Wulfenia **24** (2017): 97–120

Wulfenia
Mitteilungen des
Kärntner Botanikzentrums
Klagenfurt

Phytogeography of the Eastern Desert flora of Egypt

Monier Abd El-Ghani, Fawzy Salama, Boshra Salem,
Azza El-Hadidy & Mohamed Abdel-Aleem

Summary: 328 species in total were recorded at 500 sites between 30° 06' and 24° 00'N in the Eastern Desert of Egypt. The occurrence of species was classified into 5 constancy classes: dominant, very common, common, occasional and sporadic. A sharp decrease in the number of recorded species was noticed along the N–S direction from Cairo-Suez road in the north to Aswan-Baranis road in the south (from 179 to 23), and an increase along the E–W direction from the Red Sea coast in the east to the River Nile Valley in the west (from 46 to 80). It was found out that geographical affinities affect the patterns of species distribution: 82 annual (therophyte) species are dominant life forms within the northern part of the study area, followed by 33 species in the southern part. Phanerophytes (trees) showed a decrease in their number from north (13 species) to south (9 species), but a slight increase from east (9 species) to west (10 species). Distribution maps of local geographical subtypes of each of the 4 major chorotypes are shown and a suggested improved phytogeographical map is presented.

Keywords: chorotypes, desert vegetation, distribution maps, Egypt, local subtypes, phytogeography

Egypt lies between 22° and 32°N latitude. It is part of the Sahara of North Africa and covers a total area of over one million km^2 in the hyperarid region. The biggest part is located in the temperate zone with most of its landmass below 500 m above sea level, which limits potential diversity. Three deserts (Eastern, Western and Sinai Peninsula) form about 95% of Egypt's land. Consequently, the desert vegetation is by far the most important and characteristic type of natural plant life (Zahran & Willis 2009).

The Eastern Desert occupies the eastern part of Egypt extending from the Nile Valley eastward to the Gulf of Suez and the Red Sea, which is about 223,000 km^2, i.e. 21% of the total area of Egypt. The range of the Red Sea coastal mountains divides the Eastern Desert into two main ecological units: the Red Sea coastal land and the inland desert (Abu Al-Izz 1971; Said 1990). The inland part is a rocky plateau dissected by a number of wadis (valleys); each wadi has a channel with numerous tributaries and the Eastern Desert is divided piecemeal into the catchment areas of these drainage systems. Most of the wadis drain westward into the Nile. The inland part of the Eastern Desert can be divided into four main geomorphological and ecological regions from north to south: (1) Cairo-Suez Desert, (2) Limestone Desert, (3) Sandstone Desert and (4) Nubian Desert (Zahran & Willis 2009). From the phytogeographical point of view, the Eastern Desert is divided by El Hadidi (1980) into two main subterritories: (A) Galala Desert, including Cairo-Suez and the northern limestone plateau (*c*. 27°N lat.) and (B) Arabian Desert, including the southern limestone plateau and the Nubian Sandstone.

One of the major approaches to study phytogeography is to investigate the spatial variation in floristic composition within a study area. A second approach is to investigate the floristic relationships between study area and other areas of the earth. With this approach, the taxa within a study area are grouped into floristic elements (chorotypes or phytochoria) based on

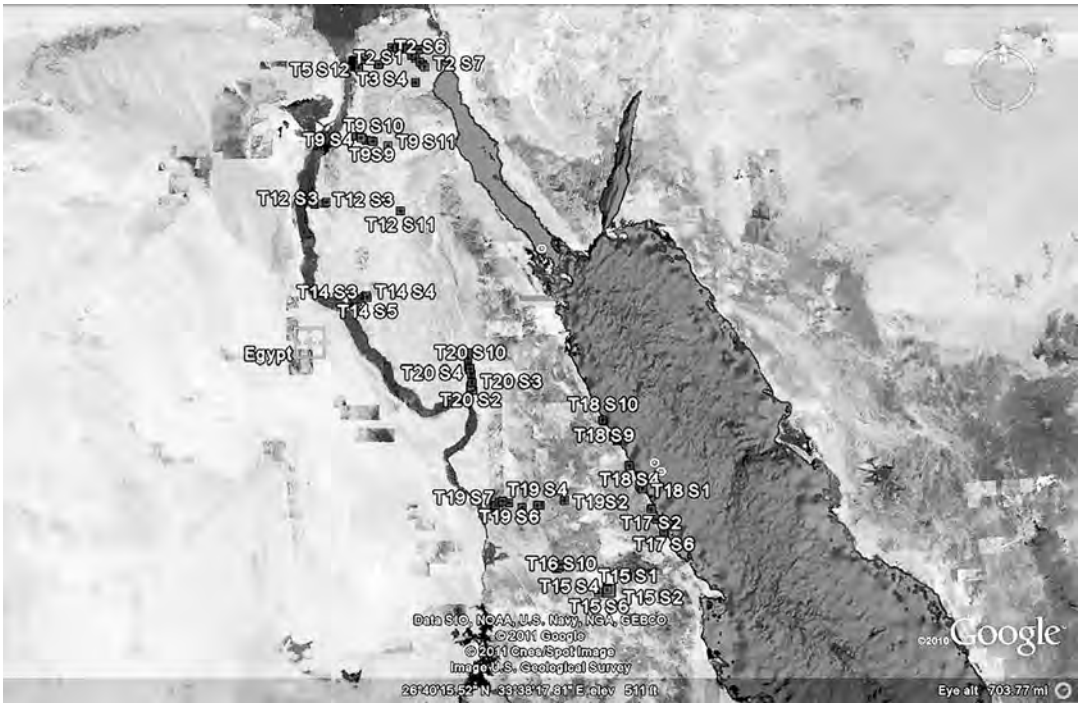

Figure 1. Map of the Eastern Desert showing the location of the 34 sectors (T1-T34).

similarities in their worldwide geographical distribution (Stott 1981). Such floristic elements have been termed geographical elements (Cain 1947; Stott 1981). The study of phytogeography is not only essential to understand origination, migration and speciation of plants, but it is also fundamental to develop strategies for biological conservation (Qian 1999; Qian et al. 2006).

During the last decades, most of the phytogeographic territories of Egypt (including the Eastern Desert) were affected by human activities such as cultivation of the deltaic part of wadis, the intensive collection of plant species for their values (medicinal, fuel, fibers etc.) and the establishment of new towns, roads, building factories and quarries. These activities cause a destructive impact on the natural flora and change the geographical distribution patterns of plants in these areas.

In a previous account of the authors on the hyperarid Eastern Desert of Egypt (Abd El-Ghani et al. 2013), a detailed analysis of biogegeographical affinities of its flora was presented. This study was designed to reassess the distribution of species in the study area regarding their geographical aspects, the interactions between life forms and chorological affinities on the one hand and species occurrence on the other. Based on obtained species distribution maps and vegetation data from our earlier publication, it is attempted to propose new phytogeographical divisions of the Eastern Desert of Egypt.

Study area

The study area lies between 30°06’ and 24°00’ N latitude (Fig. 1). The Eastern Desert of Egypt is characterized by high, rugged mountains running parallel to and at a relatively short distance from the Red Sea coast. West of the Red Sea Mountains (igneous in the south and limestone in

the north) two broad plateaus are parted by the road of Qift-Qusseir (26°N lat.). Topography, geology, geomorphology and soil of this area have been documented by Said (1962), Abu Al-Izz (1971) and Zahran & Willis (1992).

Climatically, the study area lies within the hyperarid provinces (UNEP 1992) with a mild winter and a hot summer (mean temperature of the hottest month 20–30°C) covering the Eastern Desert and the north-eastern part of the Western Desert and Gebel Uweinat area. Rainfall occurs only in winter and is due to random cloudbursts, a general feature in arid deserts: rain may occur only once every several years. Along north-south direction, a decline of rainfall is remarkable: long-term annual averages of rainfall show a decrease from 25 mm in Suez in the north to 3.4 mm in Qusseir and to almost zero mm in Mersa Alam in the south (Abd El-Ghani 1998). Variations in mean temperature along N–S direction are also remarkable. The main bulk of rain occurs in winter, i.e. Mediterranean affinity, and summer is rainless in general. On daily basis, the mean minimum temperature is high and ranges between 14 and 21.7°C in winter and mean maximum 23.1–46.1°C in summer. Relative humidity ranges from 43% in summer to 65% in winter. The Piche evaporation is higher in summer (13.7–21.5 mm/day) than in winter (5.2–10.4 mm/day). Annual average of some climatic features measured over 7 years (2006–2012) at eight meteorological stations within the study area are shown in Table 1.

Methods

Five hundred sites (complete data can be requested from the first author) were located with GPS representing 34 sectors (see Abd El-Ghani et al. 2013 for more details) covering as much as possible the different landforms in the study area (Fig. 1). Presence/absence of each species from all 500 sites was recorded. The status of species was categorized into 5 constancy classes (% occurrence of a certain species in its site/total number of sites); 1 = dominant (81–100%), 2 = very common (61–80%), 3 = common (41–60%), 4 = occasional (21–40%) and 5 = sporadic (1–20%). For life forms, an ordinal scale of 8 categories was adopted: (1) chamaephytes, (2) geophytes, (3) helophytes, (4) hemicryptophytes, (5) hydro-helophytes, (6) parasites, (7) phanerophytes and (8) therophytes. Also, the geographical aspects were organized along a 4 ordinal scale: (1) north, (2) south, (3) east and (4) west. To assess the relationships between the status (constancy class), life form and geographical aspect, the non-parametric Spearman's rank correlation *(r)* was performed. The level of significance is at 0.01 unless otherwise stated.

