Egypt. J. Bot. **Vol. 60**, No.3, pp. 719-732 (2020)

Egyptian Journal of Botany
http://ejbo.journals.ekb.eg/

Wild Plant Species in Egyptian Gardens of the Nile Region: Conservation Viewpoint

Dalia A. Ahmed[(1)], Esraa Ammar[(1, 2)#], Jens-Christian Svenning[(2)], Mohamed El-Beheiry[(1)], Kamal Shaltout[(1)]

(1)Botany Department, Faculty of Science, Tanta University, 31527, Tanta, Egypt; [(2)]Center for Biodiversity Dynamics in a Changing World (BIOCHANGE) and Section for Ecoinformatics and Biodiversity, Department of Bioscience, Aarhus University, Ny Munkegade 114, DK-8000 Aarhus C, Denmark.

THE PRESENT study aims to evaluate the role of Egyptian gardens in the Nile Region for wild plant conservation, focusing on threatened species. For this evaluation, an outline of their life forms, geographical distributions, economic uses, environmental benefits, conservation categories, and local threats in their natural habitats is given. One hundred and ninety-four trips were conducted to cover 183 gardens in the study area (summer 2012 to winter 2018). Ninety-six species were recorded, they belonged to 76 genera and 43 families. Fabaceae was the most recorded family and *Acacia* was the most represented genus. Phanerophytes was the most represented life form (39.6%). Nile region was the most represented (75 species, 78.1%) (out of them 20 species were restricted to it). Beside, 21 species were conserved in gardens from other phytogeographical regions as Sinai, Mediterranean, Gebal Elba and Deserts. Medicinal plants (58 species) were the most represented economic uses, while nitrogen fixers (37.9%) were the most represented environmental benefits. Eighty- seven species suffer from at least one threat at their natural habitats, over-collecting species (70.1%) were the most represented threats. The recorded species classified into 73 native and 23 aliens. Seven species were IUCN threatened species (5 least concerned, 1 endangered and 1 vulnerable). Our results show an unlimited role of botanic and public gardens in the Egyptian Nile Region; for plant diversity conservation, as they not only help conserve the threatened species in the study area but also help conserve wild plant species from other geographical regions.

Keywords: Economic uses, Environmental benefits, Threats and threatened species, Wild plants.

Introduction

Egypt is located in northeastern Africa; with the Egyptian Nile region across temperate grassland, desert and semi-desert biomes according to the world biomic map (Lomolino et al., 2017), with a length of about 1520km (23% of the total length of the river), and sheltering a population of about 80 million people. Egypt had an important area for plant diversity and contains about 28.8% of the threatened plants of North Africa (https://www.iucnredlist.org).

The Egyptian climate is arid to hyper-arid, so drought-tolerant species are prevalent among its wild plants.

Nile region is characterized by the accumulation of clays carrying essential nutrients (required for plant growth) collected in the form of fertile layers on the lands of the river banks, so agriculture was considered as a main craft around the river banks. Cultivated plants are often planted according to the human desire in gardens or crop fields (Manniche, 2006). The ancient Egyptians not only cultivated their required crops in fields but

#Corresponding author emails: esraa_ammar@science.tanta.edu.eg, esraaammar@bios.au.dk, Mobile: 00201030815722
: 0000-0001-7979-6432.
Received 20/12/ 2019; Accepted 4/6/2020
DOI: 10.21608/ejbo.2020.21253.1414
Edited by: Prof. Dr. Monier M. Abd El-Ghani, Faculty of Science, Cairo University, Giza 12613, Egypt.

also cultivated ornamental plants for their numerous benefits (e.g., decoration, wind-breaking, fruit, and flower production, using in traditional industry or shading and riverbank erosion control) in gardens which usually constructed in a palace or house squares or established terraces on the banks of the river or its branches (Manniche, 2006).

Gardens were defined internationally as flexible and continual institutions capable of changing through time and adapting to continue to meet the needs of the society (Blackmore, 2017). The greatest role of gardens is focusing on plant conservation as it was referred to in the Global Strategy for Plant Conservation (GSPC) (Wyse Jackson & Kennedy, 2009; McNeely, 2011; Powledge, 2011). Hence, many countries are keen on the construction of new botanic gardens or developing existing gardens according to their scientific definition of the Botanic Garden Conservation International (BGCI) for plant conservation and reintroduction of new rare species or breeding of threatened species to protect from their extinction (Powledge, 2011). Eight Egyptian gardens only were recorded according to their role of plant conservation (e.g., Montazah Palace Garden in Alexandria, Saff, Orman, and Kobba Palace Gardens in Greater Cairo and Aswan Botanic Island in Aswan).

There are several vital botanic and public gardens in the Egyptian Nile Region either historical gardens such as Ezbekeya, Kobba Palace, Zafaran Palace, Shubra Palace, and Agricultural Museum gardens in the Greater Cairo, Antoniadis gardens in Alexandria and Feryal garden in Aswan or newly established gardens (e.g., Shagar Dorr Garden in Mansoura, International Garden in Alexandria, New Damietta Garden in Damietta, etc….). Notably, Egyptian gardens play an important role in wild plants conservation; which grow naturally among cultivated plants. Hence, this study aims to evaluate the role of Egyptian gardens in the Nile Region for wild plants conservation, focusing on threatened species. For this evaluation, an outline of their life forms, geographical distributions, economic uses, environmental benefits, conservation categories, and local threats in their natural habitats is provided.

Materials and Methods

Study area

The Egyptian Nile Region is composed of the Nile Delta, Nile Fayium, and the Nile Valley. The Nile Delta is a part of the Egyptian Mediterranean coast and extends for approximately 240 km from Abu Quir headland at Alexandria in the west, to Port Said in the east, Nile Fayium is a depression below sea level, formed by wind erosion 1.8 million years ago, and covering ca 12,000 km^2 and Nile valley extends approximately 800 km from Aswan to the outskirts of Cairo (El-Shabrawy &Dumont 2009; Hamza 2009). The Egyptian Nile region is composed of 20 governorates that include various botanic and public gardens, which were established mainly for the cultivation of ornamental plants, but in between the various native wild plant species grow either planted or spontaneously (Map).

The Egyptian climate is arid to hyper-arid, with the northern part of the Nile Delta belonging to the arid region, while the Nile Valley and the southern part of the Nile Delta belonging to the hyper-arid region. The annual rainfall ranged between 80-200mm year^{-1} from 2012 to 2018 (https://power.larc.nasa.gov/). The regions with the highest precipitation are located along the Mediterranean coast (e.g., around Alexandria). The hot dry season in summer is extended from May to October (https://weather-and-climate.com).

Field trips

One hundred and ninety-four field trips (155 in Nile Delta, 36 in Nile Valley, and 3 in Nile Fayium) were conducted to cover 183 gardens in Nile Region in Egypt during summer 2012 to winter 2018. In each garden, the wild plant species were recorded and a plant sample was collected. Identification and nomenclature were according to Boulos (1995, 1999, 2000, 2002, 2005, and 2009) and the Kew Garden plant list website (http://www.theplantlist.org). Life forms of the recorded species follow the system of Raunkiaer (1937). National phytogeographical regions were gathered from the following references: Täckholm (1974), Boulos (1995, 1999, 2000, 2002, 2005, 2009), Shaltout et al. (2010). Voucher specimens of the collected species were deposited in Tanta University Herbarium (TANE).

