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SHORT COMMUNICATION

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Re-assessment of the endemic taxa in the Egyptian Flora

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1 | INTRODUCTION

From a bio-geographical view, endemism restricts the natural range of a taxon to a defined geographical distribution or habitat type (Anderson, 1994; Gaston, 1994). Steno-endemics are the narrow-distributed taxa (Gaston, 1994). Apart from climatic changes and the loss of natural habitats, excessive human activities may cause extinction to the endemic taxa (Thomas et al., 2004). The extinction rate has accelerated in recent times, causing hundreds or perhaps thousands of taxa to become extinct every year (Cunningham & Cunningham, 1997).

Egypt is perhaps the aridest country in North Africa in which desert conditions prevail throughout the country (Wickens, 1992). Egypt contains four main geographical regions: the Western Desert, the Eastern Desert, Nile land and Sinai Peninsula. River Nile land includes several islands in its mainstream and the two Delta branches. Fayium depression is connected to the Nile by a principal irrigation canal called the Youssef Sea (Zahran & Willis, 2009).

Despite many conservation studies that have taken place in Egypt for endemics, there is still a lack of comprehensive information on taxa distribution and their recent IUCN categories (Hosni et al., 2013). Eighty-four threatened species were recorded in Egypt (IUCN, 1998). El-Hadidi and Hosni (2000) provided a list of 457 threatened taxa in the Egyptian Flora, but this study did not apply the IUCN criteria used to assess species conservation status (Hosni et al., 2013). Because of the continuing decline of plant diversity, many initiatives tried to conserve the most threatened diversity.

Endemics are essential components in the Flora of most regions of the world. Most of these taxa have become exposed to extinction within the last years. The extinction of these taxa is considered a significant threat to biodiversity; therefore, this study aimed to assess the recorded taxa according to IUCN categories and prepare conservation strategies.

2 | MATERIALS AND METHODS

2.1 | Field trips

Twenty field visits were conducted from summer 2015 to spring 2020 to many locations all over Egypt (Figure 1a). Identification and nomenclature were according to Boulos (1999–2005 and 2009) and the International Plant Names Index website (http://www.ipni.org). The updated list was arranged according to LAPG III system (Haston et al., 2009), and their voucher specimens were kept in Tanta University Herbarium (TANE) and Kafrelsheikh University Herbarium.

Authentification of the taxa were assessed depending on the following references: Andrews (1950–1956); Townsend et al., (1966, 1980); Täckholm (1974); Zohary (1966, 1987); Davis (1972–1982); Jafri and El-Gadi (1977–1988); Feinbrun-Dothan (1978, 1986); Migahid (1988–1990); Al-Eisawi (1998); Collenette (1999); Boulos (1999–2005); Boulos (2009); Taifour and El-Oqlah (2014) and Shaltout et al., (2018). Some websites were consulted to collect information about the recorded taxa (See Reference section).

Life forms were assessed according to Raunkiaer (1937) system, while national distribution according to Boulos (2009).

2.2 | Conservation assessement

The conservation categories of the studied species were checked globally according to the updated IUCN Red List 2020 (https://www.iucnredlist.org). Species are assigned to a category if they meet the appropriate quantitative threshold for at least one of five criteria (IUCN, 2014). In the present study, the assessment process depends on criterion B that concerned with a geographic range in the form of either extent of occurrence (EOO) or area of occupancy (AOO)

(a)

(b)

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)			
	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented OR Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: (I) extent of occurrence; (II) area of occupancy; (III) area, extent and/or quality of habitat; (IV) number of locations or subpopulations; (V) number of mature individuals.			
(c) Extreme fluctuations in any of: (I) extent of occurrence; (II) area of occupancy; (III) number of locations or subpopulations; (IV) number of mature individuals.			

FIGURE 1 Map of Egypt including field trips to different locations in Egypt (a). 1-North Sinai Mountains, 2-Lake Bardawil, 3-Lake Manzala, 4-Lake Burullus, 5-Lake Edku, 6-Lake Mariut, 7-Omayed B. R., 8-Moghra Oasis, 9-West Mediterranean Coast, 10-Sallum Area, 11-Saint Katherine, 12- Lake Nasser, 13- Saluga and Ghazal, 14-Wadi El-Rayan, 15- Dungul and Dineigil, 16-Wadi- Allaqi. (b) IUCN criteria used in the assessment

(Figure 1b). EOO and AOO were calculated according to IUCN guidelines (2014). EOO was measured by determining the area (km^2) of a polygon drawn by the distribution points from outside, while AOO was calculated using 2 × 2 km^2 grid.

3 | RESULTS

3.1 | Floristic analysis

Forty-one endemic taxa (32 species, 4 subspecies and 5 varieties) belonging to 36 genera and 20 families were assessed. Asteraceae was the most represented family (6 taxa), followed by Caryophyllaceae and Fabaceae (each with 5 taxa). Therophytes were the most represented life form (15 taxa = 35.7% of the total taxa), followed by hemicryptophytes (11 taxa = 26.2%) (Table 1).

Sinai is the territory richest in endemics (13 families and 19 taxa), followed by the Mediterranean region (7 families and 11 taxa) (Figure 2a). Thirty-five endemics are steno-endemics (85.4%): 16 taxa in Sinai, 7 in Nile Delta, 6 in Mediterranean, 3 in Eastern Desert, 2 in Gebel Elba and one in the Oasis (*Melilotus serratifolius*). In addition, 3 taxa occur in 2 regions (7.3%), 2 in 3 regions (4.8%) and one in 5 regions (2.4%).

3.2 | Conservation assessement

Twenty-nine taxa are threatened (70.7%). Three principal IUCN categories were defined: critically endangered (CR), endangered (EN) and vulnerable (VU). Using the IUCN Red List criteria, 4 taxa were assessed as critically endangered (9.7%), 14 as endangered (34.1%), no one is vulnerable, while 11 taxa (26.8%) are believed to be extinct. On the other hand, 12 taxa have no adequate information about