Using Garmin e-Trex Legend HCx GPS, species occurrence was located at the studied 500 sites of this survey, and other available species records were taken from Cairo University Herbarium [CAI] and compiled with other collections from previous studies (e.g. Kassas & Girgis 1964, 1969; Hassan 1987; Hassan 2003). These data were then loaded to Google Earth program in order to determine the position of each species. The obtained Google Earth maps were redrawn using Adobe Illustrator CS5 v. 15.0.0.

The resulting distribution maps demonstrate clear geographical patterns: some species show certain consistency in the northern part of the study area, others are confined to the southern part and likewise in the western and eastern parts. Therefore, within each of the 4 major chorotypes, the recorded species were grouped into 5 local subtype categories: local subtype 1: widely distributed species (recorded in >25 out of the 34 sectors); local subtype 2: northerly distributed species (confined to sites located in the northern part of the study area between 30°05'N and 27°30'N);

Table 1. Annual average of some climatic features measured at eight meteorological stations within the study area over 7 years. T = mean temperature (°C), TM = maximum temperature (°C), Tm = minimum temperature (°C), PP = total annual precipitation (mm) and W = wind speed (km/h). Arrows refer to N–S and E–W directions (Courtesy of the General Meteorological Authority, Cairo).

East ← → West

	Red Sea region (East)							Nile Valley region (West)					
North	Station (N–S)	Year	T	TM	Tm	PP	W	Station (N–S)	Year	T	TM	Tm	PP	W
		2006	22.7	28.8	16.9	94.5	8		2006	22.3	28.1	16.9	32.01	11.8
		2007	23.2	29.3	17.4	2.79	12		2007	22.7	28.4	17.2	15.75	12.2
		2008	23.2	29.4	17.6	11.42	12.1		2008	23	28.7	17.7	17.54	12.2
	Suez	2009	23.2	29.2	17.6	1.78	12	Cairo	2009	23.4	28.8	18.4	4.07	13
		2010	24.4	30.3	19	6.35	12.9		2010	24.2	29.8	18.8	59.44	13.6
		2011	22.8	28.5	17.4	10.66	11.5		2011	22.1	27.7	17.1	27.68	14.9
		2012	23.4	29.4	17.8	6.85	11.4		2012	22.6	28.1	17.6	54.36	16
		2006	25.1	30.4	19.8	0	23.8		2006	22.2	29.6	14.9	1.02	9.9
		2007	25.2	30.7	19.9	70.1	22.8		2007	22.6	29.9	15.2	0	9
		2008	25.4	30.4	20.2	0	22.4		2008	22.9	30.5	15.4	3.05	9.4
	Hurghada	2009	25.3	30.4	19.9	0	21.5	Minya	2009	22.8	30.4	15.5	0	8.3
		2010	26.7	32	21.3	76.45	21.5		2010	24.1	31.9	16.8	0	10
		2011	25	29.9	19.8	0	21.8		2011	22	29.3	15	5.08	10.2
		2012	25.5	30.7	20.3	0	19.4		2012	22.6	29.8	15.6	2.54	9.6
		2006	24.2	27.6	20.2	6.1	15.5		2006	22.6	29.9	15.1	0	13.4
		2007	24.2	27.7	20.1	0	14.8		2007	22.8	30.1	15.3	0	13.4
		2008	24.5	27.8	20.7	0	15.4		2008	23.1	30.7	15.4	0	13.5
	Qussier	2009	24.4	27.8	20.5	1.02	14.1	Assiut	2009	23	30.6	15.4	0	12.9
		2010	26	29.4	22.1	13.21	12.5		2010	24.7	32.5	17	8.89	15.6
South		2011	24.7	28	20.8	0	12.7		2011	22.3	29.6	15	1.02	14
		2012	24.7	28.1	20.8	0	10.5		2012	23	30.7	15.3	10.41	12.8

local subtype 3: southerly distributed species (confined to sites in southern part of the study area between 27°30'N and 24°00'N); local subtype 4: easterly distributed species (species confined to sites in the eastern part of the study area along the Red Sea coast and not penetrating westward); and local subtype 5: westerly distributed species (species confined to sites in the western part of the study area close the Nile Valley and not penetrating eastward). This work includes selected geographical maps illustrating species distribution in different local subtypes.

Plant identification was carried out at the Cairo University Herbarium [CAI] and nomenclature followed Täckholm (1974) updated by Boulos (1999–2005). Chorotype analysis of species is based on Wickens (1976), Zohary (1973), Feinbrun-Dothan (1978–1986), etc. and life forms were classified according to Raunkiaer's system (Raunkiaer 1934). The statistical analysis was carried out using SPSS version 16.0 for Windows.

Table 2. General distribution patterns of life forms in different geographical aspects of the study area. T = total number of species, N = number of species, % = percentage in each aspect. Numbers in parentheses are the scales of life forms, status and geographical aspects. Status abbreviations: Dom = dominant, V.Com = very common, Com = common, Occ = occasional, Spo = sporadic, - = absent.

Life form categories		Geographical aspects								Status				
		North		South		East		West		Dom (1)	V.com (2)	Com (3)	Occ (4)	Spo (5)
	T	N	%	N	%	N	%	N	%	N	N	N	N	N
Chamaephytes (1)	78	40	51.3	04	5.1	12	15.4	22	28.2	05	08	10	23	32
Geophytes (2)	05	03	60	-	-	-	-	2	40	-	01	-	02	02
Helophytes (3)	03	02	66.7	-	-	01	33.3	-	-	-	-	-	-	03
Hemicryptophytes (4)	62	33	53.2	05	8.1	13	21.0	11	17.7	01	06	06	21	28
Hydrophytes-Helophytes (5)	03	-	-	-	-	01	33.3	02	66.7	-	-	-	01	02
Parasites (6)	06	06	100	-	-	-	-	-	-	-	-	01	01	04
Phanerophytes (7)	37	13	35.1	05	13.5	09	24.3	10	27.1	03	01	07	09	17
Therophytes (8)	134	82	61.2	09	6.7	10	7.5	33	24.6	01	04	12	90	172
Geographical Aspects														
North (1)										-	03	12	51	113
South (2)										01	-	02	03	17
East (3)										09	01	03	14	28
West (4)										-	16	19	22	14
Total										10	20	36	90	172

Results

In total, 328 species represent the flora of the surveyed area. Life forms examined under the geographical aspects (north, south, east and west) of the study area (Table 2) showed a general pattern: a decrease of the total number of species from the northern (Cairo-Suez road) to the southern part (Aswan-Baranis road) and gradual decrease from west (along Red Sea coast) to east (along the River Nile Valley). Therophytes are the dominant life form with the highest number of species recorded from the inland wadis of the northern part. A remarkable decrease was noticed in the number of therophytes from north to south and an increase from east (along the Red Sea coast) to west (along the Nile Valley). Also, phanerophytes (trees) showed a decrease in their number from north (13 species) to south (5 species) and a slight increase from east (9 species) to west (10 species). Hemicryptophytes, however, showed slight increase in their number from west to east.

The total number of recorded species showed clearly a gradual increase within the categories of species status. Chamaephytes showed a gradual increase in the different categories of status (Table 2) from dominant (category 1) to sporadic (category 5) and similar trend can be detected for hemicryptophytes, therophytes and phanerophytes. The relationship between the different categories of species status and their geographical aspects is presented in Table 2. The highest

Table 3. Geographical distributions of species status (constancy classes) in the local subtypes, together with the general distribution of life forms in the major chorotypes. Local subtypes abbreviations: WD = widely distributed, N = northerly distributed, S = southerly distributed, E = easterly distributed, W = westerly distributed, - = absent.

Major chorotypes	Saharo-Sindian					Mediterranean					Sudano-Zambezian					Irano-Turanian					Others				
Local subtypes	WD	N	S	E	W	WD	N	S	E	W	WD	N	S	E	W	WD	N	S	E	W	WD	N	S	E	W
Dominant	10	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Very common	-	03	-	-	15	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	01	01
Common	-	12	01	03	18	-	-	-	-		-	-	01	-	-	-	-	-	-	-	-	-	-	-	01
Occasional	-	45	03	09	17	-	02	-	01	01	-	01	-	03	-	-	02	-	-	-	-	01	-	01	03
Sporadic	-	59	03	21	07	-	19	05	02	02	-	03	05	01	01	-	04	-	-	-	-	28	04	04	05
Total number of species in the local subtypes	10	119	07	33	57	-	21	05	03	03	-	04	06	04	01	-	06	-	-	-	-	29	04	06	10
Life forms																									
Chamaephytes	66					03					02					02					05				
Geophytes	03					-					-					-					02				
Helophytes	01					01					-					-					01				
Hemicryptophytes	44					04					02					02					10				
Hydrophytes-Helophytes	01					-					-					-					02				
Parasites	05					-					-					-					01				
Phanerophytes	27					-					07					-					03				
Therophytes	79					24					04					02					25				
Total number of species	226					32					15					06					49				

number of species was recorded in the sporadic (172), while the lowest was recorded in the dominant category (10). Again, a remarkable trend of decrease in number of recorded species along the North-South direction can be observed. Whereas the dominant and sporadic species show a decrease in their numbers along East-West direction, the others exhibit a reverse trend (increase along East-West direction).