Economic uses and Environmental benefits

The potential and actual economic uses of the recorded species were assessed from information collected from local inhabitants and herbalists; and literature review (Wickens, 1980; Belal & Springuel, 1996; Shaltout, 1997; Ayyad, 1998;

Heneidy, 2010; Shaltout et al., 2010; Ahmed & Al-Sodany, 2019). Economic uses were classified into 6 major categories: grazing, medicinal, human food, timber, fuel, and other uses (e.g. making mats, baskets, chairs, ornamental uses, beach bed, soap manufacture and oil and dye extraction).

On the other hand, environmental benefits were evaluated from information collected from local inhabitants and herbalists; and reference consultation (Simpson, 1932; Täckholm, 1974; Ayyad, 1998; Zahran & Willis, 2003; Heneidy, 2010; Shaltout et al., 2010; Shaltout & Ahmed, 2012). Six aspects of environmental benefits were described as a nitrogen fixer, sand accumulator, windbreaker, canal shore retainer, shading and water purifier.

Threats upon species and their natural habitats

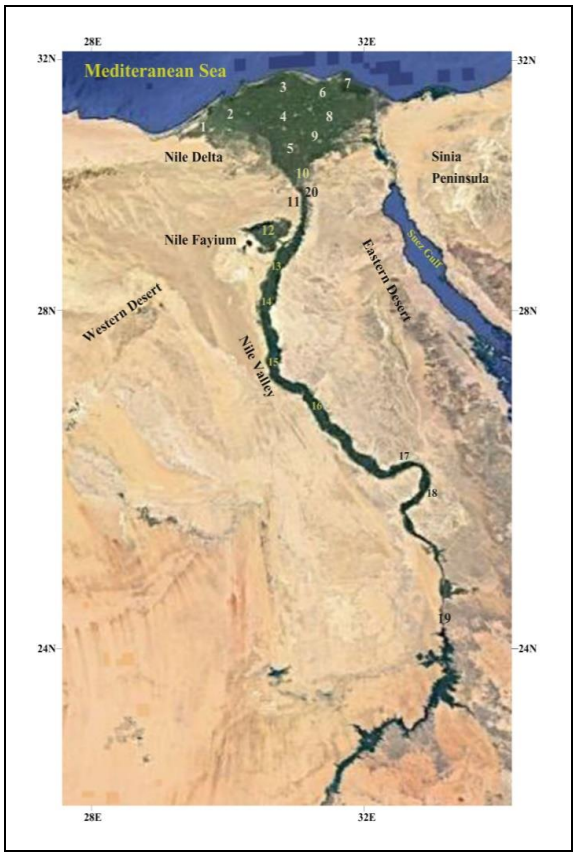
Threats are the direct and indirect causes of ecosystem degradation and species impoverishment. Six types of threats were observed in the study area and recorded. Over-collecting and over-cutting, overgrazing and browsing; clearance for agriculture; habitat loss (industrial/urban growth, coastal development); disturbance by cars or trampling; and mining and quarrying consulted (Shaltout & Ahmed, 2012).

Natural habitats of the recorded wild species are collected from Boulos (2009). They are grouped in 7 groups as following: Rocky habitats (e.g., rocky crevices, rocky hillsides, volcanic soil, and stony soil), aquatic habitats (e.g., Nile, Nile canals, Nile banks, lakes, canals, pools, ditches, and rice fields), sandy habitats (sand plains and sandy soil), cultivated habitats (e.g. weed fields, fields and escape from cultivation), wastelands, wetlands and salt-marshes.

Conservation categories and Naturalness status

The conservation categories of the recorded species were collected and checked globally according to the updated IUCN Red List 2020 https://www.iucnredlist.org and Shaltout et al. (2018), while naturalness status was collected from Shaltout et al. (2016).

A. Map showing location of the studied Egyptian botanic gardens along the Nile Region



B. Selected governorates for surveying wild plants inside their gardens; 1. Alexandria (e.g. Maamourah Gardens), 2. Beheira (e.g. Edfina Public Park), 3. Kafr El-Shaikh (e.g. Sanaa Zoo in Kafr El-Shaikh), 4. Gharbia (e.g. Montazh Public Park in Tanta), 5. Menufia (e.g. Namoozagia Garden in Shbeen El-Kom), 6. Dakahlia (e.g. Shagar El-Dorr Gardens in Mansoura), 7. Damietta (e.g. New Damietta Garden), 8. Sharqia (e.g. Zagazig Zoo), 9. Qalyubia (e.g. Qanater Public Park), 10. Cairo (e.g. Manial Palace Gardens), 11. Giza (e.g. Orman Garden), 20. Helwan (e.g. Japanese Garden), 12. Fayium (e.g. Fayium Zoo), 13. Beni Suef (e.g. Shalal Garden), 14. Minya (e.g. Minya Public Park), 15. Assuit (e.g. Fardous Garden), 16. Sohag (e.g. Karaman Island in Sohag), 17. Qena (e.g. Maaena Industrial forest), 18. Luxor (e.g. Habil Industrial Forest) and 19. Aswan (e.g. Aswan Botanic Islands) (https://www.arcgis.com).

Map. The Egyptian Nile Region includes three regions (Nile Delta, Nile Fayium and Nile Valley), showing the selected governorates for surveying wild plants inside their gardens (https://www.google.com/earth).

Results

Floristic analysis

Ninety-six wild species belonging to 79 genera and 43 families were recorded in 186 gardens in the Egyptian Nile Region. The most represented families were Fabaceae (16 species represented 16.7% of the total recorded species), followed by Poaceae (8 species= 8.3%). The most represented genera were *Acacia* (4 species), *Ficus* and *Ipomoea* (each represented by 3 species), while each of *Ageratum, Amaranthus, Brassica, Cyperus, Datura, Ephedra, Euphorbia, Malva*, *Medicago, Pennisetum, Salix* and *Tamarix* is represented by 2 species (Appendix). Phanerophytes (38 species= 39.6%) were the most represented life form, followed by therophytes (35 species= 36.5%), and hemicryptophytes (9 species= 8.4%), while each of chamaephytes, geophytes and helophytes was the less represented (4 species= 4.2%) (Appendix).

Regarding the national phytogeographical regions; species distributed in the Nile region were the most represented (75 species= 78.1%), followed by the Mediterranean species (51 species= 53.1%) and Oases (42 species= 43.8%) (Fig. 1 and Appendix). Out of 75 species recorded in the Nile region, there are 20 species (26.7%) their distribution was restricted to the Nile region. On the other hand, there are 21 species (21.9% of the total) recorded from other phytogeographical regions (6 species in mono-region and 15 species in more than one region), 16 occur in Sinai, 10 in the Mediterranean, 10 in the Deserts, 6 in the Gebal Elba and 4 in Oases) (Appendix). Regarding the world distribution; African species were the most represented (52 species= 54.2%), followed by Asian species (49= 51.0%), while the less represented species were the Australian (8= 8.3%) (Fig. 2 a). For the number of continents; 42 species were distributed in one continent (43.8%), 37 in two continents (38.5%), while 17 species were distributed in more than two continents (17.7%) (Fig. 2 b).