TABLE 1 Characteristics of the endemic taxa in the Egyptian Flora

Scientific name	Life form	Geographic distribution	Specific Location
Amaryllidaceae			
Allium mareoticum Bornm. & Gauba	GH	M	Lake Mariut, Alexandria
**Pancratium arabicum* Sickenb.	GH	M, S	Mersa Matrouh
Asparagaceae			
Bellevalia flexuosa var. *galalensis* Täckh. & Drar ex Täckh. & Boulos	Ge	De	
Bellevalia salaheidii Täckh. & Boulos	GH	M	
Muscari albiflorum (Täckh. & Boulos) Hosni	GH	M	
Muscari salah-eidii (Täckh. & Boulos) Hosni	GH	S	
Asteraceae			
**Anthemis microsperma* Boiss. & Kotschy	Th	M, S	Alexandia- Matrouh road
**Atractylis carduus* var. *marmarica* Täckh. & Boulos	Th	M, Dw	Omayed, Matrouh
Echinops taeckholmianus Amin	Hi	N	
Ifloga spicata subsp. *elbaensis* Täckh. & Boulos	Th	GE	
Senecio belbeysius Delile	Th	N	
**Sonchus macrocarpus* Boulos & C. Jeffrey	Ch	N, M, De	Alexandria
Brassicaceae			
Biscutella didyma var. *elbensis* (Chrtek) El Naggar	Th	GE	Gebal Elba
Brassica deserti Danin & Hedge	Th	S	
Rorippa integrifolia Boulos	Th	S	
Caryophyllaceae			
**Bufonia multiceps* Decne.	Hi	S	Saint Catherine
Dianthus guessfeldtianus Muschl.	Hi	De	
**Silene leucophylla* Boiss.	Hi	S	Saint Catherine
**Silene oreosinaica* Chowdhuri	Hi	S	Saint Catherine
**Silene schimperiana* Boiss.	Hi	S	Saint Catherine
Cistaceae			
Helianthemum schweinfurthii Grosser	Ch	De	
Fabaceae			
**Astragalus fresenii* Decne.	Hi	S	Saint Catherine
Melilotus serratifolius Täckh. & Boulos	Th	O	
Tephrosia kassasii Boulos	Hi	N	
Trigonella media Delile	Th	N	
Vicia sinaica Boulos	Th	S	
Fumariaceae			
**Fumaria microstachys* Kralik ex Hausskn.	Th	M	Mersa Matrouh
Lamiaceae			
**Ballota kaiseri* V. Tackh.	Ch	S	Saint Catherine
**Micromeria serbaliana* Danin & Hedge	Ch	S	Saint Catherine
**Origanum syriacum* subsp. *sinaicum* (Boiss.) Greuter & Burdet	Ch	S	Saint Catherine
Molluginaceae			
Glinus runkewitzii Täckh. & Boulos	Th	N	
Plantaginaceae			
**Veronica anagalloides* subsp. *taeckholmiorum* Chrtek & Osb.-Kos.	Th	N	Lake Mariut, Alexandria
Plumbaginaceae			
Limonium sinuatum subsp.*romanum* Täckh. & Boulos	Hi	M	

(Continues)

TABLE 1 (Continued)

Scientific name	Life form	Geographic distribution	Specific Location
Poaceae			
**Bromus aegyptiacus* Tausch	Th	N, M, De	Alexandria
Polygalaceae			
**Polygala sinaica* Botsch. var.*sinaica*	Ch	S	Saint Catherine
Polygonaceae			
Persicaria obtusifolia (Täckh. & Boulos) Greuter & Burdet	Ch	N	
Primulaceae			
**Primula boveana* Decne. ex Duby	Hi	S	Saint Catherine
Rosaceae			
**Rosa arabica* Crép.	Ph	S	Saint Catherine
Santalaaceae			
**Thesium humile* var.*maritima* (N. D. Simpson) Sa'ad	Th	M	Omayed, Mersa Matrouh
Scrophulariaceae			
**Anarrhinum forskaohlii* subsp. *pubescens* (Fresen.) D.A. Sutton	Hi	S	Saint Catherine
Solanaceae			
**Hyoscyamus boveanus* Asch. & Schweinf.	Ch	N, O, De, R, S	Saint Catherine

Note: 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 (After Boulos, 2009). The life forms are coded as follows: GH; geophyte-helophyte, Ge: geophyte, Th: therophyte, Ch: chaemaphyte, Ph: phanerophyte and Hi: hemicryptophyte. The collected species is denoted with*.

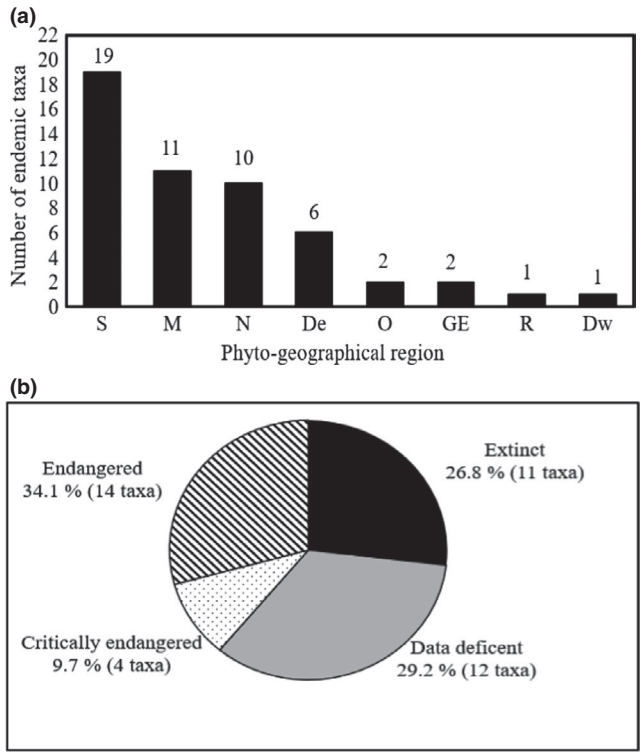

FIGURE 2 Number of endemic taxa in the Egyptian flora in relation to the national phytogeographical region (a). The phytogeographical regions are represented as follows: S: Sinai Peninsula, M: Mediterranean coastal region, N: Nile region including delta, Valley and Faiyum, De: Eastern desert, O: Oases of the western desert, GE: Gebel Elba region, R: Red Sea region and Dw: Western desert. (b) IUCN categories

their occurrence, so they were evaluated as data deficient (29.2%) (Table 2, Figure 2b).

4 | DISCUSSION

4.1 | Floristic analysis

Forty-one endemic taxa of vascular plants were recorded in the present study comparing with the previous survey of Boulos (2009) who reported 60 endemic taxa; Hosni et al., (2013) recorded 76, while Abdelaal et al., (2018) recorded 48 taxa. Two taxa in the present study (*Fumaria microstachys* and *Polygala sinaica* var. *sinaica*) were recorded only in Boulos (2009) and Hosni et al., (2013), one taxon (*Veronica anagalloides* subsp. *taeckholmiorum*) in Boulos (2009) and Abdelaal et al., (2018). Besides, one other taxon (*Silene schimperiana*) was recorded only in Boulos (2009). The differences in the number of recorded endemic species in each study are illustrated in (Appendix 1). In the present study, therophytes' dominance seems to be a response to the hot-dry climate, topographic variation and biotic influence (Heneidy & Bidak, 2001).