Four major phytogeographical chorotypes (Saharo-Sindian, Sudano-Zambezian, Irano-Turanian and Mediterranean) constitute the main bulk of the recorded flora. Table 3 summarizes the relationships between geographical distributions of the local subtypes (northerly, southerly, easterly and westerly distributed) in major chorotypes together with their constancy classes. Ten dominant species are widely distributed all over the study area; they are all of Saharo-Sindian affinity. The geographical distribution of the Saharo-Sindian chorotype within the local subtypes (Table 3) show a notable variation: 119 species in the north, 7 in the south, 33 in the east and 57 in the west. It can be noted that the majority of species in Mediterranean and Irano-Turanian chorotypes were mainly recorded in the northern part of the study area, whereas those of the Sudano-Zambezian chorotype showed a slight increase in the southern part. The composition of the other chorotypes (represented by fewer numbers of species) was mainly of cosmopolitan, palaeotropical and pantropical species (27 out of 49 species). Therophytes, chamaephytes, hemicryptophytes and phanerophytes show more affinities to the Saharo-Sindian than to other chorotypes (Table 3). Together, they constitute 216 species (65.8%) out of the total 328 recorded species.

A detailed chorological analysis of the surveyed flora (Table 4) revealed that 169 species (51.5%) of the studied species are uniregional, 41.8% of which belong to the Saharo-Sindian chorotype. Typical species of Sudano-Zambezian affinity are more represented than the others. About 35.1% of the recorded species are biregional and pluriregional, extending their distribution all over the Saharo-Sindian, Sudano-Zambezian, Irano-Turanian and Mediterranean chorotypes. The Saharo-Sindian + Irano-Turanian, the Mediterranean + Saharo-Sindian and the Irano-Turanian + Mediterranean chorotypes constitute the majority (83%) of the biregional chorotypes. Similarly, the pluriregional species show a prevalence of species of Saharo-Sindian chorotype.

Spearman's rank correlation coefficient *(r)* between the three variables (species status, life form and geographical aspect) showed that life forms do not show any significant correlation with geographical aspects ($r = -0.064$, $p = 0.247$). This proves the independent distribution of life form categories apart from their geographical aspects (north, south, east and west). On the other hand, status is positively correlated with life forms ($r = 0.195$, $p = 0.0001$), which means that the dominant chamaephytes (category 1) have the lowest number of species, followed by the sporadic chamaephytes (category 5), while the sporadic therophytes have the highest. The status, also, is negatively correlated with the geographical aspects ($r = -0.406$, $p = 0.0001$).

Geographical distribution patterns of the recorded species within the local subtypes of the major chorotypes (Appendix 1) are described below:

I. The Saharo-Sindian chorotype (Figs 2–5)

Phytogeographically, the Saharo-Sindian region is a great desert belt. It extends from Atlantic coasts of Morocco and Mauritania eastwards across the Sahara, Sinai and extra-tropical Arabia, Southern Iraq, Iran and Balochistan to the deserts of Sind, Thar, the Punjab and South of Afghanistan (Zohary 1973). It has extreme dryness of the air, high temperature and low rainfall.

Table 4. Chorological analyses of the species examined as numbers and percentages of the total number of species recorded.

Chorotypes	Number of species	(%)
Monoregional		
Saharo-Sindian	137	
Sudano-Zambezian	14	
Mediterranean	07	
Irano-Turanian	06	
Others	05	
	169	51.5
Biregional		
Saharo-Sindian + Irano-Turanian	37	
Irano-Turanian + Mediterranean	11	
Mediterrranean + Saharo-Sindian	10	
Saharo-Sindian + Sudano-Zambezian	05	
Mediterranean + Euro-Siberian	04	
Others	03	
	70	21.3
Pluriregional		
Mediterrranean + Saharo-Sindian + Irano-Turanian	27	
Mediterranean + Irano-Turanian + Euro-Siberian	10	
Others	08	
	45	13.8
Cosmopolitan	16	
Palaeotropical	06	
Pantropical	05	
Endemic	02	
Near Endemic	05	
Unknown	10	
	44	13.4
Total	328	100

The Saharo-Sindian (mono-, bi- and pluriregional) chorotype constitutes the largest group (226 species or about 68.9 % of the total flora) with variations in their growth habits and life span. The pure (monoregional) Saharo-Sindian chorotype were represented by 137 species (60.6% of the total chorotype). These species show different geographical distribution patterns in the proposed local subtypes.

Local subtype 1: Widely distributed species

This group includes 10 species (Appendix 1) with wide distribution patterns and environmental tolerances throughout the study area. *Zilla spinosa* (Fig. 2) and *Zygophyllum coccineum* are the most dominant species showing a wide range of conjunct distribution pattern all over the study area. Other species showing a considerable wide range of distribution are: *Pulicaria undulata*, *Trichodesma africanum, Acacia tortilis, Ochradenus baccatus* and *Tamarix nilotica, Zygophyllum simplex*.

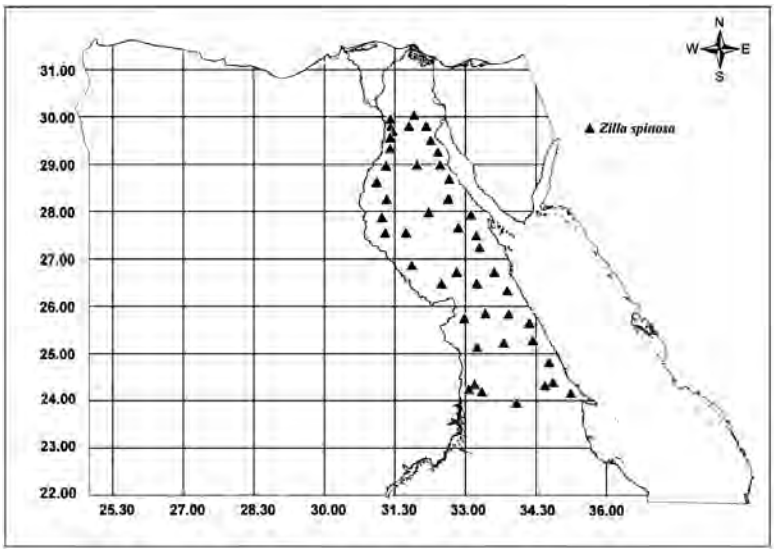

Figure 2. Distribution map of *Zilla spinosa* (widely distributed Saharo-Sindian species).

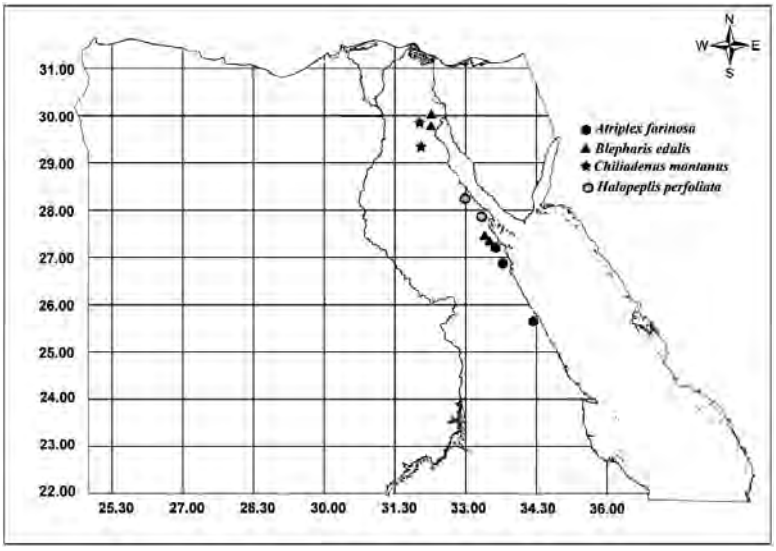

Figure 3. Distribution map of *Atriplex farinosa*, *Blepharis edulis*, *Chiliadenus montanus* and *Halopeplis perfoliata* (easterly distributed Saharo-Sindian species).

Local subtype 2: Northerly distributed species

This group includes 119 species (3 very common, 12 common, 45 occasional, 59 sporadic). They are mostly restricted to and characteristic of the inland wadis of the study area and have not been recorded eastward along the Red Sea coast. *Agathophora alopecuroides, Deverra triradiata, Limonium pruinosum, Stachys aegyptiaca* and *Traganum nudatum* are confined to Helwan and El-Saff desert, while *Pseuderucaria clavata* showed a higher presence along Kattamia-Ain Sokhna road and its surrounding wadis (Fig. 4).

Some species showed a certain degree of consistency to certain localities in the northern part of the study area. These species have not been recorded since several years and hence can be

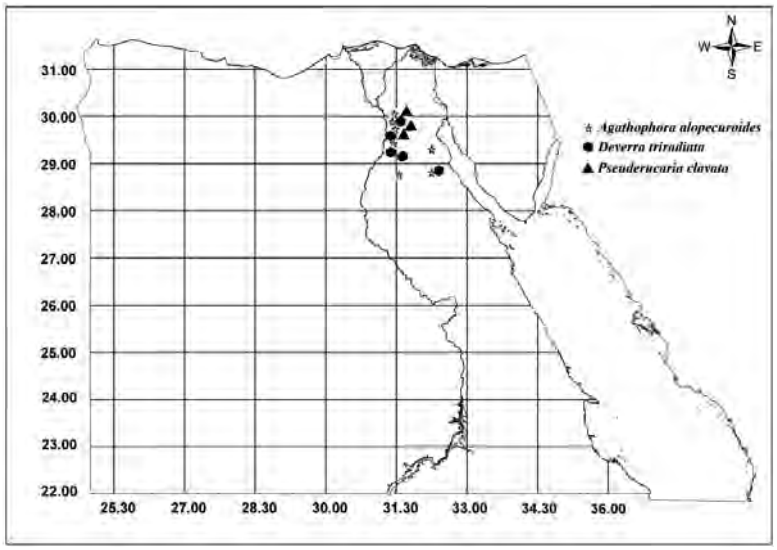

Figure 4. Distribution map of *Agathophora alopecuroides*, *Deverra triradiata* and *Pseuderucaria clavata* (northerly distributed Saharo-Sindian species).

