliferae)</b>						
8- <i>Bupleurum nanum</i> Poir.	Th	Mic.	M	Libya	Feb- May	RF
9- <i>Ducrosia ismaelis</i> Asch.	Hi	Pog.	O	Saudi Arabia	-	CF
10- <i>Ferula marmarica</i> Asch. & Taub.	Ch	Pte.	M, Dw	Libya	Feb- Apr	RF
11- <i>Pimpinella etabica</i> Schweinf.	Th	Pog.	GE	Sudan	Sep- Dec	CF
12- <i>Pycnocycla tomentosa</i> Decne.	Hi	Pog.	S	Saudi Arabia	Mar- June	RF
<b>Araceae</b>						
13- <i>Biarum oliveri</i> Blume	GH	-	M, S	Palestine	Nov- Dec	SF
<b>Arecaceae</b>						
14- <i>Medemia argun</i> (Mart.) Wuttemb. ex H. Wendl.	Ph	Bar.	O	Sudan	-	SF
<b>Asparagaceae</b>						
15- <i>Bellevalia desertorum</i> Eig & Feinbrun	Ge	Pte.	S	Palestine	March- Dec	SF
16- <i>Bellevalia eigii</i> Feinbrun	GH	Mic.	M, S	Palestine	Feb- Apr	CG
17- <i>Bellevalia sessiliflora</i> (Viv.) Kunth	GH	Bal.	M	Libya	Feb- Apr	SF, CF
18- <i>Bellevalia zoharyi</i> Feinbrun	GH	Bal.	S	Palestine	Mar- Apr	RF
19- <i>Leopoldia eburnea</i> Eig & Feinbrun	Ge	Mic.	DW, S	Palestine	Feb- Mar	SF
20- <i>Leopoldia longipes</i> (Boiss.) Losinsk. subsp. <i>negevensis</i> Feinbrun & Danin	Ge	Mic.	S	Palestine	Mar- May	RF
<b>Asteraceae (Compositae)</b>						
21- <i>Atractylis boulosii</i> Täckh.	Th	Des.	S	Palestine	Apr- Dec	SF

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Table 1. Cont. 1

Taxa	Life form	Dispersal type	Geographic distribution	Neighboring country	Flowering time	Habitat
22- <i>Carduncellus mareoticus</i> (Delile) Hanelt	Ch	Des.	M, DW	Libya	Mar- Apr	Sf, CG, RS, FW
23- <i>Carthamus glaucus</i> M. Bieb. subsp. <i>alexandrinum</i> (Boiss. & Helder) Hanelt	Th	Pte.	M	Libya	May- Aug	RS, FW
24- <i>Centaurea glomerata</i> Vahl	Th	Pog.	M	Libya	Mar- May	CF, RS
25- <i>Crepis libyca</i> (Pamp.) Shab.	Hi	Pog.	M	Libya	Apr- May	CF
26- <i>Phagnalon sinaicum</i> Bornm. & Kneuck.	Ch	Des.	S	Saudi Arabia	Mar- Apr	RF
27- <i>Picris sulphurea</i> Delile	Th	Des.	N, O, D, S	Saudi Arabia	Mar- May	SF, PDW
28- <i>Scorzonera drarii</i> Täckh. *	Hi	Des.	S	Palestine	Mar- May	CF
<b>Boraginaceae</b>						
29- <i>Nonea vivianii</i> A. DC.	Th	Pog.	M, S	Libya	Mar- April	SF, CG, R
30- <i>Podonosoma galalensis</i> Schweinf. ex Boiss.	Th	Mic.	De	Palestine	Feb- June	CG, RF
<b>Brassicaceae (Cruciferae)</b>						
31- <i>Enarthrocarpus pterocarpus</i> (Pers.) DC.	Th	Pte.	M, S	Libya	Feb- May	CF
32- <i>Isatis microcarpa</i> Gay var. <i>blephrocarpus</i> Asch.	Th	Pte.	S	Palestine	Mar-Apr	PDW, R
<b>Caprifoliaceae</b>						
33- <i>Pterocephalus arabicus</i> Boiss. *	Ch	Pog.	S	Jordan	Apr- May	RF
<b>Caryophyllaceae</b>						
34- <i>Herinaria cyrenaica</i> F. Herm.	Hi	Mic.	M	Libya	Mar- Dec	RF
35- <i>Minuartia picta</i> (Sibth. & Sm.) Bornm. var. <i>sinaica</i> (Boiss.) Bornm.	Th	Bal.	S	Palestine	Feb- May	RF
36- <i>Pterohagia arabica</i> (Boiss.) P.W. Ball & Heywood	Th	Bal.	S	Palestine	Apr- May	RF
37- <i>Silene biappendiculata</i> Rohrb var. <i>biappendiculata</i>	Th	Pog.	M, S	Libya	Feb- May	RF
<b>Cistaceae</b>						
38- <i>Helianthemum sphaerocalyx</i> Gauba & Janch.	Ch	Pog.	M	Libya	Feb- Apr	RF
<b>Colchicaceae</b>						
39- <i>Colchicum cornigerum</i> (Schweinf. ex Sickneb.) Täckh. & Drar *	Ge	Bal.	De, S	Saudi Arabia	Nov- Dec	SF, RF
<b>Convolvulaceae</b>						
40- <i>Convolvulus schimperi</i> Boiss.	Hi	Bal.	S	Saudi Arabia	Mar- June	SF, PDW
41- <i>Convolvulus spicatus</i> Haillier f.	Hi	Bal.	S	Palestine	Mar- June	SF, PDW
<b>Fabaceae (Leguminosae)</b>						
42- <i>Astragalus amalecitanus</i> Boiss.	Hi	Pog.	S	Palestine	Mar- Apr	PDW
43- <i>Astragalus camelroum</i> Barbey *	Hi	Pog.	S	Palestine	Mar- June	SF, RF
44- <i>Ebenus armitagei</i> Schweinf. & Taub.	Ch	Pog.	M	Libya	Feb- May	RF
45- <i>Lotus nubicus</i> Baker	Th	Mic.	R, GE	Sudan	-	SF, PDW
46- <i>Lupinus digitatus</i> Forssk. *	Th	Pte.	N, D	Lebanon	Feb- Apr	SF, FW
47- <i>Lupinus palaestinus</i> Boiss.	Th	Pte.	S	Palestine	Feb- Apr	SF, AL
48- <i>Tephrosia purpurea</i> (L.) Pers. subsp. <i>apollinea</i> (Delile) Hosni & El- Karemy	Ch	Pog.	N, De, R, GE	Sudan	Feb- Apr	BW, PDW
49- <i>Trifolium philistaeum</i> Zohary	Th	Mic.	S	Palestine	Mar- May	SF, PDW
<b>Fumariaceae</b>						
50- <i>Hypecoum aegyptiacum</i> (Forssk.) Asch. & Schweinf.	Th	Sar.	N, M, S	Palestine	Mar- Apr	SF
51- <i>Hypecoum aequilobum</i> Viv.	Th	Sar.	M, S	Libya	Mar- Apr	SF
<b>Gentianaceae</b>						
52- <i>Centaurium malzacianum</i> Maire	Th	Bal.	S	Saudi Arabia	Apr- May	RF
<b>Hydrocharitaceae (Valerianaceae)</b>						
53- <i>Valerianella pterovitchii</i> Asch.	Th	Des.	M	Libya	Mar- Apr	SF