Regarding the national phytogeographical region, Sinia (especially South Sinai, SSI) has the maximum number of endemics (45.2%). The richness of the Sinai region with steno-endemics is probably due to the extensive mountainous massive in this region, which prevents the dispersal of seeds for long distances. The most important area of endemism in Egypt is Saint Katherine Protectorate (SKP) in (SSI) (Zohary, 1973) due to its wet climate (Danin, 1988) and physiographic features that determine specific microhabitats, which

TABLE 2 Comparison of the red list evaluation of the endemic taxa in the present study with three previous studies according to IUCN categories

	Present study			Previous studies			
Scientific name	EOO (km^2)	AOO (km^2)	Present study	I	II	III	IV
Endemic taxa							
Anthemis microsperma	363.6	12	EN	VU	–	–	–
Atractylis carduus var. *marmarica*	1077.6	96	EN	EN	–	–	–
Bromus aegyptiacus	–	–	DD	VU	–	–	–
Hyoscyamus boveanus	2123	64	EN	LC	–	–	EN
Pancratium arabicum	120.6	12	EN	EN	EN	–	–
Sonchus macrocarpus	–	–	DD	VU	RA	–	DD
Steno–endemic taxa							
Allium mareoticum	–	–	DD	CR	EN	–	–
Anarrhinum forskaohlii subsp. *pubescens*	791	44	EN	CR	EN	EN	EN
Astragalus fresenii	–	–	EX	EN	EN	RA	–
Ballota kaiseri	56.7	8	CR	CR	EN	–	CR
Bellevalia flexuosa var. *galalensis*	–	–	DD	CR	EN	–	–
Bellevalia salaheidii	–	–	EX	EX	EN	EN	–
Biscutella didyma var. *elbensis*	–	–	DD	CR	EN	–	–
Brassica deserti	27.1	8	CR	VU	EN	–	–
Bufonia multiceps	748	204	EN	EN	EN	EN	EN
Dianthus guessfeldtianus	–	–	DD	CR	EN	EN	–
Echinops taeckholmianus	–	–	EX	EX	IN	–	–
Fumaria microstachys	–	–	DD	CR	RA	–	–
Glinus runkewitzii	–	–	EX	EX	–	IN	–
Helianthemum schweinfurthii	–	–	DD	CR	IN	IN	–
*Ifloga spicatan*subsp. *elbaensis*	–	–	DD	CR	–	–	–
Limonium sinuatum subsp.*romanum*	–	–	EX	EX	–	–	–
Micromeria serbaliana	50.2	40	EN	CR	EN	RA	EN
Melilotus serratifolius	–	–	DD	CR	–	–	DD
Muscari albiflorum	–	–	DD	CR	–	EN	–
Muscari salah–eidii	–	–	EX	EX	EN	RA	–
Origanum syriacum subsp. *sinaicum*	1621.9	132	EN	EN	EN	–	–
Persicaria obtusifolia	–	–	EX	EX	–	–	–
Polygala sinaica var. *sinaica*	466.9	56	EN	VU	–	–	EN
Primula boveana	177.4	16	EN	CR	EN	RA	CR
Rorippa integrifolia	–	–	DD	CR	EN	–	–
Rosa arabica	246	44	EN	CR	EN	EN	CR
Senesio belbeysius	–	–	EX	EX	EN	–	–
Silene leucophylla	269.3	80	EN	CR	EN	RA	EN
Silene oreosinaica	52.1	8	CR	CR	EN	–	–
Silene schimperiana	270.8	92	EN	–	EN	VU	EN
Tephrosia kassasii	–	–	EX	EX	EX	EX	–
Thesium humile var. *maritima*	512.6	64	EN	VU	–	–	–
Trigonella media	–	–	EX	EX	IN	–	–
Veronica anagalloides subsp. *teckholmiorum*	8	4	CR	–	–	–	
Vicia sinaica	–	–	EX	EX	IN	RA	–
Total			41	39	28	16	12

Note: These studies are abbreviated as follows: I: Hosni et al., (2013), II: EL-Hadidi and Hosni (2000), III: IUCN (1998) and IV: Recent individual studies. The conservation categories are coded as follows: EN, endangered; VU, vulnerable; LC, least concern; RA, rare; IN, indeterminate; CR, critically endangered; EX, extinct and DD, data deficient; AOO, Area of occupancy; EOO, Extent of occurrence.

function as refugia in the desert areas (Danin, 1999; Khedr, 2006; Mosallam, 2007; Moustafa et al., 2001).

4.2 | Conservation assessement

Using the IUCN Red List criteria, 29 threatened taxa (70.7%) were recorded. Hosni et al., (2013) evaluated 42 endemics. IUCN (1998) evaluated 17 endemics, while El-Hadidi and Hosni (2000) evaluated 31 endemics (Table 2 and Appendix 2). Ali (2010) and Contu (2012) considered *Sonchus macrocarpus* and *Melilotus serratifolius*, respectively, as data deficient. Omar (2014) evaluated *Primula boveana* as critically endangered and Omar (2017a, 2017b, 2017c) evaluated *Anarrhinum forskaohlii* subsp. *pubescens* and *Bufonia multiceps* as endangered, and *Rosa arabica* as critically endangered, respectively. Also, Omar et al., (2017) evaluated *Silene schimperiana* and *Polygala sinaica* var. *sinaica* as endangered. In addition, Omar (2018) evaluated *Micromeria serbaliana*, *Hyoscyamus boveanus*, *Silene leucophylla* as endangered taxa, while *Ballota kaiseri* as critically endangered.

In the present study, *Veronica anagalloides* subsp. *teckholmiorum* was assessed as critically endangered. *Bufonia multiceps*, *Rosa arabica*, *Anarrhinum forskaohlii* subsp. *pubescens*, *Primula boveana*, *Micromeria serbaliana* and *Silene leucophylla* were evaluated as endangered. Habitat of *Veronica anagalloides* subsp. *teckholmiorum* was damaged due to the changes in agricultural and drainage systems (Hosni et al., 2013). *Bufonia multiceps* inhabits a small mountainous area in southern Sinai. Its population size is less than 2500 mature individuals, and the mature individuals are less than 250 in each sub-population. There is a continuing decline in its habitat. Many subpopulations have low viability due to destructive overgrazing causing loss of reproductive organs (El-Hadidi et al., 1992; Omar, 2017b). *Rosa arabica* inhabits a small area. Low number of mature individuals distributed among 13 subpopulations (Omar, 2017c). The species produces small numbers of seeds with low germination rate. So it is considered severely fragmented. In general, this species is threatened by aridity and human factors such as over-collection, scientific research and overgrazing (El-Hadidi et al., 1992; Omar, 2017c). *Anarrhinum forskaohlii* subsp. *pubescens* is restricted to mountainous area in South Sinai. A severe impact was arisen due to the touristic development in its area of occurrence (El-Hadidi et al., 1992; Omar, 2017a). *Primula boveana* occupies a small mountainous area in St. Katherine Protectorate. The mature individuals population is less than 200 due to the collection of plants as souvenirs from the SKP. Also, it was collected for pharmacological studies by various scientific research centres (Omar, 2014). The distribution of *Micromeria serbaliana* is severely affected by overgrazing. Water is being relocated in some localities from elevated wadis rich in water to supply to low wadis. This activity leads to water consumption from wells and results in habitat deterioration and declines in population size (Omar, 2018). *Silene leucophylla* occupies a very restricted area due to overgrazing by sheep and goats, over-collection for scientific research. It was noticed that 50% of the germinated seedlings could not survive (Saker et al., 2011). Climate change is predicted to further reduce the available habitat of this high-elevation specialist (Omar, 2018).