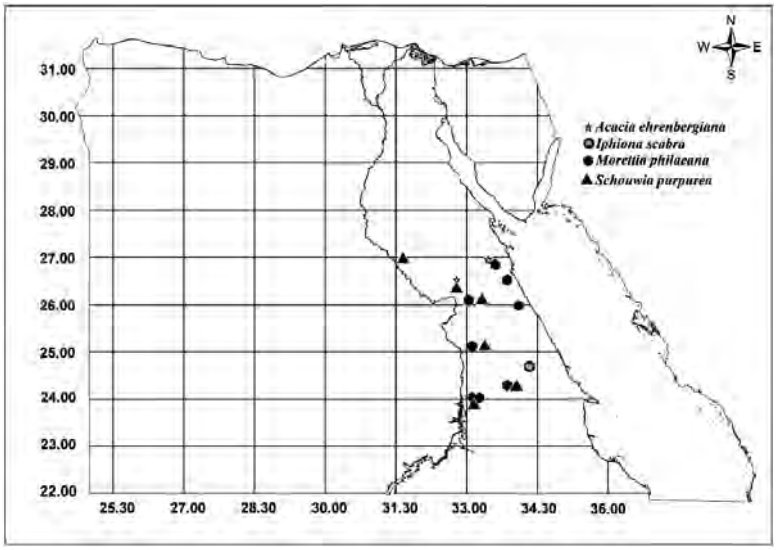

Figure 5. Distribution map of *Acacia ehrenbergiana*, *Iphiona scabra*, *Morettia philaeana* and *Schouwia purpurea* (southerly distributed Saharo-Sindian species).

considered as historical records, e.g. *Abutilon pannosum*, *Echium longifolium*, *Fagonia latifolia, Haloxylon persicum, Helianthemum sancti-antonii, Kickxia acerbiana*, *Onobrychis ptolemaica* and *Scabiosa eremophila*.

Local subtype 3: Southerly distributed species

Eight species of the Saharo-Sindian chorotype showed a certain degree of consistency to the southern part of the study area In the meantime, they are characteristic to the southern inland wadis, e.g. *Morettia philaeana, Salsola villosa* and *Schouwia purpurea* with high presence in this area and *Acacia ehrenbergiana, Fagonia thebaica* and *Iphiona scabra* with low presence (Fig. 5).

Local subtype 4: Easterly distributed species

This group of species is distributed along the eastern part of the study area and does not penetrate westward. These species can be considered as characteristic of the Red Sea coast, e.g. *Atriplex farinosa, Avicennia marina* and *Halopeplis perfoliata* distributed along the southern part of the Red Sea coastal plain (Fig. 3). *Blepharis edulis, Capparis cartilaginea, Cleome chrysantha, C. droserifolia*, *Convolvulus hystrix* and *Periploca aphylla* recorded from the Red Sea wadis and mountains.

Local subtype 5: Westerly distributed species

This group is represented by 57 species, mainly distributed in the desert wadis close to the River Nile Valley (Fig. 1). The very common, common and the sporadic species were represented by relatively equal numbers of species (15, 18 and 17, respectively). The highest occurrences were for *Fagonia brugieri* and *Caroxylon imbricatum*, followed by *Haloxylon salicornicum* and *Citrullus colocynthis*. Conspicuous stratification (layering) of different life form categories in this subtype can be noted: phanerophytes (*Phoenix dactylifera*), chamaephytes (*Centaurea scoparia* and *Heliotropium ramosissimum*), hemicryptophytes (*Cucumis prophetarum*) and therophytes (*Arnebia hispidissima, Lotus halophyllus* and *Tribulus megistopterus*).

II. The Mediterranean chorotype (Figs 6–8)

As defined by Zohary (1973), the Mediterranean region includes the most northern part of the African continent and the southern part of Europe surrounding the Mediterranean Sea. It is bounded southerly by the desert and semi-desert of the Saharo-Sindian region and easterly by the Irano-Turanian region. It is characterized by mild winter, rich in rainfall and dry summer. In this investigation, a total of 32 species were of Mediterranean origin; 7 of which were monoregional (pure) Mediterranean chorotype. Therophytes (24 species) were the dominant life form. The following shows the patterns of their distribution in the different local subtypes. Generally, the species comprising the subtypes are either occasional or sporadic.

Local subtype 1: Widely distributed species – not represented.

Local subtype 2: Northerly distributed species

The majority (21 species) of the Mediterranean chorotype was restricted to the northern part of the study area and not extending or recorded southward (Appendix 1). Notably, 16 species were therophytes and known as common weeds of Egyptian arable lands (El Hadidi & Kosinová 1971), e.g. *Cichorium pumilum, Emex spinosa, Euphorbia peplus* and *Plantago major*. Meanwhile, some desert annuals were also recorded, e.g. *Astragalus hamosus, Schismus barbatus* and *Mesembryanthemum crystallinum*.

Local subtype 3: Southerly distributed species

Mediterranean chorotype showed fewer (3) species in the southern part of the study area. Only three weedy species, *Hippocrepis constricta, Lactuca serriola* and *Lupinus digitatus* were recorded in this part.

Local subtype 4: Easterly distributed species

These species were confined to the eastern part of the study area and characteristic of the Red Sea region. Most of these species were rare and very rare (Täckholm 1974) and collected from certain localities along the Red Sea coastal lands such as *Koelpinia linearis, Malabaila suaveolens,*

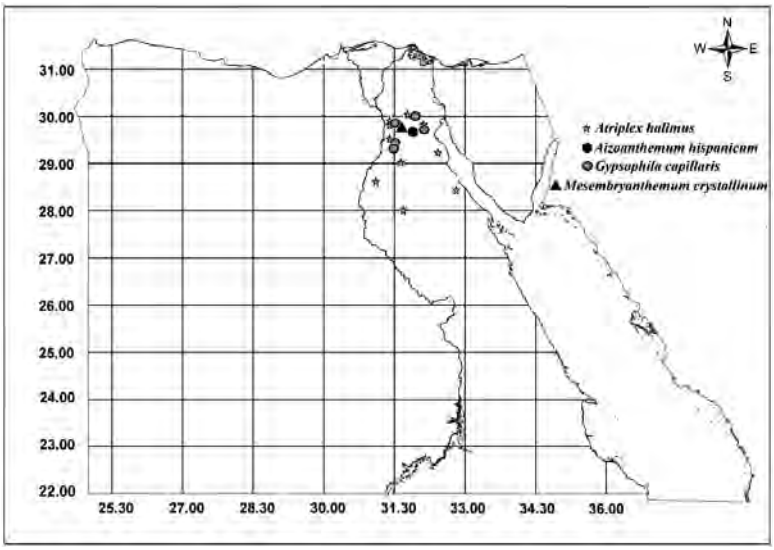

Figure 6. Distribution map of *Atriplex halimus*, *Aizoanthemum hispanicum*, *Gypsophila capillaris* and *Mesembryanthemum crystallinum* (northerly distributed Mediterranean species).

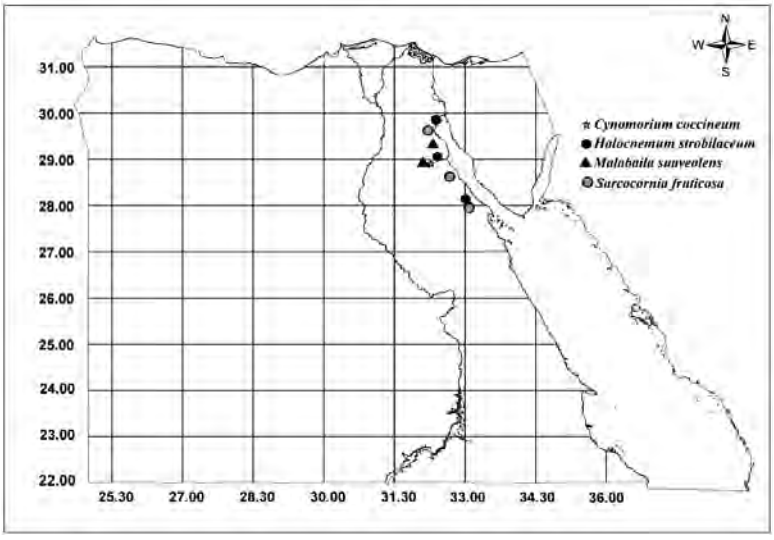

Figure 7. Distribution map of *Cynomorium coccineum*, *Halocnemum strobilaceum*, *Malabaila suaveolens* and *Sarcocornia fruticosa* (easterly distributed Mediterranean species).

and *Umbilicus intermedia* (El Hadidy & Fayed 1994/95). In this subtype, some salt-tolerant species were also recorded, e.g. *Frankenia hirsuta*, *Sarcocornia fruticosa* and *Suaeda altissima*.

Local subtype 5: Westerly distributed species

Three species were recorded in this subtype; all are among the common weeds of arable lands that were reclaimed in the western part close to the Nile River Valley.