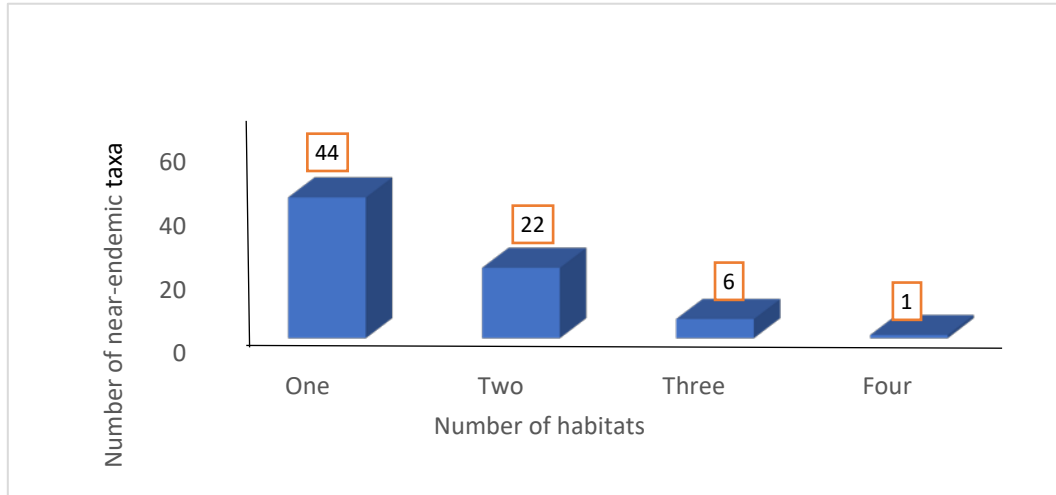
Table 1. Cont. 2

Taxa	Life form	Dispersal type	Geographic distribution	Neighboring country	Flowering time	Habitat
<b>Iridaceae</b>						
54- <i>Iris mariae</i> Barbey	Ge	Bal.	S	Palestine	Feb- Mar	SF
<b>Lamiaceae (Labiatae)</b>						
55- <i>Micromeria sinaica</i> Benth.	Ch	Mic.	S	Palestine	Mar- May	RF
56- <i>Origanum isthmicum</i> Danin	Ch	Mic.	S	Palestine	Mar- June	RF
57- <i>Thymus bovei</i> Benth.	Ch	-	De, S	Palestine	June- July	RF
<b>Plantaginaceae</b>						
58- <i>Plantago sinaica</i> (Barn.) Decne. *	Ch	Bal.	S	Jordan	Mar- Apr	MH, RF, PDW
<b>Ranunculaceae</b>						
59- <i>Delphinium bovei</i> Decne.	Th	-	S	Palestine	Mar- May	SF, PDW
60- <i>Nigella deserti</i> Boiss.	Th	Bal.	S	Palestine	Apr- July	SF
61- <i>Nigella arvensis</i> L. var. <i>beersherensis</i> Zohary	Th	Bal.	S	Palestine	Apr- July	SF
<b>Rutaceae</b>						
62- <i>Haplophyllum poorei</i> C. C. Towns. subsp. <i>negevensis</i> Zohary & Danin	Ch	Des.	S	Palestine	Mar- May	RF
<b>Scrophulariaceae</b>						
63- <i>Kickxia floribunda</i> (Boiss.) Täckh. & Boulos	Ch	Bal.	De, S	Palestine	Mar- Aug	SF, RF, DPW
64- <i>Kickxia macilenta</i> (Decne.) Danin	Ch	Bal.	S	Palestine	Mar- May	MH, RF
65- <i>Linaria joppensis</i> Bornm.	Th	Bal.	S	Palestine	Mar- April	SF
66- <i>Verbascum fruticosum</i> Post	Ch	Bal.	S	Palestine	Apr- Aug	RF, PDW
67- <i>Verbascum letourneuxii</i> Asch. & Schweinf.	Hi	Bal.	M	Libya	Apr- May	RF, RS
<b>Solanaceae</b>						
68- <i>Lycium schweinfurthii</i> Dammer var. <i>aschersohnii</i> (Dammer) Feinbrun	Ph	Sar.	M	Palestine	All the year	CF
69- <i>Withania obtusifolia</i> Täckh.	Ph	Sar.	S, GE	Palestine	-	MH, RF
<b>Tamariaceae</b>						
70- <i>Reaumuria negevensis</i> Zohary & Danin	Ch	Pte.	S	Palestine	May- June	RF
<b>Zygophyllaceae</b>						
71- <i>Fagonia mollis</i> Delile var. <i>hispida</i> Zohary	Ch	Des.	De, S	Palestine	Mar- Apr	SF, RF, PDW
72- <i>Fagonia taeckholmiana</i> Hadidi	Ch	Bal.	De	Libya	Apr- May	SF
73- <i>Zygophyllum dumosum</i> Boiss.	Ch	Pte.	De, S	Palestine	Mar- Apr	MH, RF, PDW

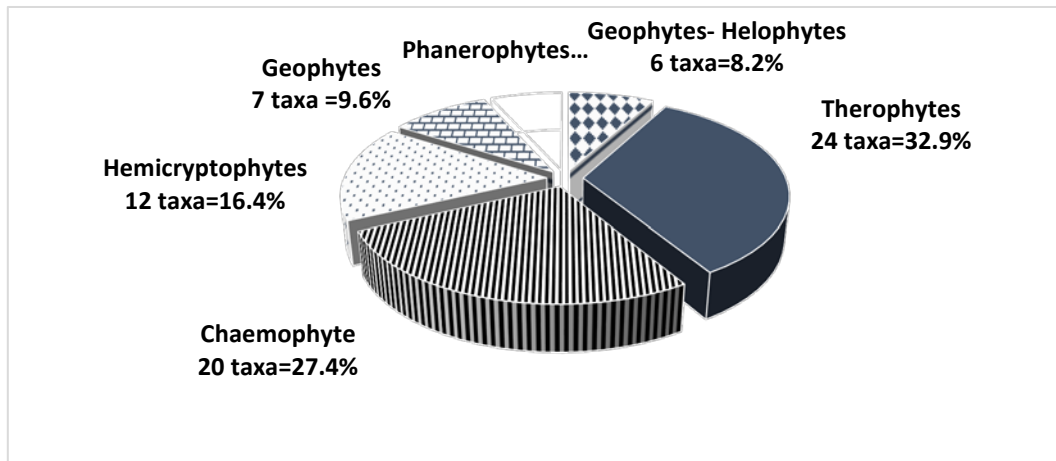
Table 2. Habitats of the near-endemic taxa in Egypt in relation to their taxonomic diversity.

Habitat	Taxon				
	Family	Genus	Species	Subspecies	Variety
Banks of water bodies (BW)	1	1	-	1	-
Desert plains, depressions and wadis (PDW)	11	15	12	1	3
Sandy formations (SF)	16	24	28	-	2
Alluvial soil (AL)	1	1	1	-	-
Cultivated fields (CF)	5	7	6	-	1
Mountains and hills (MH)	6	6	5	-	1
Rocky surfaces (RF)	19	31	31	2	3
Road sides (RS)	2	4	3	1	-
Calcareous ground (CG)	4	5	5	-	-
Ridges (R)	2	2	1	-	-
Fallow fields and waste ground (FW)	2	3	2	1	-

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**Fig. 1.** Number of near-endemic taxa in the Egyptian flora in relation to the number of habitats in which they occur



**Fig. 2.** Life form spectrum of the 73 near-endemic taxa in the Egyptian flora.

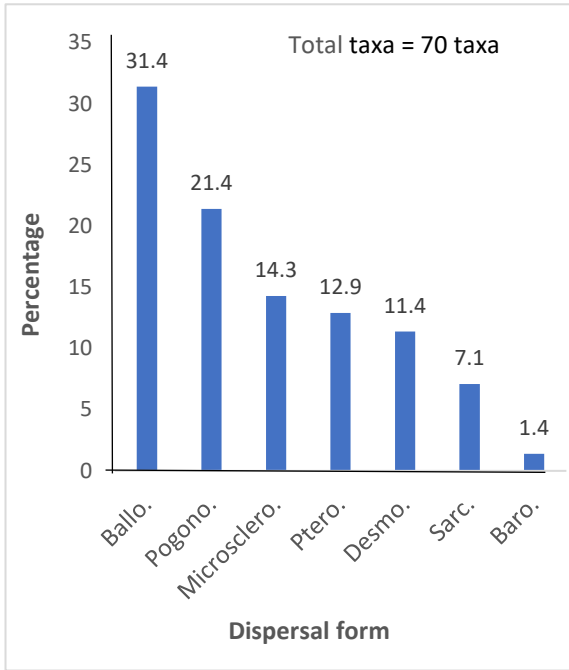
All the near-endemic taxa are bisexual, except two taxa that are unisexual dioecious plants (*Pistacia khinjuk* var. *microphylla* and *Medemia argun*). Determination of dispersal type indicated that the ballochores (22 taxa = 31.4 % of the total species) are the most represented dispersal type, followed by pogonochore (15 taxa = 21.4 %) and microsclerochores (10 species = 14.3) (**Fig. 3**). Sixty-nine taxa (94.5 %) had available data about their flowering time. There is a gradual increase in the frequency of the flowered taxa from December till reaching a maximum in March (51 taxa), followed by April (45 taxa) and May (34 taxa). In general, the period from March to May was characterized by the highest

flowering activity, while the period from August to January was the lowest (**Fig. 4**).