Six taxa were evaluated in the present study as well as two of the previous studies of Hosni et al., (2013) and El-Hadidi and Hosni (2000). Of these, *Pancratium arabicum*, *Origanum syriacum* subsp. *sinaicum* and *Silene schimperiana* were evaluated as endangered in the present study. Drought is the main threat that affecting the distribution of *Silene schimperiana*. Also, overgrazing and climatic changes cause extreme danger to the wild population of these taxa (Omar et al., 2017).

Ballota kaiseri, *Brassica deserti* and *Silene oreosinaica* were evaluated as critically endangered. Environmental conditions and human impacts have a significant influence on the diversity and distribution of *Silene oreosinaica* (Abd El-Wahab et al., 2004). Water scarcity, plant diseases and grazing by domestic and wild animals are among the threats which impacted this plant (Rabei et al., 2017). *Ballota kaiseri* is severely threatened by aridity of the area, climate change and human factors (Omar, 2018).

Five taxa evaluated in the present study as endangered were assessed in Hosni et al., (2013), three as vulnerable (*Thesium humile* var. *maritima*, *Polygala sinaica* var. *sinaica* and *Anthemis microsperma*) and two (*Atractylis carduus* var. *marmarica* and *Hyoscyamus boveanus*), in agreement with the present study were evaluated as endangered. Habitat loss due to urbanisation and tourism, clearance for agriculture and construction prosesses are the serious threats that cause decline in population size of *Thesium humile* var. *maritima* and *Anthemis microsperma*, so their assessment changed to endangered (Seif El-Nasr & Bidak, 2006).

Drought is the crucial risk affecting *Polygala sinaica* var. *sinaica*. Also, overgrazing and fragmentation of its habitats are other factors that may cause extinction to this taxon (Omar et al., 2017). Human activities, including 'overgrazing, overcutting, uprooting' are the major threats to *Hyoscyamus boveanus* (Khafagi et al., 2012). Due to climate change, this wild population could be in extreme danger in the relatively near future (Omar, 2018).

Eleven taxa were evaluated as data deficient due to inadequate information to make an accurate assessment based on its distribution and or population status. Besides, 11 taxa are believed to be extinct in the present study and Hosni et al., (2013). Four of them (*Echinops taeckholmianus*, *Senecio belbeysius*, *Trigonella media* and *Glinus runkewitzii*) are lowland plants in the Nile region whose habitats were destroyed due to the changes in agricultural and drainage systems (Hosni et al., 2013). Another two taxa (*Persicaria obtusifolia* and *Tephrosia kassasii*) are already confirmed as extinct by IUCN (1998) as well as El-Hadidi and Hosni (2000). Overgrazing and uncontrolled cutting for fuel are the main factors for establishing unfavourable conditions for most plant inhabitants.

Three taxa are known only from type locality or a single gathering viz. *Limonium sinuatum* subsp. *romanum*, *Bellevelia salaheidii* and *Muscari salah-eidii*. On the other hand, *Vicia sinaica* has not been collected throughout the last 50 years (Hosni et al., 2013). One taxon (*Astragalus fresenii*) had not been traced living, and no specimens were seen in the Egyptian herbaria since 1983 in CAI (Zahran et al., 2015).

CONFLICT OF INTEREST

All of the authors confirm that there are no conflicts of interest.

AUTHORS CONTRIBUTIONS

Mohamed Mohamed El-Khalafy and Dalia Abd El-Azeem Ahmed: **involved in** conception and design, acquisition, analysis, statistic analysis and interpretation of results, drafting the article and revising it, and approved the final version to be submitted for publication. Kamal Hussein Shaltout: **involved in** conception and interpretation of results, revising the article and approved the final version to be submitted for publication. Yassin Mohamed Al-Sodany: **involved in** revising the article. He approved the final version to be submitted for publication. Soliman Abdelfattah Haroun: **involved in** revising the article. He approved the final version to be submitted.

DATA AVAILABILITY STATEMENT

Please contact the authors for data requests.

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REFERENCES

Abd El-Wahab, R., Zaghloul, M., & Moustafa, A. (2004). *Conservation of medicinal plants in Saint Catherine Protectorate, South Sinai, Egypt*. Evaluation of ecological status and human impact, Proceeding of First International Conference on Strategy of Egyptian Herbaria, Giza, Egypt.

Abdelaal, M., Fois, M., Fenu, G., & Bacchetta, G. (2018). Critical checklist of the endemic vascular Flora of Egypt. *Phytotaxa*, *360*, 019–034. https://doi.org/10.11646/phytotaxa.360.1.2

Al-Eisawi, D. (1998). *Field guide to wild flowers of Jordan and neighboring countries* (pp. 296). Jordan Press Foundation.

Al-Eisawi, D. M., & Al-Khader, I. A. (2007). *Checklist of plants of the Hashemite Kingdom of Jordan*. Available from: http://ww2.odu.edu/~lmusselm/plant/jordan/index.php. Accessed May 2017.

Al-Ghonemy, A. (1993). *Encyclopedia of medicinal plants of the United Arab Emirates* (p. 568). University of United Arab Emirates. Al-Wahda Printing Press.

Ali, M. (2010). *Sonchus macrocarpus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/164081/5698391

Anderson, S. (1994). Area and endemism. *Quarterly Review of Biology*, *69*, 151–471.

Andrews, F. (1950–1956). *The flowering plants of the Anglo-Egyptian Sudan*, Vol. *1–3*. Sudan Government Publication.

Baierle, H. U. (1993). *Vegetation und Flora im südwestlichen Jordanien*, *Dissertationes Botanicae*, (Vol. *200*, pp. 1–254). J. Cramer, Berlin-Stuttgart.

Barnet, R. (2002). *All kinds of scented wood* (p. 277). Xulon Press.

Boulos, L. (1995). *Flora of Egypt. Checklist* (p. 287). Al Hadara Publishing, Cairo.

Boulos, L. (1999–2005). *Flora of Egypt. Four vols*. Al–Hadara Publishing.

Boulos, L. (2009). *Flora of Egypt checklist* (pp. 410). Revised Annotated Edition. Al-Hadara Publishing.

Collenette, S. (1999). *Flowers of Saudi Arabia* (pp. 800). National Commission Wild Life Conservation and Development.

Contu, S. (2012). *Melilotus serratifolius*. The IUCN red list of threatened species 2012. https://www.iucnredlist.org/species/19893139/20106404

Cunningham, W., & Cunningham, M. (1997). *Environmental science, inquiry and applications* (3rd ed., pp. 634). Mc Graw Hill Higher Education.

Danin, A. (1988). Flora and vegetation of Israel and adjacent areas. *The Zoogeography of Israel*, *30*, 251–276.

Danin, A. (1997). Contributions to the Flora of Jordan: New and interesting plants from Dana Nature Reserve, SW Jordan. *Willdenowia*, *27*, 161–175. https://doi.org/10.3372/wi.27.2714

Danin, A. (1999). Desert rocks as plant refugia in the Near East. *The Botanical Review*, *65*, 93–170. https://doi.org/10.1007/BF02857625.