III. The Irano-Turanian chorotype (Fig. 9)

According to Zohary (1973), the Irano-Turanian region covers a large area stretching from east toward China-Japan, west to Mediterranean, north to northern extra-tropical and south to north

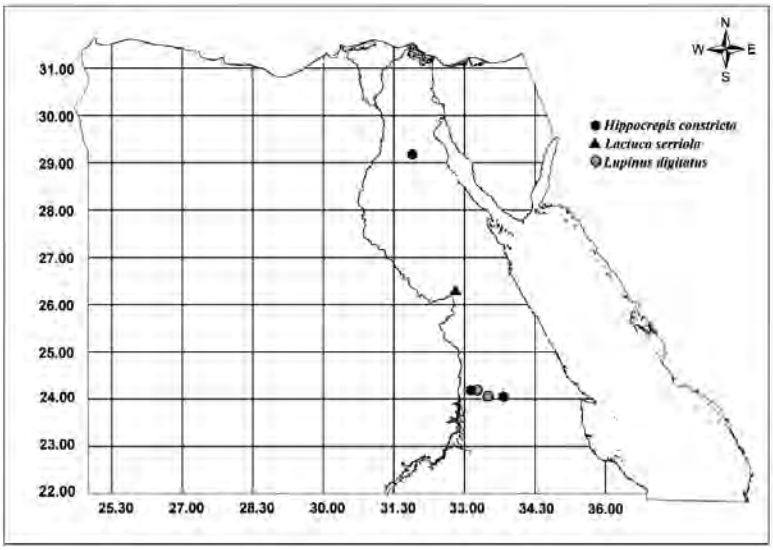

Figure 8. Distribution map of *Hippocrepis constricta*, *Lactuca serriola* and *Lupinus digitatus* (southerly distributed Mediterranean species).

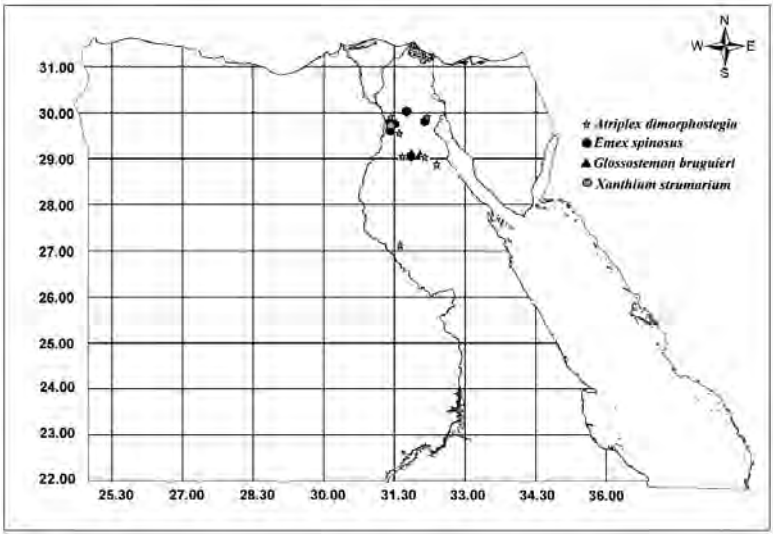

Figure 9. Distribution map of *Atriplex dimorphostegia*, *Emex spinosa*, *Glossostemon bruguieri* and *Xanthium strumarium* (northerly distributed Irano-Turanian species).

African-Indian desert region. In this study, it was represented by six species, all confined to the northern part of the study area.

Local subtype 1: Widely distributed species – not represented.

Local subtype 2: Northerly distributed species

All the 6 recorded species were confined to the northern part, e.g. *Atriplex dimorphostegia, Glossostemon bruguieri, Heliotropium arbainense* and *Paronychia sinaica* were found (Appendix 1).

Local subtype 3: Southerly distributed species – not represented.

Local subtype 4: Easterly distributed species – not represented.

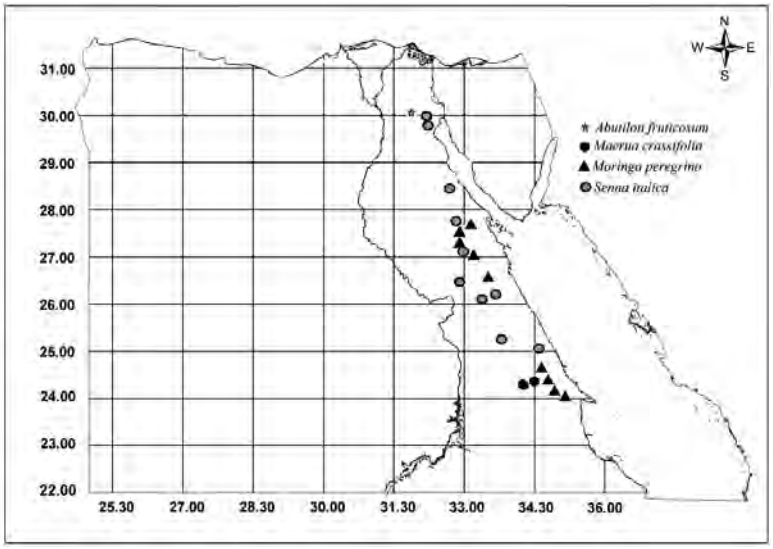

Figure 10. Distribution map of Sudano-Zambezian species: *Senna italica* (widely distributed), *Maerua crassifolia* (southerly distributed), *Abutilon fruticosum* (northerly distributed) and *Moringa peregrina* (easterly distributed).

Local subtype 5: Westerly distributed species – not represented.

IV. The Sudano-Zambezian chorotype (Fig. 10)

The Sudano-Zambezian region corresponds to the largest ecological formation in Africa, the tropical savanna in the north. It is bounded by the desert and semi-desert of the Saharo-Sindian region (Zohary 1973).

Local subtype 1: Widely distributed species – not represented.

Local subtype 2: Northerly distributed species

Four Sudano-Zambezian species showed consistency to the eastern part of the study area, e.g. *Ephedra ciliata* (gymnosperm) and the shrubs of *Farsetia longisiliqua* and *Abutilon fruticosum* (Appendix 1).

Local subtype 3: Southerly distributed species

The common recorded was *Acacia seyal* (tree). Another two occasional trees were also recorded in the southern stretches of the surveyed area, *Hyphaene thebaica* and *Maerua crassifolia*.

Local subtype 4: Easterly distributed species

Altogether, two occasionals (*Capparis decidua* and *Farsetia stylosa*) and one sporadic (*Tribulus bimucronatus*) occur in the eastern part.

Local subtype 5: Westerly distributed species

Senna italica was the only occasional species recorded from the western part.

V. The cosmopolitan, palaeotropical and pantropical species (Fig. 11)

Altogether, 27 species were recorded 16 (59%) out of which were cosmopolitans. This group included some of the most common weeds of the arable lands in Egypt such as *Sonchus oleraceus*

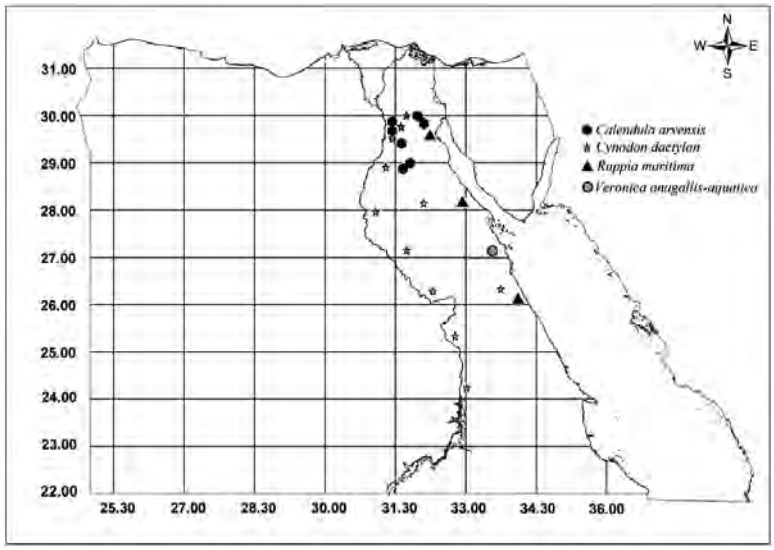

Figure 11. Distribution map of cosmopolitan species: *Cynodon dactylon* (widely distributed), *Calendula arvensis* (northerly distributed), *Ruppia maritima* and *Veronica anagallis-aquatica* (easterly distributed).

(common), *Chenopodium murale, Cynodon dactylon* and *Polypogon monspeliensis* (occasional) and the remaining were sporadic (Appendix 1).

Local subtype 1: Widely distributed species – not represented.

Local subtype 2: Northerly distributed species

Seventeen species (10 cosmopolitan, 4 palaeotropical and 3 pantropical) species were included (Appendix 1). Therophytes (12 species) dominating the other life forms, were found in northern inland wadis of the study area. The salt-tolerant species *Cressa cretica* which characterizes the salinized soils was recorded.

Local subtype 3: Southerly distributed species – not represented.

Local subtype 4: Easterly distributed species

Leptochloa fusca was the only palaeotropical species included (Appendix 1). It was found near water catchment areas, where water is collected. *Brassica nigra, Pseudognaphalium luteo-album, Ruppia maritima*, *Veronica anagallis-aquatica* and *V. beccabunga* were recorded once from the eastern part of the study area (Cairo University Herbarium records, in the year 1938) and not recorded in this work. These can be considered as historical records.