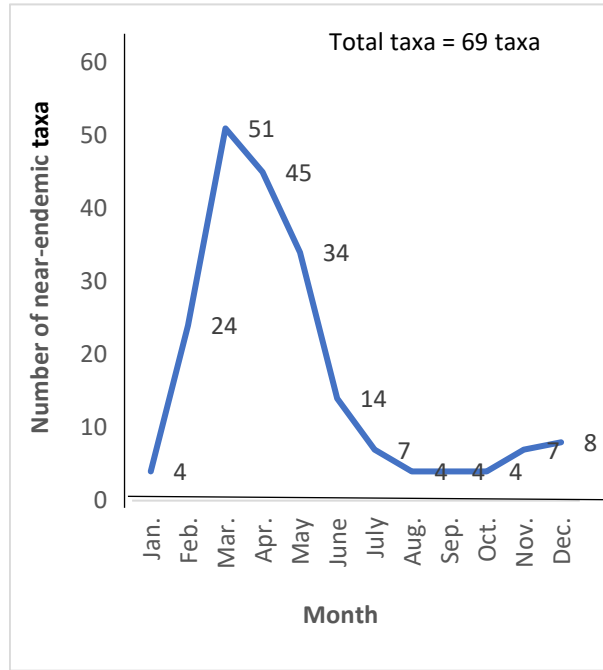
Fifty one near-endemic taxa are steno-near-endemics (69.9 % of the total taxa) which occur in only one national phyto-geographical region: 33 taxa in Sinai, 12 in Mediterranean, 2 in Oases, 3 in Eastern desert, 1 in Gebel Elba (*Pimpinella etabica*). In addition, 18 taxa occur in 2 regions (24.3 %), 2 in 3 regions (*Allium tel-avivense* and *Hypocoum aegyptiacum*) (2.7 %) and 2 in 4 regions (2.7 %) (**Fig. 5**). Sinai region is the most rich in near-endemic species as it includes 24 families and 50 taxa, followed by the Mediterranean region (13 families & 22 taxa) and Eastern Desert (8 families & 11 taxa) (**Fig. 6**).



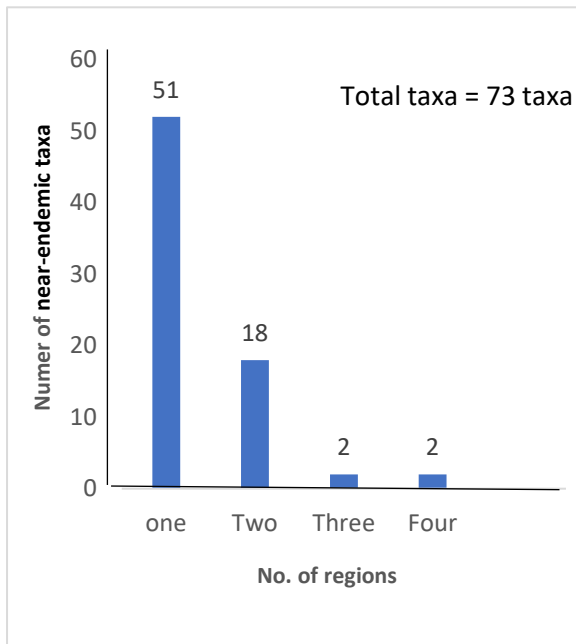
## Re-assessment of the near-endemic taxa in the Egyptian Flora



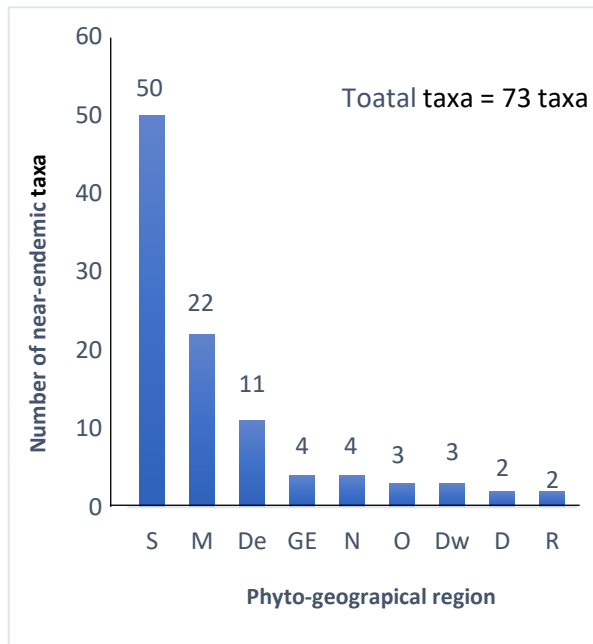
**Fig. 3.** Dispersal type spectrum of the near-endemic taxa in the Egyptian flora.



**Fig. 4.** Number of the near-endemic taxa in the Egyptian flora in relation to their flowering time.



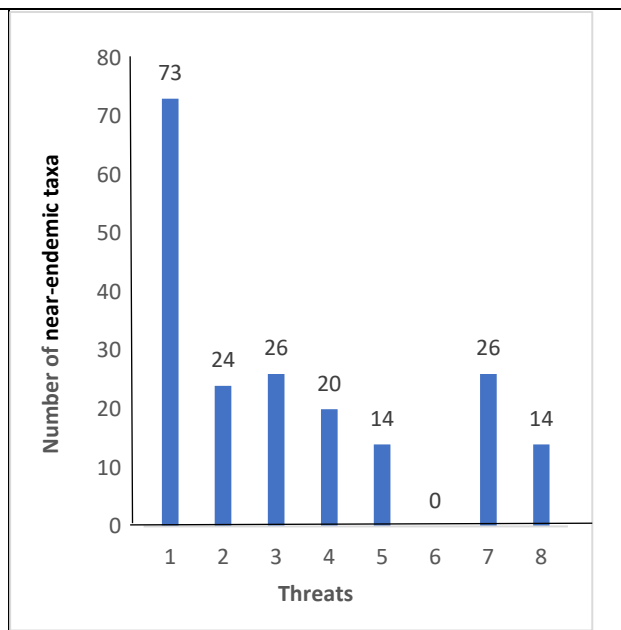
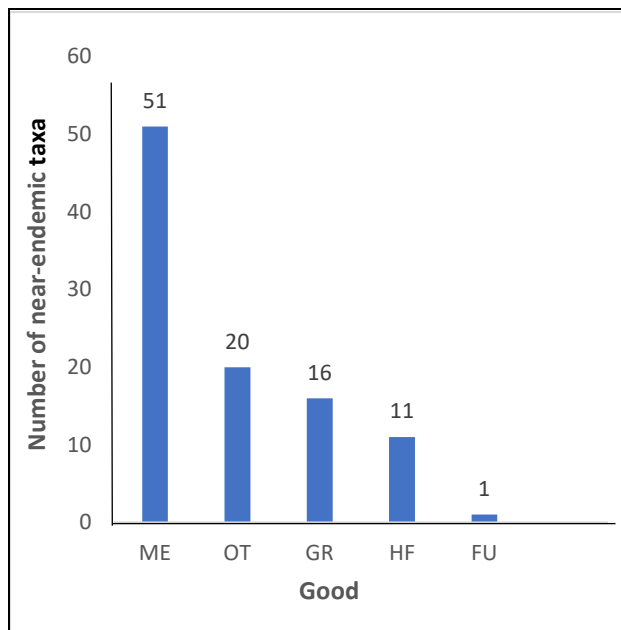
**Fig. 5.** Number of near-endemics in Egyptian flora in relation to the number of phyto-geographical regions.



**Fig. 6.** Number of near-endemic taxa in the Egyptian flora in relation to the national phyto-geographical regions. S: Sinai Peninsula, M: Mediterranean coastal region, De: Desert east of the Nile, GE: Gebel Elba region, N: Nile region including delta, Valley and Faiyum, O: Oases of the western desert, Dw: Desert west of the Nile, D: All deserts of Egypt except that of Sinai and R: Red Sea region.

The relation between the number of near-endemic taxa and the rarity forms indicated that most of them (69 taxa = 94.5 %) belong to the cell of small geographic range- small habitat- non abundant plants (SNN); while the rest 4 taxa (5.5 %) belong to the cell of small geographic range- small habitat- abundant plants (SNA). All of the near-endemic taxa have at least one aspect of the potential or actual economic goods. The goods are classified into 5 major groups: medicinal, grazing, human food, fuel and other uses (e.g. esthetic concerns, oil, industry, fodder, weaving). The offered goods could be arranged descendingly as follows: medicinal (51 taxa = 69.9 %), other uses (20 taxa = 27.4 %), grazing (16 taxa= 21.9%), human food (11 taxa = 15.1 %), and fuel (1 taxon = 1.4 %) (**Fig. 7**). Forty- seven taxa have only one good (64.4 %), 24 taxa have two goods (32.9 %), while 2 taxa have three goods (2.7 %). The available information about the services of the near-endemic taxa in the Egyptian flora is very

scarce due to the rarity of most of these taxa and extinction of others. According to the available data in the present study, most services offered by the near-endemics are sand accumulation (3 taxa), soil fertility and nitrogen fixation (8 taxa), wind breaking (5 taxa) and shading (2 taxa). All the near-endemic taxa were exposed to at least one aspect of threats, which are classified into 8 major groups: over- collecting and over-cutting, habitat loss, browsing and over grazing, clearance for agriculture, mining and quarrying, disturbance by cars or trampling, urbanization and tourism and climatic changes and environmental conditions. The threats upon the near-endemic species could be arranged descendingly as follows: over-collecting and over-cutting (73 taxa = 100 %), urbanization and tourism, browsing and over-grazing (each of 25 taxa = 34.2 %), habitat loss (24 taxa = 32.9 %), clearance for agriculture (20 taxa = 27.4 %), mining and quarrying, climatic changes and environmental conditions (14 taxa = 19.2 %) (**Fig. 8**).