Danin, A. (2000). The nomenclature news of flora Palaestina. *Flora Mediterranea*, *10*, 109–172.

Danin, A., & Hedge, I. (1998). Contributions to the Flora of Jordan 2. A new species of Satureja (Labiatae) and some new records. *Willdenowia*, *28*, 135–142.

Davis, P. (Ed.) (1972–1982). *Flora of Turkey and the east Aegean islands*. Edinburgh at the University Press.

El-Hadidi, M., Abd El-Ghani, A., & Fahmy, A. (1992). *The plant red data book of Egypt*, *1. Woody Perennials* (pp. 154). Palm Press and Cairo University Herbarium.

El-Hadidi, M., & Hosni, H. (2000). Conservation and threats. In M. N. El-Hadidi (Ed.), *Flora Aegyptiaca* (pp. 105–150). Cairo University Herbarium, The Palm Press.

Fayed, A., Zareh, M., Hassan, N., & Farried, M. (2015). A systematic revision of the genus *Teucrium* (Lamiaceae) in Egypt. *Nordic Journal of Botany*, *33*, 389–400.

Feinbrun-Dothan, N. (1978). *Flora palaestina, part three, text*. Israel Academy of Science and Humanities (pp. 481).

Feinbrun-Dothan, N. (1986). *Flora palaestina, part four, text*. (pp. 462). Israel Academy of Science and Humanities.

Gaston, K. (1994). *Rarity*. Chapman & Hall.

Germishuizen, G., & Meyer, N. (2003). *Plants of Southern Africa: An annotated checklist* (p. 1231). Strelitzia 14, National Botanical Institute, Pretoria.

Gholipour, A., & Maroofi, H. (2011). *Silene odontopetala* subsp. *congesta* (Caryophyllaceae), a New record for the Flora of Iran. *Iran Journal of Botany, Tehran*, *17*, 78–80. https://doi.org/10.22092/IJB.2011.101602

Govaerts, R. (1995). *World checklist of seed plants 1. (Parts 1, 2)* (pp. 483–529). MIM, Deurne.

Govaerts, R. (2003). *World checklist of selected plant families database in ACCESS*. Kew: The Board of Trustees of the Royal Botanic Gardens.

Haston, E., Richardson, J., Stevens, P., Chase, M., & Harris, D. (2009). The Linear angiosperm phylogeny group (LAPG) III: a Linear sequence of the families in APG III. *Biological Journal of Linnean Society*, *161*, 128–131. https://doi.org/10.1111/j.1095-8339.2009.00996.x

Heneidy, S., & Bidak, L. (2001). Multipurpose plant species in Bisha, Asir Region, South Western Saudi Arabia. *Journal of King Saud University*, *13*, 11-26.

Hosni, H., Hosny, A., Shamso, E., & Hamdy, R. (2013). Endemic and near-endemic taxa in the Flora of Egypt. *Egyptian Journal of Botany*, *53*, 357–383.

IUCN. (1998). *IUCN red list of threatened plants* (K. Walter, & J. Gillett, eds.). IUCN, Gland, Switzerland & Cambridge, The World Conservation Union (pp. 862).

IUCN. (2014). *Guidelines for using the IUCN red list categories and criteria*. Version 11. Prepared by the standards and Petitions Subcommittee. http://www.IUCN.redlist.org/documents/RedListGuidelines

Jafri, S., & El-Gadi, A. (1977–1988). *Flora of Libya*. Al- Faateh University, Faculty of Science, Department of Botany and National Academy for Scientific Research.

Khafagi, O., Hatab, E., & Omar, K. (2012). Challenges towards *Hypericum sinaicum* conservation in South Sinai, Egypt. *Jordan Journal of Biological Sciences*, *6*, 117–126.

Khedr, A. (2006). Regional patterns of rarity and life history elements in the flora of Egypt. *Tackholmia*, *26*, 141–160. https://doi.org/10.21608/TAEC.2006.12290.

Migahid, A. (1988–1990). *Flora of Saudi Arabia*, Vol. *3*. King Saud University Libraries.

Mosallam, H. (2007). Assessment of target species in Saint Katherine Protectorate, Sinai, Egypt. *Journal of Applied Sciences Research*, *3*, 456–459.

Moustafa, A., Zaghloul, M., El-Wahab, R., & Shaker, M. (2001). Evaluation of plant diversity and endemism in Saint Catherine Protectorate, South Sinai, Egypt. *Egyptian Journal of Botany*, *41*, 121–139.

Omar, K. (2014). *Primula boveana*. The IUCN Red List of Threatened Species 2014. https://www.iucnredlist.org/species/163968/1015883

Omar, K. (2017a). *Anarrhinum pubescens*. The IUCN Red List of Threatened Species 2017. https://www.iucnredlist.org/species/84119796/84119800

Omar, K. (2017b). *Bufonia multiceps*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/84119945/84119949

Omar, K. (2017c). *Rosa arabica*. The IUCN Red List of Threatened Species 2017. https://www.iucnredlist.org/species/84120072/84120074

Omar, K. (2018). *Long-term conservation planning for some endemic plant species in Egypt* (pp. 182). Conservation leader ship programme, Bird life international & Fauna and Flora international.

Omar, K., Elgammal, I., Shalof, A., Mehana, S., & Abdelbaset, F. (2017). *Final Report, community-based conservation of threatened plants* Silene shimperiana *and* Polygala sinaica *var.* sinaica (pp. 92). Conservation assessment for endemic species in Egypt. The Ruffor Foundation.

Raab-Straube, E. V., & Raus, T. (2016). Euro+Med-Checklist Notulae, 6. *Willdenowia*, *46*, 423–442.

Rabei, S., Nada, M., & El Gamal, I. (2017). Bio-systematic study on the endemic *Silene oerosinaica* from Sinai, Egypt. *Scientific Journal for Damietta, Faculty of Science*, *6*, 183–188.

Raunkiaer, C. (1937). *Plant life forms* (pp. 104). Clarendon.

Saker, M., El-Demerdash, M., & Allam, M. (2011). *In_vitro* propagation and genetic characterization as effective tools for conservation of *Silene leucophylla*, grown in St. Katherine protected area, Sinai, Egypt. *Journal of Genetic Engineering and Biotechnology*, *9*, 21–27. https://doi.org/10.1016/j.jgeb.2011.05.011

Seif El-Nasr, M., & Bidak, L. (Eds.). (2006). *Conservation and Sustainable Use of Medicinal Plants Project: National Survey, North Western Coastal Region*. Final Report. Vol. *I* & *II*. Mubarak City for Scientific Reserch and Technology Applications.

Shaltout, K., Ahmed, D., Diab, M., & El-Khalafy, M. (2018). Re-assessment of the near-endemic taxa in the Egyptian Flora. *Taeckholmia*, *38*, 61–83. https://doi.org/10.21608/taec.2018.11903

Täckholm, V. (1974). *Students' Flora of Egypt*, 2nd ed. (pp. 888). Cairo University.

Täckholm, V., & Drar, M. (1950–1969). *Flora of Egypt: Volume II-IV*, Bulletin of the Faculty of Science, Fuoad I University, no. 28-30- 36.