Local subtype 5: Westerly distributed species

Nine species were recorded, e.g. *Sonchus oleraceus* (common), *Cynodon dactylon*, *Phragmites australis* and *Polypogon monspeliensis* (occasional) and *Amaranthus viridis, Avena fatua*, *Ricinus communis*, *Solanum nigrum* and *Typha domingensis* (sporadic).

Discussion

From a phytogeographical point of view and according to Wickens (1976) and Takhtajan (1986) the study area lies within the Saharo-Sindian region of the Boreo-Subtropical zone of the

Palaeotropical Kingdom. This area is influenced by the Mediterranean, Sudano-Zambezian and Irano-Turanian regions (White 1993). These facts were revealed in the detailed chorological analysis of recorded species. Here, the Saharo-Sindian constituted the majority of mono-, bi- and pluriregional chorotypes. Species of the Saharo-Sindian region are known as good indicators of the harsh environment of the arid desert (Hegazy et al. 1998; Abd El-Ghani & Amer 2003). The dominance of the Saharo-Sindian chorotype in the study area is coinciding with the results of El Hadidi (1993), Fossati et al. (1998) and Hassan (2003). An account on the floristic composition and phytogeographical affinities of the study area and its biogeographical relationships to other adjacent deserts was published by the same authors before (Abd El-Ghani et al. 2013).

The relationship between the life forms and chorological affinities in floristic studies contributes significantly to the prevailing climatic conditions and human impacts as well. Several studies deal with this subject, e.g. Batalha & Martins (2002) in Brazilian cerrado sites, Klimeš (2003) in NW Himalayas, Becker & Müller (2007) in semi-arid regions of West and Southern Africa, Gouvas & Theodoropoulos (2007) in Mount Hymettus (Central Greece); Carvalho da Costa et al. (2007) in deciduous thorn woodland (caatinga) in north-eastern Brazil, Al-Sherif et al. (2013) in the arid region of Saudi Arabia. In the present study, the life-form spectrum is characteristic of an arid desert region with the dominance of therophytes, followed by chamaephytes, hemicryptophytes and phanerophytes. That seems to be the response to the hot dry climate, topographic variations and/or human and animal interference. A comparison of the life-form spectra of the Eastern Desert of Egypt and those in the Tihama coastal plains of Jazan region in south-western Saudi Arabia (El-Demerdash et al. 1994) showed the same results. Similar conclusions were also reported by Arshad et al. (2008) in various locations of the Cholistan desert in Pakistan.

In hyper-arid deserts like the study area, plant growth is triggered mainly by rain, which is scarce, patchy and restricted to wadis, runnels and depressions with deep fine sediments, where runoff water is collected and provides sufficient moisture for plant growth (Shmida 1985; Bornkamm 2001). Consequently, several highly adapted, drought-resistant species such as *Acacia tortilis* subsp. *raddiana, Tamarix aphylla, Ziziphus spina-christi* (trees) and *Capparis spinosa, Convolvulus hystrix, Fagonia bruguieri, Zygophyllum coccineum, Zilla spinosa* (shrubs) were among the widely distributed and very common species in this desert.

Results on the distribution of different biological spectra confirmed the dominance of therophytes, mostly of Saharo-Sindian affinity. Frequent occurrence of therophytes may be attributed to their short life cycle, water availability and the prevailing climatic conditions (Shaltout & El-Fahar 1991). The preponderance of therophytes can also be related to their high reproductive capacity, ecological, morphological and genetic plasticity under a high degree of disturbance (Grime 1979). This spectrum strongly resembles that reported by Danin & Orshan (1990) for corresponding environments in Israel.

The notable decrease of the recorded species from the northern part to the southern part can be attributed to the decrease of the mean annual average of rainfall along this gradient from 25 mm in Suez to almost 0 mm in Mersa Alam along the Red Sea coast (Abd El-Ghani 1998). However, the Red Sea coast (eastern border of the Eastern Desert) and its mountains receive more

precipitation than the Nile Valley (western border of the Eastern Desert). Most of the studied wadis (valleys) cross the Eastern Desert in E–W direction and debouch their waters into the Nile River. This may explain the increase of the recorded species along E–W direction. Plant species growth in desert wadis and water catchment areas is different than in surrounding areas which was reported by several authors (El Hadidi et al. 1986; El-Bana & Al-Mathnani 2009; Abdel Khalik et al. 2013; Salama et al. 2016).

Our results also showed some weeds in arable lands of Egypt. These weeds belong to the common weeds of Egypt (El Hadidi & Kosinová 1971; Abd El-Ghani & El-Sawaf 2004). That could be explained by the proximity of the study area to the boundaries of the agro-ecosystem of the Nile Valley, where many tracts of land have been reclaimed and cultivated. Thus, weeds have found new favourable conditions for their growth and their invasion has expanded.

Phytogeographical divisions of Egypt and especially of the Eastern Desert have often been a matter of controversy. Hassib (1951) divided the study area into 3 main phytogeographical regions: (1) Northern Arabian Desert from wadi Tumilat to Qena-Qusseir region (Da. sept.); (2) Southern Arabian Desert from Qena-Qusseir southward to Sudanian borders (Da. mer); (3) Red Sea coast comprising the coast of Red Sea from Suez Gulf southward to Gebel Elba region. On the other hand, El Hadidi (1980) included the Eastern Desert in two phytogeographical units: (1) Eastern Desert region (D) and (2) Red Sea region (R). The former can be further subdivided into: Galala Desert (Dg) and Arabian Desert (Da). While the latter can be subdivided into: the Arabian sector (Ra) that lying between 22°–28°N lat. and the Suez Gulf Sector (Rz) lying between 28°–30°N lat.

Based on the presented distribution patterns of the recorded species, the geographical distribution maps, the biogeographical relationships and the vegetation analysis (Abd El-Ghani et al. 2013), we suggest to divide the study area into two major phytogeographical divisions: the Eastern Desert and the Red Sea (Fig. 12), each of which can be further split into other subdivisions as follows:

Division 1: The Eastern Desert

This division comprised the inland desert of the study area from River Nile Valley eastward to the limits of the Red Sea Mountains. Taking into account variations in the floristic composition and species distribution, we suggest to divide this division into two subdivisions: Galala (northern) and Arabian (southern).

Subdivision 1: The northern Galala Desert (Dg)

This subterritory comprised the northern part of the study area. It extends from the northern limits at 30°N lat. southward to Minya-Assiut desert at 27°N lat. This subterritory is the most species-rich and characterized by restriction to numerous families including Aizoaceae, Alliaceae, Amaryllidaceae, Anacardiaceae, Cannabaceae, Cistaceae, Dipsacaceae, Ephedraceae, Neuradaceae, Orobanchaceae, Oxalidaceae, Portulacaceae, Primulaceae, Rutaceae, Sterculiaceae and Thymelaeaceae.

Subdivision 2: The southern Arabian Desert (Da)

It occupies the southern part of the study area; south of 27°N lat. This subterritory is characterized by a low species-diversity (25 species) with the absence of restricted families.

Division 2: The Red Sea coast (R)

This territory includes the area between Red Sea coast westward to Red Sea Mountains. This territory can be subdivided into 2 main subterritories: Red Sea coastal plain and Red Sea Mountains.

Subdivision 1: The Red Sea coastal plain (Rc)

This subterritory occupies the coastal plain of the Red Sea varying between 8 and 35 km from the coast (Zahran & Willis 1992). Here, very few characteristic species were represented: *Avicennia marina*, *Halocnemum strobilaceum*, *Atriplex farinosa*, *Arthrocnemum glaucum*, *Halopeplis perfoliata*, *Limonium axillare*, *Aeluropus lagopoides*, *Sporobolus spicatus* and *Suaeda monoica*.

Subdivison 2: The Red Sea Mountains (Rm)

It occupies the area from the limit of Red Sea coastal plain westward to the western limit of the Red Sea Mountains. This area is characterized by a large number of coastal wadis and a high diversity of plants.

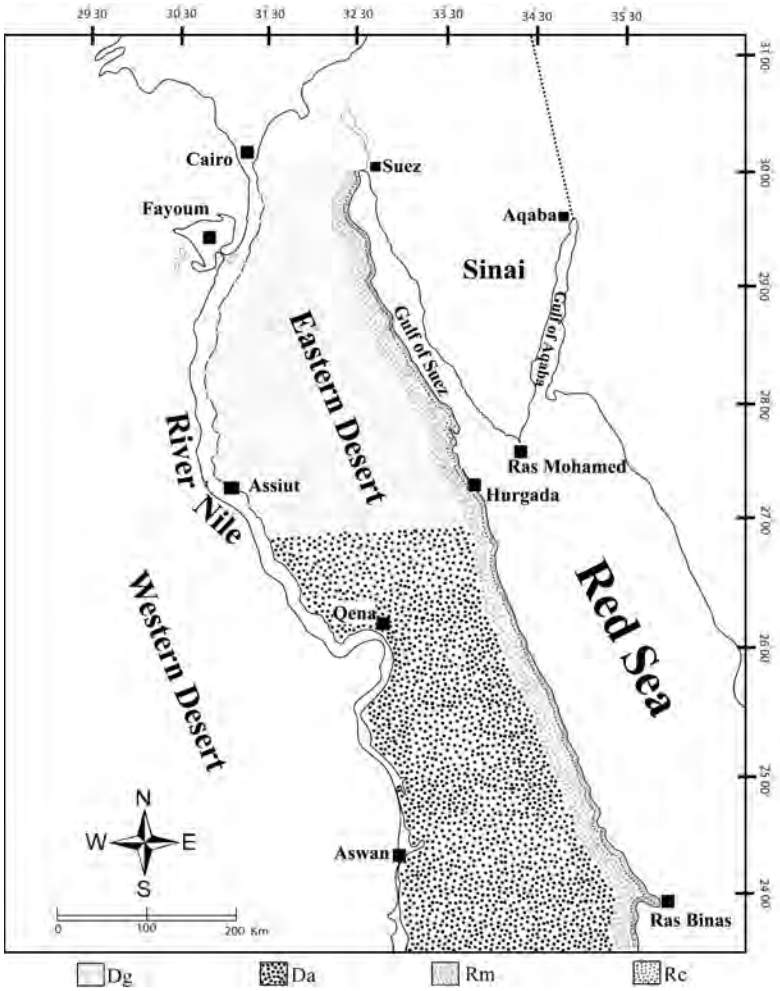

Figure 12. Map of the study area showing the proposed phytogeographical sub-divisions. Dg = Galala Desert, Da = Arabian Desert, Rm = Red Sea Mountain and Rc = Red Sea Coastal plain.