**Fig. 7.** Descending arrangement of the goods of the near endemic taxa in the Egyptian flora. ME: medicinal, OT: other uses, GR: grazing, HF: human food and FU: fuel.

**Fig. 8.** Arrangement of the threats to the near-endemic taxa in the Egyptian flora. 1- over-cutting and over-collecting, 2- habitat loss, 3- browsing and over-grazing, 4- clearance for agriculture, 5- mining and quarrying, 6- disturbance by cars or trampling, 7- urbanization and tourism, 8- climatic changes and environmental conditions.

The evaluation process was carried out depending on IUCN categories (2003- 2010). The present study depended on the criteria of geographical range of plants (extent of occurrence EOO and Area of occupancy AOO). Among the 30 near-endemic taxa which were evaluated in the present study, 5 taxa were assessed as critically endangered

(16.7 % of the total assessed near-endemics), 12 taxa endangered (40 %), while 4 taxa (13.3 %) are believed to be extinct and 1 vulnerable (3.3 %). On the other hand, 8 taxa have no adequate information about their occurrence (26.7 %) (even as herbarium specimens), so they were evaluated under category of data deficient (Fig. 9 and Table 3).

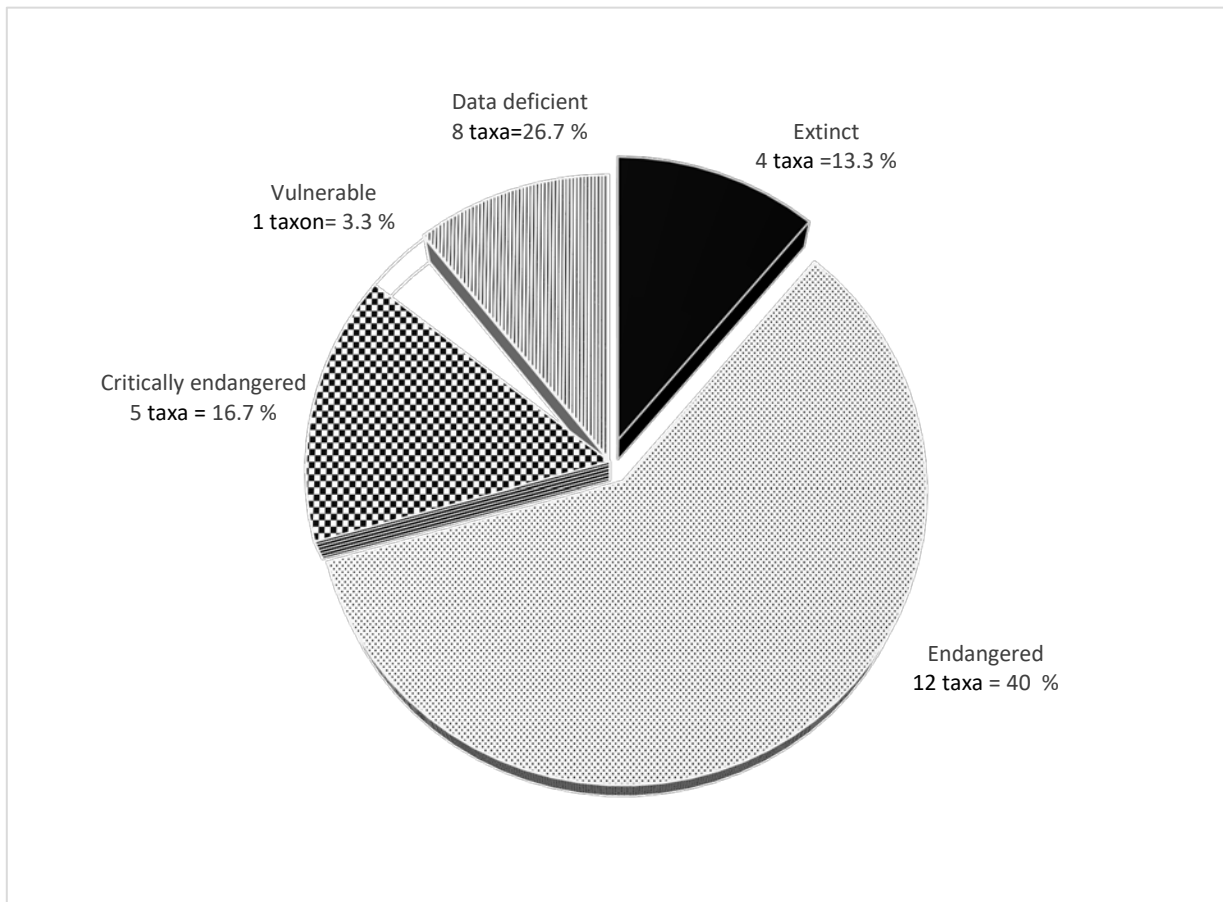


Fig. 9. IUCN categories of 30 of the near-endemic taxa in the Egyptian flora.

Based on the present as well as the previous studies (IUCN 1998, EL-Hadidi and Hosni 2000 and Hosni *et al.* 2013), 66 out of 73 near-endemics are evaluated, of these: 27 endangered (40.9 %), 16 critically endangered (24.2 %), 8 vulnerable (12.1 %), 8 data deficient (12.1 %), 2 rare (3.0 %), 4 extinct (6.1

%) and 1 least concern (1.5). On the other hand, 7 taxa were not evaluated in the present study as well as the previous studies, thus they should take priority in any forthcoming evaluation, in addition to 8 data deficient taxa (Table 3).

## Re-assessment of the near-endemic taxa in the Egyptian Flora

**Table 3.** Comparison of the red list evaluation of the near-endemic taxa of the present study with three previous studies according to IUCN categories. These studies are abbreviated as follows: I: Hosni *et al.* (2013), II: EL-Hadidi and Hosni 2000 and III: IUCN 1998. The conservation categories are abbreviated as follow: EN: endangered, VU: vulnerable, LC: least concern, RA: rare, IN: indeterminate, CR: critically endangered, EX: extinct, RE: regionally extinct and DD: data deficient. EOO: extent of occurrence, AOO: area of occupancy.

Latin name	Present study		Previous studies			Final
	EOO	AOO	I	II	III	
<b>Near-endemic taxa</b>						
<i>Allium crameri</i>	-	-	EN	RA	-	EN
<i>Allium tel-avivens</i>	-	-	-	-	-	-
<i>Bellevalia eigii</i>	-	-	-	EN	-	EN
<i>Biarum olliveri</i>	-	-	-	EN	-	EN
<i>Carduncellus mareoticus</i>	CR	CR	NT	-	-	CR
<i>Colchicum cornigerum</i>	-	-	VU	EN	-	EN
<i>Enarthrocarpus pterocarpus</i>	-	-	CR	-	-	CR
<i>Fagonia mollis</i> var. <i>hispidia</i>	EN	EN	LC	-	-	EN
<i>Ferula marmarica</i> .	CR	CR	NT	-	-	CR
<i>Hypocoum aegyptiacum</i> .	-	-	LC	-	-	LC
<i>Hypocoum aequilobum</i>	DD	DD	VU	IN	-	DD
<i>Kickxia floribunda</i>	-	-	VU	-	-	VU
<i>Leopoldia eburnea</i>	-	-	EN	-	-	EN
<i>Lotus nubicus</i>	EN	EN	-	-	-	EN
<i>Lupinus digitatus</i>	-	-	EN	EN	-	EN
<i>Nonea vivianii</i> .	-	-	VU	-	RA	VU
<i>Picris sulphureae</i>	-	-	-	-	-	-
<i>Silene biappendiculata</i> var. <i>biappendiculata</i>	DD	DD	NT	-	-	DD
<i>Tephrosia purpureae</i> subsp. <i>apollinea</i>	-	-	-	-	-	-
<i>Thymus bovei</i>	DD	DD	NT	VU	-	DD
<i>Withania obtusifolia</i> .	EN	EN	-	VU	-	EN
<i>Zygophyllum dumosum</i> .	EN	EN	-	VU	-	EN
<b>Steno-near-endemic taxa</b>						
<i>Allium barthianum</i>	EN	VU	RE	RA	-	VU
<i>Allium stamineum</i> subsp. <i>decaisnei</i>	CR	EN	-	-	-	EN
<i>Anabsis syriaca</i> var. <i>syriaca</i>	-	-	VU	VU	-	VU
<i>Astragalus amalchitanus</i>	-	-	VU	-	-	VU
<i>Astragalus camelroum</i>	-	-	EN	EN	RA	EN
<i>Atractylis boulosii</i>	-	-	-	-	RA	RA
<i>Bellevalia desertorum</i>	-	-	-	-	-	-
<i>Bellevalia sessiliflora</i>	-	-	-	-	-	-
<i>Bellevalia zoharyi</i>	-	-	-	-	-	-
<i>Bupleurum nanum</i> .	-	-	CR	-	-	CR
<i>Carthamus glaucus</i> subsp. <i>alexandrinum</i>	EN	EN	VU	-	-	EN
<i>Centaurea glomerata</i>	EN	EN	EN	-	-	EN
<i>Centaurium malzacianum</i>	DD	DD	NT	IN	-	DD
<i>Convolvulus schimperi</i> .	-	-	EN	RA	-	EN
<i>Convolvulus spicatus</i> .	-	-	CR	-	-	CR
<i>Crepis libyca</i>	EX	EX	RE	-	IN	EX
<i>Delphinium bovei</i>	-	-	-	EN	-	EN
<i>Ducrosia ismaelis</i>	-	-	CR	EN	-	CR
<i>Ebenus armitagei</i>	-	-	CR	EN	-	CR
<i>Fagonia taeckholmiana</i>	EX	EX	-	EX	-	EX
<i>Haloxyton negevensis</i>	DD	DD	VU	IN	-	DD
<i>Haplophyllum poorei</i>	-	-	EN	-	-	EN
<i>Helianthemum sphaerocalyx</i>	-	-	-	EN	-	EN
<i>Herniaria cyrenaica</i>	DD	DD	DD	-	-	DD
<i>Iris mariae</i>	EX	EX	RE	RA	-	EX
<i>Isatis microcarpa</i> var. <i>blepharocarpus</i>	CR	EN	VU	RA	-	EN
<i>Kickxia macilenta</i>	-	-	-	RA	-	RA