Economic uses and Environmental benefits

The recorded wild species indicated that; 88 species (91.7% of the total species) have at least one aspect of the potential or actual economic uses. Medicinal plants (58 species= 65.9%) were the most represented, followed by human food plants (39= 44.3%), while plants used as fuel (5= 5.7%) were the least represented (Fig. 3 a and Appendix). Thirty-nine species (44.3%) offer one economic use, (30= 34.1%) offer 2 economic uses, (8=9.1%) offer 3, while 11 (12.5%) offer more than three economic uses (Appendix). Regarding the environmental benefits, 29 species (30.2% of the total species) offer at least one of the environmental benefits. Nitrogen fixers plants (11= 37.9%) had the highest contribution, followed by windbreakers (8= 27.5%), while plants providing shading (5= 17.2%) had the least contribution (Fig, 3 b and Appendix). Eighteen species (62.1%) offer one environmental benefit, (8= 27.6%) offer 2 environmental benefits and (3= 10.3%) offer 3 environmental benefits (Appendix).

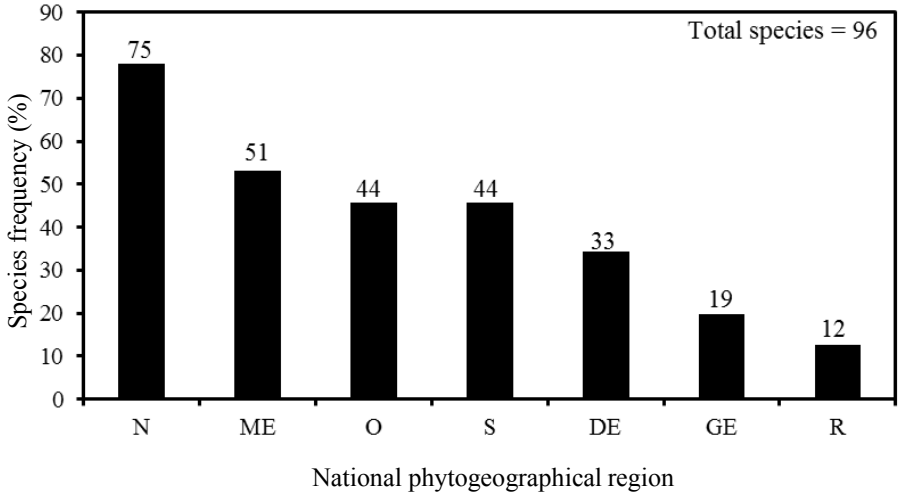


Fig. 1. Phytogeographical regions of by the wild conserved species in the Egyptian botanic gardens of the Nile Region [N: Nile region, ME: Mediterranean coastal strip, S: Sinai Peninsula, O: Oases of the Western desert, DE: Deserts, GE: Gebal Elba and R: Red Sea coastal strip].

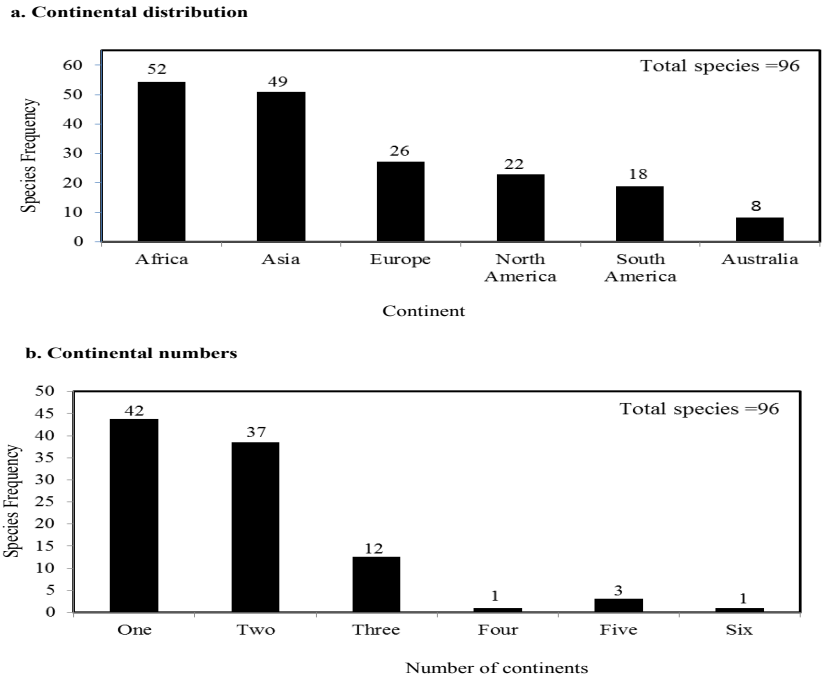


Fig. 2. Continental distribution and continental numbers of the wild species conserved in Egyptian gardens of the Nile Region.

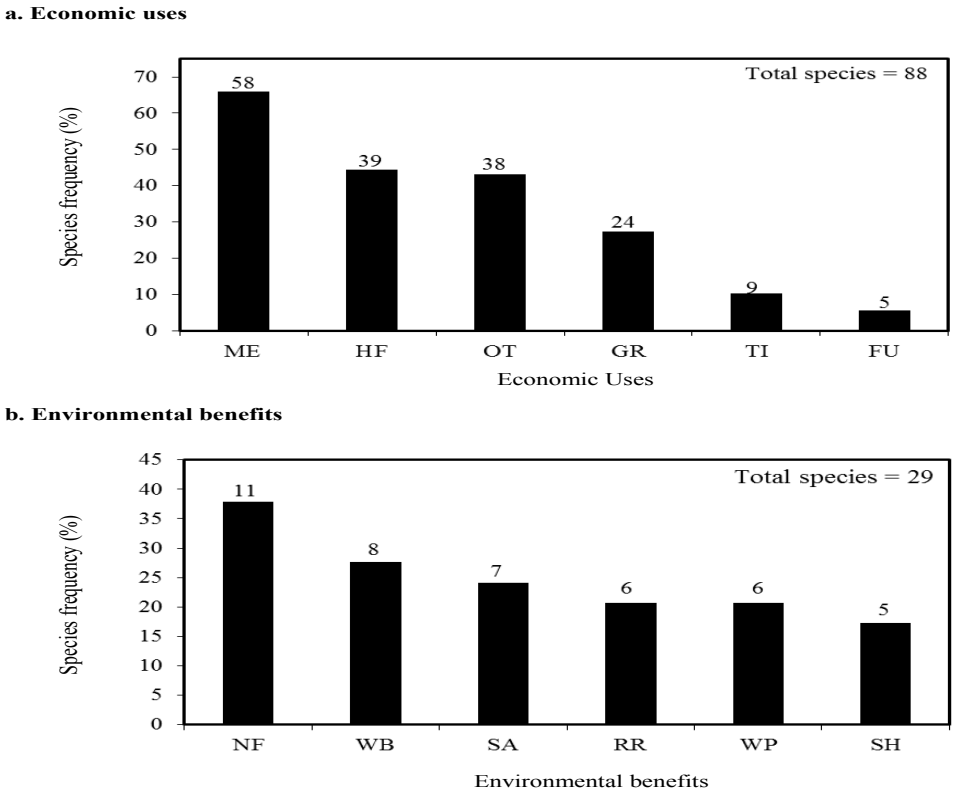


Fig. 3. Economic uses and environmental benefits offered by the wild species conserved in Egyptian gardens of the Nile Region [Economic uses are ME: Medicinal purposes, HF: Human food purposes, OT: other uses (e.g., industry, aromatic oils, dyes, painting, resin and etc.), TI: timber production and GZ: grazing. Environmental benefits are NF: nitrogen fixer, SA: sand accumulator, WB: wind breaker, RR: riverbank retainer, SH: Shading and WP: water purifier].