Täckholm, V., Täckholm, G., & Drar, M. (1941). *Flora of Egypt*: Volume *I*, Bulletin of the Faculty of Science, (pp. 1–574). Fuoad I University, no. 17.

Taifour, H., & El-Oqlah, A. (2014). *Jordan plant red list* (pp. 1289). Royal Botanic Garden.

Thomas, C., Cameron, A., Green, R., Bakkenes, M., Beaumount, L., Collingham, Y., Erasmus, B., Grainger, A., Ortega-Huerta, M., Petrson, A., Phillips, O., & Williams, S. (2004). Extinction risk from climatic change. *Nature*, *427*, 145–148.

Townsend, C., Guest, E., & Al-Rawi, A. (eds.) (1966). *Flora of Iraq*, Vols. *1-42*. Ministry of Agriculture of the Republic of Iraq.

Townsend, C., Guest, E., & Omar, S. A. (1980). *Flora of Iraq*, Vol. *4* (1-2). Ministry of Agriculture of the Republic of Iraq.

Wickens, G. (1992). *Arid and semiarid ecosystems in encyclopedia of earth system science* (Vol. *1*, pp. 113–118). Academic Press Inc.

Wolko, B., Clements, J., Naganowska, B., Nelson, M., & Yang, H. (2011). Lupinus. Chapter 9. In C. Kole (Ed.), *Wild crop relatives: Genomic and breeding resources, legume crops and forages* (pp. 153–206). Springer. https://doi.org/10.1007/978-3-642-14387-8_9

Zahran, M., Amer, M., Aflah, A., & Ghaly, O. (2015). Endemic species in Sinai Peninsula, Egypt, with Particular reference to Saint Katherine Protectorate: I- Ecological features. *Journal of Environmental Science*, *44*, 589–609.

Zahran, M., & Willis, A. (2009). *The Vegetation of Egypt*, 2nd ed. (p. (pp 437).). Springer.

Zohary, M. (1966 and 1987). *Flora Palaestina, parts one and two, text* (pp. 346, 489). Israel Academy of Science and Humanities.

Zohary, M. (1973). *Geobotanical foundations of the middle east* (pp. 739). Gustav Fischer Verlag.

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APPENDIX 1

The updated list of endemic taxa in the present study compared to the three previous related studies: 1- Boulos, 2009; 2- Hosni et al., 2013; 3- Abdelaal et al., 2018 and 4- present study. (×) refers to Exclusion from the endemics while (√) refers to being in the endemics

Excluded taxa	1	2	3	4	Reason for exclusion	Reference
Allium crameri Asch. & Boiss. ex Boiss.	√	√	√	×	Recorded in Palestine	http://www.gbif.org/occurence and http://plants.jstore.org
Euphorbia obovata Decne.	√	√	√	×	Recorded in Iran, Palestine, Syria, Lebanon and India	http://www.gbif.org/occurence, http://wcsp.science.kew.org and https://prota4u.org/database/protav8.asp?g=psk&p=Lupinus+digitatus+Forssk; Barnet, 2002.
Phlomis aurea Decne.	√	√	√	×	Recorded in Jordan and Saudi Arabia	http://plants.jstore.org and http://www.gbif.org/occurence; Kew herbarium; Al-Eisawi & El-Khader, 2007.
Rumex aegyptiacus L.	√	√	√	×	Recorded in France and Russia	http://www.gbif.org/occurence and http://plants.jstore.org
Scorzonera drarii V. Tackh.	√	√	√	×	Recorded in Palestine and Germany	http://www.gbif.org/occurence and http://plants.jstore.org
Sinapis arvensis subsp. *allionii* (Jacq.) Baillarg.	√	√	√	×	Recorded in UK, France, Italy, Spain, the Netherlands and Eretria	http://www.gbif.org/occurence and http://plants.jstore.org
Allium blomfeldianum Asch. & Schweinf	√	√	×	×	Recorded in Libya	http://www.plantsoftheworldonline.org and http://wcsp.science.kew.org; Govaerts (1995)
Colchicum cornigerum (Sickenb.) Täckh. & Drar	√	√	×	×	Recorded in Saudi Arabia, Iran, Jordan and Syria	Migahid, 1990; http://plants.jstore.org and http://www.gbif.org/occurence
Lupinus digitatus Forssk.	√	√	×	×	Recorded in Lebanon, Mauritania, Niger, Algeria, Egypt, Libya, Morocco, Senegal and Australia	http://www.plantsoftheworldonline.org, http://www.gbif.org/occurence, http://flora.org.il and https://prota4u.org/database/protav8.asp?g=psk&p=Lupinus+digitatus+Forssk; Wolko et al., 2011;
Najas pectinata Magnus	√	√	×	×	Recorded in many African countries such as Algeria, Ghana, Chad and Namibia	http://www.gbif.org/occurence, http://plants.jstore.org and http://ww2.bgbm.org/EuroPlusMed/query.asp; Boulos, 1995; Germishuizen & Meyer, 2003
Pimpinella schweinfurthii Asch.	√	√	×	×	Recorded in Saudi Arabia, Oman and Yemen	Collenette, 1999; http://www.gbif.org/occurence and 1http://www.asianflora.com
Pterocephalus arabicus Boiss.	√	√	×	×	Recorded in Jordan	http://www.gbif.org/occurence and http://wcsp.science.kew.org; Al-Eisawi & Al-Khader, 2007.
Silene odontopetala subsp. *congesta* (Boiss.) Melzh.	√	√	×	×	Recorded in Iran, but as *Silene odontopetala* subsp. *conjesta* (Boiss.) Melzh.	Gholipour & Maroofi, 2011
Veronica kaiseri Täckh.	√	√	×	×	Recorded in Jordan	http://www.missouribotanicalgarden.org; Raab-Straube & Raus, 2016.
Origanum isthmicum Danin	×	√	√	×	Recorded in Palestine	Boulos, 2002; http://www.eu-nomen.eu
Silene apetala var. *glabrata* Hosny & E. Shamso	×	√	√	×	data deficiency in the books dealing with the Egyptian flora	Täckholm et al., 1941; Täckholm & Drar, 1950, 1969; Täckholm, 1974; Boulos, 1999–2009
Solanum nigrum var. *elbaensis* Täckh. & Boulos	×	√	√	×	it was considered as a synonym to the wide spread *Solanum nigrum* L.	http://www.catalogueoflife.org/annual-checklist/2010 and https://indiabiodiversity.org/species/show/245963; Boulos (2009)
Teucrium leucocladum Boiss. subsp. *sinaicum* Danin	×	√	√	×	Recorded in Jordan	Fayed et al., 2015
Astragalus camelorum Barb.-Boiss. & Barbey	√	×	×	×	Recorded in Palestine and Jordan	http://www.gbif.org/occurence and http://www.eu-nomen.eu; Baierle, 1993; Danin, 2000
Ducrosia ismaelis Asch.	√	×	×	×	Recorded in Saudi Arabia and United Arb Emirates	Migahid, 1989; Govaerts, 2003; http://www.gbif.org/occurence; Al-Ghonemy, 1993.