Table 3. Cont. 1

Latin name	Present study		Previous studies			Final
	EOO	AOO	I	II	III	
<i>Leopoldia longipes</i> subsp. <i>negevensis</i> .	-	-	EN	-	-	EN
<i>Linaria joppensis</i>	-	-	VU	-	-	VU
<i>Lupinus palaestinus</i>	-	-	CR	EN	-	CR
<i>Lycium schweinfurthii</i> var. <i>aschersohnii</i>	-	-	VU	-	-	VU
<i>Medemia argun</i>	-	-	-	EN	EN	EN
<i>Micromeria sinaica</i> .	CR	CR	VU	RA	RA	CR
<i>Minuartia picta</i> var. <i>sinaica</i> .	CR	CR	VU	-	-	CR
<i>Nigella arvensis</i> var. <i>beersherensis</i> .	DD	DD	NT	-	-	DD
<i>Nigella deserti</i>	-	-	CR	-	-	CR
<i>Origanum isthmicum</i>	-	-	-	EN	RA	EN
<i>Phagnalon sinaicum</i> .	CR	EN	EN	RA	-	EN
<i>Pimpinella etabica</i> .	-	-	CR	RA	-	CR
<i>Pistacia khinjuk</i> var. <i>microphylla</i>	-	-	-	-	-	-
<i>Plantago Sinaica</i>	EN	EN	CR	-	-	EN
<i>Podonosoma galalensis</i> .	CR	CR	CR	IN	-	CR
<i>Pterocephalus arabicus</i>	-	-	CR	EN	RA	CR
<i>Pterohagia arabica</i>	-	-	VU	-	-	VU
<i>Pycnocycla tomentosa</i> .	EN	EN	VU	-	-	EN
<i>Reaumuria negevensis</i>	DD	DD	NT	RA	-	DD
<i>Scorzonera drarii</i>	EX	EX	EX	EN	EN	EX
<i>Trifolium philistaeum</i>	-	-	CR	-	-	CR
<i>Valerianell petrovitchii</i>	-	-	-	EN	-	EN
<i>Verbascum fruticosum</i>	-	-	CR	RA	-	CR
<i>Verbascum letourneuxii</i>	EN	EN	VU	EN	-	EN
<b>Total</b>	<b>30</b>	<b>30</b>	<b>53</b>	<b>36</b>	<b>9</b>	<b>66</b>

## Discussion

Near-endemics in the present study are the plants restricted to only two adjacent countries (Boulos 2009). According to this study, the near-endemics are 73 taxa of vascular plants belonged to 58 genera and 28 families. Comparing with the previous studies, Boulos (2009) reported that the near-endemic taxa in Egypt are 93, while Hosni *et al.* (2013) reduced the number to 61. Recent records were collected from the literature, scientific websites and global databases with specific locality, coordinates, and photos or herbarium specimens, to assess the recent distribution of the near-endemics, while taxa mentioned in a single report or research without their documentation with photos or herbarium specimens were not excluded from the near-endemics in the present work.

Twenty-two taxa in the present study were recorded also in Boulos (2009) and Hosni *et al.* (2013) as near-endemics. In addition, 6 near-endemics in the present study were recorded only in Hosni *et al.* (2013) (*Anabsis syriaca* var. *syriaca*, *Astragalus camelroum*, *Isatis microcarpa* var. *blephrocarpus*, *Nigella arvensis* var. *beersherensis*, *Plantago Sinaica* and *Thymus bovei*), while 38 were recorded only in Boulos (2009). Moreover, 7 taxa in the

present study were moved from endemics to near-endemics (*Allium crameri*, *Colchicum cornigerum*, *Lupinus digitatus*, *Plantago sinaica*, *Pterocephalus arabicus*, *Origanum isthmicum* and *Scorzonera drarii*).

In contrast with the two previous studies (Boulos 2009 and Hosni *et al.* 2013), 13 species were excluded from the near-endemics: 9 of them were reported in Egypt and Palestine (*Atractylis serratuloides*, *Onopordum alexandrinum*, *Campanula dulcis*, *Astragalus caprinus*, *Astragalus trimestris*, *Galium sinaicum*, *Solanum sinaicum*, *Aegilops longissima* and *Verbascum shimperianum*), two in Egypt and Saudi Arabia (*Hypericum sinaicum* and *Thymus decussatus*) and two in Egypt and Libya (*Valantia lanata* and *Centaurea alexandrina*), as they were also recorded in other countries. *Atractylis serratuloides* was recorded in Libya (Jafri and El-Gadi 1983) and Algeria (website 8 and website 16); *Onopordum alexandrinum* in Palestine, Jordan, Lebanon and Syria (<http://ww2.bgbm.org>); *Campanula dulcis* in Saudi Arabia and Yemen (Collenette 1999, website 15, website 17 and website 6); *Astragalus caprinus* in Libya (Jafri and El-Gadi 1980), Morocco, Tunisia, Turkey, Iran

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and Saudi Arabia (website 6); and *Astragalus trimestris* in Libya (website 15), Spain and United States (website 6). *Galium sinaicum*, *Verbascum shimperianum* and *Solanum sinaicum* were recorded also in Saudi Arabia (Migahid 1989 and website 6); *Aegilops longissima* in Turkey, Afghanistan, USA, Uzbekistan, Australia, Iran, Spain and Lebanon (website 6); *Hypericum sinaicum* in Ethiopia (website 8); *Thymus decussatus* in Palestine (website 15); *Valantia lanata* in Tunisia (website 6); and *Centaurea alexandrina* in Mali (website 8), Niger, Sudan, France and Spain (website 6).

In the present study, 19 species were excluded from the near-endemics, while they were reported as near-endemics in Boulos (2009): 11 in Egypt and Palestine (*Blepharis attenuata*, *Allium desertorum*, *Ornithogallum trichophyllum*, *Anthemis indurata*, *Lobularia arabica*, *Nasturtiopsis coronopifolia*, *Astragalus fruticosus*, *Nepeta septemcrenata*, *Plantago cryopsides*, *Reseda stenostachya* and *Veronica scardica*); 5 in Egypt and Libya (*Salsola longifolia*, *Echinops galaensis*, *Isatis microcarpa*, *Euphorbia parvula* and *Euphorbia punctata*); 2 in Egypt and Saudi Arabia (*Colchicum guessfeldtianum* and *Taverniera aegyptiaca*), and one in Egypt and Sudan (*Lotus herbanicus*). The exclusion is due to the following justifications: *Blepharis attenuata* was recorded also in Jordan (Taifour and El-Qolah 2014), Syria and Saudi Arabia (websites 6 and 16); *Allium desertorum* in Saudi Arabia and Kuwait (Migahid 1989 and website 6); *Ornithogallum trichophyllum* in Libya (Jafri and El-Gadi 1978), Turkey (website 8) and Iraq (website 6); *Anthemis indurata* in Libya (Jafri and El-Gadi 1983) and Saudi Arabia (Migahid 1989); *Lobularia arabica* in Libya (website 14), Lebanon (website 18) and Greece (website 6). *Nasturtiopsis coronopifolia* was recorded also in Libya (Jafri and El-Gadi 1977) Algeria, Tunisia and Saudi Arabia (websites 6 and 8); *Astragalus fruticosus* in Libya (Jafri and El-Gadi 1980), Saudi Arabia (Migahid 1989) Russia and Mangolia (website 6); *Nepeta septemcrenata* in Saudi Arabia (Migahid 1989) and Iran (websites 6 and 8); *Plantago cryopsides* in Malta (website 14), Kuwait, Bahrain, Jordan, Saudi Arabia and Iran

(website 6); *Reseda stenostachya* in Turkey (Davis *et al.* 1978; websites 6, 8 and 16) and Saudi Arabia (website 5); *Veronica scardica* in Albania, Hungary, Slovakia, Australia, Turkey, Germany, Syria and Georgia with specific locations and coordinates (websites 6 and 8).