Threats upon species and their natural habitats

Eighty-seven species (90.6%) were affected by at least one aspect of the potential or actual local threats in their natural habitats. Forty-seven species (54.0%) suffered from one threat, 24 species (27.6%) from two threats, 15 species (17.2%) from three threats, while only *Datura stramonium* (1.1 %) suffered from five threats (Fig. 4 a). Over-collecting and over-cutting plants (61= 70. %) were the most common threats, followed by over-grazing and browsing (28 species= 31.2%), while plants that suffer from losing their habitats (8= 9.2 %) was the least common threat (Fig. 4 b and Appendix).

Regarding the natural habitat of the recorded species, 46 species (47.9%) were recorded in cultivated habitats (e.g. weeds of cultivation, fields, escapes from cultivation or on roadsides among cultivated areas), while 30 species (31.3%) grow in aquatic habitats such as Nile canals, Nile banks, lakes, canals, pools, ditches, and rice fields (Fig.5 a and Appendix). Fifty- four species were reported in one habitat (56.3%), 30 species in two habitats (31.3%) (Fig. 5 b and Appendix).

Conservation categories and Naturalness status

Regarding the Global conservation categories according to IUCN 2020 (https://www.iucnredlist.org). Seven species out of 96 were threatened (7.3% of the total recorded species) and need conservation. Five species are least concerned (*Cyperus papyrus*, *Dichrostachys cinereal*, *Ficus carica, Nymphaea lotus* and *Pteris vittata*), while *Dracaena ombet* is endangered and *Medemia argun* is vulnerable (Table 1). Locally, these species suffer from local threats in their natural habitats as following: 6 species are suffering from over-collecting and over-cutting (e.g. *Cyperus papyrus*), while *Dracaena ombet* and *Ficus carica* are also suffering from clearance for agriculture and habitat loss, *Dichrostachys cinerea* is suffering from mining and quarrying and *Pteris vittata* is suffering from habitat loss in addition to over-collecting and overcutting (Table1).

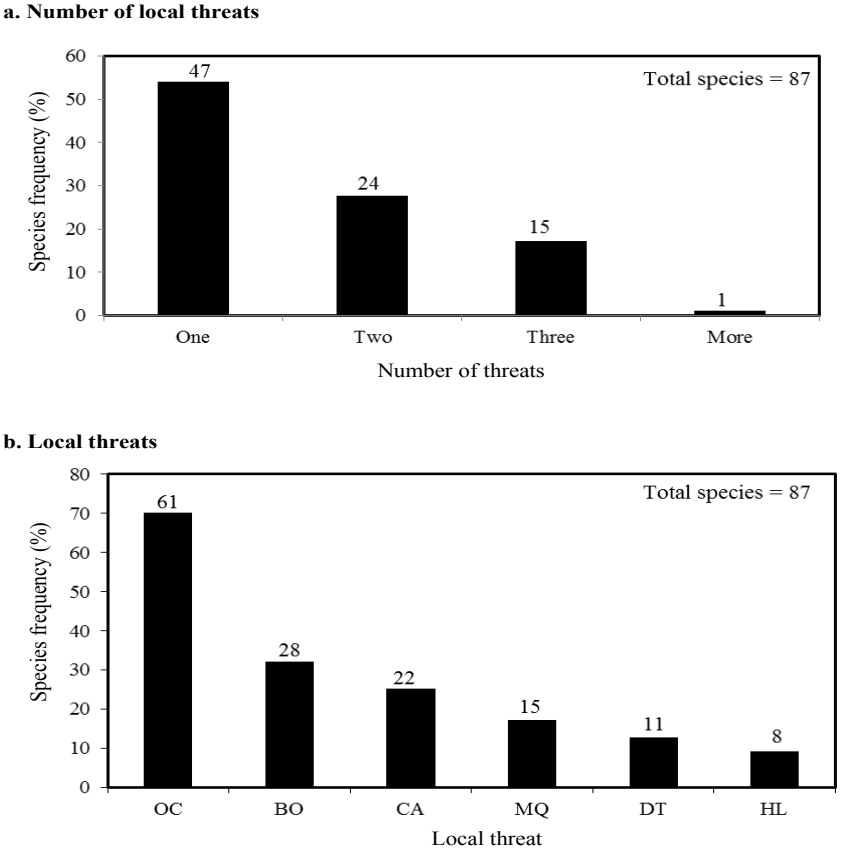


Fig. 4. Local threats upon the recorded wild species in their Egyptian natural habitats [Local threats are; BO: Browsing and over-grazing, OC: Over-collecting and over-cutting, CA: Clearance for agriculture, HL: Habitat loss, DT: Disturbance by cars or trampling and MQ: Mining and quarrying].

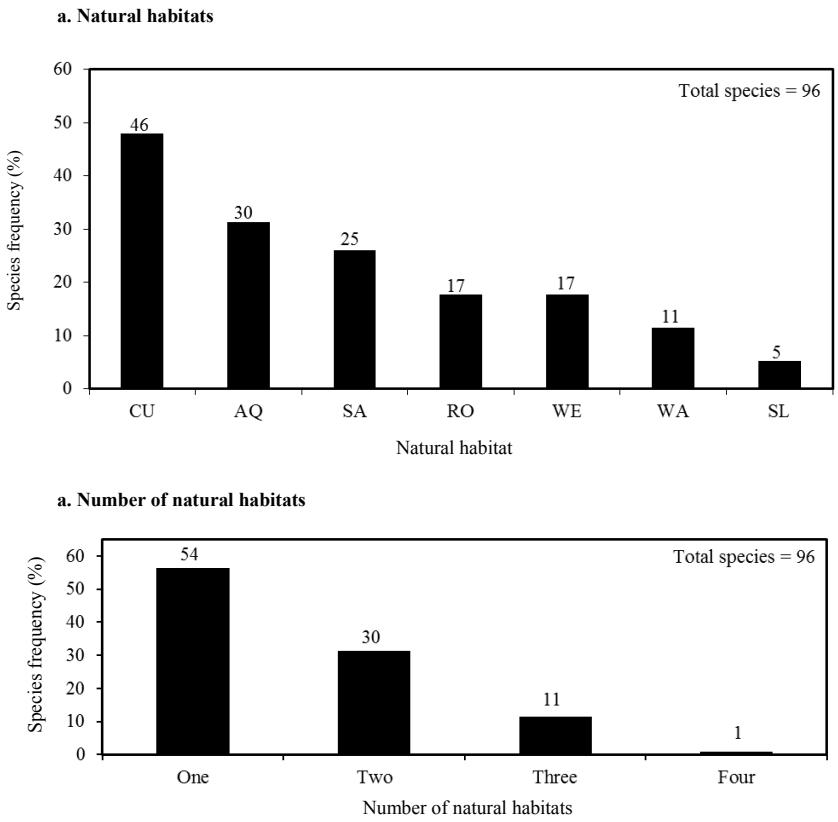


Fig. 5. Natural habitats of the wild species recorded in Egyptian gardens of the Nile Region [Natural habitats are RO: Rocky habitats (rocky crevices, rocky hillsides, volcanic soil and stony soil, AQ: Aquatic habitats (e.g., Nile, Nile canals, Nile banks, lakes, canals, pools, ditches, and rice fields), SA: Sandy habitats (e.g., coastal sand dunes, sand plains and sandy soil), CU: Cultivated habitats (e.g., weeds of cultivation, fields, escape from cultivation or on road sides among cultivated areas), WA: Wastelands, WE: Wetlands and SL: Salt-marshes].

TABLE 1. Global conservation status of the threatened species according to IUCN recorded in the Egyptian botanic gardens.