(Continues)

APPENDIX 1 (Continued)

Excluded taxa	1	2	3	4	Reason for exclusion	Reference
Phagnalon nitidum Fresen.	√	×	×	×	Recorded in Palestine, Iran Ethiopia, Pakistan and Eritrea	Danin, 1997; Danin and Hedge, 1998; http://wcsp.science.kew.org, http://plants.jstore.org and http://www.gbif.org/occurence.
Plantago sinaica (Barn.) Decne.	√	×	×	×	Recorded in Jordan and Palestine	http://wcsp.science.kew.org and http://www.eu-nomen.eu; Danin, 1997.
Silene odontopetala Fenzl	√	×	×	×	Recorded in Sweden, Turkey, Iran, Lebanon, Uzbekistan and Syria	http://www.gbif.org/occurence and http://plants.jstore.org; Gholipour & Maroofi, 2011.
Veronica catenata subsp. *pseudocatenata* Chrtek & Osb.-Kos.	√	×	×	×	Recorded in Libya	http://www.ipni.org, http://www.plantsoftheworldonline.org; Abd El-Ghani et al., 2010.
Apium graveolens var. bashmensis Hosni	×	√	×	×	Reported as synonym for *Apium graveolens* L which is a wide spread taxon in Asia, Africa and Europe	http://www.catalogueoflife.org/annual-checklist/2010, http://www.gbif.org/occurence and http://ww2.bgbm.org/EuroPlusMed/query.asp; Boulos, 2000; Germishuizen & Meyer, 2003.
Bromus hordeaceus L.	×	√	×	×	is a wide spread taxon in Europe and Western Asia	Boulos, 2005; http://www.gbif.org/occurence and http://plants.jstore.org
Crepis aegyptiaca (Schweinf.) Täckh. & Boulos	×	√	×	×	Recorded in Saudi Arabia, Iran, Afghanistan and Pakistan as a synonym of *Heteroderis pusilla* Boiss.	Boulos, 2002; and http://plants.jstore.org
Delphinium bovei Decne.	×	√	×	×	Recorded in Palestine	Boulos, 1999, 2009
Euphorbia punctata Delile	×	√	×	×	Recorded in Turkey, Azerbajan, Ecuador and Libya	http://www.gbif.org/occurence and http://plants.jstore.org; Sharashy, 2016
Euphorbia sanctae-catharinae Fayed	×	√	×	×	considered a synonym of *Euphorbia obovata* Decne.	Description of herbarium sheets, Elshamy et al. (2019)
Fagonia boulosii Hadidi	×	√	×	×	considered as synonym of *Fagonia arabica* L. which is wide spread in many countries like Mauritania, Sudan, Saudi Arabia, Yemen, Libya, Palestine and Morocoo.	http://www.theplantlist.org, http://www.gbif.org/occurence and http://plants.jstore.org; Boulos, 2000
Gnaphalium crispatulum Delile	×	√	×	×	Syn. of *Gnomophalium pulvinatum* (Del.) Greuter which was recorded in some countries other than Egypt such as Australia, Thailand, Myanmar, India with specific locations and coordinates and North Africa	http://www.gbif.org/occurence and http://plants.jstore.org; Boulos, 2002
Kickxia macilenta (Decne.) Danin	×	√	×	×	Syn. of *Nanorrhinum macilentum* (Decne.) Betsche. Recorded in Palestine	Boulos, 2002, 2009
Limonium mareoticum El Garf ex Hadidi & Fayed	×	√	×	×	Recorded in Palestine, Cyperus, France, Spain and North Africa as a synonym of *Limonium narbonense* Mill.	Boulos, 2000; Germishuizen & Meyer, 2003; http://www.catalogueoflife.org/annual-checklist/2010; Boulemtafes et al. (2017).
Muscari longistylum (Täckh. & Boulos) Hosni	×	√	×	×	Recorded in Jorrdan and Palestine	http://www.catalogueoflife.org/annual-checklist/2010 and http://plants.jstore.org; Boulos, 1995, 2005
Nepeta septemcrenata Benth.	×	√	×	×	Recorded in North West Saudi Arabia	http://www.gbif.org/occurence and http://plants.jstore.org; Boulos, 2002
Trigonella occulta Delile	×	√	×	×	Recorded in India, Pakistan, Bhutan and Nepal	http://www.ipni.org and http://www.gbif.org/occurence; Jadhav et al., 2015.
Veronica musa V. Tackholm & Hadidi	×	√	×	×	Was considered synonym of *Veronica kaiseri* Täckh.	http://www.plantsoftheworldonline.org; Boulos, 2002

(Continues)

APPENDIX 1 (Continued)

Excluded taxa	1	2	3	4	Reason for exclusion	Reference
Zygophyllum album L. var. *album*	×	√	×	×	Data deficiency in the books dealing with the Egyptian flora. Also, not recorded in the international websites of plants	Täckholm et al., 1941; Täckholm & Drar, 1950, 1969;; Täckholm, 1974; Boulos, 1999–2009.
Silene biappendiculata var. *granulata* E. Shamso	×	√	×	×	Data deficiency in the books dealing with the Egyptian flora	Täckholm, 1974; Boulos, 1999–2009.
Silene villosa var. *erecta* Täckh. & Boulos	×	√	×	×	Recorded in Palestine and West Iran	Boulos, 1999
Zygophyllum migahidii var. *isthmia* Hosny	×	√	×	×	Synonym of *Tetraena propinqua* (Decne.) Ghaz. & Osborne and reported from Saudi Arabia, Iraq, Iran and Pakistan	Beier et al., 2003; Ghazanfar & Osborne, 2015); http://www.plantsoftheworldonline.org

APPENDIX 2

IUCN code of the endemic taxa with additional information that verify the assessment. The conservation categories are coded as follows: EN: endangered, CR: critically endangered