Conclusions

The landscape of the Eastern Desert of Egypt presents a variety of landforms and eco-geomorphological units, resulting in a remarkable difference between longitudinal and transverse directions. This has caused the longitudinal and transverse differentiation of plant species which is correlated with terrain microhabitats and climatic variations mainly in temperature and rainfall. The result is a spatial heterogeneity of plant distribution patterns. Diversification and dominance of plant communities differ in longitudinal and transverse directions. The species of the southern part of this desert are more affected by the Sudanian and Irano-Turanian elements than those growing in the northern, eastern and western parts.

References

Abd El-Ghani M. M. (1998): Environmental correlates of species distribution in arid desert ecosystems of eastern Egypt. – J. Arid Environm. **38**: 297–313.

Abd El-Ghani M. M. & Amer W. (2003): Soil-vegetation relationships in a coastal desert plain of southern Sinai, Egypt. – J. Arid Environm. **55**: 607–628.

Abd El-Ghani M. M. & El-Sawaf N. (2004): Diversity and distribution of plant species in the agro-ecosystem of Egypt. – Syst. Geogr. Pl. **74**: 319–336.

Abd El-Ghani M. M., Salama F. M., Salem B., El-Hadidy A. & Abdel-Aleem M. (2013): Biogeographical relations of a hyperarid desert flora in eastern Egypt. – African J. Ecol. **52**: 173–191.

Abdel Khalik K., El-Sheikh M. & El-Aidarous A. (2013): Floristic diversity and vegetation analysis of Wadi Al-Noman, Mecca, Saudi Arabia. – Turkish J. Bot. **37**: 894–907.

Abu Al-Izz M. S. (1971): Landforms of Egypt. – Cairo: The American University in Cairo Press.

Al-Sherif E., Ayesh A. M. & Rawi S. M. (2013): Floristic composition, life form and chorology of plant life at Khulais region, western Saudi Arabia. – Pakistan J. Bot. **45**(1): 29–38.

Arshad M., Ul-Hussan A., Ashraf M., Noureen S. & Moazzam M. (2008): Edaphic factors and distribution of vegetation in the Cholistan desert, Pakistan. – Pakistan J. Bot. **40**(5): 1923–1931.

Batalha M. A. & Martins F. R. (2002): Life-form spectra of Brazilian cerrado sites. – Flora **197**: 452–460.

Becker T. & Müller J. V. (2007): Floristic affinities, life-form spectra and habitat preferences of the vegetation of two semi-arid regions in Sahelian West and Southern Africa. – Basic Appl. Dryland Res. **1**(1): 33–50.

Bornkamm R. (2001): Allochthonous ecosystems without producers. – Bocconea **13**: 201–208.

Boulos L. (1999–2005): Flora of Egypt. Vols 1–4. – Cairo: Al Hadara Publishing.

Cain S. A. (1947): Characteristics of natural areas and factors in their development. – Ecol. Monogr. **17**: 185–200.

Carvalho da Costa R., Soares de Araújo F. & Wilson Lima-Verde L. (2007): Flora and life-form spectrum in an area of deciduous thorn woodland (caatinga) in northeastern, Brazil. – J. Arid Environm. **68**: 237–247.

Danin A. & Orshan G. (1990): The distribution of Raunkiaer life forms in Israel in relation to environment. – J. Veg. Sci. **1**: 41–48.

El-Bana M. I. & Al-Mathnani A. (2009): Vegetation-soil relationships in the Wadi Al-Hayat area of the Libyan Sahara. – Australian J. Basic Appl. Sci. **3**(2): 740–747.

El-Demerdash M. A., Hegazy A. K. & Zilay A. M. (1994): Distribution of the plant communities in Tihamah coastal plains of Jazan region, Saudi Arabia. – Vegetatio **112**: 141–151.

El Hadidi M. N. (1980): An outline of the planned flora of Egypt. – Taeckholmia Addit. Ser. **1**: 1–12.

El Hadidi M.N. (1993): Natural vegetation. – In: Craig G.M. [ed.]: The agriculture in Egypt. – London: Oxford University Press.

El Hadidi M.N., Abd El-Ghani M.M., Springuel I. & Hoffman M.A. (1986): Wild barley *Hordeum spontaneum* L. in Egypt. – Biol. Conserv. **37**: 291–300.

El Hadidi M.N. & Fayed A.A. (1994/95): Materials for Excursion Flora of Egypt (EFE). – Taeckholmia **15**: 1–233.

El Hadidi M.N. & Kosinová J. (1971): Studies on the weed flora of the cultivated land in Egypt. 1. Preliminary survey. – Bot. Staatssamml. München **10**: 354–367.

Feinbrun-Dothan N. (1978–1986): Flora Palaestina. – Jerusalem: The Israel Academy of Sciences and Humanities.

Fossati J., Pautou G. & Peltier J.P. (1998): Wadi vegetation of the North-Eastern desert of Egypt. – Feddes Repert. **109**: 313–327.

Gouvas M. & Theodoropoulos K. (2007): Life-form and chorological spectra of the vegetation units of Mount Hymettus (C Greece). – J. Biol. Res.-Thessaloniki **8**: 177–187.

Grime J.P. (1979): Plant strategies and vegetation processes. – Chichester: John Wiley & Sons.

Hassan L.M. (1987): Studies on the flora of the Eastern Desert of Egypt. – Unpublished Ph.D. Thesis, Faculty of Science, Cairo University, Egypt.

Hassan A.A. (2003): Habitat and plant species diversity along the Red Sea coast in Egypt. – Unpublished M.Sc. Thesis, Faculty of Science, Cairo University, Egypt.

Hassib M. (1951): Distribution of plant communities in Egypt. – Bull. Fac. Sci. Cairo Univ. **29**: 59–261.

Hegazy A.K., El-Demerdash M.A. & Hosni H.A. (1998): Vegetation, species diversity and floristic relations along an altitudinal gradient in Southwest Saudi Arabia. – J. Arid Environm. **38**: 3–13.

Kassas M. & Girgis W.A. (1964): Habitats and plant communities in the Egyptian deserts. V. The limestone plateau. – J. Ecol. **52**: 107–119.

Kassas M. & Girgis W.A. (1969): Habitats and plant communities in the Egyptian deserts. VI. The units of deserts ecosystem. – J. Ecol. **53**: 715–728.

Klimeš L. (2003): Life-forms and clonality of vascular plants along an altitudinal gradient in E Ladakh (NW Himalayas). – Basic Appl. Ecol. **4**: 317–328.

Qian H. (1999): Spatial pattern of vascular plant diversity in North America north of Mexico and its floristic relationship with Eurasia. – Ann. Bot. **83**: 271–283.

Qian H., Wang S., He J.S., Zhang J., Wang L., Wang X. & Guo K. (2006): Phytogeographical analysis of seed plant genera in China. – Ann. Bot. **98**(5): 1073–1084.

Raunkiaer C. (1934): The plant life forms and statistical plant geography. – Oxford: Clarendon Press.

Said R. (1962): The geology of Egypt. – Amsterdam: Elsevier.

Said R. (1990): Geomorphology. – In: Said R. [ed.]: Geology of Egypt: 9–26. – Rotterdam: A.A. Balkema.

Salama F., Abd El-Ghani M., Gadallah M., El-Naggar S. & Amro A. (2016): Characteristics of desert vegetation along four transects in the arid environment of southern Egypt. – Turkish J. Bot. **40**(1): 59–73.

Shaltout K.H. & El Fahar R.A. (1991): Diversity and phenology of weed communities in the Nile Delta region. – J. Veg. Sci. **2**: 385–390.

Shmida A. (1985): Biogeography of the desert flora. – In: Evenari M., Noy-Meir I. & Goodall D.W. [eds]: Ecosystems of the world, vol. 12A: 23–77. – Amsterdam: Elsevier.

Stott P. (1981): Historical plant geography. – London: George Allen and Unwin.

Täckholm V. (1974): Students' Flora of Egypt. [2nd ed.] – Beirut: Cairo University Publ. & Cooperative Printing Company.

Takhtajan A.L. (1986): Floristic regions of the world. – Berkeley: University of California Press.

UNEP (1992): World atlas of desertification. – London: Edward Arnold.

White F. (1993): The AETFAT chorological classification of Africa: history, methods and applications. – Bull. Jard. Bot. Natl. Belg. **62**: 225–281.

Wickens G. E. (1976): The flora of Jebel Marra (Sudan Republic) and its geographical affinities. – Kew Bull., Addit. Ser. **5**: 1–368.