In addition, *Euphorbia parvula* was recorded also in France (website 8); *Euphorbia punctata* in Turkey, Azerbaijan and Ecuador (websites 6 and 8); *Salsola longifolia* in Saudi Arabia (Migahid 1988), Mouritania, Algeria, Morocco, Tunisia and Spain (websites 6 and 8); *Echinops galaensis* in Saudi Arabia (Migahid 1989, Al-Yayha *et al.* 1990 and El-Shabasy 2016), Kuwait, Yemen and Emirates (website 6); *Isatis microcarpa* in Saudi Arabia, Palestine, Jordan, Morocco, and Afghanistan with specific locations and coordinates (websites 6 and 8); *Colchicum guessfeldtianum* was reported as synonym to *Colchicum shimperi* (website 2) and recorded also in Yemen, Iran, Bulgharia (website 8), Saudi Arabia, Iraq, Lebanon, Syria, Palestine and Yemen (websites 19 and 6); *Taverniera aegyptiaca* was recorded also in Sudan, Djibouti, Ethiopia (websites 4 and 20) and Qatar (Botanouny 1981 and website 6), and *Lotus herbanicus* in Saudi Arabia (websites 6, 8 and 21).

In the present study, 20 taxa were excluded from the near-endemics, while reported as near-endemics in Hosni *et al.* (2013): 8 of them occur in Egypt and more than one adjacent country (*Allium sinaiticum*, *Centaurea scoparia*, *Dianthus sinaicus*, *Iphiona mucronata*, *Pteroccephalus sanctus*, *Polygala negevensis*, *Rhus flexicaulis*, and *Rhamnus dispermus*). Also, 4 taxa in Egypt and Palestine (*Allium roseum* var. *tourneauxii*, *Phagnalon nitidum*, *Salvia deserti* and *Stachys aegyptiaca*), 2 in Egypt and Jordan (*Anthemis melampodina* subsp. *deserti* and *Anthemis scrobicularis*), 2 in Egypt and Arabia (*Asclepias sinaica* and *Commiphora quadricincta*), 2 in Egypt and Libya (*Indigofera lotononoides* and *Stipagrostis shawii*), while *Euphorbia bivonae* var. *sinaica* and *Teuricum leucocladum* subsp. *leucocladum* var. *leucocladum* recorded in Hosni *et al.* (2013), were excluded as they were not reported in the books dealing with the

Egyptian flora (e.g. Täckholm *et al.* 1941, Täckholm and Drar 1950- 1969, Täckholm 1974 and Boulos 1999-2009).

The exclusion was due to the following justifications: *Centaurea scoparia*, and *Iphiona mucronata* were recorded also in Palestine, Jordan and Saudi Arabia (Boulos 2002, websites 6 and 8); *Allium sinaiticum* in Palestine, Jordan and Saudi Arabia (Boulos 2005 and website 6); *Dianthus sinaicus* in Palestine and Saudi Arabia (Boulos 1999 and website 6); *Rhus flexicaulis* in Sudan and Arabia (Boulos 2000), Yemen and Oman (websites 6 and 8); *Pterocephalus sanctus* in Palestine and Saudi Arabia (Boulos 2002); *Polygala negevensis* in Saudi Arabia (Boulos 2000, websites 6 and 8); and *Rhamnus dispermus* in Lebanon (Boulos 2000), Banama and Saudi Arabia (website 8). In addition, *Allium roseum* var. *tourneauxii* was recorded also in Libya (Boulos 2005); *Phagnalon nitidum* in Iran (website 8), Ethiopia, Pakistan and Eiteria (website 6); *Salvia deserti* in Palestine, Arabia (Boulos 2002 and website 6) Jordan and Saudi Arabia (website 6); *Stachys aegyptiaca* in Saudi Arabia and Spain (Boulos 2002 and website 6); *Anthemis melampodina* subsp. *deserti* in Libya ( Jafri and El- Gadi 1983), Kuwait and Saudi Arabia (Al-Rawi 1987 and website 6), *Anthemis scrobicularis* in Palestine, Arabia (Boulos 2002) and Saudi Arabia (websites 6 and 8); *Asclepias sinaica* in Syria and Jordan (websites 6 and 8); *Commiphora quadricincta* in Sudan and Arabia (Boulos 2000) Eritrea, Saudi Arabia, Nigeria and Yemen (websites 6 and 8); *Stipagrostis shawii* in Libya and Sudan (Boulos 2005); and *Indigofera lotononoides* in Sudan (Boulos 1999 and website 8).

The dominance of therophytes over the other life forms seems to be a response to the hot-dry climate, topographic variation and biotic influence (Heneidy and Bidak 2001). In Egypt, the highest humid period of the year extends from November to April which is associated with low temperature and evaporation; therefore, much favorable soil moisture. During this period, the plants start their growth activity reaching to the flowering and fruiting stages in March, April and May (Bedevian 1935, Makins *et al.* 1948, Boulos and Hadidi 1986, Griffiths 1992, Bircher 1998,

Burnie *et al.* 2004 and Heneidy 2010). Regarding the sex forms, the preponderance of the hermaphroditic taxa (i.e. bisexual taxa) is a common feature in most floras of the world. Baker and Hurd (1968) suggested that the co-evolution of hermaphroditic flowers with animal pollination might be an important advancement by early angiosperms since pollen-producing and pollen-receiving organs in the same flower allowed for efficient simultaneous deposition and removal of pollen. Ballochores followed by pogonochores are the most represented dispersal types that characterized the near-endemic taxa in the Egyptian flora. The wide distribution of ballochoric taxa may be due to their explosive nature, which is often related to rapid desiccation, and hence efficient local seed dispersal.

Records of the present study indicate that the number of near-endemic taxa had the maximum value in Sinai especially its south, as it includes 50 near-endemics (68.5 %). On the other hand, near-endemics are poor in each of Red Sea coastal strip and deserts (2.7 %). Fifty-one steno-near endemics (69.9 % out of 73 taxa) were recorded in the present study. Sinai includes the majority of steno-near endemics (33 taxa= 64.7 % of total steno-near endemics), while Eastern Desert includes 3 species and Gebel Elba includes only one species. The richness of South Sinai region with near and steno-near endemics is probably due to the extensive mountainous massive in this region which prevents the dispersal of seeds for long distances. Regarding the rarity forms, there are many ways in which a species can become rare; a theoretical framework of an eight-celled table is proposed by Rabinowitz (1981) for the different types of rarity depending on range, habitat specificity and local abundance. In the present study, 70 near-endemics (94.6 % of the total near-endemics) belonged to SNN cell (constantly sparse and geographically restricted in a specific habitat); while, 4 near-endemics belonged to SNA cell (locally abundant in a specific habitat but restricted geographically). Taxa that belong to SNA and SNN are the classic rarities in the sense of restricted endemics, often endangered or threatened. Taxa which have large ranges, but are associated with particular habitats are

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generally quite predictable in their occurrence; these taxa tend to be precarious as a result of habitat destruction (Rabinowitz 1981 and Ahmed 2009).