Scientific name	IUCN code	Number of locations	Notes
Endemic taxa			
Anthemis microsperma Boiss. & Kotschy	EN B1ab (i,ii,iii,iv,v)+2ab (i,ii iii,iv,v)	2 (fragmented)	Habitat loss due to urbanisation and tourism, clearance for agriculture and construction processes (Seif El-Nasr & Bidak, 2005). Also, Natural factors especially drought decrease the population size.
Atractylis carduus var. *marmarica* Täckh. & Boulos	EN B1ab (i,ii,iii,iv,v)+2ab (i,ii iii,iv,v)	2 (fragmented)	Destruction of habitats caused by cultivation activities, civilisation and tourism is a serious threats to many regions in Egypt, especially in the Mediterranean region (Seif El-Nasr & Bidak, 2005)
Bromus aegyptiacus Tausch	Data deficient	–	No specimens are collected through last times.
Hyoscyamus boveanus Asch. & Schweinf.	EN B1ab (i,iii,v)+2ab (i, iii,v)	3–4 (fragmented)	Habitat quality decline, decrease in the number of mature individuals due to climatic changes and human activities (khafagi et al.,2012; Mosallam, 2007)
Pancratium arabicum Sickenb.	EN B1ab (i,ii,iii,iv,v)+2ab (i,ii iii,iv,v)	2 (fragmented)	Over-collecting and habitat destruction due to tourism and urbanisation are the major threats that cause decline in the population size
Sonchus macrocarpus Boulos & C. Jeffrey	Data deficient	–	No specimens are collected through last time. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Steno-endemic taxa			
Allium mareoticum Bornm. & Gauba	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Anarrhinum forskaohlii subsp. *pubescens* (Fresen.) D.A. Sutton	EN B1ab (i,iii,iv,v)+2ab (i, iii,iv,v)	2 (fragmented)	Climatic changes, aridity of the area, overgrazing and human impacts decrease the habitat quality and population size (Omar, 2017 a; Omar & Nagy, 2015)
Astragalus fresenii Decne.	Extinct	-	*Astragalus fresenii* had not been traced living and no specimens were seen in the Egyptian herbaria since 1983 in CAI (Zahran et al., 2015)
Ballota kaiseri V. Tackh.	CR B1ab (i,iii,v)+2ab (i, iii,v)	1	Climatic changes, aridity of the area and human impacts decrease the habitat quality and population size (Omar, 2018)
Bellevalia flexuosa var. *galalensis* Täckh. & Drar ex Täckh. & Boulos	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Bellevalia salaheidii Täckh. & Boulos	Extinct	–	Known only from type locality or a single gathering and no specimens are collected through last times.

(Continues)

APPENDIX 2 (Continued)

Scientific name	IUCN code	Number of locations	Notes
Biscutella didyma var. *elbensis* (Chrtek) El Naggar	Data deficient	-	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Brassica deserti Danin & Hedge	CR B1ab (i,iii,v)+2ab (i, iii,v)	1	Habitat loss due to urbanisation and construction processes. Also, Natural factors especially drought decrease the population size.
Bufonia multiceps Decne.	EN B1ab (i,iii,v)+2ab (i, iii,v)	2 (fragmented)	Climatic changes especially sudden flooding, drought and grazing cause habitat destruction and decline in population size (Omar, 2017b; Khafagi et al., 2012)
Dianthus guessfeldtianus Muschl.	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Echinops taeckholmianus Amin	Extinct	–	Lowland plant in the Nile region whose habitats were destroyed due to the changes in agricultural and drainage systems (Hosni et al., 2013)
Fumaria microstachys Kralik ex Hausskn.	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Glinus runkewitzii Täckh. & Boulos	Extinct	–	Lowland plant in the Nile region whose habitats were destroyed due to the changes in agricultural and drainage systems (Hosni et al., 2013)
Helianthemum schweinfurthii Grosser	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Ifloga spicata subsp. *elbaensis* Täckh. & Boulos	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Limonium sinuatum subsp.*romanum* Täckh. & Boulos	Extinct	–	Lowland plant in the Nile region whose habitats were destroyed due to the changes in agricultural and drainage systems (Hosni et al., 2013)
Micromeria serbaliana Danin & Hedge	EN B1ab (i,iii,v)+2ab (i, iii,v)	2 (fragmented)	Climatic changes, aridity of the area and human impacts decrease the habitat quality and population size (Omar, 2018)
Melilotus serratifolius Täckh. & Boulos	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Muscari albiflorum (Täckh. & Boulos) Hosni	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Muscari salah-eidii (Täckh. & Boulos) Hosni	Extinct	–	Known only from type locality or a single gathering and no specimens are collected through last times.
Origanum syriacum subsp. *sinaicum* (Boiss.) Greuter & Burdet	EN B1ab (i,iv,v)+2ab (i, iv,v)	2 (fragmented)	Climatic changes, aridity of the area and human impacts especially over-collecting and insect injuries decrease the population size (Moustafa et al., 2015)
Persicaria obtusifolia (Täckh. & Boulos) Greuter & Burdet	Extinct	–	Already confirmed as extinct by IUCN (1998) as well as El-Hadidi and Hosni (2000)
Polygala sinaica Botsch. *var.sinaica*	EN B1ab (i,iv,v) + 2ab (i, iv,v)	2 (fragmented)	Climatic changes, aridity of the area and human impacts decrease the population size (Omar et al., 2017)
**Primula boveana* Decne. ex Duby	EN B1ab (i,iii,iv,v) + 2ab (i, iii,iv,v)	2 (fragmented)	Drought, low water availability and human impacts are the most threats which cause decline in habitat quality and population size (Omar, 2014; Zaghloul et al., 2016)
Rorippa integrifolia Boulos	Data deficient	–	No specimens are collected through last times. Also, no herbarium sheets were seen in different Egyptian Herbaria.
Rosa arabica Crép.	EN B1ab (i,iii,iv,v)+2ab (i, iii,iv,v)	2 (fragmented)	Climatic changes, aridity of the area and human impacts decrease the habitat quality and population size (Omar, 2017c; Moustafa et al., 2017)
Senecio belbeysius Delile	Extinct	–	Lowland plant in the Nile region whose habitats were destroyed due to the changes in agricultural and drainage systems (Hosni et al., 2013)
Silene leucophylla Boiss.	EN B1ab (i,iii,v)+2ab (i, iii,v)	2–3 Fragmented	Climatic changes, aridity of the area and human impacts decrease the habitat quality and population size (Omar, 2018)

(Continues)

APPENDIX 2 (Continued)

Scientific name	IUCN code	Number of locations	Notes
Silene oreosinaica Chowdhuri	CR B1ab (i,iii,v)+2ab (i, iii,v)	1	Drought and overgrazing are the major threats that may cause decline in habitat quality and decrease the population size (Rabei et al., 2017)
Silene schimperiana Boiss.	EN B1ab (i,iv,v)+2ab (i, iv,v)	2 (fragmented)	Climatic changes, aridity of the area and human impacts decrease the population size (Omar et al., 2017)
Tephrosia kassasii Boulos	Extinct	–	already confirmed as extinct by IUCN (1998) as well as El-Hadidi and Hosni (2000)
Thesium humile var.*maritima* (N. D. Simpson) Sa'ad	EN B1ab (i,iv,v)+2ab (i, iv,v)	2 (fragmented)	Habitat loss due to urbanisation and tourism, clearance for agriculture and construction processes (Seif El-Nasr & Bidak, 2006). Also, Natural factors especially drought decrease the population size.
Trigonella media Delile	Extinct	–	Lowland plant in the Nile region whose habitats were destroyed due to the changes in agricultural and drainage systems (Hosni et al., 2013)
Veronica anagalloides subsp. *taeckholmiorum* Chrtek & Osb.-Kos.	CR B1ab (i,iii,v)+2ab (i, iii,v)	1	Lowland plant in the Nile region whose habitats were destroyed due to the changes in agricultural and drainage systems and construction processes. Also, Natural factors especially drought decrease the population size.
Vicia sinaica Boulos	Extinct	–	This taxon has not been collected throughout the last 50 years (Hosni et al., 2013). Also, no herbarium sheets were seen in different Egyptian Herbaria