Threatened species	IUCN Categories	Local threats
Cyperus papyrus L	Least concerned	OC
Dichrostachys cinerea (L.) Wight and Arn.	Least concerned	BO, OC, MQ
Dracaena ombet Kotschy and Peyr.	Endangered	HL, OC, CA
Medemia argun (Mart.) Wurttenb. ex H.Wendl.	Vulnerable	OC
Nymphaea lotus L.	Least concerned	OC
Ficus carica L.	Least concerned	HL, OC, CA
Pteris vittata L.	Least concerned	HL

Local threats inside Egypt are OC: Over collecting and over cutting, OG: Overgrazing and browsing, CA: Clearance for agriculture, MI: Mining and quarrying and HI: Habitat loss.https://www.iucnredlist.org.

In addition to 75 wild plant species conserved in gardens in the Nile region, there are 21 species (21.9%) conserved from other national phytogeographical regions in Egypt as Sinai, Mediterranean, Deserts, Gebal Elba, and Oases (Appendix). From Gebal Elba; *Caralluma acutangula* was conserved in Orman garden in Giza and *Dracaena ombet* was conserved within 30 gardens such as Orman and Zohryia gardens in Giza, Montazah Palace, Antoniadis and international gardens in Alexandria, and Aswan Botanic Island in Aswan and from Sinai; *Alcea rosea* was conserved in 21 gardens such as Maadi district and Azhar park in Cairo, Montazah Palace

and International gardens in Alexandria, Minya Public Park in Minya, and International garden in Fayium and *Dianthus chinensis* L. was conserved in 23 gardens as Montazah Palace gardens in Alexandria, Tafahna Ashraf gardens in Dakahlia, Banha shore gardens in Qalyubia, South Valley University Campus in Qena; and International garden in Fayium (Table 2).

TABLE. 2. List of wild plant species conserved within the Nile region gardens from other phytogeographical regions.

Plant Species	No. of gardens	Garden locations in the Nile Region
Aizoon canariensis L.	1	Orman garden in Giza.
Alcea rosea L.	21	e.g., Maadi district and Azhar park in Cairo, Montazah Palace and International gardens in Alexandria, Minya Public Park in Minya; and International garden in Fayium.
Anemone coronaria L.	10	e.g., Gezira garden in Cairo, International garden Alexandria; and Feryal garden in Aswan.
Apium graveolens var. *dulce* (Mill.) DC.	20	e.g., International gardens in Alexandria, Minya Public Park in Minya; and Karaman Island in Sohag.
Atriplex halimus L.	2	Faculty of Agriculture garden, Caito University and Azhar Park in Cairo
Caralluma acutangula (Decne.) N.E.Br.	1	Orman garden in Giza.
Ceratonia siliqua L.	17	e.g., Orman, Zoo, Zohryia, Agriculture museum gardens in Giza, Manial Palace, Shubra Palace, Azahar gardens in Cairo; and Nouzha and Zoo, and Antoniadis gardens in Alexandria
Cordia sinensis Lam.	3	Manial Palace and Andalosia gardens in Cairo; and Phila Island in Aswan.
Cortaderia selloana Asch. & Graebn.	1	Aswan Botanic Island in Aswan.
Dianthus chinensis L.	23	e.g., Faculty of Science, Alexandria University and Montazah Palace gardens in Alexandria, Azahar University, Tafahna Ashraf gardens in Dakahlia, Banha shore gardens in Qalyubia, South Valley University Campus in Qena; and International garden in Fayium.
Dracaena ombet Kotschy and Peyr.	30	e.g., Orman and Zohryia gardens in Giza, Zaafaran Palace, and Azhar Gardens in Cairo, Montazah Palace, Antoniadis and international gardens in Alexandria; and Aswan Botanic Island in Aswan.
Ephedra alata Decne	12	e.g., Orman, Zoo and Zohyria gardens in Giza.
Ephedra aphylla Forssk.	16	e.g., Orman, Zoo and Zohryia garden in Giza And Manial Palace, Horreya and Shubra Palace gardens in Cairo and Nouzha and Zoo in Alexandria.
Ficus palmata Forssk.	17	e.g., Orman and Zoo gardens in Giza and Ezbekeya and Asmak gardens in Cairo.
Ipomoea pes-caprae (L.) R. Br.	45	e.g., Orman, Zoo and Zohryia gardens in Giza, Antoniadis gardens in Alexandria; and Aswan Botanic Island and Feryal gardens in Aswan.
Medemia argun (Mart.) Wurttenb. ex H.Wendl	1	Aswan Botanic Island in Aswan.
Medicago lupulina L.	7	e.g., Saff garden in Giza, Banha shore gardens in Qalyubia.and Feryal garden in Aswan.
Moringa peregrina Fiori	2	Orman and Saff gardens in Giza.
Narcissus tazetta L.	1	Saff garden in Giza.
Pistacia lentiscus L.	5	e.g., Orman and Zoo gardens in Giza and Montazh Public Park in Tanta, Gharbia.
Solenostemma argel Hayne	1	Aswan Botanc Island in Aswan

Out of the 96 wild plants, 73 species were native, while 23 were aliens. Out of the 23 alien species; 8 were casuals (*Alcea rosea, Amaranthus tricolor, Brassica rapa, Clitoria ternatea, Ipomoea pes-caprae*, *Hibiscus sabdariffa*, *Medicago sativa* and *Nigella sativa*), 13 were naturalized (*Amaranthus hybridus, Datura stramonium, D. innoxia, Euphorbia heterophylla, E. mauritanica, Ficus carica, Lantana camara, Oxalis Pes-caprae, Nicotiana glauca, Ricinus communis, Salix tetrasperma, Sesbania sesban* and *Ziziphus spina-christi*) and two were invasive species (*Eichhorina crassipes* and *Ipomoea carnea*) (Appendix, Fig. 6).

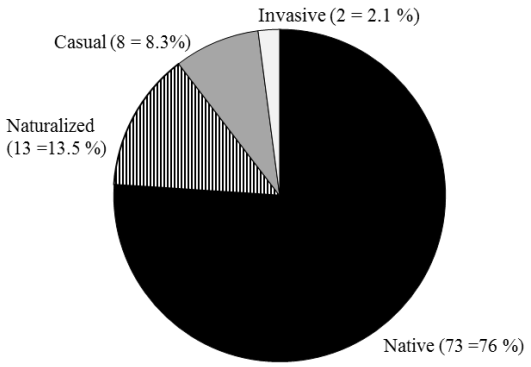


Fig. 6. Naturalness status of the wild species conserved in Egyptian gardens of the Nile Region.

Discussion

Floristic analysis

Botanic Gardens have collectively accumulated centuries of resources and expertise that now play a key role in plant conservation. The role of botanic gardens as *ex-situ* tool for conservation was expanding as they take the lead in integrated conservation of threatened species and habitats (BGCI, 2016). Ninety-six wild plant species were conserved in the Egyptian gardens; belonging to 76 genera and 43 families, they represented 4.3% of the total natural flora in Egypt. The most represented families were Fabaceae (16 species= 16.7%), followed by Poaceae (8 species= 8.3%). On the other hand, the most represented genera were *Acacia* (4 species= 4.2%), followed by each of *Ficus* and *Ipomoea* (3= 3.1%). Shaltout & Farahat (2005) reported that 74 species of which the most represented families were Poaceae (20 species= 27% of the total weed species), followed by Asteraceae (9 species= 12.2%), while *Euphorbia* (4 species= 5.4%) was the most represented genus, followed by *Amaranthus* (3 species= 4%) in Qanater Public Park.