All of the near-endemics in the present study had at least one aspect of the potential or actual economic goods. Fifty-one near-endemics (69.9 %) are of medicinal use. For example, the seeds and leaves of *Ducrosia imaelis* are used for treating stomach diseases, and has an antimicrobial activity (Al-Ghonemy 1993). Also, the whole herb, especially its aerial parts, has been used in traditional medicines to treat skin infections and to repel insects and reptiles. Cytotoxic homo-isoflavones, 8 new and 10 known compounds were isolated from the organic extract of the bulbs of *Bellevalia eigii* as part of a search for anticancer (Alali *et al.* 2015). Essential oil of *Thymus bovei* has anthelmintic, antibacterial and antioxidant effects (Jaradat *et al.* 2016). Seventeen near-endemics can be grazed and browsed by the domestic and wild animals (e.g. *Phagnalon sinaicum*, *Picris sulphurea*, *Pterocephalus arabicus*, *Silene biappendiculata*, *Micromeria sinaica* and *Plantago sinaica*). In addition, many organs (e.g. fruits, flowers, vegetative and ground parts) of 11 near-endemics are eaten by local inhabitants in different regions of Egypt. Among these plants are: *Allium barthianum*, *Carthamus glaucus*, *Thymus bovei* and *Carduncellus mareoticus*. Only one near-endemic was used as fuel (*Lycium shweinfurthii* var. *aschersohnii*). In addition, 20 near-endemics are of several traditional uses (such as: esthetic concerns, fodder, weaving and oil) (e.g. *Pimpinella etabica*, *Medemia argun*, *Enarthrocarpus pterocarpus*, *Convolvulus schimperi*).

Threats to the world's plants continue to increase as a result of human activities (IUCN 2003, 2010). Among the well-documented threats are habitat loss, poor land management, over-collection, over-grazing, and climate change. Most studies suggest that the rate at which plant species are being lost, or at least reduced in numbers, is faster than the speed at which scientists; land managers, policy-makers, and others can or will respond (IUCN 2003, 2010). All the near-endemic species suffer from at least one type

of threats in their main habitats. All the near-endemics are subjected to over-cutting and over-collecting by local inhabitants, herbalists and scientific researchers. The most serious aspect of this practice is that it usually targets rare and localized flora leading to damage them further (Seif El-Nasr and Bidak 2005a). Twenty-six near-endemics are subjected to over-grazing where sheep and goats severely depleted the natural vegetation and compete directly with native wildlife over the same food resource (Seif El-Nasr and Bidak 2005a). *Plantago sinaica* is one of the over-grazed near-endemic species in South-Sinai (Khafagi *et al.* 2012). Twenty near-endemics are damaged during agriculture process, where a complete destruction of habitats caused by cultivation activities is a serious threat to many regions in Egypt, especially in the Mediterranean region (Seif El-Nasr and Bidak 2005a).

In addition, 25 near-endemics (e.g. *Allium barthianum*, *Ferula marmarica*, *Belevallia eigii*, *Centurea alexandrina* and *Pterohagia arabica*) are exposed to habitat loss due to urbanization and tourism, clearance for agriculture and construction processes. This is one of the major threats which impact many species, in the Egyptian flora especially in the Mediterranean region. This has not only led to the complete destruction of the habitats, but also its degradation of vast areas of habitat surrounding them. In addition, 15 near-endemics (e.g. *Allium tel-avivens*, *Carduncellus mareoticus*, *Colchicum cornigerum*) were damaged during mining and quarrying; one of the major processes causing degradation in the ecosystems of many Egyptian regions due to complete destruction of plant cover (Seif El-Nasr and Bidak 2005b). In general, the major effective threats are over-cutting, over-collecting, and over-grazing which are dominant in North Sinai and Mediterranean; habitat loss, urbanization, tourism and clearance for agriculture which are abundant in the Mediterranean and Red Sea coasts as well as Sinai.

The present study provides an important material towards the conservation of near-endemic species in Egypt, especially stenendemics and near-endemics. Using the IUCN red list criteria, 30 near-endemic taxa were



evaluated as follows: 12 endangered (40 %), 5 critically endangered, 4 believed to be extinct, while only one is vulnerable. On the other hand, 8 taxa have no adequate information about their occurrence, so they were evaluated under category of data deficient. Most of the near-endemics are not evaluated due to the rarity of data about these species. Some previous studies were carried out for the assessment of near-endemic species according to IUCN categories. For example, Hosni *et al.* (2013) evaluated 61 near-endemics as follows: 17 vulnerable, 13 critically endangered, 10 endangered, 15 near-threatened, 5 regionally extinct and 1 least concern. El-Hadidi and Hosni (2000) evaluated 36 near-endemics as follows: 4 vulnerable, 16 endangered, 4 indeterminate, 1 extinct and 11 rare; while IUCN (1998) evaluated 9 near-endemics as follows: 2 endangered, 1 indeterminate and 6 rare; while Johnson (1998) and Ibrahim *et al.* (2008-2010) evaluated *Medemia argun* as critically endangered.

Two near-endemics were evaluated only in the present study as endangered species: *Lotus nubicus* (EOO = 478.2 km<sup>2</sup>, AOO = 78.0 km<sup>2</sup>) and *Allium stamineum* subsp. *decaisnei* (EOO = 89.8 km<sup>2</sup>, AOO = 26.1 km<sup>2</sup>).

Two taxa were evaluated in the present study as well as the three previous studies. *Scorzonera drarii* evaluated as endangered by IUCN (1998) and El-Hadidi and Hosni (2000), but it was believed to be extinct in the present study and Hosni *et al.* (2013), because it was known only from its type locality or a single gathering (Hosni *et al.* 2013). In addition, *Micromeria sinaica* was evaluated as rare by IUCN (1998) and El-Hadidi and Hosni (2000) and vulnerable by Hosni *et al.* (2013), but as critically endangered in the present study (EOO = 0.7 km<sup>2</sup>, AOO = 2.2 km<sup>2</sup>), as it is under the risk of extinction due to its low population size and restricted distribution (El-Hadidi *et al.* 1992).

Twelve taxa were evaluated in the present study as well as two previous studies. Of these, *Isatis microcarpa* var. *blepharocarpus* was evaluated as rare by El-Hadidi and Hosni (2000) and vulnerable by Hosni *et al.* (2013), but as endangered in the present study (EOO = 44.0 km<sup>2</sup>, AOO = 10.3 km<sup>2</sup>); *Phagnalon sinaicum* was evaluated as

rare by El-Hadidi and Hosni (2000), but as endangered by Hosni *et al.* (2013) and the present study (EOO = 834.7 km<sup>2</sup>, AOO = 249.0 km<sup>2</sup>). This species is under the risk of extinction due to its low population size and very limited geographical distribution (El-Hadidi *et al.* 1992); *Podonosoma galalensis* was evaluated as indeterminate by El-Hadidi and Hosni (2000), but as critically endangered by Hosni *et al.* (2013) and the present study (EOO = 2.9 km<sup>2</sup>, AOO = 2.1 km<sup>2</sup>); *Verbascum letourneuxii* was evaluated as vulnerable by Hosni *et al.* (2013), but as endangered by El-Hadidi and Hosni (2000) and the present study (EOO = 944.1 km<sup>2</sup>, AOO = 110.4 km<sup>2</sup>); *Allium barthianum* was evaluated as rare by El-Hadidi and Hosni (2000) and as regionally extinct by Hosni *et al.* (2013), but as vulnerable in the present study (EOO = 157.5 km<sup>2</sup>, AOO = 975.5 km<sup>2</sup>). Habitat loss due to establishment of touristic settlements was the major threat which caused this taxon to be vulnerable (field observation); *Iris mariae* was evaluated as rare by El-Hadidi and Hosni (2000) and as regionally extinct by Hosni *et al.* (2013), but it is considered to be extinct in the present study. *Iris mariae* is unique to sand and stabilized sand, and does not stray from this habitat. This habitat is threatened by the agricultural and residential development plans. *Iris mariae* is sensitive to rodents that feed on its rhizomes and to intensive grazing. (<https://redlist.parks.org.il/taxa/Iris%20mariae/>); *Crepis libyca* was evaluated as regionally extinct by Hosni *et al.* (2013) and as indeterminate by IUCN (1998), but it is considered to be extinct in the present study. On the other hand, 5 taxa (*Haloxylon negevensis*, *Centaurium malzacianum*, *Hypocoum aequilobum*, *Thymus bovei* and *Reaumuria negevensis*) were evaluated in the present study as data deficient due to inadequate information to make correct assessment based on its distribution and/or population status. The limited geographical region of *Thymus bovei* combined with over-exploitation; over-collecting as flavor to food and over-grazing by domestic livestock were other threats leading to the species decline (El-Hadidi *et al.* 1992).