Zahran M. A. & Willis A. J. (1992): The vegetation of Egypt. – London: Chapman and Hall.

Zahran M. A. & Willis A. J. (2009): The vegetation of Egypt. Plant and vegetation. [2nd ed.] – London: Springer Science and Business Media B.V.

Zohary M. (1973): Geobotanical foundations of the Middle East. – Stuttgart: Gustav Fischer Verlag.

Addresses of the authors:

Monier Abd El-Ghani (corresponding author)
Azza El-Hadidy
Mohamed Abdel-Aleem
The Herbarium, Faculty of Science
Cairo University, Giza
Egypt
E-mail: mmabdelghnai@gmail.com
elghani@yahoo.com

Fawzy Salama
Faculty of Science
Assiut University, Assiut
Egypt
Boshra Salem
Faculty of Science
Alexandria University, Alexandria
Egypt

Appendix 1. Geographical distribution of the recorded species in the major chorotypes and local subtypes.

I. Saharo-Sindian Chorotype

Subtype 1: Widely distributed species

Acacia tortilis
Farsetia aegyptia
Morettia philaeana
Ochradenus baccatus
Pulicaria undulata
Tamarix nilotica
Tetraena simplex
Trichodesma africanum
Zilla spinosa
Zygophyllum coccineum

Subtype 2: Northerly distributed species

Achillea fragrantissima
Aeluropus lagopoides
Agathophora alopecuroides
Althaea ludwigii
Anabasis setifera
Anastatica hierochuntica
Anchusa hispida
Anthemis melampodina
Artemisia monosperma
Asteriscus pygmaeus
Astragalus annularis
Astragalus bombycinus
Astragalus schimperi
Astragalus sieberi
Astragalus tribuloides
Astragalus trigonus
Atractylis carduus
Atractylis mernephthae
Atriplex leucoclada
Atriplex lindley
Brassica tournefortii
Bromus madritensis
Capparis spinosa
Caylusea hexagyna
Cenchrus ciliaris
Centaurea aegyptiaca
Centaurea calcitrapa
Chrozophora plicata
Cistanche phelypaea
Cistanche tubulosa
Cocculus pendulus
Convolvulus lanatus
Convolvulus pilosellifolius
Cullen plicata
Cuscuta pedicellata
Desmostachya bipinnata
Deverra triradiata
Diplotaxis harra
Echinocloa colona
Echinops spinosissimus
Echiochilon fruticosum
Ephedra alata
Ephedra aphylla
Erodium arborescens
Erodium crassifolium
Erodium glaucophyllum
Erodium oxyrhynchum
Erodium touchyanum
Euphorbia granulata
Fagonia glutinosa
Fagonia scabra
Fagonia tristis
Ficus palmata
Filago desertorum
Frankenia pulverulenta
Gymnocarpos decandrum
Gypsophila capillaris
Haplophyllum tuberculatum
Helianthemum kahiricum
Helianthemum lipii
Heliotropium diginum
Herniaria hemistemon
Hordeum murinum
Hyoscyamus muticus
Kickxia aegyptiaca
Lappula spinocarpos
Lasiurus scindicus
Launaea spinosa
Lavandula pubescens
Lavandula stricta
Limonium pruinosum
Lycium shawii
Medicago laciniata
Mesembryanthemum forsskalei
Mesembryanthemum nodiflorum
Moltkiopsis ciliata
Monosonia nivea
Nauplius graveolens
Neurada procumbens
Orobanche cernua
Orobanche crenata
Paracaryum intermedium
Pennisetum divisum
Phagnalon barbeyanum
Plantago ciliata
Plantago coronopus
Plantago cylindrica
Plantago ovata
Pluchea dioscoridis
Polygonum equisetiforme
Pseuderucaria clavata
Pteranthus dichotomus
Reaumuria hirtella
Reseda arabica
Reseda decursiva
Retama raetam
Rhus tripartita
Rumex cyprius
Rumex dentatus
Rumex simpliciflorus
Salvia aegyptiaca
Savignya parviflora
Scrophularia deserti
Senecio glaucus
Seriphidium herba-album
Spergularia diandra
Stachys aegyptiaca
Stipa capensis
Stipagrostis ciliata
Suaeda vermiculata
Tamarix tetragyna
Thymelaea hirsuta
Traganum nudatum
Trifolium alexandrinum
Urospermum picroides
Volutaria lippii
Ziziphus spina-christi
Zygophyllum decumbens
Zygophyllum propinqum

Subtype 3: Southerly distributed species

Acacia ehrenbergiana
Caroxylon villosum
Fagonia thebaica
Iphiona scabra
Monsonia heliotropoides
Schouwia purpurea
Silene linearis

Subtype 4: Easterly distributed species

Aeluropus littoralis
Atriplex farinosa
Avicennia marina
Cleome arabica
Cleome brachycarpa
Cleome crythansa

Cyperus conglomeratus
Halocnemum strobilaceum
Halopeplis perfoliata
Juncus rigidus
Kickxia acerbiana
Lindenbergia indica
Lotus glinoides
Peganum harmala
Periploca aphylla
Plantago afra
Sclerocephalus arabicus
Senecio flavus
Solenostemma argel
Suaeda monoica
Tephrosia apollinea

Subtype 5: Westerly distributed species

Aerva javanica
Alhagi graecorum
Anabasis articulata
Arnebia hispidissima
Artemisia judaica
Asphodelus tenufolius
Astragalus eremophilus
Astragalus vogelii
Atriplex halimus
Bassia muricata
Calligonum polygonoides
Calotropis procera
Caroxylon imbricatum
Centaurea scoparia
Chrozophora oblongifolia
Citrullus colocynthis
Cleome amblyocarpa
Cornulaca monacantha
Cotula cinerea
Crotalaria aegyptiaca
Cucumis prophetarum
Cynanchum acutum
Deverra tortuosa
Diplotaxis acris
Eremobium aegyptiacum
Eruca sativa
Fagonia arabica
Fagonia brugieri
Forsskaolea tenacissima
Haloxylon salicornicum
Heliotropium bacciferum
Heliotropium ramosissimum
Imperata cylindrica
Iphiona mucronata
Kochia indica
Launaea capitata
Launaea mucronata
Launaea nudicaulis
Leptadenia pyrotechnica
Lotus halophyllus
Matthiola livida
Nitraria retusa
Oligomeris linifolia
Panicum turgidum
Paronychia Arabica
Pergularia tomentosa
Phoenix dactylifera
Polycarpaea repens
Polycarpaea robbairea
Pulicaria incisa
Reichardia tingitana
Reseda pruinosa
Rumex vesicarius
Tamarix aphylla
Tribulus megistopterus
Trigonella stellata
Zygophyllum album

II. Mediterranean chorotype

Subtype 1: Widely distributed – not represented

Subtype 2: Northerly distributed species

Astragalus hamosus
Bidens pilosa
Cichorium pumilum
Crypsis schoenoides
Emex spinosa
Erodium cicutarium
Erodium malacoides
Euphorbia peplus
Hyoscyamus albus
Inula crithmoides
Juncus acutus
Lolium perenne
Lolium rigidum
Lotus creticus
Mesembryanthemum crystallinum
Phlaris paradoxa
Plantago major
Schismus barbatus
Spergularia marina
Urtica urens
Xanthim strumarium

Subtype 3: Southerly distributed species

Glinus lotoides
Hippocrepis constricta
Lactuca serriola
Lupinus digitatus
Withania somnifera

Subtype 4: Easterly distributed species

Frankenia hirsuta
Hyoscyamus desertorum
Suaeda altissima

Subtype 5: Westerly distributed species

Ammi majus
Avena sterilis
Malva parviflora

III. Irano-Turanian chorotype

Subtype 1: Widely distributed species – not represented

Subtype 2: Northerly distributed species

Achillea santolina
Astragalus spinosus
Atriplex dimorphostegia
Glossostemon bruguieri
Heliotropium arbainense
Paronychia sinaica

Subtype 3: Southerly distributed species – not represented

Subtype 4: Easterly distributed species – not represented

Subtype 5: Westerly distributed species – not represented

IV. Sudano-Zambezian chorotype

Subtype 1: Widely distributed species – not represented

Subtype 2: Northerly distributed species

Aizoon canariense
Ephedra ciliata
Farsetia longisiliqua
Sesbania sesban

Subtype 3: Southerly distributed species

Acacia seyal
Echium rauwolfii
Glossonema boveanum
Hyphaene thebaica
Lotononis platycarpos
Maerua crassifolia

Subtype 4: Easterly distributed species

Capparis decidua
Farsetia stylosa
Tribulus bimucronatus

Subtype 5: Westerly distributed species

Senna italica

V. Cosmopolitan, Palaeotropical and Pantropical chorotypes

Subtype 1: Widely distributed species – not represented

Subtype 2: Northerly distributed species

Amaranthus graecizans
Anagallis arvensis
Brassica rapa
Calendula arvensis
Cannabis sativa
Chenopodium album
Chenopodium murale
Convolvulus arvensis
Cressa cretica
Cyperus articulata
Dactyloctenium aegyptium
Dichanthium annulatus
Heliotropium curassivicum
Melilotus indicus
Portulaca oleracea
Sisymbrium irio
Tribulus terrestris

Subtype 3: Southerly distributed species – not represented

Subtype 4: Easterly distributed species

Leptochloa fusca

Subtype 5: Westerly distributed species

Amaranthus viridis
Avena fatua
Cynodon dactylon
Polypogon monspeliensis
Phragmites australis
Ricinus communis
Solanum nigrum
Sonchus oleraceus
Typha domingensis