In the present study, phanerophytes (37 species) were the most represented life form, followed by therophytes (35 Species). The predominance of phanerophytes (permanent buds borne at height > 25cm) among the wild plants likely reflects that they were able to tolerate drought, salinity, sand accumulation, and grazing which characterize the study area (Galal & Fahmy, 2012; Bedair et al., 2020). Also, the prevailing of therophytes reflects that the Egyptian climate is arid, so it allows the growth of many drought-tolerant wild plants, which survive the long dry periods as seeds (Wickens, 1992).

Regarding the national geographical region, the Nile taxa were the most represented, followed by Mediterranean taxa. This finding coincides with the result of Bedair et al. (2020). The recording of other phytogeographical elements rather than Mediterranean elements was a reflection of degradation of the Mediterranean ecosystem which permits the invasion of some elements from adjacent regions (Madi et al., 2002). In the present study, 21 species were recorded in the Nile region from other phytogeographical regions (16 occur in Sinai, 10 in the Mediterranean, 10 in the deserts, 6 in Gebal Elba, 4 in oases). In the present study, African species were the most represented over other taxa from adjacent continents. Egypt lies in Northeastern Africa and is considered the aridest country, where desert conditions prevail throughout the nation.

Economic and Environmental uses

Eighty-eight species (91.7% of the total species) have at least one aspect of the potential or actual economic uses. Medicinal plants were the most represented economic uses (58 species= 65.9%). For example, *Adiantum capillus-veneris*, *Alhagi graecorum*, *Ageratum conyzoides, Atriplex halimus* and *Lotus glaber* are used in folk medicine (Ayyad, 1998; Shaltout & Ahmed, 2012; Bidak et al., 2015; Ammar et al. 2020).

Vegetative and ground parts of 39 species (44.3% of the total economic species) were used as foods by people in the study area. Many inhabitants eat *Malva parviflora* leaves and shoots as a salad (Bidak et al., 2015; El-Beheiry et al.,

2015). The less represented economic uses in this study are timber production (9 spp.= 10.2%) and fuel production (5 spp.= 5.7%). Mainly, *Acacia* trees seem like a luxury type of wood for fuel, where it makes a heavy heat which burns slowly (Shaltout, 1997).

Twenty-nine species (30.2% of the total species) have at least one aspect of the potential or actual environmental benefits. Eleven species were nitrogen fixers, as most Fabaceae species that are capable of forming root associations with several bacteria. (Simpson & Ogorzaly, 1995). Eight species were noted (e.g., *Ricinus communis* and *Phoenix dactylifera*) as a windbreakers, which keep the weak growing herbs from break (Shaltout et al., 2010). Seven sand controllers were documented; these species deal successfully with drift sand (e.g., *Alhagi graecorum*, *Atriplex halimus* and *Tamarix nilotica*) (Bidak et al., 2015). Some species are capable to grow well in sandy salt marshes (e.g. *Atriplex halimus*) (Simpson, 1932). Six riverbank retainers (*Acacia nilotica*, *Alhagi graecorum*, *Balanites aegyptiaca*, *Cynodon dactylon, Salix mucronata* and *Salix tetrasperma*) were recorded. *Salix* and *Acacia* trees were noted for their bank holding ability, where their roots hold soil particles together; they are gathering around harmful weaker plants.

Six water purifiers were recorded which could accumulate wastes from water. *Eichhornia crassipes* offers dynamic ecosystem services; it can purify wastewater in an arid climate and a high temperature (Shaltout & Ahmed, 2012). *Eichhornia crassipes* also has a remarkable capacity to withstand the effect of pH changes ranging from 3 to 8 in the aquatic environment, where it adjusts the pH through 48 hours except in water-rich with iron because of the caused oxidative stress by iron (Dymond, 1948; Jamil et al., 1987). *Phragmites australis* roots act as a phytoremediation system of wastes by making stubble wetlands. It forms deep heavy roots with hollow rhizomes and an active rhizosphere. Escape oxygen from roots makes oxidized micro-places that eliminate suspended organic solids, phosphorus, lead, and nitrogen from impurities (Abdelsalam et al., 2019). Five trees were documented presenting a shading service (*Acacia laeta*, *A. nilotica*, *A. seyal*, *Sesbania sesban* and *Ziziphus spina-christi* (Boulos & El-Hadidi, 1986).

Threats upon species and their natural habitats

Nowadays, human activities are the main source of serious threats to wild plants in their natural habitats. Habitat loss, over-collection, lack of land management, invasive species, and climate change are the most documented threats and it is required that land managers and policy-makers take action to control this endless decline in plant species due to human activities (Shaltout & Ahmed, 2012). In the present study, 87 species were affected by at least one threat, of which 61 species are exposed to over-collecting and over-cutting. These species are collected as medicinal plants or for fuel woods. Over-collecting and over-cutting of wild native medicinal plants by herbalists and inhabitants for trade are reported as one of the most irregular hazardous threats. Twenty-eight species are exposed to over-grazing and browsing (Shaltout & Ahmed, 2012). Widen elimination of natural flora was dangerous, as *Phyla nodiflora* and *Malva parviflora* were severely grazed.

Heneidy (1991) and Heneidy & El-Darier (1995) noted that human activities, such as wood-cutting of natural plants, were harsher than over-grazing. For example, *Portulaca oleracea* and *Datura stramonium* were exposed to clearance for agriculture and habitat loss, where agricultural reclamation is more economically valuable than natural land preservation. Fifteen species suffer from the mining and quarrying activities (e.g., *Ipomoea carnea*, *Lotus glaber* and *Mimosa pigra*), while 8 species suffer from habitat loss (e.g., *Ficus carica*, *Datura stramonium* and *Dracaena ombet*). Hundreds of feddans of cultivated lands of *Ficus carica* were harmed for the establishment of highways and tourist villages, which led to the loss of the natural habitats of many wild plants.

From the recorded species, 46 species mostly grow in cultivated habitats (e.g. weeds of cultivation, fields, escapes from cultivation or on roadsides among cultivated areas), then 30 species in aquatic habitats (e.g. Nile, Nile canals, Nile banks, lakes, canals, pools, ditches, and rice fields). Most gardens in the study area are located in fertile and cultivated lands along the Nile River, its sub-divided branches and canals, so the main habitat of most recorded species are cultivated and aquatic habitats.

Conservation status and naturalness status

Seven of the recorded species were globally

threatened according to the IUCN Red-list 2020 (https://www.iucnredlist.org). Of these species, *Cyperus papyrus*, *Dichrostachys cinereal*, *Ficus carica*, *Nymphaea lotus* and *Pteris vittata* were least concerned, *Dracaena ombet* was endangered (EN) and *Medemia argun* was vulnerable (Vu). It is important to report that *Medemia argun* was recorded as critically endangered according to IUCN Red-list up to 2019, while in IUCN Red-list 2020, it is recorded as vulnerable. This may be due to its conservation within gardens in many regions all over the world as it was recorded in the study area in Aswan Botanic Island after its restriction in the Egyptian oases and deserts.