Fourteen taxa were evaluated in the present study and only one previous study. Of

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these, 11 taxa were evaluated in the present study and Hosni *et al.* (2013): *Carduncellus mareoticus* was evaluated as indeterminate in Hosni *et al.* (2013), but as critically endangered in the present study (EOO = 0.6 km<sup>2</sup>, AOO = 0.4 km<sup>2</sup>); *Fagonia mollis* var. *hispidata* was evaluated as Least concern by Hosni *et al.* (2013), but as endangered in the present study (EOO = 673.3 km<sup>2</sup>, AOO = 207.9 km<sup>2</sup>); *Ferula marmarica* was evaluated as near-threatened by Hosni *et al.* (2013), but as critically endangered in the present study (EOO = 5.9 km<sup>2</sup>, AOO = 1.4 km<sup>2</sup>); *Carthamus glaucus* subsp. *alexandrinum* (EOO is .1 km<sup>2</sup>, AOO is 22 km<sup>2</sup>) and *Pycnocycla tomentosa* (EOO = 661.7 km<sup>2</sup>, AOO = 423.0 km<sup>2</sup>) were evaluated as vulnerable by Hosni *et al.* (2013), but as endangered in the present study; *Centaurea glomerata* was evaluated as endangered by Hosni *et al.* (2013) and the present study (EOO = 684.4 km<sup>2</sup>, AOO = 482.4 km<sup>2</sup>); *Minuratia picta* var. *sinaica* was evaluated as vulnerable by Hosni *et al.* (2013), but as critically endangered in the present study (EOO = 16.3 km<sup>2</sup>, AOO = 3.8 km<sup>2</sup>); *Plantago sinaica* was evaluated as critically endangered by Hosni *et al.* (2013), but as endangered in the present study (EOO = 945.3 km<sup>2</sup>, AOO = 268 km<sup>2</sup>). Over-grazing and over-collecting were the major threats which cause this taxon to be endangered (Khafagi *et al.* 2012). On the other hand, 3 taxa (*Silene biappendiculata* var. *biappendiculata*, *Herniaria cyrenaica* and *Nilgella arvensis* var. *beersherensis*) were evaluated in the present study as data deficient due to inadequate information to make correct assessment based on their distribution and/or population status. In addition, 3 taxa were evaluated in the present study and El-Hadidi and Hosni (2000). Of these: *Withania obtusifolia* (EOO = 871.7 km<sup>2</sup>, AOO = 304.2 km<sup>2</sup>) and *Zygophyllum dumosum* (EOO = 146.5 km<sup>2</sup>, AOO = 42 km<sup>2</sup>) were evaluated as vulnerable by El-Hadidi and Hosni (2000), but as endangered in the present study. The small populations of *Withania obtusifolia* are highly endangered due to establishment of touristic settlements. Over-collection for medicinal uses is another reason for its decline (El-Hadidi *et al.* 1992). Over-grazing by camels highly disturb the small populations of *Zygophyllum dumosum* (El-

Hadidi *et al.* 1992); while *Fagonia taekholmiana* was evaluated as extinct in the present study and El-Hadidi and Hosni (2000). It was known only from its type locality (Heliopolis desert, near Cairo). At present, this area is under heavy industrial activities due to the establishment of Nasr town (El-Hdadidi *et al.* 1992).

Thirty-six near-endemic taxa were evaluated by the previous studies (Hosni *et al.* 2013, El-Hadidi and Hosni 2000 and IUCN 1998), but not in the present study. Among them, two taxa were evaluated by the three previous studies. *Astragalus camelroum* was evaluated as rare by Hosni *et al.* (2013) and IUCN (1998), but as endangered by El-Hadidi and Hosni (2000); while *Pterocephalus arabicus* was evaluated as critically endangered by Hosni *et al.* (2013), but as endangered by El-Hadidi and Hosni (2000) and rare by IUCN (1998). Tourism among some external factors may lead to gradual extinction of *Pterocephalus arabicus* (El-Hadidi *et al.* 1992), its natural rarity can be related to its geographical distribution. Degradation of vegetation due to overgrazing was pronounced in wadis where their vegetation is relatively rich and dense. Complete destruction of the natural vegetation is carried out for settlements. Anthropogenic activities also have dramatic effect over natural vegetation especially in desert, where plant life subsists under adverse conditions of aridity (Abd El-Ghani and Fahmi 1994).

In addition, 14 taxa were evaluated by two previous studies. Of these, *Allium crameri* was evaluated as endangered by Hosni *et al.* (2013) and as rare by El-Hadidi and Hosni (2000); *Lupinus digitatus* and *Valerianella pterovitchii* were evaluated as endangered by Hosni *et al.* (2013) and El-Hadidi and Hosni (2000); *Medemia argun* was evaluated as endangered by El-Hadidi and Hosni (2000) and IUCN (1998). This plant was exposed to cut for collection of their edible fruits and using the leaves to make strong ropes (El-Hadidi *et al.* 1992). The vegetation of this palm is influenced by human activity. The ecosystems are rare, to some extent even unique, vulnerable and critically endangered

that make protection necessary. The population size showed a dramatic decrease in the last decade. The total number of *Medemia* palms in Egypt was 31; with two fruiting females (Ibrahim *et al.* 2008-2010); *Colchicum cornigerum* was evaluated as vulnerable by Hosni *et al.* (2013), but as endangered by El-Hadidi and Hosni (2000); *Nonea vivanii* was evaluated as vulnerable by Hosni *et al.* (2013), but as rare by IUCN (1998); *Anabsis syriaca* var. *syriaca* was evaluated as vulnerable by Hosni *et al.* (2013) and El-Hadidi and Hosni (2000). The rarity of *Anabsis syriaca* var. *syriaca* is due to its limited local distribution. Also, Agricultural activities and overgrazing are main factors leading to decline of this taxa (El-Hadidi *et al.* 1992); *Convolvulus shimperi* was evaluated as endangered by Hosni *et al.* (2013), but as rare by El-Hadidi and Hosni (2000); *Ebenus armitagei*, *Lupinus palaestinus* and *Ducrosia ismaelis* were evaluated as critically endangered by Hosni *et al.* (2013), but as endangered by El-Hadidi and Hosni (2000). It was found that 94 % of the seeds of the rare legume *Ebenus armitagei* were eaten or damaged by bruchid beetles *Callosobruchus maculatus* (Hegazy and Isa 1991); this species also was only recorded from the Mediterranean sector of Egypt. The pods and seeds are severely attacked by insects which threaten plant reproduction. Also, most of the natural vegetation in the Mediterranean region had been much disturbed by clearing for establishment of new touristic settlements (El-Hadidi *et al.* 1992); *Pimpinella etabica* and *Verbascum fruticosum* were evaluated as critically endangered by Hosni *et al.* (2013), but as rare by El-Hadidi and Hosni (2000). Overgrazing and rarity of water are main factors which affect the regeneration of *Verbascum fruticosum* (El-Hadidi *et al.* 1992); while *Origanum isthmicum* was evaluated as endangered by El-Hadidi and Hosni (2000), but as rare by IUCN (1998).

Twenty taxa were evaluated by only one previous study. Of these, 5 taxa were evaluated by El-Hadidi and Hosni (2000): *Bellevalia eigii*, *Biarum oliveri*, *Delphinium bovei* and

*Helianthemum sphaerocalyx* were evaluated as endangered. The habitat of *Biarum oliveri* is sandy soil which is easily disturbed by mechanical means and the surface is easily damaged, destroying *Biarum oliveri*. Intensive grazing is also destructive (<https://redlist.parks.org.il/taxa/Biarum%20oliveri/>). *Helianthemum sphaerocalyx* was severely threatened by tourism, human settlement and extraction of oil (IUCN 1978); while *Kickxia macilenta* was evaluated as rare. The natural rarity of the *Kickxia macilenta* can be related to its geographical distribution. Degradation of vegetation due to overgrazing is pronounced in wadis where its vegetation is relatively rich and dense. Complete destruction of the natural vegetation is carried out for settlements. Anthropogenic activities also have dramatic effect over natural vegetation especially in desert, where plant life subsists under adverse conditions of aridity (Abd El-Ghani and Fahmy 1994). In addition, the extreme rarity of this taxon is related to its limited geographical distribution. The mountains of S. Sinai act as refuges that harbor the small population of this taxon (El-Hadidi *et al.* 1992).

Only one taxon (*Atractylis boulosii*) was evaluated as rare by IUCN (1998). In addition, 14 taxa were evaluated by Hosni *et al.* (2013): of these 5 taxa were evaluated as vulnerable (*Kickxia floribunda*, *Astragalus amalcanus*, *Linaria joppensis*, *Lycium schweinfurthii* var. *aschersohnii* and *Pterohagia arabica*); 5 taxa as critically endangered (*Enartherocarpus pterocarpus*, *Bupleurum nanum*, *Convolvulus spicatus*, *Nigella deserti* and *Trifolium philistaeum*); three taxa as endangered (*Leopoldia eburnean*, *Leopoldia longipes* subsp. *negevensis* and *Haplophyllum poorei*); while only one taxon (*Hypecoum aegyptiacum*) as least concern. *Hypecoum aegyptiacum* apparently disappeared from the sites where it had been previously found and there is doubt as to its existence today. There is no information on the past populations nor are the reasons for its disappearance from the sites where it had been collected in the past clear. There is also a lack of information regarding its global threat status (Shimda and Pollak 2007).

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