In addition to 75 wild species conserved in gardens of the Nile region, there are 21 species (21.9%) conserved in Nile gardens from other national phytogeographical regions in Egypt as Sinai, Mediterranean, Deserts, Gebal Elba, and Oases such as *Ceratonia siliqua* in Orman, Zoo and Zohyria gardens, *Moringa peregrina* in Orman and Saff gardens and *Medemia argun* in Aswan Botanic Island. These findings coincide with Bircher (1998) who recorded *Moringa peregrine* in Saff garden in Giza, Soliman & Amer (2002) recorded *Alcea rosea* in Maadi district, Khalifa (2006) recorded *Dracaena ombet* in Zaafaran Palace, Ain Shams University-Faculty of Agriculture, Faculty of Education gardens in Cairo, and Hamdy et al. (2007) recorded *Ceratonia siliqua* in Zohryia garden and *Ipomoea pes-caprae in* Antoniadis Gardens in Alexandria.

Alien species in the present study belonged to three categories, which are Causals (alien plants that may flourish and even reproduce occasionally in an area, but do not form self-replacing populations), naturalized (alien plants that reproduce consistently and sustain populations over many life cycles without direct intervention by humans) and invasive (Shaltout et al., 2016). Invasive species defined here as aliens producing reproductive offspring, often in very large numbers, and at considerable distances from parent plants (Eid & Shaltout, 2017). Twenty-three alien species (i.e., not native to Egypt) were recorded in the present study. Out of them; 8 species (8.3 % of the total) (e.g., *Alcea rosea, Amaranthus tricolor* and *Brassica rapa*) were casuals, 13 species (13.5%) (e.g., *Amaranthus hybridus, Datura stramonium* and *Euphorbia heterophylla*) were naturalized and 2 species (2.1%) were invasive (*Eichhorina crassipes* and *Ipomoea carnea*).

Conclusion

The present study provides evidence for the very important role of botanic and public gardens in the Egyptian Nile Region for plant diversity conservation, as they not only help conserve the threatened species in the study area but also help conserve wild species from other geographical regions. Also, our results show that the Egyptian gardens might play an important role in the future as a source of wild plants that could be used in the restoration of ecosystem projects not just for their value as biodiversity, but also for their contributions to ecosystem functioning and services

Acknowledgement: Greatest thanks to the Egyptian Cultural Affairs and Missions sector in the Ministry of High Education and Scientific Research for grants. Many thanks extend to the editor of the Egyptian Journal of Botany Prof. Dr. Salama Ouf for his patiency and many thanks to anonymous reviewers for improving this work to be in this good form.

Conflict of interests: The authors declare that they have no conflict of interest.

Authors contribution: Dalia Abd El-Azeem Ahmed: Analysis of data, statistic analysis and interpretation of results. Also, drafting the article and revising it. Approved the final version to be submitted for publication. Esraa Ammar: Design and interpretation of data, analysis of data, statistic analysis and interpretation of results. Drafting the article and revising it. Approved the final version to be submitted for publication. Jens-Christian Svenning: Drafting the article and revising it. Approved the final version to be submitted for publication. Mohamed El-Beheiry: Approved the final version to be submitted for publication. Kamal Shaltout: Conception and design, acquisition, analysis, and interpretation of results. Also, drafting the article and revising it. Approved the final version to be submitted for publication.

Ethical approval: Not applicable.

References

Abdelsalam, I.M., Elshobary M., Eladawy M.M., Nagah, M. (2019) Utilization of multi-tasking non-edible plants for phytoremediation and bioenergy

source-A review. *Phyton*, **88**(2), 96-90.

Ahmed, S.M., Al-Sodany, Y.M. (2019) Authentication of ecological, biochemical and molecular features for some Lamiaceae Species from Saudi Arabia. *Egyptian Journal of Botany*, **59**(3), 581-594.

Ammar, E., Shaltout, K., Svenning, J.C., El-Beheiry, M., Ahmed, D. (2020) Assessment of the Wild Plants in the Egyptian Botanic Gardens; Nile Region. *African Journal of Ecology*, DOI: 10.1111/aje.12757.

Ayyad, M.A. (1998) *Multipurpose species in Arab African countries*. UNESCO Cairo Office, Cairo. pp. 90.

Bedair, H., Shaltout K.H., Ahmed, D., Sharaf El-Din, A., El-Fahar, R. (2020) Characterization of the wild trees and shrubs in the Egyptian Flora. *Egyptian Journal of Botany*, **60**(1), 147-168.

Belal, A.E., Springuel, I. (1996) Economic value of plant diversity in arid environments. *Nature and Resources,* **32**(1), 33-39.

Bidak, L.M., Kamal S.A., Halmy, M.W.A., Heneidy, S.Z. (2015) Goods and services provided by native plants in desert ecosystems: Examples from the northwestern coastal desert of Egypt. *Global Ecology and Conservation*, **3**, 433-447.

Bircher, W. (1998) Delchevalerie" *Les Plantes Exotiques Cultivées en Egypte*" an updated English version. *Taeckholmia,* **18**(2), 1-111.

Blackmore, S. (2017) The future role of botanical gardens. *Tropical Plant Collections. Scientia Danica. Series B, Biologica,* **6**, 285-297.

Boulos, L. (1995) "*Flora of Egypt*"*:* Checklist. Al-Hadara Publishing, Cairo, 283p.

Boulos, L. (1999) "*Flora of Egypt*": Vol.I (Azollaceae – Oxalidaceae). Al-Hadara Publishing, Cairo, 419p.

Boulos, L. (2000) "*Flora of Egypt*": Vol.II (Geraniaceae - Boraginaceae). Al-Hadara Publishing, Cairo, 352p.

Boulos, L. (2002) "*Flora of Egypt*": Vol. III (Verbenaceae - Compositae). Al-Hadara Publishing, Cairo, 373p.

Boulos, L. (2005) "*Flora of Egypt"*. Vol. IV. Monocotyledons (Alismataceae-Orchidaceae). Al Hadara Publishing, Cairo, 617p.

Boulos, L. (2009) "*Flora of Egypt*". *C*hecklist Revised Annotated Edition. Al-Hadara Publishing, Cairo, 410p.

Boulos, L., El-Hadidi, M.N. (1986) "*The Street trees of Egypt*". The American University in Cairo Press, Cairo, Egypt, 113p.

Dymond, G.C. (1948) The water hyacinth – a cinderella of the plant world. In: " *Soil Fertility and Sewage*", Vuren, J. and Van, P. J. (Eds.), pp. 221-227. Dover Publications, New York.

Eid, M.E., Shaltout, K.H. (2017) Population dynamics of *Eichhornia crassipes* (C. Mart.) Solms in the Nile Delta, Egypt. *Plant Species Biology*, **32**, 279-291.

El-Beheiry M., Ahmed D., Ammar, E., Shaltout, K. (2015) Diversity of crop plants in Nile Delta, Egypt, *Taeckholmia,* **35**, 77- 97.

Galal, T.M., Fahmy, G. (2012) Plant diversity and community structure of Wadi Gimal protected area, Red Sea Coast of Egypt. *African Journal of Ecology*, **50**(3), 266-276.

Hamdy, R.S., Abd-Ghani, M.M., Youssef, T.L., El-Sayed, M. (2007) The floristic composition of some historical botanical gardens in the metropolitan of Cairo, Egypt. *African Journal of Agricultural Research*, **2**(11), 610-648.

Heneidy, S.Z. (1991) An Ecological Study of the Grazing Systems of Mariut. Egypt. *Ph.D. Thesis,* Faculty of Science, Alexandria University, Alexandria. 152p.

Heneidy, S.Z., El-Darier, S.M. (1995) Some ecological and socio-economic aspects of bedouins in Mariut rangelands, Egypt. *Journal of Union of Arab. Biologists*, **2**(B), 121-136.

Heneidy, S.Z. (2010) "*Plant Altas*", The Botanic Gaden (Alex)" Faculty of Science, Alexandria University, Monsha'a Al Maaref, Alexandria, Egypt, 632p.

Jamil, K., Madhavendra, S.S., Jamil, M.Z., Rao, P.V.R. (1987) Studies on water hyacinth as a biological filter for treating contaminants from agricultural wastes and industrial effluents. *Journal of Environmental Science and Health,* **22**(1), 103-112.

Khalifa, S.F. (2006) Guide on the Egyptian Botanic gardens. *The First International Conference on" Strategy of Botanic Gardens*" Agricultual Museum, Giza, 110p.

Lomolino, M.V., Riddle, B.R., Whittaker, R.J. (2017) "*Biogeography, Biological Diversity Across Space and Time*". 5th ed., Sunderland, Massachusetts, U.S.A. 759p.

Madi, M.I., Shaltout, K.H., Sharaf El-Din, A. (2002) A Flora of the coastal sand dunes of Gaza strip, Palastine. *Proc. 2nd Conf. Biol. Sci.,* Tanta Univ. **2**, 64-78.

Manniche, L. (2006) "*An Ancient Egyptian Herbal*", The American University in Cairo Press, Cairo, 184p.

McNeely, J.A. (2011) What more can plant scientists do to help save the green stuff? *Botanical Journal of the Linnean Society,* **166**, 233-239.

Powledge, F. (2011) The evolving role of botanical gardens. Hedges against extinction, showcases for botany*? BioScience,* **61**, 743-749.

Raunkiaer, C. (1937) "*Plant Life Forms*". Clarendon, Oxford. 104p.

Ricklefs, R.E. (1977) Environmental heterogeneity and plant species diversity, a hypothesis. *American Naturalist,* **111**, 576-581.

Simpson, B.B., Ogorzaly, M.C. (1995) *Economic Botany 'Plants in Our World'*, McGraw-Hill, USA, 742p.

Simpson, N.D. (1932) A report on the weed flora of the irrigation channels in Egypt. Ministry of Public Works, Government Press, Cairo, 124p.

Shaltout, K.H. (1997) Current situation of flora and vegetation of south west Egypt. In: "*Integrated Land Development of Southern Egypt*: *Available Resources and Alternative Options*". Abdel – Ghaffar, A.S., Marei, S.M. and Gaber, M.H. (Eds.), pp. 199-241. Cairo Office of International Development Research Center (IDRC) and Soil and Water Science Department, Alexandria University, Alexandria.

Shaltout, K.H., Farahat, E.A. (2005) Ornamental vegetation of Qanater Public Park. *Assiut University Journal of Botany,* **34**(2), 219-244.

Shaltout, K.H., Ahmed, D.A. (2012) Ecosystem Services of the Flora of Southern Mediterranean Desert of Egypt. *Ethnobotany Research and Applications,* **10**, 403-422.

Shaltout, K.H., Sharaf El-Din A., Ahmed, D.A. (2010) "*Plant Life in the Nile Delta*". Tanta Univ. Press, Tanta, Egypt. 231p.

Shaltout, K.H., Hosni, H.A., El-Kady, H.F., El-Beheiry, M.A., Shaltout, S.K. (2016) Composition and pattern of alien species in the Egyptian flora. *Flora-Morphology, Distribution, Functional Ecology of Plants,* **222**, 104-110.

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.

Soliman, A.W., Amer, W. (2002) "*Atlas of Trees and Flowers in Maadi district*". The Egyptian Book House, Cairo, 111p. (In Arabic).

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

Wickens, G.E. (1980) Alternative uses of browse species. In: " *Browse in Africa*; *the Current State of Knowledge*", Le Houèrou, H.N. (Ed.), pp. 155-182. The International Symposium on Browse in Africa, Addis Ababa.

Wickens, G.E. (1992) Arid and semiarid ecosystems. In: "*Encyclopedia of Earth System Science*", W.A. Nierenberg (Ed.), pp. 113-118. Vol. 1, Academic Press, San Diego.

Wyse Jackson, P.S., Kennedy, K. (2009) The Global Strategy for Plant Conservation: A challenge and opportunity for the international community. *Trends in Plant Science,* **14**, 578-580.

Zahran, M.A., Willis, A.J. (2003) "*Plant Life in the River Nile in Egypt*". Mars Publishing House, Riyadh. 531p.

الأنواع النباتية البرية داخل الحدائق المصرية في منطقة النيل: من وجهة نظر الصون

داليا عبد العظيم أحمد[1]، إسراء عمار[1،2]، جينس كريستيان سيفيننج[2]، محمد البحيري[1]، كمال شلتوت[1]
[1]قسم النبات - كلية العلوم - جامعة طنطا - مصر، [2]مركز ديناميكيات التنوع الحيوي في العالم - شعبة المعلوماتية الحيوية والتنوع الحيوي - قسم العلوم الحيوية - جامعة آرهوس - الدنمارك.

تهدف هذة الدراسة إلى تقييم دور الحدائق النباتية المصرية في منطقة النيل في حفظ النباتات البرية؛ وخاصة المهددة بالإنقراض. كما تهدف الدراسة أيضاً إلى تقييم طرز الحياة، التوزيع الجغرافي المحلي، الإستخدامات الإقتصادية والفوائد البيئية، مجموعات الصون، والتهديدات المحلية التي تتعرض لها النباتات في بيئتها الطبيعية لجميع النباتات محل الدراسة. لقد تم القيام ب 194 رحلة حقلية غطت 183 حديقة نباتية في منطقة النيل بمصر خلال المدة من صيف 2012 لشتاء 2018. وقد تم تسجيل 96 نوعاً نباتياً، تنتمي إلى 76 جنس و43 فصيلة. وكانت الفصيلة البقولية هي الأعلى تمثيلاً، بينما جنس الأكاسيا فكان هو الأعلى تمثيلاً بين الأجناس التي تم تسجيلها. أما بالنسبة إلى طرز الحياة، فكانت النباتات الظاهرة (39.6%) هي الأعلى تمثيلاً. بالنسبة للتوزيع الجغرافي المحلي والعالمي للنباتات؛ فكان لمنطقة النيل أعلى مساهمة (78.1%) من النباتات؛ من بينها 20 نبات يقتصر توزيعه على منطقة النيل، بينما 21 نبات يصان في الحدائق من مناطق جغرافية أخرى مثل منطقة سيناء، منطقة البحر المتوسط، المناطق الصحراوية، جبال علبة، والواحات. سجلت النباتات الطبية (58 نوع) أعلى الإستخدامات الإقتصادية المقدمة؛ بينما النباتات المثبتة للنيتروچين (37.9%) سجلت أعلى الفوائد البيئية المقدمة. يعاني 87 نوعاً نباتياً على الأقل من خطر بيئي واحد فى بيئته الطبيعية. تنمومعظم النباتات المسجلة (46 نوع) في البيئات الزراعية. تنقسم النباتات المسجلة إلى 73 نبات متوطن و23 نبات غير متوطن. تم تسجيل سبعة نباتات مهددة بالإنقراض تبعا للإتحاد العالمي لصون الحياة الفطرية (IUCN). أوضحت نتائج الدراسة الدور الغيرمحدود للحدائق النباتية والعامة في منطقة النيل المصرية، حيث أنها لا تساعد فقط في صون النباتات البرية المهددة داخل منطقة الدراسة، ولكن أيضاً تساعد في صون النباتات البرية من مناطق جغرافية أخرى.